Le marché des credit default swaps : effets de contagion et processus de découverte des prix durant les crises.

Mathieu Gex

UNIVERSITÉ DE GRENOBLE

THÈSE

Pour obtenir le grade de

DOCTEUR DE L'UNIVERSITÉ DE GRENOBLE

Spécialité : **Sciences de Gestion**

Arrêté ministériel : 7 août 2006

Présentée par

Mathieu GEX

Thèse dirigée par **Pascal LOUVET**

préparée au sein du **Laboratoire CERAG**
dans **l'École Doctorale de Sciences de Gestion**

Le marché des *Credit Default Swaps* : effets de contagion et processus de découverte des prix durant les crises

Thèse soutenue publiquement le **15 février 2011**,
devant le jury composé de :

M. Hervé ALEXANDRE
Professeur à l'Université Paris Dauphine, Président
M. Jean-Claude AUGROS
Professeur à l'Université Claude Bernard Lyon I et Directeur de l'Institut de Science Financière et d'Assurance (I.S.F.A.), Rapporteur
M. Rama CONT
Directeur de Recherche CNRS, Laboratoire de Probabilités et Modèles Aléatoires, *Associate Professor* et Directeur au *Center for financial engineering* à la Columbia University (New York), Membre
Mme. Virginie COUDERT
Conseiller scientifique de la direction de la stabilité financière, Banque de France et Université de Paris Ouest Nanterre la Défense, Membre
M. Pascal LOUVET
Professeur à l'Université de Grenoble et Directeur de l'Institut d'Administration des Entreprises (I.A.E.) de Grenoble, Directeur de thèse
Mme. Valérie MIGNON
Professeure à l'Université de Paris Ouest Nanterre la Défense, Rapporteur

Remerciements

Avant toutes choses, je remercie mon directeur de thèse, Pascal Louvet, pour son soutien, sa confiance et sa patience, ainsi que pour avoir accepté de gérer une thèse à distance.

Je remercie les professeurs Hervé Alexandre, Rama Cont, Virginie Coudert et Isabelle Girerd-Potin pour m'avoir fait l'honneur d'être membres de mon jury. Je remercie également les professeurs Jean-Claude Augros et Valérie Mignon pour avoir accepté d'être les rapporteurs.

Dans cette étrange aventure qu'est une thèse, je suis infiniment reconnaissant à Virginie Coudert pour les très nombreuses heures passées à travailler ensemble et pour m'avoir initié à cette science occulte et mystérieuse qu'est la rédaction d'un article académique publiable. Merci pour m'avoir si souvent permis de tenir la tête hors de l'eau, lorsque tout mener de front me semblait insurmontable.

J'ai noué de nombreux contacts à la Banque de France qui m'ont beaucoup apporté. Je remercie mes collègues et amis du SEMASFI et de la Banque de France en général pour les bons moments passés ensemble.

Je me dois de m'excuser platement auprès de Patricia Brion et Josiane Bouvet pour les avoir torturées avec mes demandes tordues de retraitement de données… Le résultat ayant largement dépassé mes attentes, je les remercie mille fois pour le temps qu'elles m'ont fait gagner dans mon travail de recherche.

Hors de la Banque de France, merci à Hélène Raymond, à Laurence Scialom ainsi qu'à l'ensemble des membres du groupe crise financière de l'Université Paris X pour leur gentillesse et pour les échanges que nous avons eus.

Il n'y a pas que le travail dans la vie. Je remercie donc tous ceux qui, à Paris comme dans la province valentinoise et grenobloise, et bien que ne saisissant pas toujours l'intérêt de s'imposer cette épreuve légèrement masochiste qu'est une thèse, sont parvenus à me faire conserver une certaine vie sociale et m'ont forcé avec sagesse à faire des breaks salutaires. Merci également d'avoir supporté la relative volatilité de mon humeur pendant ces quelques années !

Le mot de la fin sera pour ma famille. Merci pour vos encouragements, votre soutien, votre aide.

Contents

Avant propos

Cette thèse a été réalisée dans le cadre d'une convention industrielle de formation par la recherche (CIFRE) au sein de la Direction de la Stabilité Financière (DSF), direction dépendant de la Direction Générale des Opérations (DGO) de la Banque de France, entre février 2005 et février 2008. Elle a été terminée sous un statut de cadre latéral (contrat à durée indéterminée), dans un poste d'économiste-chercheur dans la même direction. Le déroulement et le contenu de cette thèse ont donc été déterminés de manière à répondre aux besoins du Service des Etudes sur les Marchés et la Stabilité Financière (SEMASFI), service qui m'a accueilli durant cette période.

Le format choisi est celui d'une thèse par articles, ce choix étant guidé par la volonté de pouvoir aborder la thématique de la thèse sous différents angles d'attaque, en phase avec les évolutions de l'environnement économique et financier. Cette thèse se compose ainsi de cinq articles, chacun, à l'exception du dernier produit récemment, étant déjà publié ou accepté pour publication dans une revue académique à comité de lecture scientifique. Ces différents articles sont donc présentés sous leur forme publiée, c'est-à-dire en anglais. Chaque article correspond à un chapitre. L'ordre des chapitres ne correspond pas à l'ordre de production des différents articles, un choix logique ayant consisté à adapter l'enchaînement des articles au fil directeur de la thèse, détaillé dans l'introduction générale. La thèse se compose ainsi des articles suivants :

- « Does risk aversion drive financial crises? Testing the predictive power of empirical indicators », 2008, *Journal of Empirical Finance* 15 (4), pp. 167-184 (chapitre I) ;
- « The Credit Default Swaps Market and the Settlement of Large Defaults », *International Economics*, 2010, n° 123 (chapitre II) ;
- « Contagion inside the Credit Default Swaps Market: The Case of the GM and Ford Crisis in 2005 », *Journal of International Financial Markets, Institutions & Money* 20 (2), 2009, pp. 109-134 (chapitre III) ;
- « Disrupted Links between Credit Default Swaps, Bonds and Equities During the GM and Ford Crisis in 2005 », *Applied Financial Economics* 20 (23), 2010, pp. 1769-1792 (chapitre IV) ;

- « The sovereign CDS market: what the failure of Lehman Brothers changed », document de travail finalisé en septembre 2010 (chapitre V) ;

Non repris dans la thèse mais utilisé en introduction :

- « *Credit default swaps* et stabilité financière : quels enjeux pour les régulateurs ? », 2009, Banque de France, *Revue de la Stabilité Financière* 13, pp. 79-93.

Introduction générale

L'octroi de crédit est au cœur de l'activité des banques et des institutions financières. Pour ces dernières, cette activité impliquait traditionnellement d'endosser le risque de crédit inhérent aux prêts accordés, c'est-à-dire la possibilité que la contrepartie ne puisse pas faire face à ses engagements, quelque soit leur nature (obligation, prêt bancaire ou créance commerciale). Ce risque peut se concrétiser à travers la dégradation de la qualité de crédit de l'emprunteur, qui se traduit souvent par une dégradation de sa note par une ou plusieurs agences de notation. Les difficultés rencontrées par l'emprunteur peuvent le conduire au défaut si ce dernier se retrouve dans l'incapacité de payer dans les délais impartis les intérêts ou de rembourser le principal. En cas de défaut avéré, le préteur subit également l'aléa du taux de recouvrement des titres de dette qu'il détient.

Une solution pour un créancier consiste alors à se focaliser plus sur la valeur des garanties liées à un prêt que sur la solvabilité de l'emprunteur, le prêteur évaluant alors les conditions dans lesquelles il pourra liquider le bien ou titre lié à ce prêt. Les incitations au rationnement du crédit dépendront donc des anticipations de taux de recouvrement en cas de liquidation de l'actif. L'hypothèse d'une bonne liquidité du marché peut conduire à des octrois de crédit considérables, comme l'a montré l'évolution du marché hypothécaire américain durant la période précédant la crise des *subprimes*. Le recours à des techniques de transfert du risque de crédit permet aux banques et aux autres prêteurs de bénéficier de garanties sur les conditions de liquidation des actifs sous-jacents à un prêt, quelque soit sa nature. Elles permettent ainsi à ces institutions de libérer du capital qui assurera l'expansion de leur activité d'intermédiation du crédit (Duffie, 2008) et expliquent le succès qu'à connu le modèle *originate-to-distribute*, auprès de la grande majorité des banques et institutions financières, jusqu'à son effondrement en 2007.

Cependant, le transfert de risque implique des coûts. En premier lieu, une *lemon premium*, telle que décrite par Akerlof (1970), liée au fait qu'une entité achetant un prêt dispose de moins d'information que celle qui le vend. Elle infèrera donc que la valeur de ce prêt est au mieux celle proposée par le vendeur, mais vaut peut-être moins, et exigera par conséquent une prime. En second lieu un coût lié à l'aléa moral, la pratique du transfert de risque constituant une incitation à diminuer les standards d'octroi de crédit et à un contrôle moins efficace du risque de défaut de l'emprunteur. En contrepartie, le transfert de risque améliore la diversification des portefeuilles et permet de réduire le coût du capital nécessaire à l'octroi de crédits additionnels. Les banques seront donc incitées à recourir au transfert du risque de crédit jusqu'à ce que son coût excède les gains issus de la réduction des exigences en capital que ce transfert permet ; ce qui apparaît comme une situation d'équilibre (Froot *et al*., 1993 ; Froot et Stein, 1998).

Les *credit default swaps* (CDS) ont été les produits les plus utilisés par les participants de marché pour assurer ce transfert du risque de crédit. Les incitations à recourir à ces produits ont eu pour conséquence une véritable explosion de ce marché. Cependant, la crise des *subprimes*, que ces instruments sont accusés d'avoir attisée, sinon provoquée, incite à s'interroger sur les conditions dans lesquels ce risque a réellement été transféré ainsi qu'aux conséquences de ce transfert sur la dynamique des marchés.

1. L'émergence du marché des CDS

1.1. Innovation financière et émergence des CDS

L'idée d'étendre le spectre des produits dérivés au risque de crédit a émergé lors d'un *offsite weekend* organisé par la banque américaine J.P. Morgan à Boca Raton, en Floride. Cette station balnéaire a par la suite été considérée comme le lieu de naissance des instruments de transfert du risque de crédit (*credit risk transfert instruments* – CRT). L'ordre du jour des réunions organisées durant ce weekend était de tenter de répondre une fois de plus à cette fuite en avant qu'est l'innovation financière, liée au fait qu'il n'existe pas de propriété intellectuelle concernant les produits financiers (Tett, 2006). Dans les années 80, une réponse avait été la création des *swaps* de taux (*interest rate swaps* – IRS[1]). Au départ produit de niche destiné à un faible nombre d'investisseurs prêts à payer des marges importantes pour y accéder, les IRS sont rapidement devenus des produits largement négociés, à tel point que ce marché est devenu le deuxième marché le plus important du monde après celui des titres de dette publique. Les banques, en situation de forte concurrence, ont ainsi dû diminuer fortement leurs marges sur ces instruments.

Pour développer des produits dérivés dédiés au risque de crédit, J.P. Morgan a tiré parti de sa forte exposition sur les titres de dette publique de gouvernements européens et du risque de défaut afférent, qui n'était pas négligeable dans le contexte de l'époque. Le premier contrat ayant la nature d'un dérivé de crédit développé par la banque stipulait ainsi qu'en cas de défaut de l'un des titres composant un panier d'obligations d'Etats européens, les investisseurs compenseraient J. P. Morgan pour la perte occasionnée. La banque disposait donc d'une couverture contre le défaut de l'une des obligations du panier ; les investisseurs recevraient en contrepartie une commission pour endosser ce risque. Ce premier contrat est assimilable aux produits connus aujourd'hui sous le nom de *first-to-default*.

---

[1] Le premier IRS, entre la Banque Mondiale et IBM, a été mis en place par Salomon Brothers en 1981.

L'occasion pour J.P. Morgan de créer le premier contrat de *credit default swap* (CDS) s'est présentée en 1994, lorsqu'Exxon a souhaité ouvrir une nouvelle ligne de crédit auprès de la banque (Tett, 2010). L'objectif de cette ligne était de couvrir les pertes potentielles de 5 milliards USD liées à la marée noire provoquée en 1989 par le naufrage de l'Exxon Valdez. Exxon étant un client historique de J. P. Morgan, il était délicat pour la banque de refuser la mise en place de cette ligne de crédit. Cependant, selon le cadre réglementaire défini par les accords de Bâle en 1988 et appliqué par les pays du G10 à partir de 1992, les banques devaient disposer d'une réserve de capital à hauteur de 8% des prêts accordés[2]. Le coût en capital pour J. P. Morgan aurait donc été substantiel. Pour éviter cette surcharge en capital réglementaire tout en accordant le prêt à Exxon, la banque a mis en place, avec la Banque Européenne de Reconstruction et de Développement (BERD) un contrat par lequel cette dernière supporterait le risque de crédit d'Exxon. En cas de défaut, la BERD compenserait J. P. Morgan et serait rémunérée pour cette protection pendant la durée du contrat. J. P. Morgan n'aurait donc plus à monopoliser du capital pour assurer le prêt à Exxon et pourrait utiliser ce montant pour financer des activités plus rentables.

Les régulateurs ont accepté l'argument selon lequel, le risque ayant été transféré au niveau comptable à une autre entité par le biais du CDS, l'acheteur de protection n'aurait plus à supporter la charge en capital liée, faisant des CDS un *credit risk mitigant* (BCBS, 2006).

Les principales raisons qui ont justifié le développement rapide des dérivés de crédit dès le début des années 90 se retrouvent donc dès ce premier contrat (Bruyère, 2005) :

- La possibilité de se protéger efficacement contre le risque de crédit ;
- Le rattrapage d'un retard technologique entre des méthodes de gestion des risques de marché sophistiquées et de gestion du risque de crédit plus rudimentaires ;
- L'apport des CRT en matière d'optimisation du capital réglementaire ;
- La possibilité d'augmenter les montants de crédit accordés en contournant les limites d'autorisation par contrepartie *via* le transfert de risque ;
- Le développement d'une innovation financière permettant d'exploiter de nouvelles niches générant une forte rentabilité comparativement aux produits

[2] Dans le cadre des accords de Bâle I, ce ratio, dit ratio Cooke, intégrait également une seconde pondération afférente à la notation de l'emprunteur. Dans le cas d'Exxon, entreprise non bancaire, cette seconde pondération était de 100% de ces 8%, soit une rétention de capital de 8% *in fine*.

dérivés classiques (*plain vanilla*) dont les marges avaient été fortement dégradées par la concurrence entre banques.

1.2. CDS et transfert de risque de crédit

Parmi les différents dérivés de crédit, les CDS sont les plus négociés. Un CDS met en relation deux contreparties, un acheteur et un vendeur de protection. L'acheteur de protection transfert le risque de crédit associé à un actif de référence, obligation ou prêt, au vendeur de protection sans que l'actif de référence soit cédé par l'acheteur de protection au vendeur de protection. Il s'agit donc d'une exposition synthétique. L'acheteur de protection, qui est vendeur de risque, sera couvert contre la survenance du défaut de l'entité de référence. Le vendeur de protection, qui est acheteur de risque, est rémunéré pour cette prise de risque, à travers le paiement d'une prime. Cette prime, exprimée annuellement, est généralement payée sur une fréquence trimestrielle (plus rarement sur une base semestrielle ou annuelle).

Le versement de cette prime constitue la jambe fixe du *swap* et s'exprime comme la valeur de la prime en points de base multipliée par le montant notionnel de la transaction. Si l'actif de référence ne fait pas défaut, le versement de la prime est assuré jusqu'à la maturité du contrat, le plus souvent 5 ans.

La jambe variable du *swap* ne sera activée qu'en cas de défaut. Le versement de la prime est alors suspendu. Cette jambe variable permet de répliquer la décote subie par l'actif de référence suite au défaut et de compenser l'acheteur de protection pour cette perte. La dernière prime versée est calculée au prorata de la période courant entre le dernier versement et le défaut.

Supposons donc qu'un investisseur A achète un CDS de prime c sur l'entité X à B pour une certaine valeur faciale F. Ce contrat le couvre contre le risque de défaut de X du jour de son achat t_0 jusqu'à son échéance T, par exemple 5 ans :

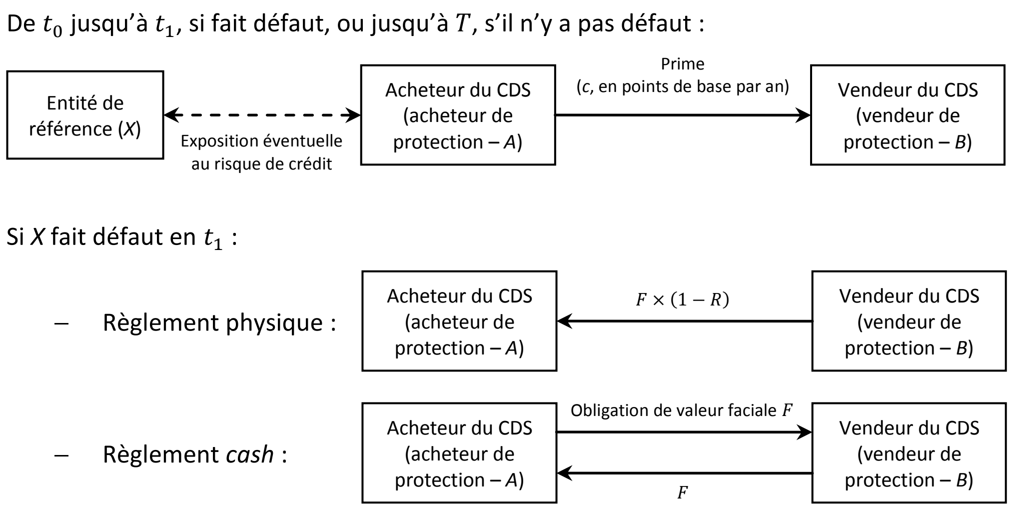
- A s'engage à verser à B un montant proportionnel à la valeur faciale couverte ($F \times c$) sur toute la durée du contrat (de t_0 à T), ou jusqu'au défaut, si un défaut intervient sur la période. Naturellement, la prime c augmente avec la probabilité de défaut de X et baisse avec le taux de recouvrement attendu, suivant approximativement le *spread* obligataire ;
- en contrepartie, B s'engage à lui verser une somme en cas de défaut, qui le compense entièrement de sa perte.

Si l'actif de référence fait défaut en t_1, deux options sont possibles pour ce règlement :

- un règlement physique, A délivre à B le titre sous-jacent et B lui verse l'intégralité de la valeur faciale F ;
- un règlement en espèces, B verse à A la somme $F \times (1 - R)$ en t_1, où R est le taux de recouvrement ; A ne transfère pas le titre sous-jacent.

Ces mécanismes sont illustrés dans la Figure 1. Théoriquement, dans les deux modes de règlement, l'acheteur du CDS qui détient une obligation de même valeur faciale est couvert entièrement contre le risque de défaut par le CDS. Ceci est évident en cas du règlement physique. C'est aussi le cas s'il y a règlement en espèces (règlement *cash*) et si le marché des CDS est bien en phase avec celui des obligations ; il pourra récupérer $F \times R$ en revendant son obligation sur le marché secondaire et le reste de la valeur faciale $F \times (1 - R)$ auprès du vendeur. Le chapitre II revient en détail sur les mécanismes opérationnels mis en place par les participants de marché pour gérer ces deux types de règlements.

Figure 1 : Credit Default Swap



1.3. *Transfert de risque de crédit et transfert de propriété d'un actif*

L'une des innovations majeures des deux dernières décennies est l'élargissement considérable de la gamme d'instruments de transfert du risque de crédit. Le développement de ces outils restera cependant indubitablement associé à la crise de 2007-2009, crise la plus importante qu'ait connue la finance depuis la seconde guerre mondiale.

Les CRT, en dissociant théoriquement le risque de crédit des autres types de risques, permettent à un participant de marché donné de transférer à un autre le risque de crédit qu'il assumait initialement. Bien que le transfert de risque de crédit ait connu une croissance forte sur la période récente à travers le développement de produits *ad hoc*, cette technique découle en fait de pratiques de marché bien établies. En suivant Chaplin (2005), il est possible d'assimiler une opération de pension livrée, ou *repo*, à un dérivé de crédit.

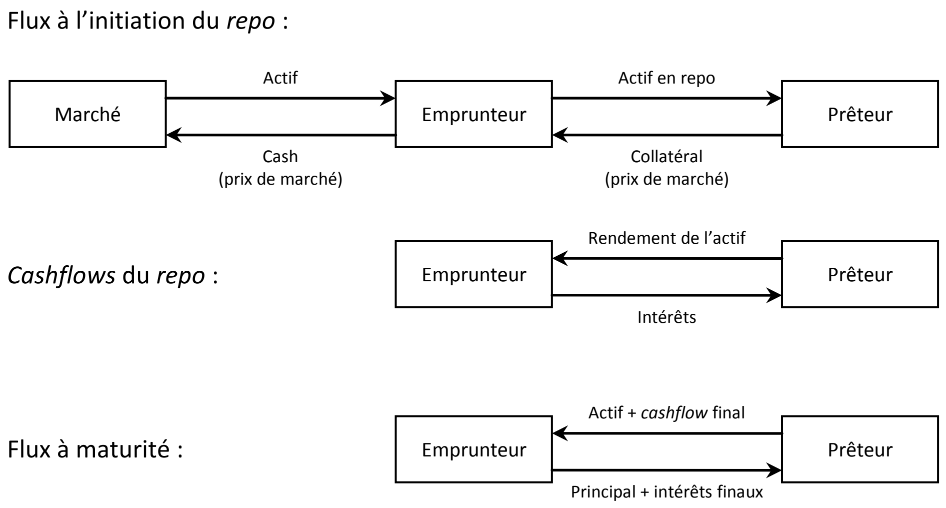
Pour assurer leurs besoins de financement, les banques utilisent des titres, qu'elles apportent en collatéral contre du *cash*. Ce prêt de titres contre espèces est un prêt collatéralisé sur lequel est imposé un taux d'intérêt, le *general collateral rate* (GC *rate*). Dans la majorité des cas, ce financement est de court terme (quelques mois), voire très court terme (au jour-le-jour). Le GC *rate* sera donc très faible, typiquement légèrement inférieur au LIBOR.

Un *repurchase agreement*, ou *repo*, est un contrat par lequel un investisseur vend un actif à une contrepartie avec obligation de rachat au bout d'une période fixée à l'avance et un prix prédéterminé (Figure 2). Cette opération permet à l'investisseur de se fournir en liquidité sur la période concernée, puisque la vente de l'actif est réglée en espèces. Ce montant de *cash* est calculé par rapport à la valeur de marché de l'actif. Une décote (*haircut*) pourra être appliquée de manière à tenir compte de la qualité de l'actif qui sert de collatéral au prêt.

A la maturité du *repo*, les flux générés par l'actif sont transférés au détenteur initial de l'actif. Pour rémunérer le prêt de *cash*, l'emprunteur paie des intérêts à un taux dépendant du type d'actif faisant l'objet du contrat, le taux de *repo*. L'emprunteur de *cash* rembourse le prêt et récupère l'actif. Si l'actif vendu subit un défaut pendant la durée de vie du contrat, le *repo* est accéléré (il se termine avant la date initialement prévue), l'actif est récupéré par l'emprunteur qui rembourse alors le prêt.

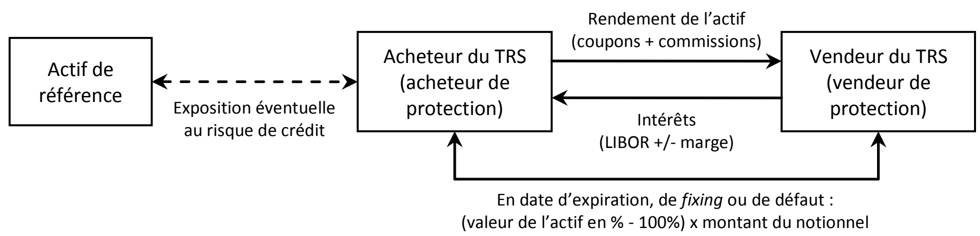
Dans le cas d'un *repo*, bien que la détention de l'actif passe légalement de l'emprunteur au prêteur pendant la durée du contrat, le détenteur initial reste l'agent qui recevra la totalité des *cashflows* liés à l'actif, que ce dernier fasse défaut ou non.

Figure 2 : *Repurchase agreement*



Comparons cette structure à celle d'un *total return swap* (TRS). Un TRS est une transaction hors-bilan à travers laquelle l'acheteur de TRS verse au vendeur l'intégralité des rendements économiques d'un actif de référence incorporant un risque de crédit (obligation ou créance) pendant une durée déterminée. Le versement correspondra donc à la variation de valeur de marché, positive ou négative, et s'effectuera soit à maturité, soit à intervalles réguliers (*fixing*), par exemple lors de la tombée des coupons (Figure 3).

Figure 3 : *Total return swap*



Le vendeur de TRS est vendeur de protection : il reçoit le rendement total de l'actif de référence et acquiert donc la totalité des attributs économiques de cet actif. En échange de ce rendement, il verse à l'acheteur de TRS, qui est acheteur de protection, des intérêts sous forme de coupons périodiques, généralement à taux variable, soit LIBOR plus ou moins une marge.

Si le TRS impose un règlement physique à maturité, l'acheteur de TRS devra livrer l'actif de référence au vendeur de TRS à l'expiration du contrat et recevra en retour la valeur de cet actif, déterminée lors de la mise en place du contrat.

Le vendeur de protection endosse également le risque de défaut. En cas de défaut de l'actif sous-jacent, le contrat est dénoué. Le règlement peut se faire physiquement (le vendeur de protection reçoit l'actif décoté et verse le montant notionnel couvert à l'acheteur de protection) ou en espèces (le vendeur de protection verse un montant égal au pair moins le taux de recouvrement, soit la valeur constatée de l'actif après défaut de l'actif de référence)[3].

Considérons une situation où l'acheteur de TRS détient effectivement l'actif de référence. Il se trouve dans une situation comparable à celle du prêteur dans le cas du *repo* : sur une période donnée, il détient un actif tout en ayant transféré le risque de crédit associé à cet actif à sa contrepartie. Le vendeur de TRS reçoit les rendements de l'actif sous-jacent et est exposé au risque de crédit de cet actif sans le détenir, situation similaire à celle de l'emprunteur.

La différence majeure entre un TRS et un contrat de *repo* est que le TRS n'impose pas la détention de l'actif sous-jacent. Ceci explique qu'un TRS est considéré comme un dérivé de crédit alors que ce n'est pas le cas d'un *repo*. Avant la crise de 2007-2009, les TRS ont été largement utilisés par des *hedge funds* pour constituer des expositions économiques sur des actifs sous-jacents sans avoir à les financer. La possibilité de transférer le risque de crédit d'une entité de référence sans détenir l'actif sous-jacent explique le succès du marché des dérivés de crédit.

1.4. Déclenchement des CDS

Jusqu'à présent nous avons eu recours au terme de défaut pour caractériser l'événement déclenchant un CDS. Bien que très largement utilisé, ce terme peut être trompeur car il pourrait être identifié au seul défaut de paiement, qui n'est que l'un des événements de crédit pouvant provoquer ce déclenchement. Quatre catégories d'événements de crédit sont retenues par les définitions de l'*International Swaps and Derivatives Association* (ISDA).

Premièrement, la faillite de l'entité de référence (*bankruptcy*), reconnue comme effective par tout document confirmant que l'entité de référence ne peut plus faire face à ses

3 Alternativement, les cocontractants peuvent décider d'un TRS impliquant que les flux se poursuivent jusqu'à maturité en cas de défaut. Les flux sont alors réajustés en tenant compte de la décote subie par l'actif suite au défaut.

obligations. Aux Etats-Unis, la banqueroute se traduit le plus souvent par la mise de l'entreprise sous protection du Chapitre 11 de la loi sur les faillites.

Deuxièmement, le défaut de paiement (*failure to pay*), qui implique que l'entité de référence ne soit pas parvenue à payer les intérêts liés à sa dette ou à rembourser le principal de cette dette[4]. Dans le cas des entités de référence de pays émergents, une période de grâce peut s'appliquer avant que le défaut de paiement ne devienne effectif.

Troisièmement, l'accélération de la dette (*obligation acceleration*), lorsque la dette est remboursée par anticipation suite à un manquement aux termes de l'emprunt. Cet événement de crédit, rarement utilisé, concerne principalement les souverains émergents.

Quatrièmement, la restructuration de la dette (*restructuring*), lorsque l'une des caractéristiques de la dette est modifiée. Les principales causes de restructuration sont la diminution des intérêts ou du principal, le rallongement de la maturité de la dette, la modification de la devise, la modification de l'ordre de subordination de la dette au sein des créances de l'entité de référence. Cependant, pour que la restructuration déclenche le CDS, il faut que la modification d'une des clauses de la dette se traduise par une dégradation de la situation du créancier. Il faut de plus que le montant de la dette restructurée dépasse l'équivalent de 10 millions USD et que la modification n'ait pas été prévue initialement, à l'émission de la dette. Par ailleurs, dans le cas d'une modification de la devise, une exception est faite si la redénomination de la dette est effectuée dans une devise standard.

Les clauses de restructuration des contrats de CDS ont évolué dans le temps (Packer et Zhu, 2005). La clause initiale, dite *Old-Restructuring* (Old-R), qui correspond aux définitions ISDA de 1999, n'impose pas de contraintes de maturité aux obligations livrables. Les clauses *Modified-Restructuring* (Mod-R ou MR) et *Modified-Modified-Restructuring* (Mod-Mod-R ou MMR) ont été introduites dans les *2003 Credit Derivatives Definitions* de l'ISDA. La restructuration Mod-R s'applique principalement aux CDS dits américains (contrats dont les entités de référence sont nord-américaines). Dans ce cas, les obligations livrables doivent présenter une maturité limitée au minimum entre : (i) la date de maturité finale du titre restructuré le plus long et (ii) 30 mois après la date de restructuration. La restructuration Mod-Mod-R s'applique principalement aux CDS dits européens (contrats dont les entités de référence sont européennes). La maturité des obligations livrables doivent présenter une maturité limitée au minimum entre : (i) la

---

4 Dans le cas où le CDS ne s'appliquerait qu'aux obligations de l'entité de référence, un défaut de paiement sur un prêt de cette entité ne déclenchera pas le CDS.

date de maturité du CDS et (ii) 60 mois après la date de restructuration pour les titres restructurés, 30 mois pour les autres obligations livrables. La clause Old-R reste utilisée pour les CDS souverains de pays développés, ainsi que pour les entités de référence émergentes et japonaises. Le Tableau 1 détaille le type de clause de restructuration appliquée par catégorie de CDS.

Tableau 1 : Clauses de restructuration par type d'entité de référence

						Restructuring			
	Banruptcy	Failure to pay	Failure to pay (grace period app.)	Obligation acceleration	Repudiation / Moratorium	Old-R	Mod-R	Mod Mod R	Multiple holder obligation rquired
Asian sovereign		✓			✓	✓			✓
Singapore sovereign		✓			✓	✓			✓
Latin America sovereign			✓	✓	✓	✓			
Emerging European and Middle Eastern sovereign			✓	✓	✓	✓			
Western European sovereign		✓			✓	✓			✓
Japan sovereign		✓			✓	✓			
Australia sovereign		✓			✓		✓		✓
New Zealand sovereign		✓			✓		✓		✓
U.S. municipal full faith and credit		✓				✓			
U.S. municipal general fund		✓				✓			
U.S. municipal revenue		✓				✓			
North American corporate	✓	✓			✓				✓
European corporate	✓	✓						✓	✓
Australia corporate	✓	✓					✓		✓
New Zealand corporate	✓	✓					✓		✓
Japan corporate	✓	✓				✓			
Singapore corporate	✓	✓				✓			✓
Asia corporate	✓	✓				✓			✓
Subordinated European insurance corporate	✓	✓				✓			✓
Emerging European corporate LPN	✓		✓		✓	✓			✓[a]
Emerging European corporate	✓		✓		✓	✓			✓[a]
Latin America corporate B	✓		✓	✓	✓	✓			
Latin America corporate BL	✓		✓	✓	✓	✓			✓

[a] La clause stipulant que le titre de dette doive être détenu par plusieurs obligataires (exclusion des prêts bilatéraux) n'est pas nécessairement intégrée pour les CDS sur des entités de référence d'Europe émergente.

Sources : Mahadevan *et al*. (2010).

1.5. Documentation des contrats de CDS

Les CDS étant des instruments négociés de gré-à-gré (*over-the-counter* – OTC), les participants de marché ont développé une documentation spécifique visant à clarifier de manière systématique les obligations des cocontractants. Cette documentation précise les caractéristiques déterminantes du contrat à partir des définitions proposées par l'ISDA, ainsi que les éléments techniques (juridiction compétente et convention de décompte des jours, par exemple).

Pour faciliter la gestion des contrats de CDS, les banques ont recours à un *Master Agreement*, contrat cadre proposé par l'ISDA. Ce *Master Agreement* stipule les conditions de l'ensemble des CDS passé entre l'acheteur de protection et le vendeur de protection qui sont généralement des grandes banques. Il se présente comme un contrat relativement flexible, qui laisse la possibilité aux cocontractants d'ajouter des conditions spécifiques à travers une annexe au contrat (*Credit Support Annex* – CSA).

Le *Master Agreement* a été modifié au cours du temps pour tenir compte des évolutions du marché et de la meilleure connaissance de la gestion des CDS acquise par les participants. Par conséquent, les contrats les plus anciens sont régis par un *Master Agreement* légèrement différent des derniers contrats signés.

En pratique, la documentation de l'ISDA s'est fortement inspirée de celle utilisée pour les *interest rate swaps* (IRS). Ceci explique la terminologie retenue pour les contrats de CDS qui peut sembler quelque peu étrange de prime abord. Ainsi, les termes de *fixed rate payer* et *floating rate payer* qui font référence respectivement à l'acheteur et au vendeur de protection. Le terme de *swap* de défaut s'inspire également des IRS en considérant que l'acheteur de protection paie sur une base régulière une prime de *swap* pour bénéficier d'une protection contre le risque de défaut de l'entité de référence.

2. Les réformes en cours

2.1. Evolution des définitions de l'ISDA

L'occurrence d'événements de crédit a permis de préciser les définitions de l'ISDA relatives aux contrats de CDS, en particulier celles liées aux principales caractéristiques des CDS. Ainsi, dès 1998, le défaut de la Russie, suite à une restructuration de sa dette en monnaie locale et la suspension des transactions sur ses titres, a montré les limites de la documentation sur les contrats de CDS. La structure complexe de la dette russe a conduit à un certain nombre de litiges sur les modalités de règlement des CDS, ce qui a amené les participants de marché à apporter des précisions sur l'identité de l'émetteur, les clauses afférentes à la dette et la qualité des créanciers dans la rédaction des contrats (Olléon-Assouan, 2004).

En 2000, le défaut de l'entreprise américaine Armstrong World Industries, sans que sa maison mère, Armstrong Holdings, fasse défaut, a conduit les participants de marché à améliorer leur référencement des entités de référence. En effet, certains contrats avaient été signés sur l'entité de référence Armstrong, sans précisions complémentaires, invalidant de ce fait la protection que les acheteurs de CDS croyaient détenir (Bruyère, 2005)[5].

Le défaut de l'entreprise américaine Conseco, en 2000 également, a été le premier à poser la question de la définition de la restructuration et de son règlement, cet événement étant de loin le plus complexe à gérer (Bruyère, 2005 ; Packer et Zhu, 2005). Comme vu précédemment, différentes clauses de restructuration des contrats de CDS ont été adoptées. La clause initiale, dite *Full-Restructuring* (FR) ou *Old-Restructuring* (Old-R), qui correspond aux définitions ISDA de 1999, n'imposait pas de contraintes de maturité aux obligations livrables. La restructuration d'une partie de la dette de Conseco (à hauteur de 3 milliards USD), en 2000, a conduit à une modification de cette clause. Lorsque les CDS ont été déclenchés par cette restructuration, les acheteurs de protection pouvaient livrer la dette restructurée, qui présentait des coupons plus élevés et une décote très faible, ou des titres de dette de l'entreprise de maturité résiduelle longue (Bruyère, 2005 ; Chaplin, 2005). Ils ont donc massivement choisi cette solution car elle leur permettait de maximiser la compensation en *cash*[6]. Cependant cette solution était fortement au désavantage des vendeurs de protection. Pour maîtriser les effets liés au choix du titre de dette le moins cher à livrer (*cheapest-to-deliver*), les clauses *Modified-Restructuring* (Mod-R ou MR) et *Modified-Modified-Restructuring* (Mod-Mod-R ou MMR) ont été introduites dans les *2003 Credit Derivatives Definitions* de l'ISDA.

En 2001, deux événements de crédit ont amené les participants de marché à préciser les caractéristiques des obligations livrables. D'une part le moratoire sur la dette de l'Argentine fin 2001 a conduit à intégrer les obligations zéro coupon dans la catégorie des obligations livrables (Olléon-Assouan, 2004). D'autre part, le défaut de l'entreprise

5 Cet événement a amené au développement de services juridiques gérant la rédaction des contrats et au recours, par la majorité des acteurs, à la nomenclature RED (*Reference Entity Database*) proposée par le prestataire de services Markit. Cette nomenclature repose sur une base de données mettant à jour les entités de références et leur affectant un code alphanumérique unique. Cette base participe également à mieux gérer les cas de fusion ou de scission d'une entité de référence, lorsqu'il est nécessaire de définir ce qu'il advient du contrat de CDS (gestion du *successor*).

6 Dans le cadre du règlement physique des CDS, les acheteurs de protection pouvaient s'assurer un versement plus important en livrant les titres longs, non restructurés et fortement décotés. En effet, si R est le taux de recouvrement des titres longs, non restructurés pour lesquels la décote est forte, et R' celui des titres restructurés et faiblement décotés, alors $R < R'$. Le versement en *cash* par les vendeurs de protection aux acheteurs de protection est $(1 - R)$ en cas livraison des titres longs, supérieur au versement effectué en cas de livraison des titres restructurés, $(1 - R')$.

britannique Railtrack, placée en 2001 sous administration, a permis de préciser les caractéristiques des obligations livrables[7].

2.2. Amélioration de la gestion du risque opérationnel

En parallèle de cette évolution des définitions utilisées dans la rédaction des contrats de CDS, les participants de marché se sont progressivement dotés d'un ensemble de dispositifs visant à améliorer la gestion du risque opérationnel et à sécuriser les transactions.

L'industrie est parvenue à résoudre le problème du risque opérationnel lié au délai de validation des transactions (*confirmation backlogs*). La mise en place de la plateforme électronique Deriv/SERV développée par la *Depository Trust and Clearing Corporation* (DTCC)[8] a permis d'automatiser et de confirmer électroniquement les opérations ; 98% des transactions sont confirmées électroniquement, contre 50% pour l'ensemble des dérivés OTC. Le volume de confirmations en attente à l'heure actuelle a ainsi diminué de 75% depuis 2005 et les délais de confirmation sont passés de plusieurs semaines à environ une journée en moyenne (ISDA, 2010). Le marché des CDS est ainsi devenu l'un des marchés de gré à gré les plus automatisés.

L'introduction du protocole de novation de l'ISDA en 2005, qui spécifie des délais précis pour donner son accord à la novation d'un contrat, a également participé à cette amélioration. La novation est le processus par lequel une contrepartie à un CDS transfère les obligations liées au contrat à une nouvelle entité. L'absence de confirmation de la novation retarde la validation de la transaction ; de telles situations augmentent le risque opérationnel et de contrepartie, un investisseur pouvant ne pas être informé du transfert des obligations liées au CDS vers une nouvelle contrepartie. Le protocole de l'ISDA impose le consentement de la contrepartie avant le transfert du contrat vers cette nouvelle entité à travers un processus de confirmation électronique.

---

[7] Lors de cet événement de crédit, la banque japonaise Nomura, qui détenait des CDS sur cette entreprise, est entrée en conflit avec Credit Suisse First Boston. Cette dernière considérait, contrairement aux autres vendeurs de protection sur cette entité de référence, que le contrat de CDS excluait des titres livrables les obligations convertibles, actifs que Nomura avait souhaité couvrir par l'achat de CDS. La banque japonaise a ainsi été contrainte de revendre ses obligations convertibles pour acheter des obligations à taux fixes et les livrer à Credit Suisse First Boston dans le cadre du règlement physique, avec un coût pour Nomura de 1,2 millions GBP. L'affaire a été portée devant la justice britannique qui a finalement tranché en faveur de Nomura (Nomura, 2004 ; Bruyère, 2005). Par la suite, les caractéristiques des obligations livrables ont été plus clairement précisées dans le cadre des contrats de CDS.

[8] La firme new-yorkaise DTCC est une holding créée en 1999 pour regrouper les activités de DTC (*Depository Trust Corporation*), entité fondée en 1973 pour fournir un service de *clearing* et règlement et NSCC (*National Securities Clearing Corporation*), entité fondée en 1976 et proposant des services de *clearing*, règlement, *risk management*, compensation centralisée et de garantie d'exécution des contrats. L'objectif initial de ces entités était de répondre à la "crise du papier" des années 60 et 70, causée par la difficulté à gérer les documents sous forme papier face à l'explosion des marchés financiers. DTCC comprend aujourd'hui 10 filiales, chacune fournissant des services dédiés à des segments de marché et des profils de risque spécifiques (DTCC, 2010).

Le recours au processus de compression des portefeuilles a permis de diminuer dans des proportions importantes le nombre de contrats de CDS redondants, liés à l'empilement des positions. Ceci revient à éliminer, au sein des portefeuilles de plusieurs *dealers*, les positions qui se compensent multilatéralement et à les remplacer par un nombre réduit de contrats présentant la même exposition nette résiduelle. Cette technique est utilisée pour l'ensemble des dérivés OTC ainsi que pour des transactions structurées et hybrides. Les investisseurs y ont eu largement recours à partir de 2008 pour réduire le nombre de contrats surnuméraires au sein de leurs portefeuilles de CDS. La compression des portefeuilles a été facilitée par la migration des contrats vers un calendrier de type IMM (*Inside Market Midpoint*), fixant des dates de maturité et de paiement des coupons au 20 des mois de mars, juin, septembre et décembre de chaque année, ce qui a augmenté leur niveau de standardisation et leur liquidité[9]. Ainsi, le principal fournisseur de service de compression, TriOptima annonçait avoir comprimé un volume de transactions égal à 30,2 trillions USD en 2008[10].

Cependant, l'évolution la plus emblématique est celle de la gestion du règlement des événements de crédit. Le défaut de l'Argentine en 2001 a été le premier pour lequel s'est posé la question du règlement des CDS lorsque le montant de CDS sur une entité de référence donnée est supérieur à celui de la dette sous-jacente. En effet, comme pour tout produit dérivé, il n'existe pas de limite au montant de CDS qui peuvent être signés sur une entité de référence, contrairement au montant de sous-jacent, qui est limité par l'encours de dette émise. Par conséquent, dans le cadre d'un règlement physique, les acheteurs de protection, s'ils ne détenaient pas initialement la dette, vont devoir se la procurer sur le marché pour pouvoir la livrer aux acheteurs de protection. Le montant de CDS sur la dette de l'Argentine étant nettement supérieur à l'encours de dette, ces mouvements d'achats au moment du défaut se sont traduits par un renchérissement de la valeur de la dette (effet de *squeeze*). Ceci est contre-intuitif, le prix des obligations subissant normalement une décote lors d'un défaut. Pour limiter cet effet de *squeeze*, le règlement du défaut sur le marché des CDS a été le premier à pouvoir être effectué partiellement en espèce.

Le cas de l'Argentine n'est pas apparu comme isolé. De manière à régler le défaut d'entités de référence dont le volume de dette était inférieur à celui du montant notionnel

9 Pour une entité donnée, tous les contrats de CDS d'une maturité de 5 ans, par exemple, émis dans la fenêtre de 3 mois comprise entre deux dates de référence du calendrier IMM (ou date de *roll*) présenteront une maturité identique, d'exactement 5 ans.

10 Le manque de standardisation du marché des CDS constitue toutefois une limite aux possibilités de compression dans le futur.

de CDS, les participants de marché, sous l'égide de l'ISDA, ont mis en place en 2005 une procédure standardisée d'enchères, suite aux faillites de plusieurs entreprises du secteur des équipementiers automobiles et des compagnies aériennes. En effet, les montants de protection sur certains noms de ces secteurs dépassaient également le montant d'actifs sous-jacents livrables nécessaires dans le cadre d'un règlement physique. Par exemple, la faillite de Delphi en 2005 a montré qu'il y avait 5,6 fois plus de notionnel en CDS que de dette (28 milliards USD de CDS contre 5 milliards de dollars d'obligations et emprunts). Le ratio était encore plus élevé pour Collins & Aikman ou les compagnies aériennes Delta Airlines et Northwest Airlines. Par ailleurs, l'appartenance de certains de ces CDS à des indices imposait de disposer d'un taux de recouvrement unique, de manière à ce que tous les investisseurs ayant une position sur un indice soient traités de la même façon. Le processus d'enchère actuel, détaillé dans le chapitre II, permet à tous les investisseurs de participer et laisse la possibilité de choisir entre un règlement physique ou un règlement *cash*. Il permet de déterminer un prix final unique qui sera appliqué à l'ensemble des investisseurs en situation de règlement en espèce.

2.3. Standardisation des procédures à travers l'adoption de nouveaux protocoles

Depuis mars 2009, le marché a évolué vers une standardisation accrue des procédures de négociation et de règlement des CDS, l'objectif étant à terme de faciliter le recours à des chambres de compensation. Cette évolution s'est traduite par l'adoption par les participants de marché des *Big Bang Protocol* et *Small Bang Protocol*, ceci de manière rétroactive pour les contrats existants.

Un CDS n'est pas un titre mais un contrat ; c'est la nature de cet engagement contractuel qui a été modifiée par l'ISDA, initialement aux États-Unis puis en Europe, de manière à standardiser les pratiques de marché. Dans la terminologie de l'ISDA, deux éléments sont à différencier. Tout d'abord les *Supplements* qui consistent en une modification des définitions retenues par l'ISDA. Ces *Supplements* s'appliquent donc au dernier document de référence listant les définitions de l'ISDA. Ensuite, le *Protocol*, c'est-à-dire un engagement contractuel, pour un acteur sur le marché des CDS, d'appliquer un *Supplement* dans la confirmation des nouveaux CDS auxquels il participera et des anciens CDS dans lesquels il est déjà engagé[11].

Le 8 avril 2009, un nouveau protocole visant à standardiser les contrats portant sur des sous-jacents américains est entré en vigueur. Les modifications des définitions pour les

[11] Les réformes de 2009 se sont ainsi traduites par l'inclusion des *May 2003 Supplement* et July *2009 Supplement* dans les définitions de l'ISDA (ISDA, 2010).

CDS américains sont acceptées par les participants de marché via la reconnaissance du *2009 ISDA Credit Derivatives Determinations Committees and Auction Settlement CDS Protocol*, plus connu sous le nom de *Big Bang Protocol*. Parmi les amendements les plus importants imposés aux contrats américains se trouve l'*Auction Supplement* qui traduit l'application du processus d'*hardwiring* des enchères, qui revient à généraliser l'utilisation des enchères pour déterminer les conditions de règlement d'un événement de crédit[12].

Pour faciliter la mise en œuvre du processus d'enchère, le *Big Bang Protocol* a également prévu la création des *Determination Committees* (DC), en charge de la reconnaissance officielle des événements de crédit (auparavant, cette reconnaissance s'effectuait de manière bilatérale, entre cocontractants). Il intègre par ailleurs l'abandon de la restructuration dans la liste des événements de crédit déclenchant les CDS américains. En effet, l'occurrence d'un événement de crédit pour restructuration est souvent délicate à démontrer. Or, lorsqu'une entreprise américaine souhaite restructurer sa dette, elle se met dans la plupart des cas sous la protection du chapitre 11 de la loi sur les faillites car ce dernier permet de bénéficier d'un environnement privilégié pour mener à bien une restructuration. Recourir au chapitre 11 déclenche automatiquement le défaut par banqueroute, la clause de restructuration a donc peu d'intérêt pour les CDS américains car la restructuration est quasiment toujours précédée par la faillite. Ainsi, alors que la majorité des CDS américains incluaient une clause Mod-R avant 2009, 21,7% des CDS américains avaient migré vers des contrats sans clause de restructuration (*No-Restructuring* ou No-R) mi-2009 (Markit, 2009a)[13].

Le manque d'homogénéité entre les différentes lois sur les faillites des pays européens, et en particulier l'absence en Europe de l'équivalent du chapitre 11 américain, rendait délicate la suppression de la clause de restructuration parmi les événements de crédit déclenchant les CDS. Ceci explique que cette clause concerne la quasi-totalité des contrats européens à l'heure actuelle (99,6%)[14]. Le 27 juillet 2009, le *Small Bang Protocol*, qui conserve la restructuration, a permis l'extension du *Big Bang Protocol* aux

[12] Pour une présentation détaillée du *Big Bang Protocol*, voir Markit (2009a).

[13] Cette migration est un retour vers les toutes premières pratiques adoptées par les *dealers* new-yorkais qui recouraient initialement à des contrats No-R avant de s'orienter vers des clauses Mod-R pour des raisons réglementaires (Chaplin, 2005).

[14] Courant 2009, 96,0% des CDS européens intégraient une clause Mod-Mod-R, 3,2% une clause Old-R et 0,4% une clause Mod-R (Markit, 2009b).

CDS européens. Il étend par ailleurs la compétence des *Determination Committees* aux CDS européens ainsi que le recours aux enchères[15].

D'après l'ISDA, au 8 avril 2009, 86% des clients et plus de 98% des transactions à sous-jacents américains avaient adopté le *Big Bang Protocol*. Le 27 juillet 2009, date d'entrée en vigueur du *Small Bang Protocol*, 2 132 entités financières avaient adhéré au *Small Bang Protocol*[16]. Par la suite, ces réformes ont été étendues aux autres types de contrats de CDS existants.

3. En pratique, quel transfert du risque ?

3.1. La difficulté d'estimer la taille du marché

Bien que la gestion des risques sur le marché des CDS ait connu des améliorations notables, un certain niveau d'incertitude continue d'entourer le montant des risques effectivement transférés par ces instruments.

Pour évaluer cette taille, trois principales sources de données sont actuellement disponibles, recourant toutes à des méthodes de collecte des données différentes et sur des échantillons de participants de marché relativement hétérogènes : la *Market Survey* de l'ISDA, les *OTC derivatives statistics* de la Banque des Règlements Internationaux (BRI) et les données tirées de la *Trade Information Warehouse* (TIW) de DTCC[17]. Sans surprise, les résultats obtenus divergent d'une source à l'autre (Tableau 2). Ceci complique leur interprétation et pose la question de la pertinence des séries collectées ainsi que de la réconciliation des définitions appliquées.

Plusieurs définitions sont utilisées par les institutions réalisant ces collectes de données, chacune présentant son intérêt mais également ses limites et conduisant à des mesures différentes des expositions des intervenants de marché.

Les volumes bruts, utilisés par la BRI et DTCC, peuvent être assimilés à un indicateur de l'évolution du volume d'activité sur le marché. Cependant, la nature OTC du marché des CDS et le manque de standardisation qui en découle rendent les contrats difficilement fongibles et diminue la liquidité du marché, ce qui impose aux intervenants de multiplier

---

[15] Pour une présentation détaillée du *Small Bang Protocol*, voir Markit (2009b).

[16] Cette évolution s'est accompagnée d'une standardisation des primes de CDS américains, fixées à un montant de 100 bp et 500 bp. La compensation entre la prime de CDS observée sur le marché et le coupon fixe s'effectue par le paiement d'un versement initial (*upfront fee*).Dans le cas des CDS européens, cette harmonisation s'est faite sur quatre niveaux de primes : 25, 100, 500 et 1 000 bp.

[17] Sur la période 1996-2006, deux autres sources, Fitch et la *British Bankers Association*, ont également publié des statistiques sur l'évolution du marché des CDS.

les positions pour augmenter et diminuer leur exposition. Les volumes bruts résultent donc d'un empilement de transactions et ne constituent pas un élément d'appréciation du risque attaché aux positions.

Les montants nets recensés par DTCC sont la somme des positions nettes, à l'achat ou à la vente, de chaque contrepartie sur une entité de référence donnée. Ils correspondent aux montants maximums susceptibles d'être échangés entre acheteurs et vendeurs de protection en cas de défaut d'un émetteur, dans l'hypothèse d'un taux de recouvrement nul et en l'absence de collatéralisation des transactions.

Enfin, la BRI estime une valeur de marché brute des contrats, mesurée comme la valeur de marché des contrats après compensation bilatérale des positions, compression des contrats[18] et collatéralisation. Dans le cadre de cette mesure, la compensation n'est pas limitée aux seules positions sur CDS mais englobe l'ensemble des positions de dérivés OTC couvertes par un même *Master Agreement* signé avec une contrepartie, après une éventuelle compensation multilatérale (cycle de compression) et après collatéralisation. Cette mesure est celle permettant d'apprécier le mieux le risque de contrepartie sur le marché des CDS, l'exposition au risque étant fonction de la valeur de marché des contrats.

Tableau 2 : Caractéristiques des statistiques sur les CDS de l'ISDA, de la BRI et de DTCC

	ISDA (*Market Survey*)	BRI[a] (*OTC derivatives statistics*)	DTCC (*Trade Information Warehouse*)
Date de la première publication	Juin 2001	Décembre 2004	Octobre 2008
Fréquence	Semestrielle	Semestrielle	Hebdomadaire
Type de collecte	Base volontaire	Base volontaire	Ensemble des transactions confirmées auprès de DTCC Deriv/SERV
Echantillon :			
- couverture géographique	21 pays	Pays du G10	52 pays
- déclarants	78 répondants membres de l'ISDA (*primary members*)	56 *reporting dealers*[a]	24 grands *dealers* et plus de 1 700 acteurs du *buy side*
Statistiques	Montants notionnels bruts	• Montants notionnels bruts à l'achat et à la vente, avant tout accord de *netting* bilatéral • Valeur de marché brute	• Montants notionnels bruts à l'achat et à la vente • Montants notionnels nets à l'achat et à la vente

[a] La BRI réalise également une étude triennale (*Triennial Central Bank Survey of Foreign Exchange and Derivatives Market Activity*) plus détaillée commentant l'évolution de l'ensemble des marchés dérivés OTC.

Sources : BIS, ISDA, DTCC.

[18] Pour cela, la BRI utilise des données relatives aux cycles de compression fournies par TriOptima.

Bien que la collecte réalisée par l'ISDA soit la plus ancienne, les statistiques de la BRI restent la source de référence pour étudier l'évolution du marché des CDS et des dérivés OTC en général[19]. A partir d'octobre 2008, DTCC a mis à la disposition du public des données relativement détaillées. DTCC effectue des opérations *post-trade* telles que le *netting* des positions et le règlement centralisé des paiements ; cette entité assure également le règlement des versements liés à des événements de crédit. Dans le cas des CDS, DTCC joue un rôle notarié en enregistrant les contrats de CDS dans sa *Trade Information Warehouse* (TIW). Cet enregistrement assure la reconnaissance légale du contrat (CPSS, 2010). Fin décembre 2009, date de dernière publication des statistiques BRI disponible, la TIW affichait un montant notionnel brut de 25,2 trillions USD contre 32,7 trillions USD pour les données BRI et de 30,1 trillions USD pour la *Market Survey* de l'ISDA.

Le manque de détails disponibles sur les statistiques produites par l'ISDA rend difficile leur comparaison avec les deux autres sources. Cependant, plusieurs informations permettent de réconcilier les données de la BRI et de DTCC de manière satisfaisante.

Selon DTCC, la TIW couvre environ 95% des transactions sur le marché des CDS. Néanmoins, ce facteur ne permet pas de retrouver le chiffre de la BRI. Deux principales raisons peuvent expliquer cet écart entre les montants notionnels nets enregistrés. Premièrement, une définition différente des contreparties : la BRI identifie les *reporting dealers*, institutions financières transmettant leurs données à la BRI, les autres institutions financières et les contreparties non financières ; DTCC distingue les *dealers*, principaux intermédiaires de marchés pour les CDS et les *non dealers* (clients)[20]. Deuxièmement, les différences d'échantillon : la BRI collecte les informations des banques dont le siège est basé dans les pays du G10 alors que la TIW couvre un nombre plus important de pays.

Le fait que les statistiques de la BRI couvrent la majorité des transactions non standardisées, lesquelles ne sont pour l'instant globalement pas enregistrées par la TIW, est le facteur jouant le plus sur l'écart observé entre les deux sources (Gyntelberg *et al.*, 2009). Cette conclusion est cohérente avec l'estimation du FMI qui considère que bien que la TIW centralise 95% des transactions entre *dealers*, ce pourcentage doit être ramené à 75% si l'on intègre les transactions entre *dealers* et *non dealers*, peu couvertes par DTCC. On retrouve alors bien une concordance entre les deux bases à fin 2009 : 75% du

[19] Sur son site, l'ISDA renvoie aux statistiques de la BRI pour obtenir des données plus détaillées.

[20] DTCC référence également les transactions entre non dealers. Celles-ci ne représentent cependant que 0,1% des montants enregistrés.

montant notionnel de 32,7 trillions USD enregistré par la BRI représente 24,5 trillions USD, soit un écart inférieur à 3% avec les données de DTCC.

3.2. Croissance du marché et impact de la crise de 2007-2009

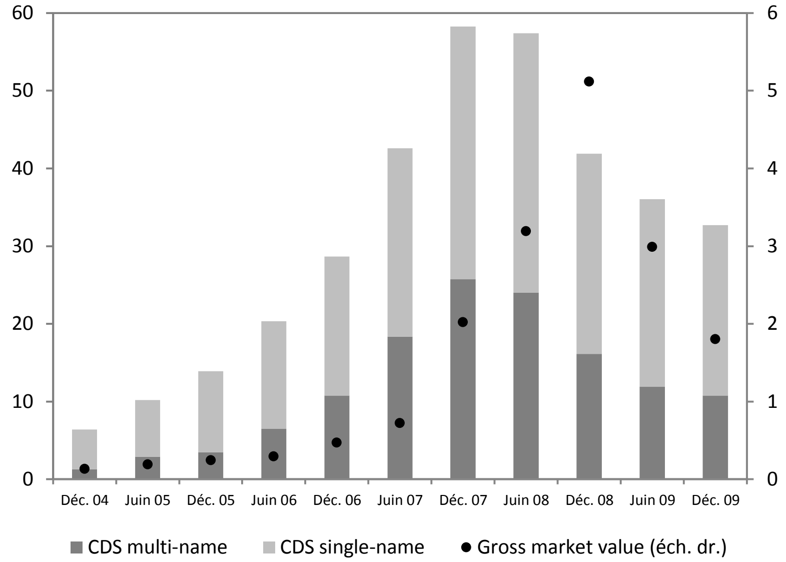
En termes de volumes, le montant notionnel de dérivés de crédit reste faible comparé à celui des dérivés de taux. Selon les données de la BRI, alors que le montant des dérivés de taux OTC était de 450 trillions USD fin 2009, celui des CDS était de 33 trillions USD. Cependant, la croissance du marché des CDS depuis son émergence a été la plus forte parmi les marchés dérivés OTC. Entre décembre 2004, date à laquelle la BRI a intégré les CDS dans ses *Semiannual OTC derivatives statistics*, et décembre 2009, le taux de croissance annuel moyen des encours de CDS a été de 31,2%, contre 15,4% pour les dérivés de taux.

L'envolée de ce marché, fulgurante de 2004 à 2007, a accompagné celui de la finance structurée. Les CDS ont servi notamment de support aux *Collateral Debt Obligations* (CDO) synthétiques et aux indices ABX, qui sont des indices de CDS sur des tranches d'*Asset Backed Securities* (ABS) de prêts *subprime* (Fender et Scheicher, 2008). Or la crise financière a porté un coup d'arrêt brutal au développement des crédits structurés, les prix et les volumes échangés s'étant effondrés pour les CDO et les ABS en 2008 (FMI, 2008), à tel point que ces actifs étaient alors régulièrement qualifiés de « toxiques », c'est-à-dire non revendables sur un marché.

L'imbrication des positions, qui résulte de la nature OTC du marché, contribue à multiplier le nombre de contrats : si un agent veut se retirer d'un contrat, il ne peut généralement pas le revendre ou l'effacer, il doit en créer un autre en sens inverse pour le compenser avec une autre contrepartie (Longstaff *et al*., 2005). Ce fonctionnement particulier explique l'encours de CDS pharamineux, le notionnel brut ayant atteint 58,2 trillions USD fin 2007 avant de redescendre à 32,7 trillions USD en décembre 2009, selon les chiffres de la BRI (BIS, 2010) (Graphique 1).

Le fait que les intervenants de marché aient fortement recouru, sur la période récente, à de la compression de portefeuilles explique cet effondrement du montant notionnel brut total de CDS. La réduction a été logiquement plus élevée pour les CDS *multi-name* (indices ou paniers de CDS) que pour les CDS individuels (dits *single name*). En effet, les CDS *multi-name* référençant principalement des indices dont la standardisation permet mécaniquement une compensation plus efficace des positions, les effets attendus des cycles de compression sur ce segment sont supérieurs. Si l'on prend en compte non pas le notionnel mais la valeur de marché des contrats, la taille du marché est estimée à 2,0 trillions fin 2007 et 1,8 trillions en juin 2010 (BIS, 2010), soit 5,5% du montant brut.

Graphique 1 : Montants notionnels bruts et valeur de marché des contrats (en trillions USD)



Sources: BRI.

3.3. *Les CDS comme vecteur de risque systémique*

Comme pour l'ensemble des dérivés, l'augmentation de l'activité sur le marché des CDS s'explique en grande partie par l'activité dite spéculative, c'est-à-dire l'utilisation des CDS comme des instruments de transaction, traités en portefeuille de négociation. L'objectif est alors de réaliser des profits à travers des stratégies de *trading*. Cette activité est une source de liquidité pour le marché, que la seule activité de couverture ne pourrait suffisamment fournir. Cependant, les mouvements de marché qu'elle occasionne conduisent les agents à réviser leurs anticipations sur la probabilité de défaut de l'entité de référence.

La volatilité exceptionnelle des primes de CDS dès le début de la crise de 2007-2009, laisse penser que le marché a pu surréagir. Ce phénomène a été particulièrement fort dans le cas des CDS ayant pour entité de référence des titres de dette de pays développés. Cette intuition fait écho aux conclusions d'Andritzky et Singh (2005) qui s'interrogeaient déjà dès le milieu des années 2000 sur la pertinence du niveau des primes de CDS souverains dans le cas des pays émergents. Le marché des CDS a pu être considéré comme responsable des mouvements observés sur le marché de la dette sous-jacente.

Par ailleurs, les variations des primes de CDS sont également susceptibles d'avoir un impact sur les prix d'autres actifs financiers à travers les relations qu'entretient le marché des CDS avec les autres marchés. Le transfert d'information entre le marché des CDS et son marché sous-jacent peut avoir des conséquences sur les conditions de financement des entreprises et d'une manière plus large, sur l'ensemble de l'économie. De plus, les CDS étant considérés comme des outils de référence par les participants de marché pour mesurer la solidité des entreprises, ils sont utilisés dans certains modèles de prix d'actifs.

Bien que les standards de marché se soient améliorés depuis sa création, plusieurs éléments mettent en doute l'hypothèse d'un marché des CDS efficient et résilient aux périodes de crise, comme le montre le chapitre II.

Les CDS et les incitations des créanciers des sociétés en détresse financière

Avant l'existence du marché des CDS, les créditeurs étaient souvent tentés de laisser survivre une société en détresse financière un certain temps, quitte à abandonner une partie de leurs créances, pour lui faire passer les échéances fatidiques. Ces délais pouvaient dans certains cas sauver l'entreprise de la faillite. Les créanciers cherchaient ainsi à éviter autant que possible une procédure de faillite, car celle-ci implique, soit un recouvrement des créances long et incertain, soit la revente de la dette sur un marché secondaire où il faut accepter une forte décote.

L'existence des CDS a renversé les incitations des créanciers. Si la valeur de leur dette est couverte entièrement par un CDS, les créanciers ont maintenant intérêt à des faillites aussi rapides que possible. La mise en faillite déclenche en effet automatiquement dans un délai inférieur à un mois le règlement des CDS. Les créanciers sont alors assurés de récupérer l'intégralité de la valeur faciale de leur créance. Les incitations à négocier, à accorder de nouveaux prêts ou des délais, disparaissent totalement devant la perspective de ce paiement intégral et rapide. Les détenteurs de CDS qui ne possèdent pas la créance sous-jacente sont encore plus impatients de voir se déclencher un défaut. En outre, des problèmes juridiques viennent compliquer la situation et entraver la capacité des créanciers à négocier avant la mise en faillite s'ils sont couverts par des CDS (Matthews et Yelvington, 2008). La participation à ces réunions de négociations peut en effet leur fournir une information d'*insider* jugée incompatible par la *Securities and Exchange Commission* (SEC) avec des prises de positions sur les CDS.

La gestion du risque de contrepartie et les limites de la collatéralisation

La nature OTC des contrats de CDS rend la gestion du risque de contrepartie déterminante. Ce risque correspond au défaut de l'une des deux parties au contrat. Dans le cas d'un défaut de l'acheteur de protection, le vendeur de protection ne percevra plus la prime liée au contrat. Dans le cas d'un défaut du vendeur de protection, l'acheteur perdra sa couverture et devra remplacer le contrat. Il subira donc un coût, le coût de remplacement, si le niveau de la prime de CDS a augmenté entre temps. Il peut également s'agir de l'incapacité du vendeur de protection de régler la jambe variable du contrat en cas de défaut de l'entité de référence. La multiplication des contrats des CDS, liée à l'imbrication des positions, contribue à augmenter significativement le risque de contrepartie sur le marché.

Pour se protéger contre le risque de contrepartie, les participants de marché collatéralisent leurs positions sous la forme d'une marge initiale, à la signature du contrat, et d'appels de marge réguliers qui visent à couvrir l'exposition résiduelle nette d'une partie vis-à-vis de l'autre et ainsi à atténuer la perte encourue en cas de défaut. Le collatéral permettra à la contrepartie non défaillante de remplacer sa position[21], il constitue également une provision pour un éventuel règlement. Lorsqu'une entité commence à avoir des problèmes, plusieurs mécanismes se mettent en place pour déclencher des appels de marge supplémentaires. Le signal peut être donné par l'augmentation de la prime de CDS ou la baisse du prix de l'obligation ; dans certains cas, principalement aux Etats-Unis, cela peut être la dégradation de la notation de l'entité de référence ou du vendeur. Cependant, plusieurs éléments limitent la protection contre le risque de contrepartie.

Premièrement, bien que la quasi-totalité des transactions entre *dealers*, c'est-à-dire les principales grandes banques actives sur le marché, soit colléralisée et que le montant de collatéral apporté soit révisé sur une fréquence quotidienne, ce n'est pas le cas pour les transactions entre *dealers* et *non dealers*. Ainsi, selon l'ISDA, seuls deux tiers des expositions sur dérivés de crédit seraient couverts par du collatéral. Les seuils minimums à partir desquels du collatéral est versé (*unsecured threshold*) ne peuvent expliquer à eux seuls qu'un tiers des expositions non couvertes. Certaines entités bien notées par les agences de notation ne versent toujours pas de collatéral, cela a notamment été le cas des *monolines*.

[21] En pratique, les participants de marché gèrent leur risque de contrepartie sur l'ensemble de leur portefeuille de dérivés OTC en fonction de leur position agrégée face à une contrepartie donnée. Selon l'ISDA, sur l'ensemble du marché des dérivés OTC, le collatéral échangé est à plus de 80% constitué de *cash*.

Deuxièmement, les CDS sont fortement sujets au phénomène de *jump-to-default* qui complexifie le calibrage et la gestion des appels de marges. Ce phénomène correspond à une augmentation brutale de la prime de CDS et donc de la valeur de marché du contrat qui précède un événement de crédit sur l'entité de référence. Le niveau du collatéral a donc de fortes chances d'être insuffisant pour absorber cette hausse et le délai trop court pour permettre à l'acheteur de protection d'ajuster son appel de marge. Si le défaut de l'entité de référence s'accompagne d'une incapacité du vendeur de protection de verser la jambe variable, l'acheteur de protection subira des pertes substantielles, en dépit des pratiques de collatéralisation.

Troisièmement, les appels de marge présentent un caractère procyclique. Une dégradation de la situation du vendeur de protection, par exemple l'abaissement de sa note par les agences de notation, se traduira par une augmentation des appels de marge. Cette demande de collatéral supplémentaire est susceptible de déclencher une crise de liquidité et d'affaiblir l'entité en difficulté voire de précipiter son défaut. Ainsi, alors que l'assureur américain AIG n'était pas tenu de collatéraliser ses positions en tant que contrepartie notée AAA, la dégradation de sa notation l'a contraint de répondre à des appels de marge : de septembre à décembre 2008, sa filiale AIG Financial Products a versé 22,4 milliards USD à ses 20 contreparties les plus importantes. AIG ne disposant pas des liquidités suffisantes pour assurer ces versements, la Reserve Fédérale a dû secourir l'entreprise pour éviter sa faillite[22].

Un transfert du risque de crédit limité par la forte concentration du marché

Le développement rapide des dérivés de crédit n'est pas allé de pair avec une diversification des intervenants. Au contraire, l'exposition du secteur financier est considérable. Le marché est surtout dominé par des acteurs financiers, du côté des acheteurs aussi bien que des vendeurs. Les risques qui étaient censés sortir du système financier y sont finalement restés concentrés. Les banques représentaient 58% des acheteurs et 43% des vendeurs de CDS en 2006 ; les *hedge funds*, 29% des acheteurs et 31% des vendeurs (FMI, 2008). Fin 2008, au niveau global, les dix principaux *dealers* agrégeaient plus de 90% des montants notionnels bruts de CDS. Cette concentration est la plus forte aux Etats-Unis, où les cinq plus grandes banques commerciales représentent 97% de l'activité du marché, dont 30% est réalisée par la banque J.P. Morgan[23].

[22] De telles clauses, non spécifiques au marché des CDS, restent cependant relativement peu répandues. Elles interviennent principalement dans le cadre de montages de produits structurés et sont utilisées essentiellement aux Etats-Unis.

[23] Source : *Office of the Comptroller of the Currency*, données fin 2008.

Le défaut d'entités financières actives sur le marché des CDS telles que Lehman Brothers, la quasi faillite d'AIG, la disparition de certains acteurs de premier plan comme Bear Sterns et le retrait de nombreux *hedge funds* ont concouru à renforcer la concentration des acteurs. De plus, ceci a provoqué une accentuation du risque de contrepartie.

Par ailleurs, alors que les risques restent dans la sphère financière, la protection vendue porte largement sur le secteur financier lui-même. Fin décembre 2009, pour les 100 entités de référence présentant les montants bruts de CDS *single name* les plus importants, 31% de ces montants concernaient des entités de référence du secteur financier. Ce chiffre passe à 35% si l'on considère les montants nets[24]. Cette corrélation élevée entre le secteur d'activité du vendeur de protection et celui de l'entité de référence augmente le risque de défaut en chaîne[25]. En effet, le risque d'un double défaut, soit le défaut d'une entité à la fois contrepartie active sur le marché dérivé et entité de référence, est non négligeable.

Le marché des dérivés de crédit n'a donc pas opéré le transfert des risques qu'il était censé assurer. Loin d'avoir redistribué le risque de crédit, les CDS ont contribué à l'intensification du risque systémique à travers la concentration des risques sur un nombre réduit d'acteurs fortement interconnectés, peu nombreux et à la fois acheteurs, vendeurs et sous-jacents. En particulier, le défaut d'un *dealer* est susceptible de provoquer un effet de domino et de propager le risque de défaut (Cont, 2010). On a assisté ainsi à l'émergence d'un nouveau type de risque systémique, le *too interconnected to fail* qui s'est substitué au *too big to fail* (Brunnermeier, 2009).

4. Contribution de la thèse

Dès le milieu des années 2000, alors que ce marché des CDS était dans sa plus forte phase de hausse, certains auteurs, comme Andritzky et Singh (2005) ou Tett (2006), anticipaient déjà les risques liés aux CRT. Cependant, les CDS eux-mêmes ne peuvent être considérés comme étant responsables de la crise de 2007-2009. En effet, ces produits n'ont jamais été considérés comme des « actifs toxiques » car leur marché est resté actif ; de plus, les investisseurs peuvent se débarrasser de ces contrats en en souscrivant un autre en sens inverse. Pourtant, leur marché a été aussi affecté par la crise. D'une part, le coût de la protection a augmenté considérablement, en raison du risque de défaut croissant des

[24] Source : DTCC (données de la semaine du 25 décembre 2009).

[25] On parle généralement de *wrong way risk*.

emprunteurs. D'autre part, des effets de contagion ont pu être à l'œuvre. Le développement de ce marché et son comportement pendant la crise posent donc plusieurs questions. Premièrement, dans quelle mesure les épisodes de crise perturbent-ils le fonctionnement opérationnel du marché des CDS ? Ces perturbations ont-elles un impact sur les prix des actifs sous-jacents ? Deuxièmement, existe-t-il des phénomènes de contagion au niveau du marché des CDS lui-même ? Troisièmement, quelle est la nature des relations entre le marché des CDS et les autres marchés, en particulier le marché obligataire sous-jacent ? Quatrièmement, ces relations sont-elles perturbées pendant les périodes de crise ? Les chapitres II à V fournissent des éléments de réponses à ces questions en étudiant deux périodes de tension fortes que le marché des CDS a connu depuis son émergence : la dégradation en catégorie spéculative de General Motors (GM) et Ford en mai 2005 ; la crise financière de 2007-2009 et son évolution en crise de la dette publique à partir de fin 2009.

4.1. Les enseignements tirés de la faillite de Lehman Brothers

A la fin de l'été 2008, lorsque des contreparties majeures comme AIG et Lehman Brothers ont été au seuil de la banqueroute, la confiance dans le fonctionnement du marché des CDS a été fortement ébranlée (Purtle et Yelvington, 2008 ; Brunnermeier, 2009). A partir de ce moment, le risque de contrepartie a été considéré comme un danger majeur alors qu'il avait été vu comme négligeable auparavant. Les grandes institutions financières actives sur ce marché étaient jusque là considérées comme sûres ; la quasi-faillite d'AIG et la banqueroute de Lehman Brothers ont démenti cette croyance.

La faillite de Lehman Brothers, le 15 septembre 2008, reste ainsi l'événement le plus marquant de la crise de 2007-2009. Son impact sur les marchés a été majeur, en particulier pour les CDS. Cette faillite a conduit à réévaluer le risque associé au marché des CDS. La question s'est posée de la robustesse des mécanismes du marché, en particulier la capacité du marché à faire face au règlement d'un défaut majeur, impliquant un grand nombre d'acteurs à travers deux dimensions. Premièrement, Lehman Brothers était une entité de référence sur laquelle un grand nombre de CDS avaient été signé. Les montants de notionnel sur l'entité Lehman Brothers étaient ainsi estimés à des niveaux très importants, de 200 à 500 milliards USD (Yelvington et Taggert, 2008), le chiffre le plus fréquemment cité étant celui reporté par le *Financial Times* de 400 milliards USD. L'importance de ces sommes laissait craindre que les vendeurs ne puissent faire face à leurs engagements. Deuxièmement, le risque de contrepartie s'est matérialisé concrètement pour la première fois avec cette faillite. Lehman Brothers était un *dealer* très actif sur le marché ; les contrats ayant Lehman Brothers comme contrepartie se trouvaient annulés et les participants de marché engagés dans des CDS avec la banque devaient donc faire face au remplacement de leurs contrats. Ce problème a été en partie résolu le week-end précédant l'annonce de faillite au cours d'une séance de *netting*, qui a eu lieu sous l'égide de DTCC (Moodys, 2008). Par le jeu des compensations, cette séance a permis de retirer du marché plus de 300 000 contrats de CDS pour lesquels Lehman Brothers était contrepartie.

Comme le montre le chapitre II, la crainte que la faillite d'une entité de taille importante provoque une réaction en chaîne touchant l'ensemble du marché a été attisée par la taille pharamineuse du marché des CDS et l'opacité sur les expositions dues en partie à l'empilement des positions des participants de marché. Le défaut de Lehman Brothers a illustré les travers du manque d'informations à la disposition des individus avant l'occurrence d'un événement de crédit, les vrais montants de CDS en jeu lors de la faillite de la banque n'étant toujours pas connus précisément à ce jour (Gerson Lehrman Group, 2008). La prise de conscience par les agents des vulnérabilités du marché ont conduit à une vague de réformes sans précédent, parmi lesquelles une meilleure collatéralisation des positions, la compression des portefeuilles et la migration du marché vers une compensation centralisée des transactions. Le chapitre II cherche, au regard des faiblesses mentionnées précédemment, à estimer la résilience du marché face aux faillites majeures qui sont intervenues récemment.

Le chapitre II revient en particulier sur le mécanisme des enchères qui permet la gestion opérationnelle des événements de crédit. Puisque de nombreux détenteurs de CDS ne possèdent pas le titre sous-jacent, la taille de la dette à régler dépasse le montant existant de titres. Il en résulte un manque d'obligations livrables, qui peut entrainer un renchérissement artificiel de leur prix au moment du règlement. C'est pourquoi un système d'enchère a été mis en place par le fournisseur de services Markit pour déterminer le taux de recouvrement (ou prix final du titre). Le système assure le règlement physique et monétaire au même prix. L'enchère a lieu en deux étapes destinées à déterminer : (i) le taux de recouvrement intermédiaire (ou *Inside Market Midpoint* – IMM) et la somme des offres nettes d'achats et de ventes pour le règlement physique (appelée *open interest*) ; (ii) le taux de recouvrement ou prix final. Le chapitre II examine ces deux étapes dans le cas de l'enchère sur Lehman Brothers. Pour cela, sont décrits les stratégies des vendeurs et des acheteurs ainsi que les liens avec le marché obligataire. Ce chapitre décrit également les liens observés entre les prix issus des enchères et ceux tirés du marché obligataire secondaire. Helwege *et al*. (2009) ont étudié ce processus d'enchère sur un échantillon de 10 entreprises ayant connu un événement de crédit. Sur la base de la documentation fournie par les administrateurs des enchères, Markit et Creditex (2010), le chapitre II étend cet échantillon à 27 entreprises. Il étudie par ailleurs en détail les enchères de Lehman Brothers, Washington Mutual, CIT et Thomson, entreprises qui ont connu des défauts de taille importante, susceptibles de perturber le marché, au cours de la période 2008-2009 ; ainsi que le cas particulier du défaut technique des *Government Sponsored Entreprises* (GSE), Fannie Mae et Freddie Mac. L'analyse précise des données communiquées par Markit et Creditex tout au long du processus d'enchère pour ces défauts permet de mettre en lumière plusieurs anomalies dans les taux de recouvrement finaux. Les caractéristiques du marché des CDS, ainsi que certains comportements de la part des participants de marché, permettent d'expliquer ces résultats.

Il reste donc des incertitudes importantes concernant le fonctionnement même du marché des CDS et les relations qu'il entretient avec les autres marchés. A travers des effets de contagion, les primes de CDS ont ainsi pu influencer l'évolution du prix d'autres actifs, en particulier celui des *spreads* obligataires sous-jacents, et modifier les conditions de financement des entreprises et, d'une manière plus générale, de l'économie. Toutes les inquiétudes soulevées pendant la crise de 2007-2009 et notamment la peur d'un effet systémique ont montré qu'il fallait davantage réguler ce marché. La dernière partie du chapitre II est consacrée à décrire les réformes en cours. Des mesures réglementaires sont mises en place progressivement en collaboration avec le secteur financier afin d'améliorer les pratiques de marché et de renforcer la gestion des risques. Le passage à une contrepartie centrale est un élément clé du dispositif pour accroître la résilience du marché. L'enregistrement des transactions est aussi un élément important pour réduire l'opacité du marché et donner aux superviseurs une meilleure connaissance des risques qu'il comporte.

4.2. Effets de contagion au sein du marché des CDS

Sur les marchés financiers, la contagion peut être définie de manière générale comme une baisse simultanée des prix d'actifs. De manière plus restrictive, il est possible de considérer que les phénomènes de contagion ne s'observent que durant les périodes de crise, ou de limiter ces phénomènes à ce que Forbes et Rigobon (2002) nomment *shift-contagion*, c'est-à-dire une chute des prix d'actifs au-delà des comouvements observés durant les périodes tranquilles. De nombreuses études se sont penchées sur les raisons expliquant l'existence de phénomènes de contagion (pour une revue de la littérature, voir Pericoli et Sbracia, 2003). Trois principaux types de contagion peuvent être distingués, selon le type de marché étudié (Huang et Xu, 2000 ; Pritsker, 2001) : les crises de changes, provoquées par des attaques spéculatives ; les crises bancaires, se propageant par un effet de domino dû aux liens entre institutions financières ; la contagion au sein des marchés financiers.

Les phénomènes de contagion liés aux crises de change ont été particulièrement étudiés, dans le but de mieux comprendre la crise asiatique de 1997 (Baig et Goldfajn, 2002 ; Corsetti *et al*., 1999, Kaminsky et Reinhart, 2000 ; Masson, 1998). Les canaux de contagion détectés dans le cas des crises de change sont également à l'œuvre sur les marchés financiers. L'effondrement de LTCM en 2001, par exemple, fut étudié selon cette perspective (Pritsker, 2001). C'est également le cas pour les crises bancaires, dans une moindre mesure cependant. Il semble donc plus pertinent de s'intéresser aux canaux de transmission plutôt qu'aux marchés financiers eux-mêmes. Quatre grandes catégories de canaux de transmission peuvent ainsi être détectées : (i) les ventes simultanées d'actifs dues à l'assèchement de la liquidité des investisseurs ; (ii) la modification des croyances et préférences des investisseurs ; (iii) les comportements moutonniers et (iv) le risque de contrepartie.

Les problèmes de liquidité que rencontrent les investisseurs durant les périodes de crise constituent le premier canal de contagion. Des effets de contagion se produisent lorsque les investisseurs réagissent à des pertes importantes subies sur un marché donné dans un contexte de forte diversification des portefeuilles. Lorsqu'un marché s'effondre, les participants de marché devront faire face à une réduction de leur richesse et auront alors tendance à retirer leurs fonds d'autres investissements risqués (Schinasi et Smith, 2001 ; Goldstein et Pauzner, 2004 ; Caramazza *et al*., 2004), ce qui incitera de larges catégories d'acteurs à liquider leurs positions. Un tel comportement peut être observé même si les agents sont rationnels et les marchés parfaits. Ces effets de contagion peuvent s'expliquer par le comportement des intermédiaires financiers, l'internationalisation des passifs des banques pouvant être une source de vulnérabilité (Allen et Gale, 2000). Ces pressions à la vente sont par ailleurs renforcées par les appels de marge sur les positions à fort effet de levier (Calvo, 1999). La valorisation des actifs financiers à la valeur de marché par les institutions financières contribuera à ces liquidations des actifs, les participants de marché étant contraints par leurs dispositifs de *risk management* (Schnabel et Shin, 2004 ; Shin, 2008) ; à leur tour, ces liquidations imposées par les dispositifs de *risk management* tendront à se répercuter sur les prix des actifs, ce qui participera à étendre la crise (Adrian et Shin, 2008).

Pour Acharya *et al*. (2008), de tels effets de contagion dus à des problèmes de liquidité ont été observés sur le marché des CDS durant l'épisode de crise de 2005 provoqué par la dégradation en catégorie spéculative de la notation de GM et Ford. Pour démontrer cette hypothèse, ils considèrent un échantillon d'entreprises des secteurs automobile et financier et tentent d'isoler des rendements des CDS une composante ne pouvant pas être attribuée au risque de défaut. Pour cela, ils calculent les « innovations » des primes de CDS obtenues à partir des résidus d'une régression intégrant les rendements boursiers comme variables explicative. L'augmentation des corrélations entre les innovations des CDS de l'échantillon et celles de GM et Ford traduit un choc de liquidité exogène qui a augmenté les risques de contrepartie et d'inventaire.

Un deuxième effet de contagion provient de la modification des croyances et préférences des agents en période de crise. Lorsqu'une crise affecte un marché, les investisseurs tendent à réévaluer à la hausse le risque associé à d'autres catégories d'actifs. Ceci provoque alors une augmentation de l'ensemble des primes de risques. L'ensemble des prix des actifs risqués baisse et les investisseurs tendent à réallouer leur richesse vers des actifs moins risqués. Cette situation peut être concomitante à un assèchement de la liquidité. Dans les modèles de Caballero et Krishnamurthy (2005, 2007) les intermédiaires financiers sont à l'origine de ces phénomènes de *flight-to-quality*. Pour Kumar et Persaud (2002), c'est la chute brutale de l'appétit pour le risque des investisseurs qui les conduit à exiger des rendements plus importants pour l'ensemble des actifs risqués, ce qui provoque la propagation de la crise. Les actifs risqués étant moins liquides que les actifs plus sûrs, ce phénomène de *flight-to-quality* peut s'accompagner d'un effet de *flight-to-liquidity* (Vayanos, 2004).

Un troisième type de contagion est lié aux comportements moutonniers (pour une revue de la littérature, voir Bikhchandani et Sharma, 2000). De tels comportements se produisent dès que les choix d'investissements d'un agent sont influencés par ceux d'autres agents. L'information se propage alors en cascade à travers les prix de marché. Les comportements moutonniers peuvent être le fait d'agents rationnels faisant face à des coûts d'information élevés (Calvo, 1999 ; Calvo et Mandoza, 2000). Ils diminuent par ailleurs les effets liés au risque réputationnel dans le cas où l'investissement ne produirait pas les rendements escomptés (Persaud, 2000). Une autre raison réside dans les effets de mimétisme qui sont une caractéristique intrinsèque de la nature humaine et n'épargnent pas les participants de marché.

Le quatrième canal de contagion est celui du risque de contrepartie. Dans l'économie réelle, un risque de contrepartie existe dès qu'une entreprise est en situation de détresse financière et que cela se répercute sur d'autres firmes à cause des liens qui existent entre elles. Pour une entreprise donnée, une forte dépendance à une entreprise en situation de détresse financière peut conduire à des pertes importantes. Par conséquent, les intensités de défaut de firmes interdépendantes sont liées entre elles, conduisant leurs *spreads* de crédit à évoluer de concert durant les crises. Ce type de risque de contrepartie a été formalisé par Jarrow et Yu (2001).

Jorion et Zhang (2007) en particulier ont démontré empiriquement la présence de tels effets sur le marché des CDS. Ils montrent que les firmes d'un même secteur d'activité sont affectées négativement par une banqueroute provoquée par la mise sous protection du chapitre 11 de la loi américaine sur les faillites. Elles subissent donc des effets de contagion. Au contraire, elles peuvent être affectées positivement par un recours au chapitre 7. Dans ce deuxième cas, la liquidation d'un concurrent peut avoir des effets favorables, pouvant neutraliser les effets de contagion, comme le montrent Lang et Stulz (1992). Un autre type de risque de contrepartie, également présent sur le marché des CDS, est le risque d'un défaut du vendeur de protection. Ce type de risque a augmenté significativement après la faillite de Lehman Brothers en septembre 2008. Lehman Brothers était une contrepartie importante sur le marché des CDS, sa faillite a soulevé des craintes sur la capacité des autres vendeurs de protection à honorer leurs contrats. Jorion et Zhang (2009) fournissent des preuves de l'existence de ce type de contagion en montrant que les annonces de faillites ont un impact sur les primes de CDS.

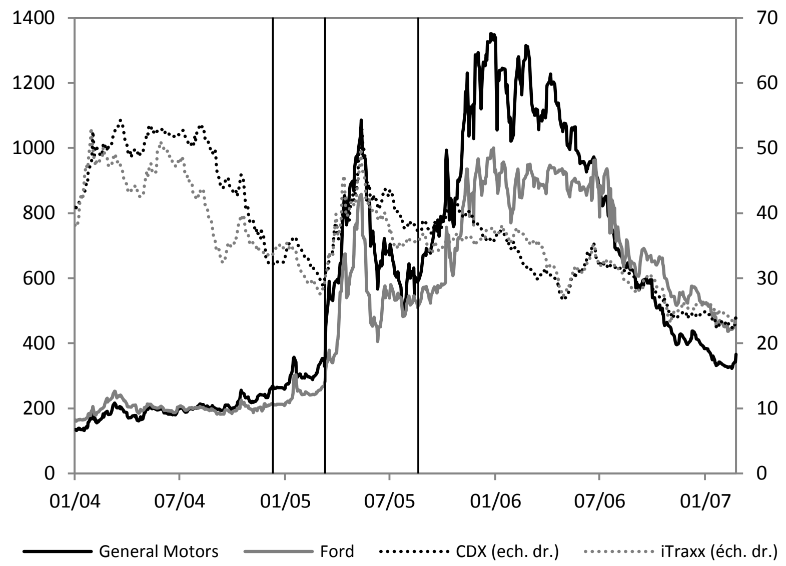
4.3. Etude empirique des effets de contagion lors de la crise de 2005

La crise provoquée par la dégradation de la note de GM et Ford en catégorie spéculative a provoqué une augmentation brutale des primes de CDS. Cet épisode, qui a connu une forte réaction du marché des CDS, peut être considéré comme un événement précurseur de la crise des *subprimes*. L'intérêt de considérer cette période est qu'elle présente l'avantage d'être clairement identifiable dans le temps, débutant précisemment en mars 2005, lorsque les principales agences de notation ont fait perdre à la dette de ces entreprises le statut d'investissement non spéculatif. Plusieurs années s'étant écoulées depuis cet épisode, il est plus aisé d'estimer rétrospectivement son impact sur le marché des CDS dans son ensemble.

Les difficultés rencontrées par GM et Ford en 2005 ont eu des répercussions importantes sur le marché du crédit. En effet, les encours de dette émise par ces deux entreprises de dimension internationale étaient conséquents et représentaient 3% du marché obligataire de catégorie non spéculative en 2005 et près de 15% du marché *high yield* (Packer et Woolridge, 2005). Lorsque les principales agences de notation ont dégradé en catégorie spéculative les deux entreprises, le coût de la protection contre leur défaut a augmenté substantiellement (de 260 bp pour GM et 110 bp pour Ford). Cette hausse s'est immédiatement propagée à l'ensemble du marché des CDS. Les principaux indices de CDS ont ainsi connu une forte augmentation (Graphique 2).

Graphique 2 : Primes des CDS de General Motors et Ford et primes des principaux indices de marché (en points de base)

Les barres verticales délimitent les différentes périodes retenues pour étudier la crise de 2005. Période de référence (pré-crise) : 15/12/04 à 15/03/05 ; période de crise : 16/03/05 à 24/08/05 ; période post-crise : 25/08/05 à 28/02/07.



Sources: Bloomberg, J.P. Morgan.

Le chapitre III, revient sur cet épisode en tentant de détecter toutes les formes possibles de contagion qui ont pu jouer un rôle dans cette crise par le biais des différents canaux décrits précédemment. Le choc provoqué par cet événement a certainement réduit la liquidité du marché, comme le suggèrent Acharya *et al*. (2008), les intermédiaires financiers ayant dû faire face à des appels de marge supplémentaires et ayant subi une dégradation de leur ratio de *risk management*. Cependant la crise a pu se propager à travers d'autres canaux de transmission. Tout d'abord, les investisseurs ont reconsidéré la possibilité que ces deux entreprises majeures, considérées jusqu'alors comme sûres, fassent défaut. Ensuite, des comportements moutonniers ont pu se produire, comme c'est souvent le cas lors d'épisodes de crise. Enfin, la modification de la perception du risque de contrepartie de l'ensemble des firmes a pu jouer, la faillite de GM et Ford pouvant avoir des conséquences néfastes pour l'ensemble des secteurs d'activité et le secteur automobile en particulier. Des effets de contagion et de compétition ont donc pu être à l'œuvre.

Les phénomènes de contagion sont généralement caractérisés par une hausse des comouvements entre les rendements des actifs risqués. Cette augmentation des corrélations est souvent considérée comme un symptôme de contagion (Baig et Goldfajn, 2002; De Gregorio et Valdès, 2001). Plusieurs méthodes empiriques ont été développées pour mesurer ces comouvements de manière appropriée (pour une revue de la littérature, voir Dungey *et al*., 2003), parmi lesquelles certaines consistent à comparer les corrélations avant et pendant la crise. Le chapitre III teste l'hypothèse de l'augmentation des corrélations entre les primes de CDS de GM et Ford, entreprises considérées comme étant à l'origine de l'épisode de crise de 2005 et celles d'un échantillon de CDS d'entreprises américaines et européennes figurant dans les principaux indices de CDS, le CDS nord-américain et l'iTraxx européen. Une augmentation statistiquement significative de la corrélation entre la période précédant la dégradation en catégorie spéculative de la notation des deux entreprises et la période de crise pour la majorité des CDS de l'échantillon révèle la présence de phénomènes de contagion entre les deux périodes.

Cependant, les crises s'accompagnent en général d'une forte augmentation de la volatilité, ce qui peut constituer un biais dans le calcul des corrélations (Boyer *et al*., 1999). Il est nécessaire de corriger ces corrélations pour estimer si les mécanismes de transmission des prix ont été modifiés par la crise, phénomène que Forbes et Rigobon (2002) définissent comme de la *shift-contagion*. Lorsque les corrélations sont corrigées de ce biais grâce à l'approche proposée par Boyer *et al*. (1999) et Forbes et Rigobon (2002), il s'avère que la hausse des corrélations en période de crise, une fois corrigées de l'augmentation de la volatilité, est rarement significative. Peu de cas de *shift-contagion* sont donc détectés lors de cet épisode.

Cette première étape présente cependant des limites. En effet, la période de crise étudiée doit être suffisamment longue pour intégrer un nombre d'observations considéré comme suffisant, alors que la réaction du marché des CDS à la dégradation de la notation de GM et Ford a été très rapide. Le recours à des corrélations conditionnelles montre une augmentation significative de ces corrélations pendant la période de crise et en particulier pendant la première semaine de la crise. Ces résultats confirment que des phénomènes de contagion ont été à l'œuvre au sein du marché des CDS durant l'épisode de crise de 2005. Cependant, les mécanismes de transmission des prix à l'intérieur du marché des CDS n'ont pas été modifiés pendant cette période, la hausse de la volatilité ayant été suffisante pour provoquer une augmentation significative des corrélations pour l'ensemble des entreprises de l'échantillon, en particulier pour les entreprises du secteur automobile, qui ont été les plus concernées.

4.4. La déformation des relations entre marchés lors de la crise de 2005

La nature OTC et le manque de régulation du marché des CDS ont pu renforcer les incitations à mettre en place des stratégies spéculatives pendant les périodes de crise. Comme les CDS sont un moyen de négocier le risque de défaut, leur prix est fortement lié à celui des obligations sous-jacentes.

Théoriquement, comme un CDS est censé protéger les investisseurs contre le risque de défaut d'un emprunteur, sa prime est égale au *spread* obligataire sur le même emprunteur pour la même maturité (Duffie, 1999 ; Hull et White, 2000 ; Hull *et al*. 2004). La prime de CDS doit donc évoluer parallèlement au *spread*. Dans la réalité, la prime de CDS n'est jamais exactement égale au *spread*, même si elle en est très proche, pour un certain nombre de raisons (O'Kane et McAdie, 2001 ; Cossin et Lu ; 2004; Blanco *et al*., 2005). Cossin et Lu (2004) ont montré que la base, écart entre la prime de CDS et le *spread* obligataire, s'expliquait majoritairement par une prime de liquidité. Longstaff *et al*. (2005) ont également prouvé ce rôle clé de la liquidité en montrant que les rendements obligataires intégraient une prime de liquidité qui n'était pas présente sur le marché des CDS.

Un certain nombre d'études ont cherché à détecter de manière empirique les déterminants de la prime de CDS (Aunon-Nerin *et al*., 2002 ; Ericsson *et al*., 2004 ; Houweling et Vorst, 2005). Alexander et Kaeck (2006) ont étudié les variations des composantes sectorielles de l'iTraxx, le principal indice de CDS européen. Ils montrent que ces variations peuvent être expliquées en partie par la volatilité implicite de l'indice boursier DJ Eurostoxx 50. De plus, selon ces auteurs, l'iTraxx est sujet à des changements de régimes et est particulièrement sensible aux variations de variables issues du marché boursier pendant les périodes de crise. Andritzky et Singh (2006) montrent également que la détermination du prix des CDS peut être perturbée par les tensions financières, en particulier les taux de recouvrement, qui sont un facteur clé pendant les périodes de crise.

Le développement rapide du marché des CDS, ainsi que le fait que les montants notionnels de protection signée sur une entité de référence donnée étaient dans la majorité des cas supérieurs aux montants de titres de dette sous-jacents, ont également conduit à s'interroger sur la manière dont se déroule le processus de découverte des prix d'actifs. Un certain nombre d'études ont conclu que le marché des CDS est *leader* par rapport au marché obligataire, dans le sens où les innovations sur les prix vont des CDS aux obligations et non l'inverse (ECB, 2004 ; Blanco *et al*., 2005 ; Zhu, 2006 ; Baba et Inada, 2007 ; Bowe *et al*., 2009). Crouch et Marsh (2005) ont montré que ce lien était particulièrement fort dans le cas des entreprises du secteur automobile.

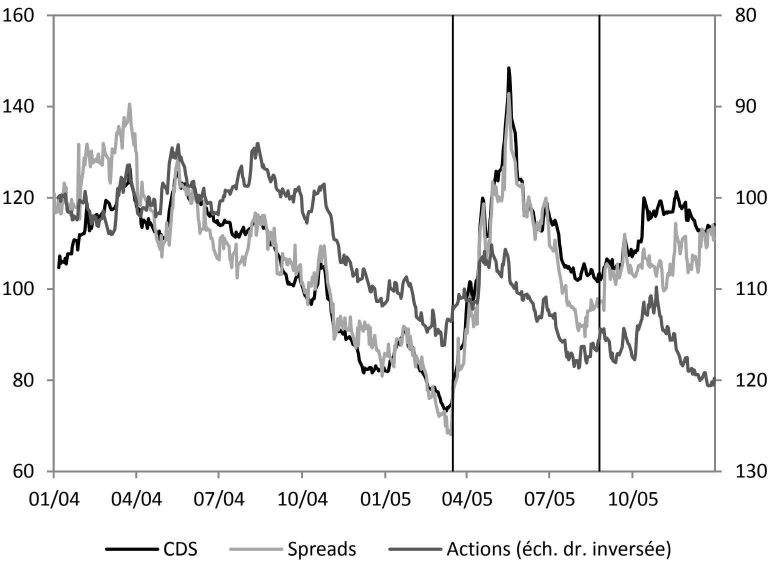
Le chapitre IV cherche à estimer si ce lien a été affecté lors de la crise de 2005, événement précurseur de la crise ayant débuté en 2007. Il se présente comme une prolongation du chapitre III et utilise la même base de données, c'est-à-dire un échantillon de CDS sélectionnés pour leur liquidité, présent dans les principaux indices de CDS européens et nord-américains. Cette base est complétée par les *spreads* obligataires des entreprises étudiées (Graphique 3). Le recours à des *Vector Error Correction Models* (VECM) ou à des modèles *Vector Auto-Regressive* (VAR), selon les propriétés statistiques de séries, permet d'estimer les liens entre marchés. Pour tester la présence d'une rupture de ces liens lors de l'épisode de crise de 2005, une approche non-linéaire de la cointégration est retenue dans le cas des modèles VECM, dans l'esprit de Gonzalo et Pitarakis (2006) ; pour les modèles VAR, les résultats obtenus à travers une mesure de la causalité à la Granger lorsque le modèle est estimé sur la période tranquille sont comparés à ceux obtenus lorsqu'il est estimé sur la période de crise.

Sur l'échantillon étudié, le marché des CDS est *leader* dans le processus de découverte des prix d'actifs. Par ailleurs, la relation habituelle entre les deux marchés est modifiée par la crise. Durant cette période, les primes de CDS s'accroissent plus que les *spreads* obligataires, les investisseurs renchérissant le prix de la protection. Ceci peut être dû à la nature spéculative du marché.

Le chapitre IV s'intéresse également au lien entre CDS et cours boursiers. Si l'on se place dans le cadre du modèle de Merton (1974), une augmentation de la prime de CDS est liée aux difficultés financières d'une entreprise et devrait aller de pair avec une baisse du prix de son action. Cependant, certaines études concluent que le marché boursier est *leader* par rapport au marché des CDS (Norden et Weber, 2004 ; Byström, 2008). Malgré tout, d'autres travaux obtiennent des résultats moins tranchés (Scheicher, 2006). La même méthode que précédemment est appliquée en associant à chaque prime de CDS le cours boursier de l'entité en question. Il s'avère que le marché des actions précède le marché des CDS, au niveau de l'échantillon d'entreprises sélectionnées. De plus, il apparaît à nouveau que la relation habituelle a été bouleversée par la crise. Par exemple, les actions de GM et Ford n'ont pas baissé continûment pendant la crise, comme on pouvait s'y attendre, bien que leur volatilité ait beaucoup augmenté.

Graphique 3 : Primes de CDS, *spreads* obligataires et cours boursiers (moyenne de l'échantillon étudié)

Les barres verticales délimitent la période de crise (du 16/03/05 au 24/08/05). Les primes de CDS et les *spreads* obligataires sont exprimés en points de base. Les cours boursiers sont en base 100 au 05/01/04 et représentés sur l'échelle de droite inversée.



Sources: Bloomberg, Datastream.

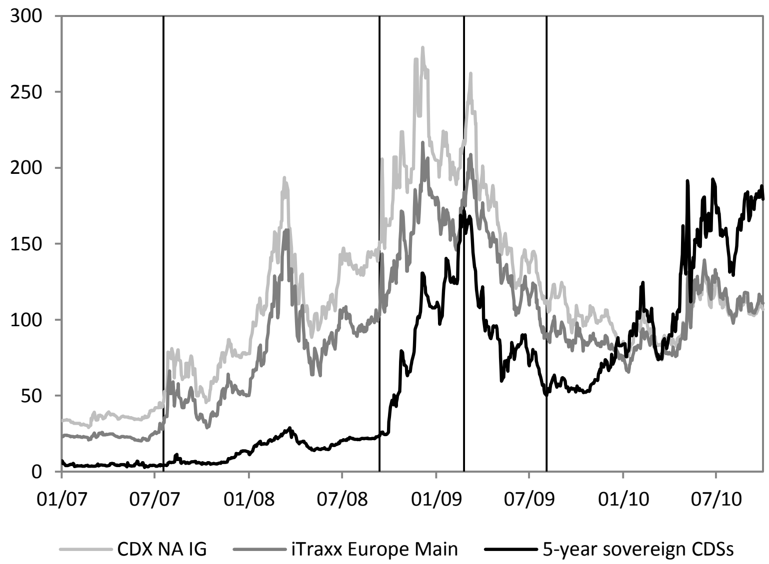
4.5. *CDS souverains et processus de découverte des prix d'actifs*

La crise débutée en 2007 a constitué le choc le plus important subi par le marché des CDS. Sur l'ensemble du marché, les primes de CDS ont atteint des niveaux record suite à la faillite de Lehman Brothers. Bien que le coût de la couverture ait augmenté pour l'ensemble des entités de référence, cette hausse a été particulièrement brutale dans le cas des primes de CDS souverains de pays développés. En effet, les Etats ont dû se porter au secours de leurs systèmes bancaires nationaux qui menaçaient de s'effondrer. La situation est devenue critique au moment de la faillite de Lehman Brothers, après laquelle le gouvernement américain s'est décidé à intervenir massivement, suivi en cela par les autres Etats des pays développés. Il en a résulté une dégradation drastique et durable des finances publiques de la plupart des pays, accentuée encore par la récession ultérieure. Le risque souverain des pays développés, jusque là considéré comme négligeable a été brusquement réévalué par les marchés. Ceci s'est traduit par une hausse du coût de financement et des primes de CDS de ces Etats (Graphique 4). Le chapitre V s'intéresse à ce phénomène et à l'évolution de la crise financière en crise de la dette souveraine.

En théorie, ces mouvements reflètent les réactions normales des marchés, les défaillances étant supposées être plus fréquentes en période de crise. Les expériences passées rappellent que l'ensemble des souverains, émergents comme développés, a subi des crises conduisant le plus souvent à une restructuration de la dette, (Reinhart et Rogoff, 2009). Cependant, l'ampleur des mouvements observés a constitué une source d'inquiétude, interrogeant sur le bien fondé des niveaux de prime atteints et leur cohérence avec les fondamentaux macroéconomiques et laissant penser que ce segment du marché aurait particulièrement surréagi. Cette intuition fait écho aux conclusions d'Andritzky et Singh (2005) qui s'interrogeaient dès le milieu des années 2000 sur la pertinence du niveau des primes de CDS dans le cas des pays émergents. L'existence d'une sur-réaction des primes de CDS a pu par ailleurs ouvrir la voie à des phénomènes de contagion.

Graphique 4 : Primes des CDS des principaux indices de marché et de l'indice synthétique de CDS souverains à 5 ans (en points de base)

L'indice synthétique de CDS souverains est construit comme la moyenne équipondérée des CDS à 5 ans des pays présents dans les indices de marché G7 et Western Europe proposés par Markit. Les barres verticales délimitent les différentes périodes retenues pour étudier la période de crise. Période 1 : 01/01/07 à 18/07/07 ; période 2 : 19/07/07 à 12/09/08 ; période 3 : 15/09/08 à 24/02/09 ; période 4 : 25/02/09 à 04/08/09 ; période 5 : 05/08/09 à 30/09/10.



Sources: Bloomberg, J.P. Morgan.

La dégradation récente des finances publiques au sein de la zone euro et des Etats les plus avancés de l'Organisation de Coopération et de Développement Economiques (OCDE) a favorisé l'activité sur les CDS souverains de ces pays, jusqu'alors très peu négociés. Ces produits sont apparus comme une nouvelle mesure du sentiment de marché. L'émergence récente du marché des CDS souverains de pays développés explique que peu d'études se soient pour l'instant consacrées à explorer sa dynamique. L'expansion spectaculaire de ce nouveau compartiment du marché des CDS, qui a progressé de 29% en 2009, pourrait avoir fait évoluer l'environnement financier, le développement de la négociation de CDS souverains de pays développés ayant influencé la dynamique du marché des titres souverains en général (Boone *et al*., 2010). Selon Duffie (2010), les stratégies spéculatives n'auraient cependant pas conduit à une hausse du coût de financement des Etats de la zone euro. Le chapitre V revient dans un premier temps sur les caractéristiques des contrats de CDS souverains et des stratégies auxquelles les investisseurs ont pu avoir recours sur ce segment du marché, ainsi que sur l'évolution de l'activité de négociation des CDS souverains avant et pendant la crise. Il cherche en particulier à associer les ruptures dans l'évolution de la liquidité de ce marché à un certain nombre d'événements, comme les difficultés rencontrées par Bear Stearns, la faillite de Lehman Brothers et la mise en place des plans d'aide publique, ayant pu contribuer à intensifier l'activité de négociation des CDS souverains par les participants de marché (ces différentes périodes sont représentées sur le Graphique 4).

Dans un deuxième temps, le chapitre V applique l'approche adoptée pour étudier l'évolution des liens entre marchés lors de la crise de 2005, et présentée dans le chapitre IV, au marché des CDS souverains. Un certain nombre de travaux ont cherché à estimer de quel manière se déroulait le processus de découverte des prix d'actifs pour des CDS souverains de pays émergents. Les résultats obtenus sont moins tranchés que dans le cas des CDS d'entreprises. Ainsi, alors que Bowe *et al*. (2009) concluent que le processus de découverte des prix d'actifs se déroule sur le marché des obligations d'Etat libellées en devise, Ammer et Cai (2007) constatent, sur un échantillon de pays différent, que lorsque le marché obligataire est relativement illiquide, le marché des CDS tend à dominer le marché sous-jacent. Coudert et Gex (2010b) ont cherché à déterminer de quelle manière se déroulait le processus de découverte des prix d'actifs sur une période allant de début 2007 à fin mars 2010. Dans le cas des CDS souverains des principaux pays européens, ils constatent que le marché obligataire précède le marché des CDS, aussi bien pendant la période calme d'avant-crise que durant les turbulences financières ayant succédé au sauvetage de Bear Stearns. Il apparaît cependant que ce caractère directeur diminue pendant la crise et est moins prononcé pour les Etats considérés comme les plus fragiles.

Le recours à un modèle vectoriel dynamique, grâce à l'intégration d'un filtre de Kalman, montre que les liens entre le marché des CDS et le marché obligataire dans le cas de huit pays de la zone euro[26] se sont renforcés sur la période s'étendant de début 2007 à fin septembre 2010, en particulier suite à la faillite de Lehman Brothers et au sauvetage de Bear Stearns, dans une moindre mesure cependant. Sur la période étudiée, le marché obligataire tend à précéder le marché des CDS souverains. Un résultat notable est que ce lien de causalité s'inverse pour l'ensemble des pays à partir de début 2010, les huit pays de l'échantillon présentant une causalité allant des CDS vers les *spreads* obligataires, alors que les relations de causalité allant des *spreads* obligataires vers les CDS souverains tendent à disparaître pour l'ensemble des pays sur la même période.

L'intégration pour chaque pays d'un indice de CDS bancaires[27] dans le modèle vectoriel permet de capter dans quelle mesure les interventions publiques, qui se sont traduites par un transfert de risque des banques vers les Etats, ont pu participer à modifier ces relations. Il apparaît que : (i) le nombre de relations de causalité allant des CDS souverains vers les CDS bancaires augmente suite aux difficultés rencontrées par Bear Stearns et à la faillite de Lehman brothers ; (ii) à l'inverse, les relations de causalité allant des CDS bancaires vers les CDS souverains tendent à disparaître après la faillite de Lehman Brothers ; (iii) une causalité allant des CDS bancaires vers les *spreads* obligataires souverains est détectée pour la majorité des pays juste après l'annonce des difficultés rencontrées par Bear Stearns et la faillite de Lehman Brothers, mais disparaît rapidement après ces événements et suite à la mise en place de la majorité des plans d'aides.

Avec le développement de la crise, le risque économique lié à chaque souverain a donc été plus fortement intégré par les participants de marché dans leur estimation de la solidité des sytèmes bancaires nationaux. Les investisseurs ont rapidement anticipé et intégré que le rôle des banques centrales, en tant que prêteur en dernier ressort le plus probable, puis celui des Etats, serait déterminant. Les résultats montrent que l'influence du marché des CDS souverains sur les autres marchés a significativement augmenté avec les tensions subies par les Etats, en dépit des faibles montants notionnels de CDS souverains comparativement aux encours de titres de dette publique sous-jacente.

[26] Autriche, Belgique, Espagne, France, Grèce, Italie, Pays-Bas et Portugal.

[27] Cet indice est construit pour chaque souverain de l'échantillon comme un panier des CDS des principales banques du pays, lorsqu'il est possible d'en construire un. Les CDS des banques grecques ne présentant pas un niveau de liquidité considéré comme suffisant, il n'est pas possible de calculer d'indice de CDS bancaires pour ce pays.

5. Plan de la thèse

La thèse s'intéresse à des épisodes de crise qui ont affecté le marché des CDS et à la façon dont ces épisodes ont pu avoir un impact sur l'évolution des prix sur les marchés. Les périodes de crise sont souvent précédées de périodes de fort appétit pour le risque qui peuvent être à l'origine de bulles spéculatives sur le prix des actifs financiers, créant ainsi des vulnérabilités. Un effondrement brutal de l'optimisme des investisseurs peut ensuite conduire à une forte baisse des prix et provoquer une crise financière. Le chapitre I revient sur la dichotomie entre prix du risque et quantité de risque qu'il est possible de faire en recourant au cadre général d'un modèle à noyau, tel que défini par Campbell *et al*. (1997) ou Cochrane (2001). Le cadre théorique fourni par les modèles de détermination des prix d'actifs, et plus précisément le *Consumption* CAPM (CCAPM), permet en effet d'effectuer cette décomposition. Ce prix du risque peut être assimilé à l'aversion pour le risque des agents. Certains auteurs préfèrent utiliser le terme d'appétit pour le risque, défini comme ce prix du risque affecté d'un signe négatif (Kumar et Persaud, 2002 ; Gai et Vause, 2006).

Le chapitre I s'intéresse ainsi au rôle des anticipations des investisseurs et aux outils qu'ils ont développés pour capter cette évolution des préférences et la tendance à s'orienter vers des catégories d'actifs plus ou moins risqués à travers l'étude d'épisodes de crises de change et de crises boursières sur la deuxième moitié des années 90 et la première moitié des années 2000. Les fluctuations de l'aversion pour le risque sont en effet souvent considérées comme un facteur explicatif des crises. En effet, dans ce cadre, toute augmentation de l'aversion pour le risque se traduira par une augmentation de l'ensemble des primes de risque et affectera donc tous les prix de marché, que la quantité de risque commune à tous les actifs ait été modifiée ou non. Si ce phénomène se produit soudainement, il pourra être à l'origine d'une crise. Ce chapitre permet ainsi de mieux comprendre, à travers un cadre théorique général, par quels biais des tensions ont pu se propager au sein du marché des CDS et affecter d'autres marchés, en particulier le marché sous-jacent.

Le chapitre II étudie l'épisode de crise débuté en 2007 sous l'angle de la capacité du marché des CDS à gérer de manière efficace le règlement de défauts de grande ampleur. Il revient ainsi sur le fonctionnement du marché et sur les dispositifs mis en place par les participants de marché pour régler les défauts. Il permet ainsi une meilleure compréhension des mécanismes à l'œuvre et constitue un socle technique pour les chapitres suivants. Il tente d'estimer si les taux de recouvrement observés sur le marché des CDS sont cohérents avec les prix obligataires du marché secondaire et explore les raisons expliquant les écarts constatés.

Le chapitre III s'intéresse aux phénomènes de contagion au sein du marché des CDS durant la crise de 2005, déclenchée par la dégradation en catégorie spéculative de GM et Ford, émetteurs obligataires de taille importante. Ce chapitre s'interroge donc sur la résilience du marché des CDS.

Le chapitre IV étend la problématique du chapitre III au transfert d'information du marché des CDS vers d'autres marchés, le marché obligataire sous-jacent et le marché boursier, durant la même période de crise. Il permet donc d'évaluer dans quelle mesure le développement du marché des CDS a pu constituer un nouveau canal de propagation dans la diffusion des crises.

Le chapitre V mesure de quelle manière ce transfert d'information s'est produit durant la crise des *subprimes* et son évolution en crise de la dette publique, suite au transfert de risque des banques vers les Etats provoqué par la mise en place des plans d'aides au secteur financier. Il s'intéresse en particulier au développement du marché des CDS souverains de pays européens et tente d'estimer de quelle manière l'émergence de ce segment du marché aurait pu avoir un impact sur les conditions de financement des souverains de la zone euro.

Chapter I Does risk aversion drive financial crises? Testing the predictive power of empirical indicators[*]

Abstract

There are several types of risk aversion indicators used by financial institutions. These indicators, which are estimated in diverse ways, often show differing developments, although it is not possible to directly assess which is the most appropriate. Here, we consider the most well-known of these indicators and construct others with standard methods. As financial crises generally coincide with periods in which risk aversion increases, we try to check if these indicators rise just before the crises and also if they are able to forecast crises. We estimate logit and multilogit models of financial crises – exchange rate and stock market crises – using control variables and each of the risk aversion indicators. In-sample simulations allow us to assess their respective predictive powers. Risk aversion indicators are found to be good leading indicators of stock market crises, but less so for currency crises.

JEL classification: C33; E44; F37; G12.

Keywords: Risk aversion; Leading indicators of crises; Currency crises; Stock market crises; Crises prediction.

[*] This is a joint article with Virginie Coudert. Published in the *Journal of Empirical Finance* 15 (2008), p. 167-184. NOTICE: this is the author's version of a work that was accepted for publication in the *Journal of Empirical Finance*. Changes resulting from the publishing process, such as peer review, editing, corrections, structural formatting, and other quality control mechanisms may not be reflected in this document. Changes may have been made to this work since it was submitted for publication. A definitive version was subsequently published in the *Journal of Empirical Finance*, Vol. 15, Issue 2, (2008), doi:10.1016/j.jempfin.2007.06.001.

1. Introduction

Risk aversion can be precisely defined within the framework of asset pricing models (Campbell *et al*., 1997; Cochrane, 2001). In this context, any risk premium can be decomposed into two components: a "price of risk", which is common to all financial assets, and a "quantity of risk", which is specific to each asset. Risk aversion can be assessed by the "price of risk" obtained in this way. Other authors refer to "risk appetite", which is just the same "price of risk" with a negative sign (Kumar and Persaud, 2002; Gai and Vause, 2006).

In this framework, any increase in risk aversion sets off a raise in all risk premia, and therefore simultaneous a fall in asset prices across all financial markets. If this occurs suddenly, this may prompt a financial crisis. The interesting feature about this theoretical decomposition is that the financial crisis may burst even if the "quantity of risk" included in the assets has not changed.

Despite the readiness of its theoretical definition, risk aversion raises thorny issues when it comes to empirical matters, as it is not directly observable. Distinguishing the risk perceived by agents from risk aversion itself is very delicate. Several methods have been developed to assess risk aversion, especially by financial institutions. Disappointingly, they yield empirical indicators, which often show different trends. We try here to review them and assess their respective relevance. For doing this, we rely on a criterion derived from their theoretical properties: we assume that a "good" risk aversion indicator should significantly increase before financial market crises. This criterion allows us to discriminate the helpful empirical indicators.

The main aversion indicators which are commonly used by financial institutions can be grouped in different types: the *Global Risk Aversion Indexes*, the "GRAIs", introduced by Kumar and Persaud (2002), based on the correlation between volatilities and changes in assets' prices; indicators using a principal components analysis (PCA) on risk premia, as constructed by Sløk and Kennedy (2004); the *Volatility Index*, the "VIX", using implicit volatility of option prices, created by the Chicago Board Options Exchange (CBOE, 2004); the *Liquidity, Credit and Volatility Index*, the "LCVI", a synthetic indicator constructed by J.P. Morgan (Prat-Gay and McCormick, 1999; Kantor and Caglayan, 2002); the ICI, used by State Street and based on the movements in investors' portfolios (Froot and O'Connell, 2003). We calculate the two first categories: the GRAI and a PCA indicator with empirical data on financial prices; we use the original series provided by their authors for the VIX, LCVI and ICI.

We then test these indicators ability to forecast currency and stock market crises. Much work has been done to attempt to construct "leading indicators" of crises, since the Mexican crisis in 1995 (Kamnisky et al., 1997; Berg and Pattilo, 1999; Bussière and Fratzscher, 2006). The idea underlying this research has been to identify economic variables that behave in a particular way prior to periods of crisis. Their aim is to assess probabilities of crisis at a specific horizon (generally one or two years), taking account of the information available on the economic variables. Most of them use logit models that link a qualitative endogenous variable (equal to 1 for crises and 0 for quiet periods) to a set of quantitative exogenous variables (Frankel and Rose, 1996; Sachs et al., 1996; Radelet and Sachs, 1998). These models are estimated for a large number of countries and periods. We use the same method here, adding risk aversion indicators to the usual variables, in order to test their impact on financial crises.

The rest of the paper is organized as follows. Section 2 theoretically states the risk aversion concept which will be used in the framework of standard asset pricing models (CCAPM and CAPM). Section 3 describes the empirical methods for constructing the risk aversion indicators. Section 4 gives the definition of crises for foreign exchange and stock markets; it also presents the different logit and multilogit models used for forecasting. We successively use these models with control variables and/or with each risk aversion indicator. Section 5 gives the estimation results for currency crises; Section 6 for stock market crises and reversals. Section 7 concludes.

2. Theoretical framework

2.1. Risk aversion in the CCAPM

The CCAPM allows to link asset prices to the consumer's utility function. To keep it simple, we assume that there is a single risky asset, two periods of time, t and $t+1$, constant consumer prices and a utility function that is separable over time. The agent's non-financial income in period $t+1$ is a stochastic variable depending on the state of the world in $t+1$. The agent maximises his expected utility by choosing an optimal quantity of asset to buy in the first period, as in the following programme. A further assumption is that the agent can buy and sell freely this asset without transaction costs.

$$\begin{cases} \max_{\{\xi\}} u(c_t) + E_t[\delta u(c_{t+1})] \\ c_t = y_t - p_t \xi \\ c_{t+1} = y_{t+1} + x_{t+1} \xi \end{cases} \tag{I.1}$$

We denote consumption in t as c_t, non-financial revenue as y_t, the price of the asset as p_t, gross income from the asset $x_t + 1$, and the quantity of asset bought in t as ξ. δ is the intertemporal discount factor, which captures the consumer's preference for present.

The price of the asset p_t is deduced from the first order condition:

$$p_t = E_t\left[\delta \frac{u'(c_{t+1})}{u'(c_t)} x_{t+1}\right] \tag{I.2}$$

The asset price expressed in Equation (I.2) can be interpreted as the expected income x_{t+1},discounted by a discount factor, denoted m_{t+1} and referred to as the "stochastic discount factor" (SDF, thereafter):

$$p_t = E_t(m_{t+1}x_{t+1}) \tag{I.3}$$

with

$$m_{t+1} = \delta\left[\frac{u'(c_{t+1})}{u'(c_t)}\right] \tag{I.4}$$

To express the risk premia, we use the gross return on the asset, dividing income x_{t+1} by the price p_t (i.e. $R_t = \frac{x_{t+1}}{p_t}$)[28]:

$$1 = E(m_{t+1}R_{t+1}) \tag{I.5}$$

By definition, the income from a risk-free asset does not vary with states of the world, which amounts to saying that the risk-free rate in $t+1$, denoted R^f_{t+1}, is known in advance:

$$R^f_{t+1} = \frac{1}{E(m_{t+1})} \tag{I.6}$$

By definition, the risk premium equals the difference $E(R_{t+1}) - R^f_{t+1}$, i.e. the expected excess return on the risky asset compared to that on the risk-free asset.

Considering Equations (I.5) and (I.6), we have:

$$E(R_{t+1}) - R^f_{t+1} = -\mathrm{cov}(m_{t+1}, R_{t+1})R^f_{t+1} \tag{I.7}$$

The risk premium therefore equals minus the covariance of the return on the risky asset with the SDF multiplied by the risk-free rate. It can be decomposed as follows:

$$E(R_{t+1}) - R^f_{t+1} = \left(-\frac{\mathrm{cov}(R_{t+1}, m_{t+1})}{\mathrm{var}(m_{t+1})}\right)\left(\frac{\mathrm{var}(m_{t+1})}{E(m_{t+1})}\right) \tag{I.8}$$

[28] To lighten the notation, from now on, we suppress the subscripts on E_t, as well as on the variance and covariance, for they are all calculated in time t.

Generally speaking, assuming there are several assets subscripted from $i = 1$ to n:

$$E\left(R_{t+1}^{i}\right) - R_{t+1}^{f} = \left(-\frac{\operatorname{cov}\left(R_{t+1}^{i}, m_{t+1}\right)}{\operatorname{var}(m_{t+1})}\right)\left(\frac{\operatorname{var}(m_{t+1})}{E(m_{t+1})}\right) \quad \text{(I.9)}$$

which can be written in the form:

$$E\left(R_{t+1}^{i}\right) - R_{t+1}^{f} = \beta_{i,m}\lambda_{m} \quad \text{(I.10)}$$

with

$$\beta_{i,m} = -\frac{\operatorname{cov}\left(R_{t+1}^{i}, m_{t+1}\right)}{\operatorname{var}(m_{t+1})} \quad \text{(I.11)}$$

and

$$\lambda_{m} = -\frac{\operatorname{var}(m_{t+1})}{E(m_{t+1})} \quad \text{(I.12)}$$

We can consider that λ_m is the price of risk, which is common to all assets, and that $\beta_{i,m}$ is the specific quantity of risk associated with each asset.

Often, the price of risk λ_m is regarded as corresponding to risk aversion. We do the same in this paper. However, to avoid any confusion, it should be distinguished from the parameter of risk aversion in the consumer's utility function. For example, using the conventional power utility function $u(c_t) = \frac{1}{1-\gamma}c_t^{1-\gamma}$ where γ is the coefficient of relative risk aversion, the SDF is written:

$$m_{t+1} = \delta\left(\frac{c_{t+1}}{c_t}\right)^{-\gamma} \quad \text{(I.13)}$$

The expected return and price of risk depend on the rate of growth in consumption, denoted Δc:

$$\begin{gathered} E\left(R_{t+1}^{i}\right) = R_{t+1}^{f} + \beta_{i,\Delta c}\lambda_{\Delta c} \\ \lambda_{\Delta c} = -\gamma \operatorname{var}(\Delta c) \end{gathered} \quad \text{(I.14)}$$

2.2. Consistency with the CAPM

The CCAPM model may be regarded as being a general representation from which the other models currently used to determine asset prices can be deduced. The CAPM of Sharpe (1964) and Lintner (1965a, 1965b) may be considered a particular case of the CCAPM. We therefore express the SDF depending on the return, denoted R_{t+1}^{W}, on the "wealth portfolio" held by the consumer. This return R^W thus serves to approximate the marginal utility of consumption:

$$m_{t+1} = a - bR^W_{t+1} \tag{I.15}$$

a and b are parameters > 0.[29]

R^W is proxied by the return on a broad portfolio of stocks regarded as "the market portfolio". The return on the market portfolio, denoted R^m, equals the average return on all of the assets indexed by $i = 1$ to n weighted by their share α_i, so that:

$$R^m_{t+1} = \sum_i \alpha_i R^i_{t+1} \tag{I.16}$$

This assumes that the consumer's wealth is invested across the whole of the market. If the return on the market portfolio is denoted R^m, the SDF will then be:

$$m_{t+1} = a - bR^m_{t+1} \tag{I.17}$$

Using Equations (I.7) and (I.17) and assuming again that there are several assets, indexed by $i = 1$ to n, then:

$$E(R^i_{t+1}) = R^f_{t+1}\text{cov}(R^i_{t+1}, a - bR^m_{t+1}) = R^f_{t+1} b \ \text{cov}(R^i_{t+1}, R^m_{t+1}) \tag{I.18}$$

The expression of the risk premium is obtained by dividing and multiplying the right side of Equation (I.18) by $\text{var}(R^m_{t+1})$:

$$E(R^i_{t+1}) = R^f_{t+1} + R^f_{t+1} b \ \text{var}(R^m_{t+1}) \left(\frac{\text{cov}(R^i_{t+1}, R^m_{t+1})}{\text{var}(R^m_{t+1})}\right) \tag{I.19}$$

Identifying to Equation (I.6), we can write Equation (I.19) in the following form, which is consistent with the CCAPM:

$$E(R^i_{t+1}) = R^f_{t+1} + \beta_{i,m}\lambda_m \tag{I.20}$$

with

$$\beta_{i,m} = \frac{\text{cov}(R^i_{t+1}, R^m_{t+1})}{\text{var}(R^m_{t+1})} \tag{I.21}$$

$$\lambda_m = b\,\frac{\text{var}(R^m_{t+1})}{E(R^m_{t+1})} \tag{I.22}$$

The market return plays a similar role to that of changes in consumption in the previous model.

[29] The theoretical values of these parameters are obtained by setting: $1 = E_t(m_{t+1}R^W_{t+1})$ et $1 = E(m_{t+1})R^f_{t+1}$.

2.3. *Consistency with factor models*

The Arbitrage Pricing Theory (APT) (Ross, 1976), based on the lack of arbitrage opportunities, relies on the assumption that yields on different securities depend on one or more common factors which are not directly observable. APT specifies neither their number nor their nature. In the framework of the CAPM, the only factor to consider is the market return. In other models, several factors are retained. For instance, Fama and French (1996) show that a three-factor model may explain the change in excess return of US stocks portfolios. The SDF is expressed according to a number of factors f, which may be different from consumption or market returns.

$$m_{t+1} = f'_{t+1} b \tag{I.23}$$

As the factors f are not directly observable, a factor analysis method, such as a Principal Component Analysis (PCA), is needed to estimate them (see Cochrane, 2001, p. 175).

3. The risk aversion indicators

3.1. *Indicators of the GRAI type*

An increase in risk aversion should lead to an increase in risk premia across all markets, but the increase should be greater on the riskiest markets. This is the idea on which the GRAI is based, devised by Persaud (1996): changes in risk aversion may therefore be represented by the correlation across different assets between price variations and their volatility. The framework is given by a CAPM model of the type that we can express as in Equations (I.20)-(I.22). If we add an assumption of independent returns on different markets, the risk premium on each security i no longer depends on the covariance with other premia, but only on the security's variance (denoted σ_i^2).

$$E\left(R_{t+1}^i\right) - R_{t+1}^f = \lambda \frac{\operatorname{cov}\left(R_{t+1}^i, \alpha_i R_{t+1}^i\right)}{\operatorname{var}\left(R_{t+1}^m\right)} = \lambda \frac{\alpha_i \sigma_i^2}{\sigma_m^2} \tag{I.24}$$

By deriving formula (I.24) in relation to λ, we obtain the change in the expected risk premium when risk aversion increases:

$$\frac{\partial\left[E\left(R_{t+1}^i\right) - R_{t+1}^f\right]}{\partial \lambda} = \frac{\alpha_i \sigma_i^2}{\sigma_m^2} \tag{I.25}$$

Thus, an increase in risk aversion results in an increase in the expected risk premium of the asset i that is proportional to the volatility of asset i's return, according to Equation (I.25).

By deriving formula (I.24) in relation to σ_i^2, we obtain the change in the risk premium across the different assets $1, \ldots, n$ when the asset's volatility, i.e. the risk associated with i, increases:

$$\frac{\partial\left[E\left(R_{t+1}^i\right)-R_{t+1}^f\right]}{\partial \sigma_i^2}=\frac{\alpha_i \lambda}{\sigma_m^2} \tag{I.26}$$

Equation (I.26) shows that an increase in asset i's volatility brings about an increase in the risk premium of i that is proportional to the risk aversion, but does not depend on i's volatility.

The GRAI indicators calculated use variations in prices rather than in expected excess returns, which explains the change in sign in the correlation.

The expected return equals the anticipated change in price:

$$E\left(R_{t+1}^i\right)=E\left(P_{t+1}^i\right)-P_t \tag{I.27}$$

By assuming that $E\left(P_{t+1}^i\right)$ is constant and using Equations (I.27) and (I.24), we obtain:

$$\frac{\partial\left[P_t\right]}{\partial \lambda}=\frac{\alpha_i \sigma_i^2}{\sigma_m^2} \tag{I.28}$$

The GRAI is therefore calculated as a correlation with a negative sign between price changes of the different assets and their volatility. By construction, the GRAI does not measure levels of risk aversion but rather changes in it. Spearman's correlation is often used, which is a correlation between ranks of variables. Instead of a correlation, a regression coefficient between price variations and volatilities may also be used (which is also given a negative sign). The indicator is then called the Risk Aversion Index (RAI), as proposed by Wilmot *et al*. (2004).

In order to be entirely rigorous, confidence intervals need to be constructed around the estimated values. When this is done, GRAI indicators are often found to be in a non-significant area (more than half of the values in Kumar and Persaud's study). However, it must be admitted that these confidence intervals are not calculated for other empirical risk aversion indicators. Kumar and Persaud (2002) applied this approach to ex post excess returns on foreign exchange markets, Baek *et al*. (2005) on developed and emerging stock markets. Several financial institutions and private banks, such as the IMF and J.P. Morgan, subsequently constructed their own GRAI. Others like Crédit Suisse First Boston (Wilmot *et al*., 2004) and the Deutsche Bundesbank (2005) have constructed RAIs.

From a theoretical standpoint, the construction is based on simplifying assumptions that are probably not borne out in reality (Misina, 2003, 2006). Especially, if the assumption of independence of excess returns is dropped, the change in risk premium due to risk aversion is no more proportional to the asset volatility (as it is the case in Equation (I.25)), which means that the GRAI does not correctly measure risk aversion changes. From an empirical point of view, the GRAI and RAI also display some limitations. The measurements show that these indicators are very volatile. This seems counterintuitive, as a good indicator should be stable during quiet periods. Moreover, changes in the indicator over time differ quite markedly depending on the period chosen for the calculations of volatility of returns as well as on the market concerned.

Here, we calculate a GRAI and a RAI for the foreign exchange and stock markets using monthly data over the period from January 1995 to September 2005. For both, volatility is calculated over the two previous years. For the currency GRAI, the sample comprises 15 exchange rates against the USD; excess returns are equal to the spread between the 3-month forward rate and the actual spot rate three months later. For the stock market GRAI, the sample is made up of the main stock market indices of 27 developed and emerging economies (for more details, see Appendix A).

3.2. A PCA indicator

As shown in section 2.3, in the framework of a factor model, a PCA should be applied to risk premia in order to identify common factors in their variations. The first common factor can generally be interpreted as the price of risk, if certain conditions are met, notably that it increases with each risk premium. In fact, this indicator is constructed exactly like a weighted average of risk premia, the weighting being given by the PCA.

PCA allows to extract from a set of n quantitative variables correlated among one another a list of p new variables called “factors” $f_1, \dots, f_p$ $(p \leq n)$ that are uncorrelated among one another. The common factors are constructed as linear combinations of n initial variables.

In order to condense the information, only the k first factors are considered, as they explain, by construction, the bulk of total variance. The proportion of total variance accounted for by these k first factors constitutes an overall measure of the quality of the PCA. Choosing how many factors to use is difficult. Two criteria are often used to make this choice: the Joliffe criterion – which consists in cutting off once the percentage of explained variance reaches a certain threshold (for example 80%) – and the Kaiser criterion, which only keeps eigenvalues greater than one if the correlation matrix is worked on.

This PCA approach is used by Sløk and Kennedy (2004) on stock and bond markets in developed and emerging market countries. According to them, the variance-explained weighted average of the first two common factors is strongly correlated with the OECD's leading indicator of industrial production and a measure of global liquidity. In this case, therefore, PCA captures the impact of the risk of the overall macroeconomic environment and liquidity risk on changes in risk premia. McGuire and Schrijvers (2003) studied – also using PCA – common developments in risk premia in 15 emerging market countries. The first factor, which explains the bulk of the common variation, is interpreted as representing the investor risk aversion. The Deutsche Bundesbank (2004) calculates a risk aversion indicator by means of PCA using risk premia on investment and speculative grade corporate bonds in developed countries and sovereign risk premia for some Asian and Latin American countries.

Here we calculate a PCA indicator on risk premia. The risk premia used have been chosen so as to be representative of the changes observed across the fixed income market as a whole. These are, on the one hand, option adjusted spreads (OAS) on corporate bonds and swap spreads for the major developed markets; and, on the other, the EMBI Global sovereign spread and a corporate spread for emerging market economies[30]. Details of these series are given in Appendix A. The estimation period is from December 1998, when the indices used for emerging market countries were introduced, to December 2005. The method used here is PCA carried out using a set of standardised risk premia.

The results show that the first factor explains 68% of the common variation of risk premia. The correlation of each of the risk premia with this first factor is positive. In addition, all of the original risk premia are well represented in this first factor, the weightings being of comparable order of magnitude; there is therefore no problem of over-or underrepresentation of certain series. For these reasons, we can consider that this first common factor gives a good representation of risk aversion.

The second factor explains 19% of the common variation of risk premia. We analyse it since it satisfies the Joliffe criterion, at the 80% threshold, and the Kaiser criterion. This second factor is negatively correlated with a measure of global liquidity. This is approximated here by the inverse of average short-term rates of the four largest

[30] Risk premia on stock markets are not used on account of the great disparity in results obtained using the principal methods, which are mainly based on the Gordon-Shapiro model but with different underlying assumptions.

economies (United States, euro area, United Kingdom and Japan), weighted by GDP ($\rho = 0{,}69$). We also note a high positive correlation between the second factor and swap spreads, which are often regarded as being strongly influenced by global liquidity developments.

3.3. Simple and aggregated indicators: the VIX and the LCVI

Some analysts use raw series to estimate changes in investors' perception of risk. For instance, the price of gold is sometimes used on the basis that, during periods of uncertainty, investors reallocate their wealth to assets traditionally perceived as safe, such as gold. The same is true of the Swiss franc exchange rate.

The implied volatility of options is also used to provide an indication of the amounts an investor is prepared to pay to protect themselves from the risk of price fluctuations. The VIX, used in the following sections, equals the implied volatility on the S&P 500. It is regarded by many market analysts as a direct gauge of fear (CBOE, 2004).

Several indicators have been created by aggregating elementary series. These measures are relatively simple to put in place and can be easily interpreted. In most cases, they are weighted averages of a number of variables. The best-known indicators of this type are J.P. Morgan’s Liquidity, Credit and Volatility Index or LCVI (Prat-Gay and McCormick, 1999; Kantor and Caglayan, 2002), UBS’s Risk Index (Germanier, 2003), Merrill Lynch’s Financial Stress Index (Rosenberg, 2003) and the Risk Perception Indicator of the Caisse des Dépôts et Consignations (Tampereau and Teiletche, 2001).

We select the LCVI, often regarded as being a satisfactory measure of risk aversion. Dungey *et al*. (2003), for example, use it to study changes in risk aversion during the financial crises in emerging markets. The LCVI aggregates three types of information: first, two series capturing liquidity developments (yield spreads between a benchmark and little-traded US Treasury bills and spreads on US swaps); second, two risk premia indicators (yield spreads on speculative grade corporate bonds and the EMBI); and third, three measures regarded in this approach as representative of market volatility (the VIX, volatility on foreign exchange markets and the Global Risk Aversion Index – GRAI).

These aggregate indicators may seem limited in their power to explain risk perception, as the underlying elementary variables are influenced by many factors other than investors’ propensity to take risks. This is not offset by aggregating them, which consists, more or less, in calculating an arithmetical average, with an arbitrary weighting of the different series.

3.4. *Other measures: the ICI*

We also select the State Street's Investor Confidence Index (ICI) which is based on a measure in volume terms rather than prices (Froot and O'Connell, 2003). This index can be regarded as a GRAI calculated in terms of quantities. A rise in it corresponds to an increase in risky assets in the portfolio of a range of investors. It thus points to a trend of growing risk appetite, and a fall signals the reverse. In order to compare it directly with other risk aversion indicators, we give it a negative sign. The index is calculated every month using State Street's proprietary database on the portfolios of institutional investors.

Option prices are also used to extract information on risk aversion. Indicators based on option prices are obtained by comparing risk-neutral probabilities, calculated on options prices, with investors' subjective probabilities (Tarashev *et al*., 2003, Scheicher, 2003, Bliss and Panigirtzoglou, 2004, for a survey, see Gai and Vause, 2006).We have not used this type of indicator here as it is tricky to estimate empirically subjective probabilities using historical data. We have not used either in our comparison indicators based on the optimisation under constraint of a consumption model, of which the Goldman Sachs indicator is an example (Ades and Fuentes, 2003). Indeed, many studies have shown that the CCAPM underperform models that use market data, such as the CAPM, and conclude to its low explicative power (Mankiw and Shapiro, 1986; Cochrane, 1996; Hansen and Singleton, 1982, 1983; Wheatley, 1988). However, the CCAPM theoretical model is still not discredited since these poor empirical findings may come from specifications on the utility function or on the parameters (Campbell and Cochrane, 2000).

3.5. *Comparison of the indicators*

The different indicators react more or less to periods of crisis (see Appendix B, these periods are identified by vertical columns). Prior to the Asian crisis in 1997 and the Russian crisis in the summer of 1998, the VIX and LCVI show a rise in risk aversion. Prior to the Asian crisis in 1997 and the Russian crisis in the summer of 1998, the VIX and LCVI show rise in risk aversion[31]. However, the GRAI and RAI do not display any very clear trend. During the stock market crisis in the early 2000s, several indicators signal an increase in risk aversion: the PCA, the GRAI and the RAI (which are positive as they point to a rise in risk aversion). The VIX, LCVI and ICI do not show any very clear trend. The terrorist attacks of 11 September 2001 coincide with a peak of risk aversion in

[31] In the case of the LCVI, only the Russian crisis is concerned, as the series is only available from the end of 1997.

the VIX, the LCVI and the PCA. The other indicators do not record any particular change at this time.

One reassuring point to be underlined, however, is that these indicators are positively correlated between one another, even if the variations in them differ. The cross-correlations of these indicators show that 20 out of 28 of these correlations are positive (Table I.1). Of the seven remaining, only four are significantly different from zero.

Table I.1: Cross-correlations of risk aversion indicators

	Stock market GRAI	Currency RAI	Stock market RAI	PCA	VIX	LCVI	ICI
Currency GRAI	0.09	0.85**	0.07	0.07	-0.18**	0.09	-0.07
Stock market GRAI		0.17*	0.85***	0.53***	0.24***	0.35***	-0.12
Currency RAI			0.13	0.14	-0.14	0.14	-0.11
Stock market RAI				0.40***	0.15*	0.25**	-0.19*
PCA					0.83***	0.51***	-0.39***
VIX						0.56***	-0.20*
LCVI							0.03

Significantly different from zero at the * 90%, ** 95%, *** 99% confidence levels.

4. Methodology used to assess the link between risk aversion indicators and crises

We attempt to determine whether the risk aversion indicators described above can serve as leading indicators of crises, or whether they can help to improve forecasts using existing models. All along, we assume that a "good" risk aversion indicator should increase before a currency or stock market crisis. We carry out two estimates: on the foreign exchange market and on the stock market. Theoretically, investor risk aversion is the same on all markets, as a rational investor maximises his expected gains by making investment choices across all types of assets. We will therefore use the same risk aversion indicators, except for the GRAI where we have two distinct indicators. The sample of panel data includes monthly data for the period from July 1995 to September 2005 for 20 emerging countries for currency crises and 27 countries for stock market crises. The countries and exact sources of the series are given in Appendix A.

4.1. Definition of currency crises

In order to construct leading indicators of crises, an essential first step is to identify the crisis periods that occurred in the sample under review. Crisis periods are identified by so-called "simultaneous" indicators, which will be used to construct the model's dependent variable. The usual method consists in first of all constructing a "pressure" indicator on the foreign exchange market (for example, Sachs *et al*., 1996; Kamnisky *et al*., 1997; Corsetti *et al*., 1998; Burkart and Coudert, 2002; Bussière and Fratzscher, 2006).

For each country i, the pressure indicator, denoted $C'_{i,t}$, equals a weighted average of the currency's depreciation, $e_{i,t}$, and relative losses in international reserves, $r_{i,t}$.

$$C'_{i,t} = \alpha_{i,t} e_{i,t} + (1 - \alpha_{i,t}) r_{i,t}$$
$$\alpha_{i,t} = \frac{1/\mathrm{var}(e_{i,t})}{[1/\mathrm{var}(e_{i,t}) + 1/\mathrm{var}(r_{i,t})]} \qquad \text{(I.29)}$$

The weighting used between the two series is inversely proportional to their conditional variance. The reference currency to measure depreciation is the dollar for all the currencies of Latin America and Asia, since they are regarded as being more or less part of a "dollar area". In the case of European currencies, we have used the euro (and the Deutsche Mark before 1999) except when the currency was pegged to another currency. For example, when currencies were pegged to a basket, it is the change relative to this basket that is considered (for example, Hungary and Poland from July 1995 to December 1999). Countries that have had periods of hyperinflation (defined here by inflation higher than 150% in the six preceding months) are given particular treatment (in our sample, Bulgaria and Romania). In this case, we split the sample into two sub-samples: a sub-period of normal inflation and another of hyperinflation, as the measurement of averages and standard deviations is different for these two types of period.

When the pressure indicator goes above a certain threshold, it is deemed that there is a currency crisis. The threshold used is generally two or three standard deviations above the mean. The greater the number of standard deviations, the smaller the number of identified crises. Here we set the number of standard deviations to 3. This threshold allows to detect all the known crises in the sample (the Asian countries in the second half of 1997 or in Brazil in January 1999 and Argentina in January 2002). The currency crisis indicator $C_{i,t}$ is then defined as

$$C_{i,t}^{\text{Currency}} = 1 \text{ if } C'_{i,t} > \overline{C'_{i,t}} + 3\sigma_{i,t}$$
$$C_{i,t}^{\text{Currency}} = 0 \text{ otherwise.} \qquad \text{(I.30)}$$

The average $C'_{i,t}$ and standard deviation $\sigma_{i,t}$ are first calculated on data from August 1993 to December 1997, then conditionally by gradually adding one month to the sample. Here again in the case of hyperinflation countries, we split the sample into two sub-samples.

We add an extra criterion to avoid counting the same crisis several times: if a crisis is detected within a 12-month period following another crisis, it is automatically cancelled out. In total, 18 crises are detected, that is, an average 0.9 crisis per country over the period.

4.2. Definition of stock market crisis

There are fewer studies that address stock market crises. Nonetheless, it seems reasonable to define a stock market crisis as a sharp and rapid drop in share prices or in an index[32]. Two methods are used. Mishkin and White (2002) identify crises as falls in the price of a security or an index below a certain threshold (set arbitrarily at 20%) over a chosen time period (which may be a week, a month, a year, etc.).

Patel and Sarkar's approach (1998) consists in calculating an indicator, the CMAX, which detects extreme price levels over a given period (set to 24 months). This involves dividing the current price by the maximum price over the previous 2-year period. If $P_{i,t}$ is the stock price at time t and i, the country, then:

$$\text{CMAX}_{i,t} = \frac{P_{i,t}}{\max(P_{i,t},\ldots,P_{i,t-24})} \tag{I.31}$$

This indicator equals 1 when $P_{i,t} = \max(P_{i,t}, \ldots, P_{i,t-24})$. This is the case when that is a monotonous upward trend during the preceding 2 years. The more prices fall, the closer $\text{CMAX}_{i,t}$ gets to 0. Here again, to define crises, a threshold is used to identify periods when $\text{CMAX}_{i,t}$ is abnormally low. The threshold used is generally equal to the mean less two or three standard deviations.

Over our sample, by using a threshold of two standard deviations below the mean, we identify crises that correspond to recognised events over the period. The stock market crisis indicator $\text{C}_{i,t}^{\text{Stock}}$ is defined as following:

$$\begin{gathered} C_{i,t}^{\text{Stock}} = 1 \text{ if } \text{CMAX}_{i,t} < \overline{\text{CMAX}_{i,t}} - 2\sigma_{i,t} \\ C_{i,t}^{\text{Stock}} = 0 \text{ otherwise.} \end{gathered} \tag{I.32}$$

[32] An alternative approach consists in seeking to detect the bursting of speculative bubbles, defined as the emergence of a substantial and lasting deviation of a share price or index from its fundamental price, followed by an adjustment period then a return to the fundamental equilibrium. The difficulty in applying/implementing this method lies in the practical determination of the fundamental value as well as the econometric identification of these bubbles (Boucher, 2004).

In order to have a sufficiently large sample, the mean $\overline{\text{CMAX}_{i,t}}$ and standard deviation $\sigma_{i,t}$ are first calculated over 10 years from March 1995 to March 2005 and then conditionally by gradually adding one month at a time to the sample. As with currency crises, if a crisis is detected within a 12-month period following another crisis, it is automatically cancelled out. There are 33 crises in the sample, i.e. an average of 1.2 crises per country. Almost all of them occur during the stock market fall in the early 2000s.

Given the indicator's construction, the fall in share prices is already well under way when it signals a crisis. It is not, therefore, the turning point that is identified, but rather the point at which there has already been an abnormal drop in prices. On the other hand, the advantage of this indicator is that it only identifies confirmed crises that wipe out a substantial share of the gains made over the two previous years.

4.3. *The dependant variable in the regression*

Using the crises defined above, we construct an indicator denoted $I_{i,t}$ composed solely of 0s and 1s. It equals 1 for the 12 months preceding crises and the crisis itself, and 0 in the quiet periods. The 11 months following the crisis are excluded from the sample as the post-crisis period is irrelevant for the estimates and may even distort estimates if it is aggregated with quiet periods:

$$\begin{gathered} I_{i,t} = 1 \text{ if } \exists k \in \{0, \dots, 12\} \text{ such as } C_{i,t+k} = 1 \\ I_{i,t} = \text{n.a. if } \exists k \in \{0, \dots, 11\} \text{ such as } C_{i,t-k} = 1 \\ I_{i,t} = 0 \text{ otherwise.} \end{gathered} \quad \text{(I.33)}$$

The number of 1s in this indicator is therefore roughly 12 times bigger than the number of crises actually spotted. This is the indicator used as a dependent variable in the regressions that follow. In seeking to estimate the probability that the variable $I_{i,t}$ is equal to 1, we estimate the probability of a crisis within a one-year horizon. For the sake of brevity, we will refer to this indicator $I_{i,t}$ as a “crisis indicator”, using a misnomer.

For multilogit models, a second variable $J_{i,t}$ is constructed in order to discriminate the periods just following the crises. It is equal to the previous one, except that it is set to 2 during the 11 periods following the crises.

$$\begin{gathered} J_{i,t} = 2 \text{ if } \exists k \in \{0, \dots, 11\} \text{ such as } C_{i,t-k} = 1 \\ J_{i,t} = 0 \text{ otherwise.} \end{gathered} \quad \text{(I.34)}$$

4.4. The models used

We carry out three types of estimate in turn. First, we estimate a base model, denoted Model (1), with the explanatory variables that are generally used to predict crises. This model is as follows:

$$\Pr(I_{i,t} = 1) = f\left(\alpha_0 + \sum_{k=1}^{n} \alpha_k X_{i,t}^{k}\right) \quad \text{(I.35)}$$

where $I_{i,t}$ is the crisis indicator variable described above, $X_{i,t}^{k}$ the explanatory variables for crises, and f a logistical function of the type: $f(z) = \frac{e^z}{1+e^z}$.

Secondly, Model (2) estimates the same Equation with the control variables by adding a risk aversion indicator λ_t among the explanatory variables:

$$\Pr(I_{i,t} = 1) = f\left(\alpha_0 + \sum_{k=1}^{n} \alpha_k X_{i,t}^{k} + \alpha_{n+1}\lambda_t\right) \quad \text{(I.36)}$$

We try out, in turn, the VIX, the LCVI, the PCA, the GRAI, the RAI and the ICI as the risk aversion indicator λ_t. Thirdly, Model (3) estimates the same equation with the risk aversion indicator as the only explanatory:

$$\Pr(I_{i,t} = 1) = f(\alpha_0 + \alpha_{n+1}\lambda_t) \quad \text{(I.37)}$$

In the same way, we estimate successively three multilogit models which include post-crisis periods by using $J_{i,t}$ as the crisis indicator variable[33]. We want to see if this method improves the quality of the models as well as their predictive power[34].

For currency crises, most studies use the same explanatory variables in their model (for an exhaustive list, see Berg and Pattilo, 1999). Here we tried out a number of variables and used those that are significant for our sample. These are the real exchange rate (against the dollar for Asian and Latin American countries and against the euro for European countries, quoted directly, with an increase corresponding to a depreciation of the emerging economy's currency); official international reserves as a ratio of broad money, in year-on-year terms; and the interest rate on the money market taken in real terms.

For the stock market, the explanatory variables used, among those proposed by Boucher (2004), are the following: the price earnings ratio (PER) in level terms, the year-on-year change in stock prices, and real interest rates. All of these explanatory variables have been standardised for each country in order to obtain homogenous data for all countries.

[33] For a detailed discussion of multilogit models, see Pindyck and Rubinfeld (1998), section 11.2.

[34] Due to lack of space, only the main conclusions of the multilogit models are presented here. Detailed results are available upon request.

4.5. Assessing the predictive power

The fitted values of the regression give the estimated probabilities of a crisis within one year. In order to obtain genuine crisis "predictions", the models should be estimated over a given period, then simulated out-of-sample. Here, the problem in using out-of-sample simulations is that there are hardly no crises at the end of our sample (from 2003 on), so forecasting on the latter period would be fallacious, as we could not know the ratio of crises correctly predicted by our models. Moreover, as the sample is already small, splitting it would weaken the reliability of the estimates. In addition, Inoue and Kilian (2005) showed that in-sample tests could be more powerful than out-of-sample tests, when using small samples. For all these reasons, we prefer to present the in-sample simulations.

In order to obtain crisis predictions, a probability threshold needs to be set, above which it is decided that a crisis is predicted by the model. Here we have used 20%, to present the results. This level is comparable to those chosen in similar studies (see, for example, Berg and Patillo, who review existing models in order to compare them and set thresholds at 25% and 50%). We assess the predictive power of the models by calculating two ratios: the percentage of correctly predicted crises, which equals the number of crises correctly predicted divided by the total number of crises; the ratio of "false alarms", which equals the number of crises wrongly predicted divided by the number of crises predicted.

5. Regression results for currency crises

5.1. Significance of the control variables and the risk aversion indicators

In Models (1) and (2), the explanatory variables of currency crises have the expected signs (Table 2)[35]. Appreciation of the real exchange rate and a fall in international reserves relative to broad money are supposed to increase the risk of crisis, which corresponds to the negative signs found. The sign is positive on the real interest rate, an increase in which may signal a central bank's difficulty in maintaining the currency's parity. These three variables are significantly different from zero at the 99% level over the two estimation periods. The estimates are markedly more fragile for the shorter period as the number of crises is smaller, falling from 18 to 7 (for example, the Asian crises in 1997 disappear from the sample).

[35] To compare the results of the three models, the estimation sample must be identical. However, some of our indicators (LCVI, PCA and ICI) start later (in December 1998) than the others (GRAI, RAI and VIX, in July 1995). In order to keep the information about the 1997 crises as far as possible, we present the results of all three models for GRAI, RAI, VIX, on a sample starting in July 1995 and for LCVI, PCA and ICI on a sample starting in December 1998.

Table I.2: Logit estimates, currency crises, Models (1) and (2)

	Estimation period: 07/1995-09/2005 Number of observations = 2186				Estimation period: 12/1998-09/2005 Number of observations = 1521			
	Base Model (1)	Model (2) GRAI	Model (2) RAI	Model (2) VIX	Base Model (1)	Model (2) PCA	Model (2) LCVI	Model (2) ICI
Constant	1.50***	0.29***	1.43***	1.17***	-0.20	2.03***	-0.07	-2.83*
Real exchange rate	-4.47***	-4.26***	-4.42***	-5.21***	-2.93***	-5.43***	-2.86***	-3.35***
Reserves/M2	-0.96***	-0.92***	-0.92***	-0.97***	-0.89***	-0.93***	-0.91***	-0.93***
Real interest rate	1.19***	1.21***	1.21***	1.12***	1.76***	0.60***	0.78***	0.72***
Risk aversion indicator		0.86***	0.26***	0.05***		0.34***	0.00	-0.03*
Log likelihood	-508.2	-501.4	-504.0	-502.9	-289.6	-249.1	-289.6	-256.0
Pseudo R^2	0.16	0.17	0.17	0.17	0.04	0.06	0.04	0.05
Correctly predicited crises[a]	61.2%	63.4%	62.5%	62.9%	24.1%	26.6%	24.1%	26.6%
False alarms[b]	59.1%	57.6%	58.8%	57.8%	65.5%	61.1%	66.1%	65.0%

Significantly different from zero at the * 90%, ** 95%, *** 99% confidence levels (Student's *t*).

[a] Number of crises predicted correctly as % of total number of crises.

[b] Number of crises wrongly predicted as % of number of crises predicted.

In Models (2) and (3), the risk aversion variables have the expected positive sign, which means that a rise in them contributes to increasing the probability of a crisis. The only exceptions are the ICI, which is found negative, and the LCVI, not significantly different from zero (Table I.2 and I.3).

Table I.3: Logit estimates, currency crises, Model (3)

	Estimation period: 07/1995-09/2005 Number of observations = 2186			Estimation period: 12/1998-09/2005 Number of observations = 1521		
	GRAI	RAI	VIX	PCA	LCVI	ICI
Constant	-2.20***	-2.20***	-2.80***	-3.00***	-3.24***	-4.54***
Risk aversion indicator	0.35***	1.11***	0.03***	0.15***	0.00	-0.02
Log likelihood	-736.9	-732.0	-647.2	-307.3	-311.1	-311.1
Pseudo R^2	0.01	0.01	0.00	0.01	0.00	0.00
Correctly predicited crises[a]	0%	0.9%	0%	0%	0%	0%
False alarms[b]	n.a.	88.9%	n.a.	n.a.	n.a.	n.a.

Notes: see Table I.2.

n.a.: no crisis predicted by the model.

The multilogit estimates confirm the results for the pre-crisis periods. They also improve the regression quality (McFadden pseudo R^2 and likelihood). In the post-crisis periods, most significant risk aversion indicators have a positive coefficient (except the PCA in Model (2)). The positive sign found could be interpreted by the fact that investors remain timid during a certain period of time after the crises. On the contrary, if there was an instant renewal of optimism after the crisis, the sign would have been negative.

5.2. *Predictive power for currency crises*

Sixty-one percent of crises are correctly predicted by the base Model, when estimated on the longer period (July 1995 to September 2005); the ratio of false alarms is 59% (Table I.2). As previously noticed, when estimation is made on the reduced period (starting in December 1998), results are less reliable, which implies that the percentage of correctly predicted crises falls (to 24%).

Introducing a risk aversion indicator only slightly improves the model's forecasts. The best performing risk aversion indicators (the GRAI and the PCA) only add 2% to the percentage of correctly predicted crises compared to the base Model, while slightly reducing the ratio of false alarms. The RAI and the VIX only add 1%, the LCVI 0%. When taken alone in Model (3), the predictive capacity of all risk aversion indicators is null (Table I.3). Results are not very different with multilogit models. Here, the indicators PCA and LCVI improve the predictive power of the model by 4% on the reduced period.

6. Regression results for stock market crises

6.1. *Significance of the control variables and the risk aversion indicators*

All of the explanatory variables introduced into the base Model of stock market crises are significant (Table I.4)[36]. The sign is positive for the PER, an increase in which may indicate an overvaluation of stock prices. It is negative for returns, which already tend to decline at the onset of the crisis, as well as for real interest rates.

When they are introduced into the regressions on stock market crises, the risk aversion indicators are significant and positive both with the other explanatory variables (Table I.4) or when taken alone (Table I.5). Here again, the only exceptions are the ICI, which is negative, and the LCVI, which is not significant.

In the multilogit estimates, the post-crisis periods are mainly associated with negative coefficients for risk aversion indicators, which means that the risk aversion decreases just after the crisis.

[36] Unlike in the previous case, shortening the estimation period does not reduce the quality of the estimates. Indeed, the number of crises in the sample is not affected if we start our estimates in December 1998, given that most of the stock market crises took place in the early 2000s. As a result, here we only present the results for the shorter period, which makes it possible to compare the accuracy of the different indicators directly.

Table I.4: Logit estimates, stock market crises, Models (1) and (2)

	Estimation period: 12/1998-09/2005 Number of observations = 1918						
	Base Model (1)	Model (2) GRAI	Model (2) RAI	Model (2) VIX	Model (2) PCA	Model (2) LCVI	Model (2) ICI
Constant	-2.70***	-2.73***	-2.59***	-4.02***	-3.19***	-2.52***	-5.29***
PER	0.38***	0.43***	0.40***	0.39***	0.38***	0.37***	0.38***
Returns	-2.14***	-2.03***	-2.04***	-1.90***	-1.58***	-2.14***	-2.08***
Real interest rate	-0.35***	-0.43***	-0.41***	-0.41***	-0.53***	-0.33***	-0.36***
Risk aversion indicator		1.44***	0.69***	0.06***	0.56***	0.00	-0.03**
Log likelihood	-592.8	-573.7	-570.7	-583.4	-518.8	-592.4	-589.6
Pseudo R^2	0.31	0.33	0.33	0.32	0.39	0.31	0.31
Correctly predicited crises[a]	80.8%	82.3%	80.5%	81.1%	86.2%	84.1%	81.4%
False alarms[b]	51.4%	49.8%	50.0%	51.8%	49.9%	51.3%	50.8%

Notes: see Table I.2.

Table I.5: Logit estimates, stock market crises, Model (3)

	Estimation period: 12/1998-09/2005 Number of observations = 1948					
	GRAI	RAI	VIX	PCA	LCVI	ICI
Constant	-1.62***	-1.48***	-5.01***	-2.36***	-1.49***	-6.79***
Risk aversion indicator	1.89***	0.98***	0.15***	0.70***	0.00	-0.05***
Log likelihood	-834.5	-829.0	-785.0	-671.1	-886.8	-862.9
Pseudo R^2	0.05	0.06	0.11	0.23	0.00	0.03
Correctly predicited crises[a]	64.1%	69.2%	46.7%	79.6%	0%	36.2%
False alarms[b]	71.2%	70.2%	76.5%	59.3%	n.a.	78.7%

Notes: see Table I.2.
n.a.: no crisis predicted by the model.

6.2. *Predictive power for stock market crises*

The base Model predicts 81% of stock market crises, with a false alarm ratio of 51%. Added into a regression with the control variables, the risk aversion indicators slightly increase these good results in terms of prediction (Table I.4). One interesting result is that even when they are taken alone, all the risk aversion indicators obtain good results (with the exception of the LCVI). The PCA perform best, with 80% of crises correctly predicted and 59% of false alarms, then come the RAI and the GRAI (with 69% to 64% of crises correctly predicted and around 70% of false alarms) (Table I.5). As for currency crises, multilogit models do not improve these forecasts.

How can the PCA's good performance be explained? As the PCA is a linear combination of the eight spreads on which it is calculated, we may wonder whether the estimates would be further improved by replacing this PCA indicator in regressions by the spreads themselves. The results show that the eight spreads give estimates that are more or less equivalent to those obtained with the PCA: for example 87% of correctly predicted crises, versus 86% with the PCA in Model (2); 79% versus 80% in Model (3). Using a synthetic indicator such as the PCA is therefore preferable.

These good results in predicting stock market crises should be interpreted, recalling that it is not the turning point that is predicted by the model, but a point when the drop in stock prices is already such that the situation is "abnormal". Consequently, it is not surprising that risk aversion has already started to increase before the crisis thus defined breaks out.

6.3. *Can stock market reversals be predicted?*

By construction, the previous indicator detects stock market crisis once the prices have already strongly fallen down. So it detects crises when they are already well developed. It is also interesting to observe the behaviour of the risk aversion indicators around the reversal points, when the prices are the highest.

We detect stock market reversals using the stock market crises previously displayed. When a crisis is identified, we detect the reversal point as the maximum price over the two previous years:

$$R_{i,t} = 1 \text{ if } \begin{cases} \exists k \in \{0, \dots, 24\} \text{ such as } C_{i,t+k} = 1 \\ \text{and} \\ P_{i,t} = \max\left(P_{i,t}, \dots, P_{i,t+24}\right) \end{cases} \tag{I.38}$$

As for previous crisis indicators, we construct the reversal indicator $I'_{i,t}$ that equals 1 during the reversal and the 12 preceding months; 0 during the quiet periods. The 11 months following the reversal are excluded from the sample. For multilogit models, the reversal indicator $J'_{i,t}$ equals $I'_{i,t}$ except for the post crises periods, for which it is set to 2.

All the dependent variables are significant in Model (1) (Table I.6). The risk aversion indicators are significant and positive in Model (2) and (3), except the ICI (Tables I.6 and I.7). Therefore, risk aversion increases during the periods preceding the crises. This matches the investor's feeling of wariness regarding the carrying on with the market upward trend.

Here again, multilogit models improve the estimates. The behaviour of risk aversion indicators is homogenous during the post-crisis period: in Models (2) and (3), the indicators' coefficients are significant and positive, except the ICI. The positive sign means that risk aversion carries on increasing after the reversal. This is consistent with the fact that the crisis is not instantly cleared up, but spans a certain amount of time.

Model (1) allows to predict 50% of the reversals, with a false alarms ratio of 67%. Some of the risk aversion indicators improve the forecasts, notably the PCA and the LCVI (70% and 66% of correctly predicted crises) (Table I.6). When used alone, the best performances in reversals detection are also obtained by the PCA and the LCVI (36% and 46%). On the other hand, the VIX and the RAI's predictive power are null (Table I.7). The false alarms ratio remains high for all the indicators (more than 70%). The multilogit models do not improve significantly these forecasts. Finally, predicting reversals gives weaker performances than forecasting crises, as previously defined. An explanation could be that risk aversion keeps increasing after the reversal, along with the development of the crisis.

Table I.6: Logit estimates, stock market reversals, Models (1) and (2)

	Estimation period: 12/1998-09/2005 Number of observations = 1918						
	Base Model (1)	Model (2) GRAI	Model (2) RAI	Model (2) VIX	Model (2) PCA	Model (2) LCVI	Model (2) ICI
Constant	-1.83***	-1.76***	-1.72***	-4.80***	-2.11***	-4.52***	-7.10***
PER	0.19***	0.19***	0.29***	0.06***	-0.02	0.15***	0.17***
Returns	0.77***	0.85**	0.79***	1.02***	1.24***	0.82***	0.80***
Real interest rate	0.50***	0.45***	0.47***	0.33***	0.22***	0.16*	0.46***
Risk aversion indicator		1.50***	0.38***	0.13***	0.59***	0.06***	-0.06***
Log likelihood	-736.3	-712.2	-728.2	-681.8	-613.4	-652.4	-717.4
Pseudo R^2	0.10	0.13	0.12	0.16	0.23	0.19	0.12
Correctly predicited crises[a]	50.0%	53.0%	49.3%	60.7%	69.5%	66.1%	52.4%
False alarms[b]	66.6%	66.0%	68.0%	60.9%	55.4%	60.3%	65.0%

Notes: see Table I.2.

Table I.7: Logit estimates, stock market reversals, Model (3)

	Estimation period: 12/1998-09/2005 Number of observations = 1948					
	GRAI	RAI	VIX	PCA	LCVI	ICI
Constant	-1.66***	-1.63***	-3.17***	-1.87***	-4.20***	-6.37***
Risk aversion indicator	1.14***	0.31***	0.07***	0.31***	0.05***	-0.05***
Log likelihood	-818.8	-828.6	-814.3	-776.2	-734.6	-819.2
Pseudo R^2	0.02	0.01	0.01	0.06	0.10	0.02
Correctly predicited crises[a]	27.1%	0%	6.0%	35.6%	45.6%	23.2%
False alarms[b]	72.8%	n.a.	94.7%	79.8%	71.8%	76.9%

Notes: see Table I.2.

n.a.: no crisis predicted by the model.

7. Conclusion

Empirical risk aversion indicators are intended to provide a synthetic indication of market sentiment with regard to risk. Here, we try to test the relevance of the most commonly used indicators. Assuming that risk aversion increases before crises, we compare the ability of these indicators to forecast financial crises. For this, we use logit and multilogit models of currency and stock market crises successively with and without control variables. The results show that most of them are significant as leading indicators in the regressions. The multilogit models also show that risk aversion indicators remain high during the months following the crisis.

As regard to their predictive power, the results are quite different according to the type of crises. For currency crises, the indicators barely improve the prediction made by the usual control variables, such as the real exchange rate, the ratio of reserves to money supply and the real interest rates. They also perform poorly when taken alone in the regression. By contrast, in the case of stock market crises and reversals, most of the risk aversion indicators tested yield satisfactory results. The best predicting performances are obtained by a principal component analysis on risk premia.

Appendix

Appendix A - *The database*

A.1 The GRAI

Exchange rates against USD according for the following countries: Australia, Canada, Czech Republic, Germany then euro area from 1999, Hong Kong, Japan, Mexico, New Zealand, Norway, Poland, South Africa, Sweden, Switzerland and the United Kingdom. Source: Bloomberg. For Czech Republic, Mexico and Poland, data for 3-month forward rates start respectively from Dec 1996, Nov 1997 and July 1998. The currency RAI is made up of the same sample, except these 3 countries, as a different number of series over time would produce abrupt changes in the regression slope.

The stock market GRAI (and RAI) include the major stock market indices of 27 developed and emerging economies: Argentina, Australia, Austria, Belgium, Brazil, Canada, Denmark, Finland, France, Germany, Greece, Hong Kong, Indonesia, Ireland, Italy, Japan, Malaysia, Netherlands, Norway, New Zealand, Portugal, South Africa, Spain, Sweden, Turkey, the United Kingdom and the United States. Source: Bloomberg.

A.2 Components of the PCA

8 risk premia are used: 4 corporate bond spreads for the euro area and the United States: for each area, one spread for investment grade and another for speculative grade. These spreads are calculated by Merrill Lynch; 2 spreads for emerging markets: first, The Emerging Markets Bond Index Global (EMBI Global) (an index calculated by J.P. Morgan since mid-1998 that represents the average price of sovereign dollar-denominated bonds issued by emerging countries) and second, an index of corporate debt, denominated in dollars or euros and issued abroad, of a large number of emerging market countries, calculated by the bank Merrill Lynch; 2 swap spreads, one for the euro area and one for the United States. Source: Bloomberg.

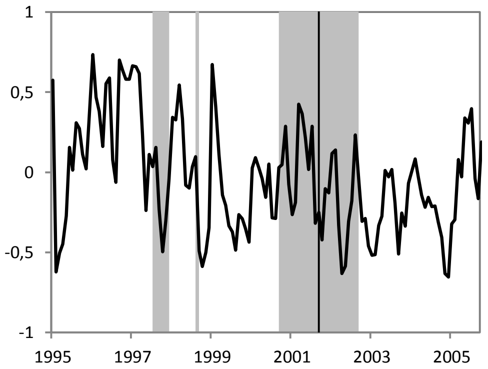
A.3 Crisis indicators

Currency crisis: 20 countries: Argentina, Brazil, Bulgaria, Chile, Colombia, Czech Republic, Estonia, Hungary, Indonesia, Latvia, Lithuania, Mexico, Philippines, Poland, Romania, Singapore, South Korea, Thailand, Uruguay and Venezuela. Source: IMF's International Financial Statistics (IFS). To obtain the reserves/M2 ratio: total reserves minus gold, line 1 l.d., money, line 34, quasi-money, line 35; to calculate the real exchange rates: line ae, consumer prices index (CPI), line 64; to calculate the real interest rates: money market rates, lines 60, 60b or 60a (depending on the availability of data and in this order of preference), and CPI. When monthly data were not available, we made linear interpolation using quarterly data.

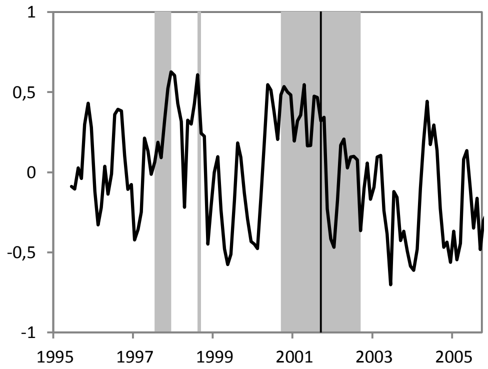
Stock market crisis: same 27 countries as for the GRAI, and same stock market indexes. The returns have been calculated as year-on-year increase in each stock market index. The PER have been obtained from Bloomberg. Interest rates have been taken from the IMF's IFS database and calculated in the same way as for currency crises.

Appendix B - Risk aversion indicators graphs

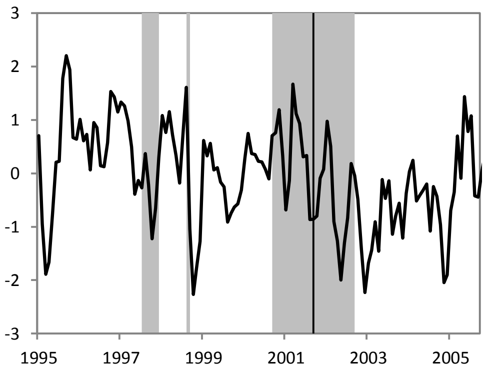
GRAI
calculated on the foreign exchange market



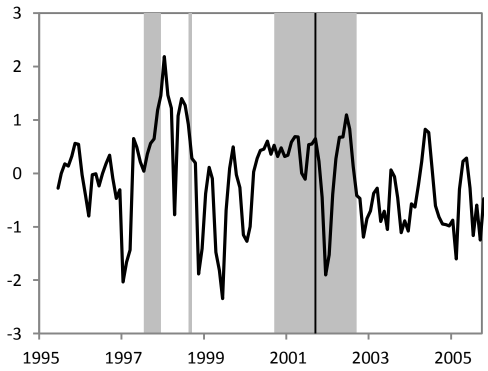
GRAI
Calculated on the stock market



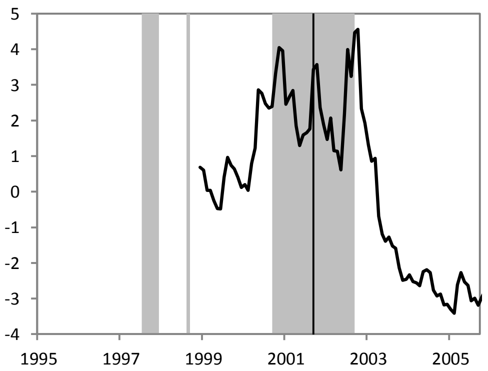
RAI
calculated on the foreign exchange market



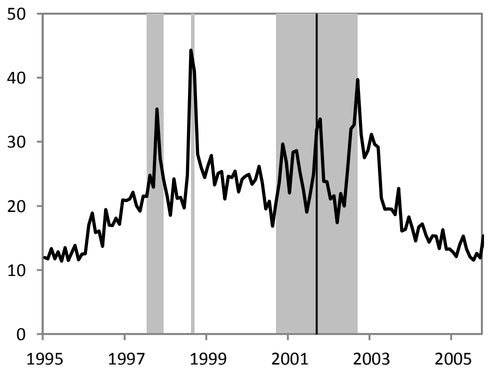
RAI
Calculated on the stock market



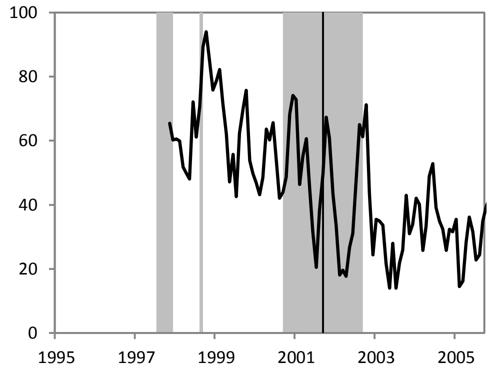
Risk aversion indicator measured
by the fist component of the PCA



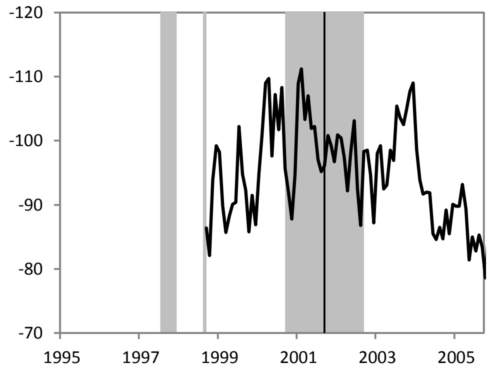
VIX



LCVI


100
80
60
40
20
0
1995
1997
1999
2001
2003
2005

ICI


-120
-110
-100
-90
-80
-70
1995
1997
1999
2001
2003
2005

Chapter II The credit default swap market and the settlement of large defaults*

Abstract

The huge positions on the credit default swaps (CDS) have raised concerns about the ability of the market to settle major entities' defaults. The near-failure of AIG and the bankruptcy of Lehman Brothers in 2008 have revealed the exposure of CDS's buyers to counterparty risk and hence highlighted the necessity of organizing the market, which triggered a large reform process. First we analyse the vulnerabilities of the market at the bursting of this crisis. Second, we unravel the auction process implemented to settle defaults, the strategies of buyers and sellers and the links with the bond market. We then study the way it worked for key defaults, such as Lehman Brothers, Washington Mutual, CIT and Thomson, as well as for the Government Sponsored Enterprises, which reveals some oddities in the final prices. Third, we discuss the ongoing reforms aimed at strengthening the market resilience.

JEL classification: D44; G01; G15; G33.

Keywords: Credit derivatives; Bankruptcy; Credit default swap; Auction.

* This is a joint article with Virginie Coudert. Published in *International Economics* (2010), n° 123. We thank Gunther Capelle-Blancard and two anonymous referees for helpful remarks.

1. Introduction

Credit derivatives, which consist chiefly of credit default swaps (CDS), have been a cause of concern since the bursting of the present financial crisis. The CDS market soared from 2004 to 2007 in step with the growth of structured finance. CDS were much used in the synthetic Collateral Debt Obligations (CDOs) as well as in the ABX indices, which are CDS indices on tranches of subprime Asset Backed Securities (ABS). The financial crisis brought the development of structured credit to a sudden halt, as CDO and ABS prices and trading volumes collapsed in 2008 (IMF, 2008). Meanwhile, the CDS stayed buoyant all through the crisis, essentially for three strands of reasons: (i) the rise in the default probability strengthens the importance of a default insurance for many investors and paves the way for speculative gains for others; (ii) new segments of the market emerged during the crisis, such as the sovereign CDS which were not really traded before at least for the advanced countries; (iii) contrary to CDOs, CDS never suffered from a lack of liquidity, as investors can offload CDS contracts by writing others in the opposite direction.

The most patent effect of the crisis on the CDS market has been the surge in the cost of protection, in line with the mounting risk of borrower default. The higher premia could also have been due to contagion effects, already evidenced on the CDS markets during previous episodes (Jorion and Zhang, 2006; Coudert and Gex, 2010a). Meanwhile the notional value of outstanding CDS fell from USD 58 trillion at the end of 2007 to USD trillion to USD 36 trillion in June 2009 (BIS, 2009). However, this decrease is not very meaningful, for it stems from the netting of positions, and not to a reduction of trade.

At the end of summer 2008, when key counterparties as AIG and Lehman Brothers were on the verge of bankrupting, confidence in the functioning of the CDS market was seriously undermined (Purtle and Yelvington, 2008; Brunnermeier, 2009; Eichengreen *et al.*, 2009). Since that time, counterparty risk has emerged as a major threat, after previously being viewed as negligible. Large financial institutions operating on the market had been thought to be reliable, whereas the near collapse of AIG and the Lehman bankruptcy gave the lie to that belief.

Fears that the failure of a major firm might bring down the entire market had been fuelled by factors such as the huge size of the CDS market, the exposure of the financial sector and the presence of interlocking, opaque positions. Mounting concerns highlighted the market's vulnerabilities and accelerated the introduction of reforms, including larger margin calls, netting and the establishment of a central counterparty. Nevertheless, one has to recognize that the successive defaults of major firms in 2008 and 2009 were settled orderly. For this reason it is interesting to look back on these events in order to better understand the functioning of the market and how participants' positions were settled.

The aim of this article is therefore to analyse the characteristics and vulnerabilities of the CDS market as well as the settlement process during episodes of large defaults. In particular, we unravel all the stages of the auction procedure that makes the settlement, and the strategies of the participants at each step. We rely on the descriptions made by Markit and Creditex (2010) as well as the documents provided by the International Swaps and Derivatives Association (ISDA), such as ISDA (2008). Helwege et al (2009) have also studied this auction process, considering a sample of 10 firms. Here, we broaden the sample to 27 entities in default. We also scrutinize several key episodes more closely, by analysing the defaults of Lehman Brothers, Washington Mutual, CIT and Thomson, as well as the special case of the Government Sponsored Agencies (GSEs). To do that, we use the data on the auctions released by Markit and Creditex at each stage of the process. This analysis evidences that the auction process though running smoothly have led to some oddities in recovery rates in several cases.

The remainder of the article is organised as follows. Part 2 reviews the characteristics of the CDS market and its vulnerabilities at the bursting of the present crisis. Part 3 analyses the auction procedures to settle defaults. Part 4 describes the links between the prices given by the auction process and the bond market. Part 5 analyses several major settlements that have occurred in 2008 and 2009. Part 6 describes the ongoing reforms on the CDS market.

2. Characteristics of the CDS market

2.1. Basic functioning

CDS are designed to cover the risk of default borne by creditors and transfer it to other agents. Three parties are involved: a protection buyer (*A*); a protection seller (*B*); and a reference entity (*X*), which is the underlying borrower and may be a company or a sovereign. The CDS allows *A* to buy protection against the risk of a default by borrower *X*, while *B* receives payment for providing that protection.

Assume that A buys a CDS on X from B for face value F. The contract covers A against the risk of default by X from the day of purchase t_0 to maturity T (say five years).

– *A* agrees to pay a premium that is a percentage of the debt face value $(F \times c)$ to *B* for the term of the agreement, (from t_0 to T), or until default, if one occurs during the period. Premiums are usually paid quarterly. Obviously, premium c increases with *X*'s probability of default and declines with the expected recovery rate, roughly following the bond spread.

– In return, *B* agrees to pay *A* a sum in the event of default that fully compensates *A*'s loss.

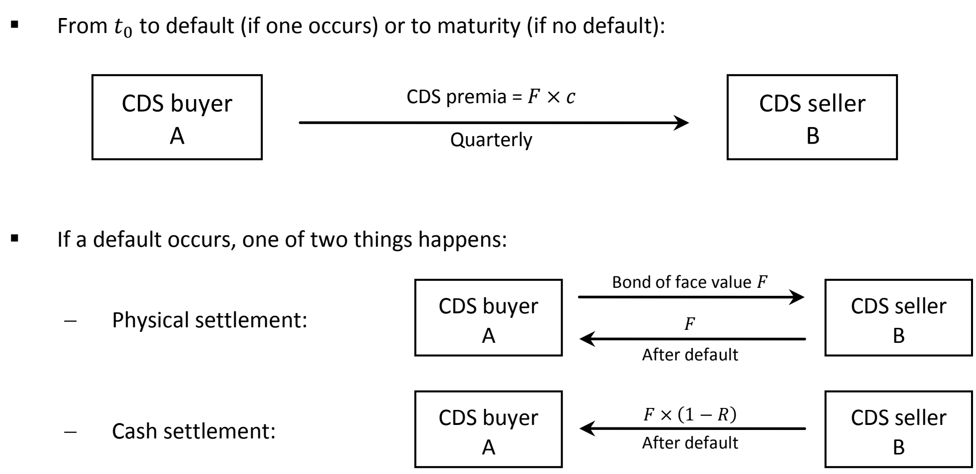
If *X* defaults, two settlement methods are possible:

– physical settlement, where A delivers the underlying security to *B*, and *B* pays *A* the full face value F;

– cash settlement, where B pays A the amount $F \times (1 - R)$, where R is the recovery rate; *A* does not deliver the underlying security.

These mechanisms are illustrated in Figure II.1. In theory, under both methods, a CDS buyer who holds a bond with the same face value is fully protected by the CDS against the risk of default. This is obvious in the case of physical settlement. It is also true if there is a cash settlement and if the CDS market is in step with the bond market. The buyer will be able to recover $F \times R$ by reselling the bond on the secondary market and the remainder of the face value $F \times (1 - R)$ to the seller.

Figure II.1: The functioning of a CDS



The notion of “default” itself needs to be clarified. It generally refers to the borrower’s bankruptcy or his failure to pay interest on his debt or the principal within given delays.

Nevertheless, CDS settlements can be triggered by broader “credit events”, including bankruptcy, such as failure to pay, but also restructuring and repudation/moratorium. These credit events are documented in great detail by the International Swaps and Derivatives Association (ISDA).

2.2. The speculative use and consequences on settlements

Financial derivatives, whether futures, options or swaps, are designed to hedge risky positions on the underlying assets. However, in practice, they are also widely used to speculate. CDS are no exception: though they were created to hedge default risk, many buyers use them for speculation, as they do not hold the underlying securities.

An investor may buy a CDS without holding the underlying debt, just to pocket the cash $F \times (1 - R)$ in case of default. Most of the time, she buys a CDS on X without even expecting a default: if she merely expects that X's probability of default assessed by the market is going to increase, she can make a profit simply by buying a CDS now and unwinding her position later.

Buying CDS without holding the underlying assets is usually referred to as “naked CDS”. This speculative use of CDS comes down to short-selling bonds. It has been violently criticized, especially by European government officials during the 2010 Greek crisis. Indeed, the surging spreads on the Greek sovereign CDS have raised concerns for the cost of public borrowing in this country, which reached unbearable levels. Fearing contagion, Germany decided to ban the use of naked CDS on euro-government bonds in May 2010. Indeed, naked CDS market can contribute to fuel bearish speculation, just like the short-selling of bonds or stocks. On the one hand, the CDS spreads have been evidenced to lead the bond spreads in times of crises, in the corporate as well as in the sovereign segment (Coudert and Gex, 2010b), which points to their role in fuelling bearish speculation. On the other hand, the use of naked CDS in itself is obviously not responsible for the financial difficulties of the Greek government. According to Duffie (2010), this speculation is the result of investors’ distrust, not its cause.

Indeed, the traded volumes on the CDS market exceed those of the underlying bonds for a number of companies. As an example, in the 2005 Delphi failure, the notional value of CDS (USD 28 billion) exceeded actual bonds and loans (USD 5 billion) by a factor of 5.6. Collins & Aikman, Delta Airlines and Northwest Airlines had even higher ratios. More generally, for the non –financial corporate sector as a whole, the CDS market has nearly outsized the bond market, as it reached $9.5 trillion versus $10.0 trillion for their long-term debt securities in September 2009.[37]

Because the amount of protection often exceeds the deliverable underlying assets, the default settlement process has changed. Settlement can no longer be exclusively physical, because this would artificially boost the price of the underlying bonds over the normally expected recovery rate. Cash settlement has therefore increased. Furthermore, some CDS on defaulting entities belonged to indices, such as the European iTraxx or the North American CDX, which are composed of a basket of CDS. A priori, investors in CDS indexes do not hold the underlying bonds. To guarantee that they will be treated fairly, a single recovery rate is necessary. Since the 2005 failures involving automotive parts manufacturers and airlines, an auction system has been introduced to provide fair treatment and to link the two settlement methods. Participation to an auction is based on a bilateral agreement, signed by the organisers of the auction (Creditex, ISDA and Markit) and any participating bidder willing to participate in the auction. This agreement also specifies which jurisdiction applies in case of dispute, generally New York State law for American reference entities, English law for other contracts.

2.3. CDS and incentives for creditors of companies in financial distress

Before the CDS market emerged, creditors were often tempted to let a financially distressed company survive for a while – even if this meant giving up part of their claims – so that it could get past the critical deadlines. In some cases the extra time was enough to save the company from failure. By acting in this way, creditors were doing their best to avoid bankruptcy proceedings, which would involve either a drawn-out and uncertain recovery process or a fire-sale of the debt on a secondary market.

CDS may have reversed the usual incentives for creditors, although few papers have been devoted to this topic, outside Matthews and Yelvington (2008). If the value of creditors' debt is fully covered by a CDS, then it is in their interest for the company to fail as quickly as possible, because failure automatically activates CDS settlement within less than a month and creditors can be sure of recouping the entire face value of their claim. The prospect of swift, full payment removes any incentive to negotiate or grant new loans or extra time. CDS holders who do not possess the underlying claim are especially impatient for default to occur. Moreover legal issues may complicate matters and hinder creditors from negotiating before a failure if they have CDS protection. Taking part in

[37] CDS figures concern gross notional amounts of single-name CDS for non-financial corporates, source: DTCC, those for long-term securities are extracted from the BIS.

talks may provide them with inside information, which the US Securities and Exchange Commission views as incompatible with holding CDS positions.

As regards contracts in which failed entities are counterparties (such as in the Lehman case), the US bankruptcy code was amended in October 2005 to clarify the safe harbour status of financial instruments, including forwards, swaps and CDS (Matthews and Yelvington, 2008). The amendments also facilitated netting of contracts between different counterparties and the failed entity.

2.4. Vulnerabilities

Although the situation is changing, at the time the subprime crisis burst out, the CDS market was exclusively an over-the-counter (OTC) market with no central counterparty, which created a number of vulnerabilities (Segoviano and Singh, 2008; Singh and Aitken, 2009). The failure of a major firm caused counterparty risk to materialise truly for the first time on the CDS market, with AIG’s bailout and Lehman’s bankruptcy. Several factors contributed to magnify concerns, including interlocking positions, the financial sector's exposure concentrated on a handful of major institutions, market opaqueness.

Interlocking positions resulted from the nature of the OTC market, which played a part in increasing the number of contracts. An agent wishing to withdraw from a contract cannot usually sell it or tear it up. Instead he has to write a new contract in the opposite direction with another counterparty to offset the original (Longstaff *et al*., 2005). This singular method of functioning engenders a larger number of participants, interlocking positions between financial participants and increased counterparty risk. Incidentally it is also the reason for the huge amounts outstanding in the underlying contracts: outstanding notional amounts reached USD 58 trillion in gross terms at the end of 2007, before coming down to USD 36 trillion in June 2009 because of the netting of positions, according to BIS (2009) statistics. Taking the market value of contracts rather than the notional value, the market is estimated at USD 2 trillion at end-2007 and USD 3 trillion in June 2009 (BIS, 2009).

The financial sector has considerable exposure. The credit derivatives market has not transferred risk as it was supposed to. The market, buyers and sellers alike, is dominated by financial participants. Risk that was supposed to be taken out of the financial sector has remained concentrated there. Banks accounted for 58% of CDS buyers and 43% of sellers in 2006, while hedge funds accounted for 29% of buyers and 31% of sellers (IMF, 2008).

The crisis led to a higher concentration of the market. First, some major CDS dealers, such as Bear Stearns, Lehman Brothers and Merrill Lynch, exited the market . These entities were among the top 12 counterparties on the CDS market by trade count and notional amount before the crisis (Fitch, 2007). Second, smaller players, such as non-bank institutions, retreated from the market after experiencing losses in the aftermath of Lehman Brothers' bankruptcy, according a study by the ECB (2009) using the BIS statistics. Third, deleveraging strategies have dampened the appetite for protection selling, which resulted in a reduction in the activity of some major protection sellers, such as hedge funds, monolines or credit derivatives product companies (CPDC). The collapse of synthetic CDOs and SIVs also played a role in this reduction. Consequently, the ten main dealers accounted for over 90% of CDS gross notional values at the world level, at the end of 2008. More strikingly, the five main commercial banks were responsible for 97% of gross notional values in the United States[38].

Moreover, the most traded CDS concern reference entities in the financial sector. Protection sold on financial reference entities amounted to 40% of the gross outstanding of single-name CDS (Duquerroy *et al*., 2009). This evolution has reinforced the risk of double default, as illustrated by the failure of Lehman Brothers, which was at the same time a major CDS dealer and a highly traded reference entity. This increasing concentration of the CDS market have resulted in a greater systemic risk, due to the transfer of credit risk between a smaller number of market participants, that are simultaneously protection buyers and sellers, as well as underlying entities. This has contributed to the emergence of the "too interconnected to fail" risk, which has overridden the "too big to fail" risk (Brunnermeier, 2009).

Market opaqueness was another source of concern, because it created great uncertainty about the exposure of different participants. The OTC nature of the CDS market makes it difficult to estimate the size of the market. At the time of Lehman Brothers' bankruptcy, only aggregated data were available to the public through two main data providers, BIS and ISDA. Moreover, the lack of harmonisation of the respective data collection processes, in terms of type of products and number of reporting institutions, for instance, and the use of different definitions, hampered a precise assessment the exposure of market participants. Given the amounts in play, doubts were expressed about the ability of sellers of protection on Lehman Brothers to honour their commitments. In particular there were concerns that some hedge funds might fail, worsening the systemic risk.

---

38 Source: Office of the Comptroller of the Currency (OCC). Total gross notional amounts (bought and sold) for J.P. Morgan amounted to USD 8,391 billion at end-2008, or 30% of worldwide activity.

2.5. The role of margin calls

To mitigate risk of non-payments, an initial margin is generally posted when the contract is signed; then, regular (typically daily) margin calls, ensure that provisions are set aside for future settlement. For OTC markets, these margin calls are made on a bilateral basis. When a borrower begins to run into problems, several mechanisms are activated to trigger additional margin calls. The signal may be an increase in the CDS premium or a decline in the price of the bond; in some cases, especially in the United States, it may be a rating downgrade for the reference entity or seller.

Generally speaking, margin calls are aimed at guarantying that the CDS seller will be able to meet the final payment if needed. The rising margin calls are deducted from the payments made in the event of a default. This collateralisation procedure is usually included in contracts between dealers. In the case of transactions between dealers and non-dealers, 66% of CDS issued in 2008 were collateralised, mainly through cash payments, according to ISDA[39]. One limitation of the margin call process concerns the "jump-to-default", or the sudden increase in CDS premiums before a default, which often leaves little time to adjust margin calls.

In the case of Lehman Brothers, bonds were still trading at over 80% of their par value less than two weeks before the failure, implying margin calls of approximately 20% of the CDS notional. In the days after the default, bonds fell to 30% of par, triggering margin calls of 70%. When the settlement auction was held, bonds had fallen again to 13% of par, so margins were 87%. Since the final settlement price was 8.625% of par, just 4% of the notional remained for sellers to deliver (Gerson Lehrman Group, 2008).

2.6. Ramifications of the AIG bail-out ant the Lehman Brothers failure

AIG, the US largest insurance company, was a major player in the CDS market before its near failure in September 2008. In particular, it had sold huge amounts of CDS on CDOs including US subprime mortgage. The subprime crisis forced AIG to mark down theses assets. When AIG was downgraded by rating agencies in September 2008, AIG's counterparties asked for more collateral, to such an extent that AIG was not able to meet the collateral-calls on its CDS (Weistroffer, 2009). As AIG was not able to raise more liquidity on the market, it was on the verge of failing. Because of the giant size of the company and its interconnections with all major financial institutions in the world, its failure would have had a disastrous systemic effect on the global financial system. In

[39] Source: ISDA Margin Survey 2009.

other words, AIG was typically "too big to fail". That is the reason why it was bailed out by the Fed.

Lehman Brothers was the fourth-largest US investment bank**.** As a key participant in the subprime securitisation process, it had kept heavy exposure to the riskiest tranches on its balance sheet. As Lehman Brothers sustained major losses after the subprime crisis erupted in summer 2007, its share price dropping by 73% in the first half of 2008, [40] it was forced to sell off assets. Lehman announced its bankruptcy on 15 September[41] and filed for Chapter 11 protection[42]. On 10 October, three weeks after the failure, CDS were settled through an auction. We review below this settlement process, taking Lehman as an example.

3. Auction mechanisms in default settlements

The auction process is designed by Markit to determine a recovery rate, or final price. The system covers physical settlement. A Dutch auction is used to exchange securities and determine the final price. Cash settlement then takes place at the same price. The system makes it possible to exchange bonds without pushing up the price of the debt.

The auction has two stages, which are used to determine, in succession: (i) an intermediate recovery rate, or inside market midpoint (IMM), and the sum of net buy and sell requests for physical settlement, called open interest; (ii) the recovery rate, or final price.

3.1. First stage

Only a small number of dealers participate in this stage (14 in the case of the Lehman auction). These represent all the possible counterparties (or market makers) for investors wanting to buy or sell protection on the defaulting entity. These dealers handled all the CDS written on this name[43].

The first stage of the auction includes two types of data provided by dealers:

---

[40] In summer 2008, its market capitalisation totally collapsed as the share price fell from a high of USD 85.8 in February 2007 to USD 3.7 on 12 September 2008.

[41] As previous negotiations with potential buyers failed (Korea Development Bank, Barclays and Bank of America).

[42] On 20 September the courts ruled that Barclays could take over Lehman's North American operations and New York building. On 22 September Nomura announced that it was taking over the Asia Pacific operations, followed by the investment banking business in Europe and the Middle East.

[43] To have CDS dealer status, an entity has to be on the list of CDS dealers, which is held by ISDA and posted on the association's website.

- A bid/offer spread (as a percentage of the par) at which they are ready to buy or sell bonds (see matched markets, Table II.1). The size of the spread was generally 2% in the Lehman auction. For example, according to the first line in Table 1, Bank of America was ready to buy Lehman Brothers' bond at 9.5% of the par and to sell it at 11.5%. The associated amount is USD 5 million or the lowest face value of deliverable debt securities (USD 5 million in the case of Lehman Brothers), whichever is higher
- A net amount corresponding to the volume of bonds that the dealer wants to buy or sell in a physical settlement.

Dealers have a 15-minute window to transfer the data to the Creditex electronic platform.

Table II.1: Bid/offer spread (matched markets) for the Lehman Brothers auction

Dealer	Bid	Offer	Dealer
Banc of America Securities LLC	9.5	11.5	Banc of America Securities LLC
Barclays Bank PLC	8	10	Barclays Bank PLC
BNP Paribas	9	11	BNP Paribas
Citigroup Global Markets Inc.	9.25	11	Citigroup Global Markets Inc.
Credit Suisse Securities (United States) LLC	8	10	Credit Suisse Securities (United States) LLC
Deutsche Bank AG	8	10	Deutsche Bank AG
Dresdner Bank AG	9.5	11.5	Dresdner Bank AG
Goldman Sachs & Co	8.875	10.875	Goldman Sachs & Co
HSBC Bank United States, National Association	10	12	HSBC Bank United States, National Association
JPMorgan Chase Bank, National Association	9	11	JPMorgan Chase Bank, National Association
Merrill Lynch, Pierce, Fenner & Smith Inc.	8	10	Merrill Lynch, Pierce, Fenner & Smith Inc.
Morgan Stanley & Co. Inc.	8.25	10.25	Morgan Stanley & Co. Inc.
The Royal Bank of Scotland PLC	9.25	11.25	The Royal Bank of Scotland PLC
UBS Securities LLC	8.75	10.75	UBS Securities LLC

Sources: Creditex, Markit.

3.1.1. IMM

Bids and offers are sorted so that the highest bids are matched with the lowest offers (Table II.2). In other words, bids are sorted in descending order, offers in ascending order.

To obtain the IMM, matched orders, i.e. for which there is a bid equal to or higher than an offer (called "tradeable markets"), are eliminated. In the Lehman Brothers case, the HSBC bid was matched with the Barclays offer. These two prices were taken out (first shaded line in Table II.2), leaving 13 bid/offer pairs.

Table II.2: IMM for the Lehman Brothers auction[a]

Dealer	Bid	Offer	Dealer
HSBC Bank United States, National Association	10	10	Barclays Bank PLC
Banc of America Securities LLC	9.5	10	Credit Suisse Securities (United States) LLC
Dresdner Bank AG	9.5	10	Deutsche Bank AG
Citigroup Global Markets Inc.	9.25	10	Merrill Lynch, Pierce, Fenner & Smith Inc.
The Royal Bank of Scotland PLC	9.25	10.25	Morgan Stanley & Co. Inc.
BNP Paribas	9	10.75	UBS Securities LLC
JPMorgan Chase Bank, National Association	9	10.875	Goldman Sachs & Co
Goldman Sachs & Co	8.875	11	BNP Paribas
UBS Securities LLC	8.75	11	Citigroup Global Markets Inc.
Morgan Stanley & Co. Inc.	8.25	11	JPMorgan Chase Bank, National Association
Barclays Bank PLC	8	11.25	The Royal Bank of Scotland PLC
Credit Suisse Securities (United States) LLC	8	11.5	Banc of America Securities LLC
Deutsche Bank AG	8	11.5	Dresdner Bank AG
Merrill Lynch, Pierce, Fenner & Smith Inc.	8	12	HSBC Bank United States, National Association

[a] The IMM is the average of the framed numbers, or 9.75%.

Sources: Creditex, Markit.

The IMM is the mean (rounded to the nearest one-eighth) of the best half (i.e. highest) of bids and the best half (i.e. lowest) of offers. Half of 13 is rounded to the next whole number, making seven pairings (framed area of Table II.2). The IMM is thus 9.75% (9.80% to the nearest one-eighth).

3.1.2. Open interest

Each dealer also indicates: (i) the amount of bonds (and thus CDS) that it wants to trade in a physical settlement; and (ii) a direction (bid or offer). The open interest is the difference between the amount of bonds bid and offered that the 14 dealers want to physically settle at the IMM price. It may be buy open interest or sell open interest, because of the possibility of cash settlement. Physical settlement is used to liquidate bond positions.

In the Lehman auction, the amount of bonds that dealers wanted to sell exceeded the amount they wanted to buy (Table II.3). Net open interest was therefore to sell. In physical settlement, if there is no auction, protection buyers have to deliver the discounted bond; in the case of an auction, they have to sell it. This interest to sell can be understood to reflect an excess supply of bonds that will put downward pressure on prices in the second stage.

Table II.3: Physical settlement requests in the Lehman Brothers auction

Dealer	Amount (USDm)	Bid/Offer
BNP Paribas	141	Offer
Banc of America Securities LLC	170	Offer
Citigroup Global Markets Inc.	187	Offer
Credit Suisse Securities (United States) LLC	191	Offer
Deutsche Bank AG	390	Offer
Goldman Sachs & Co	464	Offer
HSBC Bank United States, National Association	480	Offer
Merrill Lynch, Pierce, Fenner & Smith Inc.	574	Offer
Morgan Stanley & Co. Inc.	755	Offer
The Royal Bank of Scotland PLC	870	Offer
UBS Securities LLC	1,470	Offer
Barclays Bank PLC	30	Bid
Dresdner Bank AG	130	Bid
JPMorgan Chase Bank, National Association	612	Bid
Sum of Buy Physical Requests	772	
Sum of Sell Physical Requests	5,692	
Sum of Physical Request Trades	772	
Sum of Limit Order Trades	4,920	
Net Open Interest: USD 4.92 bn to sell		

Sources: Creditex, Markit.

3.1.3. Adjustment amounts

A penalty system is in place to ensure that dealers do not deliberately quote off-market prices to skew the outcome. If a dealer is on the “wrong side” of the IMM[44], it has to pay the amount of the quote multiplied by the difference between the IMM and its price. The penalty is paid only if the bid (offer) crosses with an offer (bid) when the IMM is calculated. For example, HSBC's bid (10%) was higher than the IMM (9.75%), as shown in Table 2. Since the net open interest was to sell, the bid was on the wrong side and crossed with the Barclays offer (also 10%). HSBC was therefore subject to a penalty of USD 5 million x (10% – 9.75%) = USD 12,500[45]. This penalty compensated exactly for the fact that in the second stage HSBC bought at a lower price (IMM of 9.75%) than the one it offered (10%).

3.2. Second stage

All information on the first stage is released publicly on the Creditex website. After the publication of the results, dealers and investors can determine their limit orders for the

44 i.e. a bid that exceeds the IMM when the open interest is to sell, which would drive the price upwards when it is supposed to go down; or an offer that is below the IMM when the open interest is to buy, which would pull the price downwards when it is supposed to go up.

45 Adjustment amounts are paid as a penalty to the ISDA, which uses them to defray the costs of holding the auction. If the amount of penalties exceeds the cost of the auction, the remaining amount is distributed pro rata to dealers that are net buyers of bonds.

second part of the auction during a 2-3 hour window. In the second stage, participation is no longer restricted to dealers: all final protection holders who wish to physically settle may take part. They send limit orders to their dealers [46]. These orders are forwarded to the auction administrator and used to exhaust the open interest calculated in the last stage. Since the direction of the open interest (buy or sell) is known at the end of the first stage, limit orders are only in the relevant direction, i.e. sell in the case of Lehman Brothers.

The orders submitted by the main dealers in the first part of the auction are entered in the order book. Orders that cross in the first stage (HSBC and Barclays in this case) go through at the IMM, typically in an amount of USD 5 million. Next, for open interest to sell, orders are used in the following manner. The highest buy order is matched at the amount requested, then the next highest order is filled and so on until the open interest or the order book is exhausted. If the open interest is used up first, the final price is that of the last limit order to be executed. If the order book runs out, the final price is the par when open interest is to buy and zero in the case of sell open interest.

In the Lehman auction, the first 71 orders used up all the sell open interest. The final orders to be placed are framed in Table II.4. The final price thus came out at 8.625%, which is very low. The last four orders were not completely filled but were executed pro rata to exhaust the open interest.

Table II.4: Establishing the final price of Lehman Brothers auction

Dealer	Bid	Size
Goldman Sachs & Co	10.75	50
…	…	…
Banc of America Securities LLC	8.75	10
JPMorgan Chase Bank, National Association	8.625	500
Banc of America Securities LLC	8.625	10
UBS Securities LLC	8.625	5
Goldman Sachs & Co	8.625	5
Barclays Bank PLC	8.5	50
…	…	…
Goldman Sachs & Co	0.125	4 000

Sources: Creditex, Markit.

An additional procedure prevents price manipulation by ensuring that the final price does not deviate too much from the IMM. If the last limit order results in a price that deviates by more than a specified cap amount (typically 1% of par) [47], the final price will be set at the IMM plus or minus the cap amount. This procedure is applied only when the

[46] A limit order indicates a bid or offer price and will be executed only if there is an equivalent or better counterparty. It may be partially filled if there are not enough of the corresponding securities in the order book.

[47] The protocol for the Lehman Brothers auction set a cap amount of 1%.

difference between the final price and the IMM is on the wrong side, i.e. positive in the case of sell open interest and negative in the case of buy open interest. The procedure was not activated in the Lehman auction. The difference between the price of the last order (8.625%) and the IMM (9.75%) was -1.125%, i.e. on the right side for sell open interest, because it makes sense for the price to fall when there is an excess of sell orders. The final price was therefore 8.625% after the second stage of the auction.

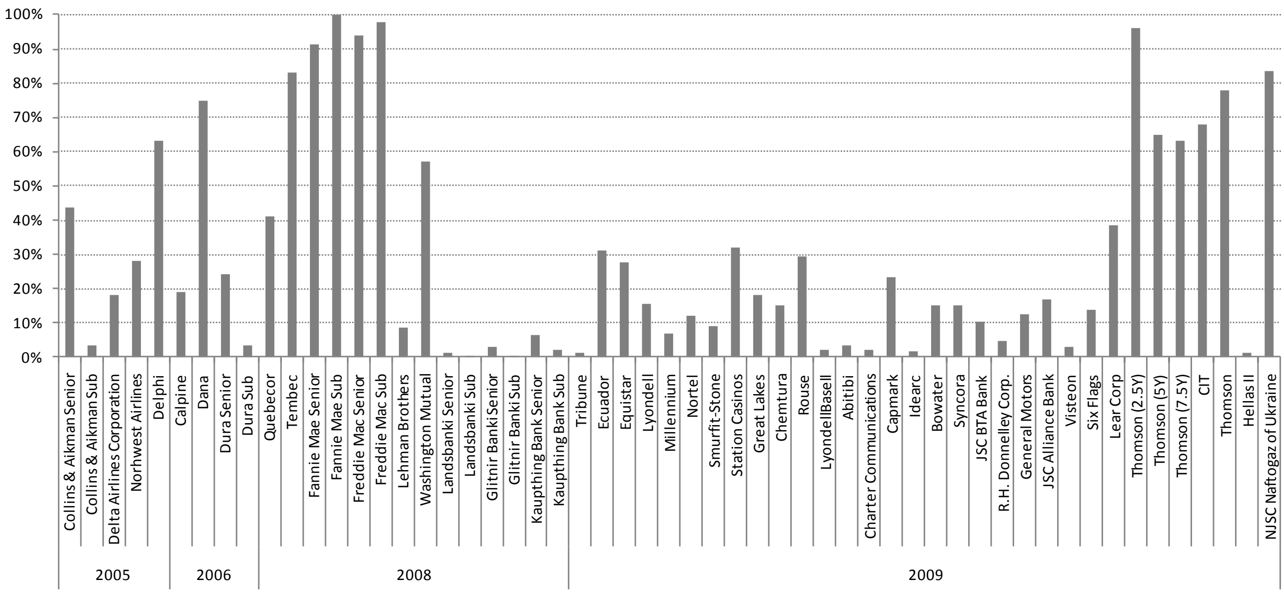
4. Links between final settlement and bond prices

4.1. Observed recovery rates in auctions

In the case of Lehman Brothers, the recovery rate was extremely low, only 8.675% of facial value. Historical data for previous auctions can be used to observe the recovery rates obtained in other defaults on the CDS market (Chart II.1). On average, over the 2005 – 2009 period, the CDS recovery rate was 31%. However, this figure is definitely overstated because it includes the settlement for CDS on government-sponsored enterprises (GSEs), i.e. Fannie Mae and Freddie Mac, where the recovery rate was over 90%. In this case, the holders of CDS on these entities triggered the default clauses, even though the debt was guaranteed by the US government. Fannie Mae and Freddie Mac can therefore be viewed as unrepresentative “false” defaults and should be removed from the sample.

When GSEs are taken out of the sample, the average recovery rate is 26% for the 2005-2009 period. It falls to 13% between the Lehman Brothers failure and the end of July 2009 from 36% before. There is therefore a downward trend typical of recessions or financial crises. At the end of 2009, recovery rates however posted a sharp increase (62% on average on the five last months of 2009), partly due to the improvement of the global economic environment and the specificities of several defaults. These figures show how wrong it is to assume constant recovery rates when extracting probabilities of default from CDS premiums, although it is commonly done by market participants. This point is well made by Duffie (1999). More recently, Andritsky and Singh (2006) and Singh and Spackman (2009) have also evidenced that CDS premiums are highly affected by changes in recovery rates during periods of financial distress.

Chart II.1: Recovery rates (CDS auctions' final prices) from 2005 to 2009



Note: LCDS auctions have been excluded.
Sources: Creditex, Markit.

4.2. *Consistency with bond prices*

Roughly speaking, as a CDS hedges the risk of default of a bond, holding a portfolio containing a bond and a CDS is equivalent to a long position in a risk-free asset. Therefore, the yield rate of the bond minus the CDS premium should approximately be equal to the risk-free rate (Duffie, 1999; Hull and White, 2000).

$$y_t - c_t \simeq r_t \qquad \text{(II.1)}$$

where y_t denotes the bond yield, c_t the CDS premium on the same entity at the same maturity , and r_t the risk-free rate at the same maturity.

This relationship is only approximate, for a number of reasons that have to do with differences in the nature of bond and CDS markets. The main differences are due to accrued interest, the "cheapest to deliver option", the liquidity premium, counterparty risk, etc… (O'Kane and McAddie, 2001; Aunon-Nerin *et al*., 2002; Cossin and Lu, 2004; Olléon-Assouan, 2004; De Wit, 2006). Arbitrage between the two markets generally ensures some convergence towards this relation in the long-run, as shown by some empirical studies using vector error correction models on different samples (Baba and Inada, 2007; Norden and Weber, 2004; Blanco *et al*., 2005; Crouch and Marsh, 2005;

Zhu, 2006). The adjustment process may depend on several factors, the CDS market having a tendency to lead the bond market in bearish periods (Coudert and Gex, 2010b).

The portfolio long in bonds and in the matching CDS is equivalent to a risk-free asset, not only in returns but also in price level. To illustrate the point, let us make the simplifying assumptions of a constant risk-free rate equal to the discount rate. In this case, a portfolio composed by a bond of facial value EUR 1 and the corresponding CDS is equivalent to a risk-free rate bond of facial value EUR 1:

$$P_t + C_t \simeq 1 \qquad \text{(II.2)}$$

where P_t is the price of the bond and C_t the price of the CDS a time t.

This relationship should hold at the time of the settlement, denoted t_1. At that time, the CDS price is worth $(1 - R_S)$, where R_S is the final recovery price. The price of the bond should move accordingly to meet the final price of the auction.

$$P_{t_S} \simeq R_S \qquad \text{(II.3)}$$

In other words, the recovery rate found by the auction is expected to be close to the price of the bond market at the same time.

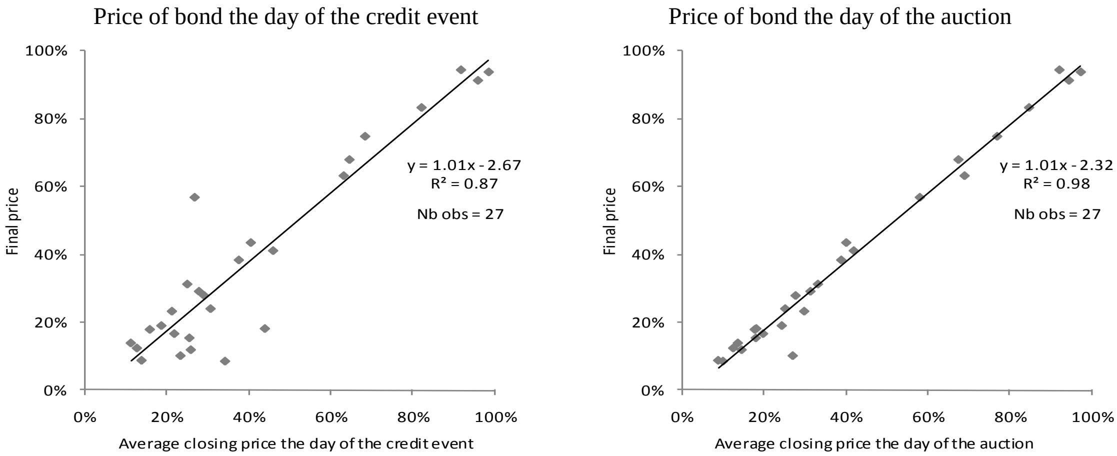
In reality, this relationship between the bond price and the final price of the auction only holds approximately, and may unravel as arbitrage opportunities become scarcer (Martin and Lasarte, 2008). This is because the CDS market is frozen just before the settlement procedure, whereas the secondary market can continue to accept trades, as some investors are specialised in the distressed segment. The auction system seeks to limit the differences between the two markets and mostly manages to do so (Helwege *et al*., 2009). As a matter of fact, the auction process allows CDS buyers and sellers who would prefer a cash settlement to confront demand and supply of deliverable bonds on a temporary market. The final price should naturally be close to the prices on the secondary bond market, ensuring for a CDS buyer, equivalence between the settlement of her CDS contracts within the auction or by buying underlying bonds on the secondary market and delivering them to the CDS seller.

4.3. Empirical insights

One way to assess the consistency of the recovery rate determined by the auction process and the prices on the secondary market is to compare the evolution of the deliverable obligation daily prices and the final price. To do so, we start from the sample of entities reported in Chart II.1, that defaulted over the period 2005-2009, and select those for which bonds prices are available in Bloomberg. We exclude securities with too low liquidity, as measured by the number of missing values over the period spanning from the day of the credit event to the settlement date[48]. After filtering, we get a sample made of 27 senior CDS auctions[49].

Chart II.2 compares the final price to the average price of deliverable bonds, for each of the 27 auctions. The graph on the left gives the bond price the day of the credit event. The graph on the right is taken the day of the auction. As expected, all the observations are distributed closely around the bisecting line. However, observations are much closer to this line the day of the auction, in the right hand-side graph, as the relationship is much stronger. By comparing these two graphs, we clearly observe a tightening of the gap between the bond prices and the final price, from the day the credit event is announced until the day of the auction. This confirms the reduction in arbitrage opportunities before the auction date. Various factors yield the remaining divergences, justifying that arbitrage opportunities could hardly be cancelled. These factors are related to those mentioned in section 4.2. The auctions described in the next section reports some cases of distortions.

Chart II.2: Final price of the auction compared to deliverable bond price taken the day of the credit event announcement and the day of the auction, for 27 entities



Sources: Bloomberg, Creditex, ISDA, Markit.

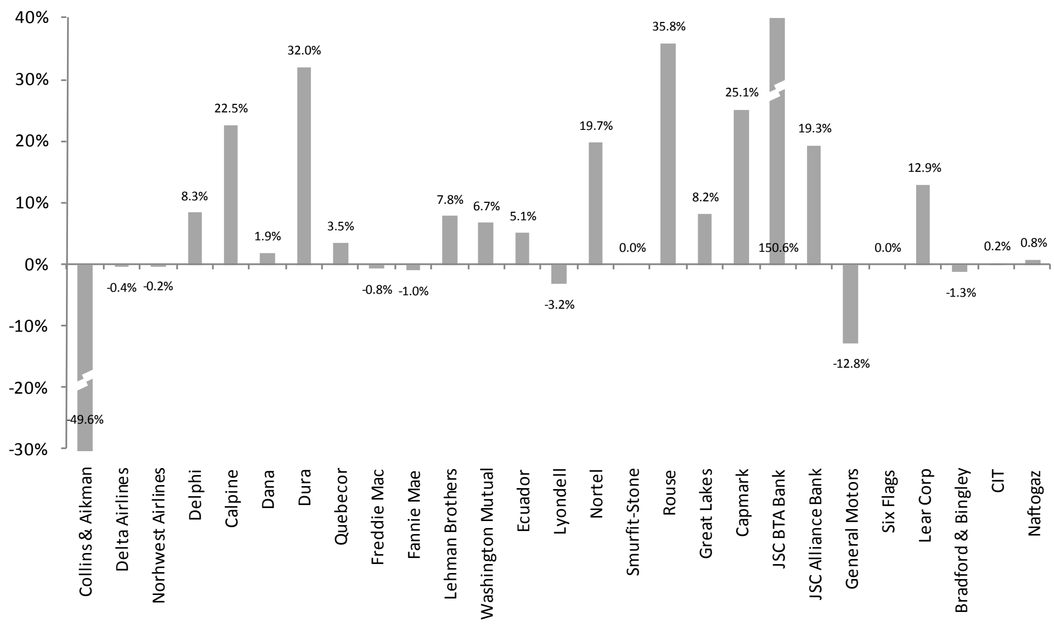
Another issue is to consider the evolution in the bond price in the immediate aftermath of the auction. This is interesting since the settlement does not take place immediately after the auction, but only after several days. Therefore, profits can be made ex post if a

48 Timelines of the auctions come from ISDA protocols and press releases relates to these auctions.

49 Collins & Aikman, Delta Airlines, Northwest Airlines, Delphi, Calpine, Dana, Dura, Freddie Mac, Fannie Mae, Lehman Brothers, Washington Mutual, Ecuador, Lyondell, Nortel, Smurfit-Stone, Rouse, Great Lakes, Capmark, JSC BTA Bank, JSC Alliance Bank, General Motors, Six Flags, Lear Corp, Bradford & Bingley, CIT, Naftogaz, Quebecor.

discrepancy has appeared between the final rate of the auction and the bond price on the secondary market. An examination of the data for our sample of 27 entities shows that this is the case. On the whole, there is a large gap between the two prices, as shown in Chart II.3. In most cases, the price bond is higher than the final price, which means that the bond on the defaulted entity has bounced back, and performed much better than expected.

Chart II.3: Gap between bond price at settlement date and final price (in percentage)



Sources: Bloomberg, Creditex, ISDA, Markit.

5. Oddities observed in large settlements

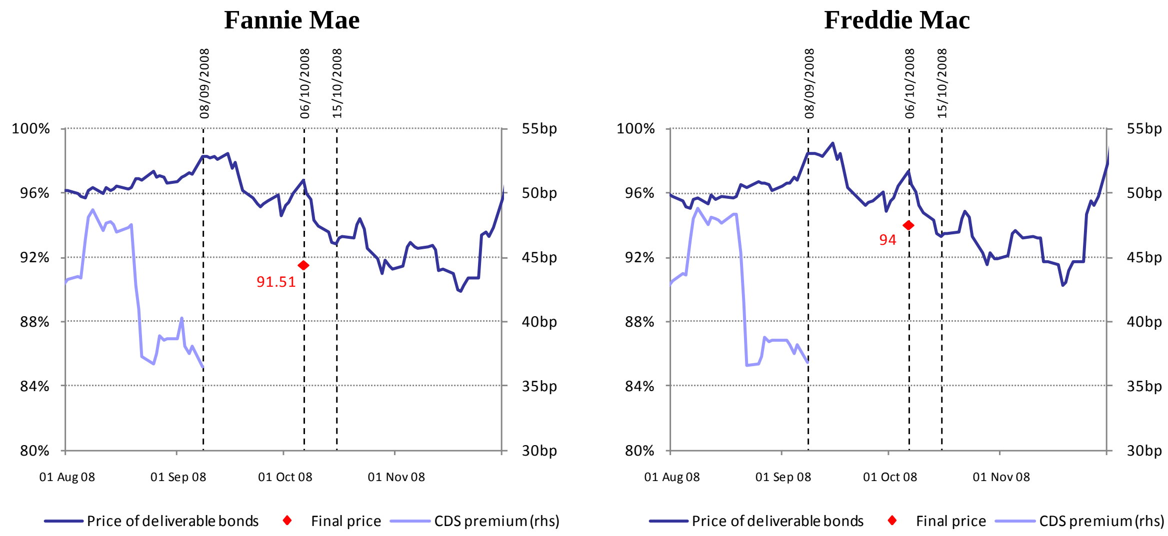
Until now, default settlements on the CDS market have been implemented in an orderly manner. However, a closer look at various settlements evidences some oddities in the final recovery rates, as shown below. The stakes are different from one firm to the other, according to the kind of event that has triggered the settlement. The credit event can be a U.S. government's seizure in the case of Fannie Mae and Freddie Mac, a bankruptcy as for Lehman Brothers, Washington Mutual and CIT, or a debt restructuring for Thomson.

5.1. Freddie Mac and Fannie Mae: technical factors

Technical factors can influence the final price. Auctions on the CDS linked to Freddie Mac and Fannie Mae have raised questions on the efficiency of the auction process and the quality of CDS as hedging tools. On September 8 2008, both GSEs were taken into conservatorship by the US Treasury, which constituted a credit event and triggered CDSs on the senior and subordinated debt of the two firms. This event was considered as a technical default, according to the ISDA documentation.

In a physical settlement, CDS buyers will prefer to deliver the cheapest underlying bonds, which are often bonds with optional features, to CDS sellers. The presence of deliverable bonds with specific characteristics could then push the final price down. As a large amount of the GSEs' senior debt included such features and was quoted at a lower price than straight bonds, the ISDA drew up a list of deliverable obligations which excluded the majority of these kinds of bonds, mainly zero-coupon notes. However, the decision to include callable obligations and range accruals in the list still contributed to lower expectations of recovery rates (Pengelly, 2008). The auction ended with final prices of 91.51% for Fannie Mae and 94% for Freddie Mac, far from prices on the secondary market, 98% on average (Chart II.4).

Chart II.4: GSEs senior CDS premium and bond price



Dates: 08/09/08: default announced; 06/10/08: auction; 15/10/08: settlement.
Sources: Bloomberg, Creditex, ISDA, Markit.

Paradoxically, auctions on the GSEs' subordinated debt led to recovery rates higher than prices for senior bonds. The scarcity of deliverable obligations explains this result.

Indeed, the total amount of subordinated bonds deliverable in the auction was very small (USD 8 billion and USD 5 billion for Fannie Mae and Freddie Mac respectively) in comparison with the outstanding credit protection on the two firms, estimated to as much as USD 1.2 trillion, according to Reuters. For the record, the total debt of the two GSEs reached USD 1.6 trillion.

In the first step of the auction, the sum of physical request to sell was equal to zero, leading to a buy net open interest. The final price was driven by this lack of market participants willing to physically deliver subordinated bonds and the net open interest was exhausted at a recovery rate close to par and higher than the final price for senior bonds (99.9% and 98% for Fannie Mae and Freddie Mac, respectively).

5.2. Lehman Brothers and Washington Mutual: uncertainty about the amounts at stake

Lehman Brothers was the fourth-largest US investment bank and a major counterparty on the market, having written hundreds of thousands of contracts. This problem was partly resolved over the weekend preceding the failure announcement during a netting session supervised by the Depository Trust & Clearing Corporation (DTCC) (Moody's, 2008), which enabled more than 300,000 CDS contracts with Lehman Brothers as a counterparty to be taken off the market. Moreover, notional amounts on the Lehman Brothers entity were also very large, ranging between USD 200-500 billion (Yelvington and Taggert, 2008). The most commonly cited figure, reported by the *Financial Times*, was USD 400 billion. The sheer size of these amounts created doubt that sellers would be able to honour their commitments.

The *Financial Times* and ISDA estimated the gross notional value of CDS contracts written on Lehman Brothers at USD 400 billion just after the failure. Based on this amount and a recovery rate of 8.625%, default settlement would have entailed an enormous transfer of USD 366 billion from protection sellers to buyers. These estimated pre-settlement gross amounts greatly overestimate net positions. Moreover, they bear no relation to the figure of USD 72 billion reported by DTCC at that time for all Lehman Brothers contracts recorded in its Trade Information Warehouse (TIW), which covered 90% of CDS between dealers according to DTCC. There are thus questions over the actual CDS amounts involved (Gerson Lehrman Group, 2008).

The final settlement is known to have totalled USD 5.2 billion. If the recovery rate was 8.625%, we can deduce that the settled contracts corresponded to a notional value of

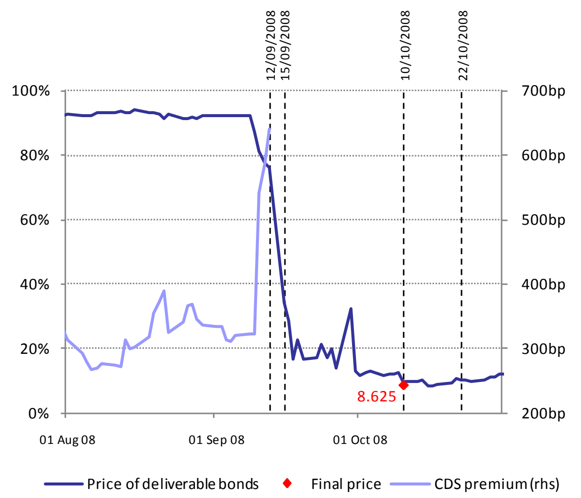
$\frac{5.2}{(1-8.625\%)}$ = USD 5.7 billion. As the final settlement took place after market participants' positions were netted, the amounts involved were considerably reduced. Based on the figure of USD 72 billion reported by DTCC, the netting process, which reduced the notional value to USD 5.7 billion, divided the positions by a factor of 12.6, giving a ratio of 7.9% between net and gross values. This is not substantially different from the 5.7% netting ratio estimated by the BIS (Gerson Lehrman Group, 2008). If the gross notional value was USD 400 billion, as reported in the press, netting made it possible to reduce the gross positions by much more, i.e. to 1.3%. This is not an unrealistic ratio either, however, given its similarity to Fitch's estimate of 2%. All in all, given the contradictory (but not refuted) information in circulation, the gross amounts involved can still not be identified with certainty.

In the case of Lehman, the relationship between the bond price and CDS premium shows opposing movements around the time of the failure (Chart II.5). The CDS premium, which stood at 280 bp in August, leapt to 630 bp just before the failure was announced. In fact, the final trades of 12 September, which are not recorded in Bloomberg data, were executed at much higher premiums. Meanwhile, the average price of Lehman bonds plummeted. Trading at 85% of par until early September, it collapsed just before the failure was announced, falling to approximately 30% at end-September and 20% in October. After the failure, it is noteworthy that the CDS settlement price from the auction (8.625%) was markedly lower than the price of the underlying bonds, which were trading at around 12% of par the day before the auction. This differential reflects the closing-off of arbitrage opportunities between the underlying and CDS, whose market was frozen by the auction procedure. Uncertainty before the auction about the amounts that would be involved could have contributed to this result.

In the case of Washington Mutual, the auction ended with a recovery rate of 57%, well below that of the secondary market of about 65% two days before the auction (Chart II.6). Washington Mutual was the United States' largest savings and loan association before its failure in September 2008. Huge losses on the subprime market, especially via Option Adjustable Rate Mortgages (ARMs) led the Office of Thrift Supervision (OTS) to place the firm into the receivership of the Federal Deposit Insurance Corporation (FDIC) on 25 September, after a massive bank run of USD 16.4 billion in deposits on a 10-day period. The next day, Washington Mutual filed for chapter 11 of Bankruptcy Code, which was the largest bank failure in the United States up to date, triggering CDS referencing the bank.

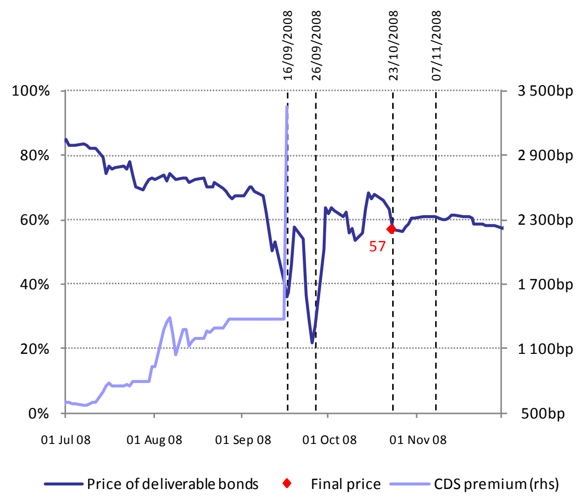
Washington Mutual's CDS were very actively traded, and a large number of dealers had actually stacked positions, buying and selling protection on the bank, which were finally offset (Reuters, 2008). The net open interest at the end of the first step of the auction, USD 988 million to sell, was low compared to Lehman Brothers net open interest of USD 4.9 billion. In the second step of the auction, a smaller number of bid orders than in the Lehman case was posted by participants to the auction (195 vs. 435 bids) and a higher number orders was necessary to exhaust the open interest (87 vs. 71 bids), which pushed the final price down.

Chart II.5: Lehman Brothers CDS premium and bond price



Dates: Friday 12/09/08: last day of trading on CDS market; Monday 15/09/08: default announced; 10/10/08: auction; 22/10/08: settlement.

Chart II.6: Washington Mutual CDS premium and bond price



Dates: 16/09/08: last day of trading on CDS market; 26/09/08: default announced; 23/10/08: auction; 07/11/08: settlement.

Sources: Bloomberg, Creditex, ISDA, Markit.

5.3. *Thomson: squeeze effects in a restructuration credit event*

CDS contracts and market practices were standardized in 2009, though still diverging on the effects of a restructuring (Duquerroy *et al*., 2009). On the one side, North American practices on credit events were restated by the ISDA CDS in the so-called "Big Bang" that came into force on 8 April 8[50]. For each major economic area[51], a Determination Committee was created to decide whether a credit event has occurred and determine the terms of any auction. The Big Bang excludes restructuring from the list of credit event triggering American CDS. Indeed, the law of the United States prompts firms to file under chapter 11 of Bankruptcy Code before restructuring their debt, which triggers

[50] See Markit (2009a) for a detailed review of the CDS Big Bang.

[51] Americas, Asia excluding Japan, Australia – New Zealand, Europe – Middle East – Africa (EMEA), Japan.

automatically a bankruptcy credit event. Consequently, restructuring credit events are very scarce on North American CDS. Additionally, restructuring events are difficult to detect and market participants had considered dropping restructuring on North American CDS for years. At the time the Big Bang took place, 27.1% of North American CDS were "No Restructuring" trades according to Markit.

On the other side, there is no unified legal framework for European countries and features comparable to chapter 11 do not exist. Consequently, 99.3% of European CDS include a restructuring clause and excluding restructuring from the list of credit events in European contracts was hence hardly possible[52]. On 27 April 2009, a "Small Bang" concerning Europe, filled out the "Big Bang" in order to extend the auction process to restructuring event[53].

When a CDS is triggered because of a restructuring event, maturity restrictions apply on deliverable obligations. To take into account these limitations, buckets have been defined in order to aggregate CDS and deliverable bonds according to their maturity. A limitation date is associated to each bucket: 2.5 years, 5 years, 7.5 years, 10 years, 12.5 years, 15 years, 20 years and 30 years. Shorter maturity obligations are always deliverable in longer maturity buckets. If a CDS is positioned in a bucket where no bonds are deliverable, it will be moved in a shorter maturity bucket which includes a deliverable obligation.

Restructuring actually involves a multiple auction mechanism as an auction can occur in each bucket including both CDS and deliverable obligations. The Determination Committee determines whether an auction will take place in a given bucket by applying the "500/5" criterion. An auction will automatically be held if 500 or more CDS are triggered in a bucket and 5 or more dealers are counterparties to these contracts. If the criterion is not validated, the Determination Committee conducts a vote to determine if an auction should still take place. To ensure that parties to a CDS have the ability to settle via the auction, a "movement option" can be exerted in the case an auction is not held in a given bucket. This means that if the CDS is triggered by the protection buyer, the trade can be moved to the next earliest maturity bucket; if the CDS is triggered by the protection seller, the trade can be moved to the 30 year maturity bucket if there is an auction for it. This asymmetry aims at maximizing the number of bonds the protection buyer will be able to deliver when he is not the one to have triggered the contract. Lastly, protection buyers can choose not to trigger their CDS, using the "use it or lose it" option,

[52] Market players assess the cost of the restructuring clause to about 5 bp to 10 bp, compared to a "No Restructuring" contract on the same reference entity.

[53] See Markit (2009b) for a detailed review of the CDS Small Bang.

if they anticipate that a subsequent credit event (the bankruptcy of the reference entity) would have a higher pay-out.

The first restructuring auction under the “Small Bang” concerned the French electronics firm Thomson on October 22 2009. Because all the debt of the company was privately placed, it took two months to the European Determination Committee to draw up the list of deliverable obligations. According to the DTCC and ISDA, Thomson CDS contracts amounted to about USD 2.1 billion and 7,496 contracts were triggered. An auction took place for 3 buckets: 2.5 years, 5 years and 7.5 years. The auction for the shortest maturity produced a surprisingly high recovery rate of 96.25%, compared to final rates for the 5 year and 7.5 year maturities, of 63.125% and 63.25%, respectively. The large discrepancies in the final prices across maturities have cast doubts on the efficiency of the auction mechanism in case of a restructuring (Merriman and Baird, 2009).

As a matter of fact, the short list of deliverable obligations led to a scarcity of available securities in the 2.5 year bucket. This shortage was moreover exacerbated by the high demand in Thomson bonds, due to the inclusion of Thomson in several off-the-run iTraxx Europe indexes. The small sell open interest of the 2.5 year bucket, USD 80.967 million, was exhausted by a single order exactly equal to the open interest, posted by J.P. Morgan at a very high bid of 96.25%. Ending with a high recovery allows low payments for cash settlements, which would be rational for J.P. Morgan if we assume that the bank was a net protection seller.

For longer term buckets, i.e. 5 years and 7.5 years, final prices were significantly lower, compared to the 2.5 year bucket. In the first stage of these two auctions, Deutsche Bank provided nearly 75% of the sell physical requests[54], leading to larger open interests of USD 221 million and USD 148 million for the 5 year and 7.5 year bucket respectively. Consequently, a larger number of bid orders was needed to exhaust these open interests to sell, shrinking the final price. Assuming that Deutsche Bank was a net protection buyer, the low recovery rate of the longer buckets would ensure higher payments from protection sellers.

5.4. CIT: the possible impact of CDO deals

Lack of information about the underlying strategies settled by CDS buyers and sellers can also make the final price unpredictable. CIT, a major financial institution in the United

[54] i.e. USD 228 million of the USD 365 million of deliverable obligations for the 5 year bucket and USD 254 million of the USD 286 million of deliverable obligations for the 7.5 year bucket. Deutsche Bank also contributed to USD 120 million of the USD 150 million deliverable bonds in the case of the 2.5 year bucket.

States, went bankrupt on November 3 2009. It was a lender for small and medium size firms. CDS on CIT were highly traded. CIT settlement had the largest outstanding volumes the auction process had seen to date: around USD 3.1 billion in single name CDS and USD 2.9 billion in the CDX indexes the firm was included in. Moreover, CIT's CDS were very popular items to include in synthetic CDOs, which are not registered by DTCC. In July 2008, 2,470 CDO tranches with exposure to CIT had been rated by Standard & Poor's. A significant part of the outstanding amounts of CDS was hence impossible to assess (Brettell, 2009).

Two types of strategies can explain diverging guesses about the final price witnessed before the auction. First, banks that originate the synthetic CDOs hedged their exposures by selling CDS on the underlying reference entities[55]. Consequently, they would have sold large amounts of CDS on CIT and would receive bonds at the settlement date; which means they had to buy them in the auction. A large amount of orders to buy would have driven up the price of underlying bonds as well as the final price.

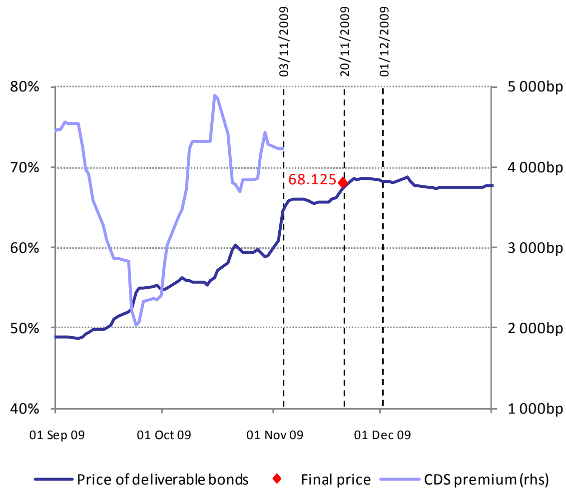
Second, a potentially high number of investors bought CDS on CIT in order to hedge their exposure on underlying bonds or set up CDS basis trades. They were expected to deliver the underlying bond at the settlement date and hence would be sellers of bonds in the auction, pushing down the final price and the price of underlying bonds.

The first type of strategies certainly prevailed as the average price of underlying bonds continuously increased throughout the months preceding the credit event (Chart II.7). Between, 30 October and 3 November 2009, date of the credit event, the price increased by 5.5%. An additional rise in price of 2.9% occurred on the secondary market between the bankruptcy and the auction.

During the first step of the auction process, requests to sell the bonds (USD 1.5 billion) were almost twice those to buy (USD 785 million). Consequently, market participants posted orders to buy bonds in the second step. Because of its small size, USD 729 million, compared to Lehman Brothers for instance (USD 4.92 billion), the net open interest was quickly exhausted. The final price, 0.6% higher than the average price of underlying bonds the day of the auction (68.125%), was driven by these buying pressures.

[55] The bank that originates a synthetic CDO transfers risk on an underlying basket of credit to a SPV with CDS. The bank is CDS buyer and the SPV CDS seller. Premia paid by the bank to the SPV are used to remunerate investors in the CDO. In most cases, the bank would hedge its position by selling CDS on the reference entities included in the CDO and would then act as CDS seller in an auction on an underlying reference entity.

Chart II.7: CIT CDS premium and bond price



Dates: 03/11/09: default announced; 20/11/09: auction; 01/12/09: settlement.

Sources: Bloomberg, Creditex, ISDA, Markit.

6. Recent and ongoing reform

Some developments have already contributed to improve the functioning of the CDS market, others are still under way. First, the transfer of CDS from one market participant to another has been facilitated by different steps and resulted in a trade compression. The use of DTCC's electronic platform Deriv/SERV to automate and confirm electronically CDS trades has reduced the volume of outstanding confirmation by 75% since 2005, as well as confirmation times. Subsequently, 99% of CDS transactions eligible to electronic trade were effectively confirmed electronically in 2009 and confirmation times dropped from several weeks in 2005 to 1.1 business days on average in 2009 (ISDA, 2010). Electronic trading facilitated the "novation" of CDS contracts. "Novation" means the transfer of the obligations of a CDS counterparty related to a CDS contract to another market participant. If novation is not confirmed, the transaction is delayed and market participants are facing operational and counterparty risk as it is not possible for them to know if the obligations under the contract have been effectively transferred. Under the 2005 ISDA Novation protocol, when a CDS contract is transferred from a given counterparty to another one, electronic confirmation is used to reassign the obligations under the contract before transferring the contract to the new entity.

Consequently, there has been a drastic reduction in redundant contracts due to interlocking positions between financial participants. This trade compression has consisted in eliminating positions that can be multilaterally netted from the portfolios of several dealers, replacing them with a smaller number of contracts with the same net residual exposure. According to TriOptima, leading firm in compression services for CDS contracts through its TriReduce process, 30.2 trillion USD in CDS notional were eliminated in 2008. The contraction in the market size can therefore be attributed to trade compression. This has contributed to mitigate the counterparty risk.

The hardwiring of the auction process has benefited from these innovations. These regular compression cycles have reduced operational risk and facilitated the settlement of credit events. Moreover, since 2008, specific compression processes have been put into place in order to reduce interlocking positions on a defaulted firm before the auction (Freddie Mac and Fannie Mae, Lehman Brothers and Thomson among others).

Second, the Big Bang Protocol on American reference entities has rationalised market practices since 8 April 2009 on; the Small Bang Protocol has done the same for European ones, since 27 July 2009. The auction processes have been automatically implemented when credit events occurred since and are retroactively applied to existing contracts. Moreover, changes in the North American and European Convention for CDS contracts modified the way single-names CDS were quoted. The use of fixed coupon and upfront payments to trade CDS, similarly to CDS indices, rather than the CDS premia, fostered the standardisation of CDS contracts in order to facilitate their clearing in a central counterparty clearing house (CCP) [56].

Third, the global regulatory response is still pending, although first elements have been already implemented. The public authorities called for all contracts to be recorded in a common repository. At the present time, this means that market participants have to record their contracts in the Trade Information Warehouse set up by DTCC in 2006. This initiative has helped to mitigate operational risk through increased automation and electronic trade confirmation. This infrastructure aims at recordkeeping and maintenance of the data relative to CDS transactions, in order to provide supervisors, as well as market participants, with an accurate view of the underlying obligations and of the risks related to the market and improve market transparency. Moreover, the storage of CDS data in the Trade Information Warehouse ensures the legal enforceability of the contracts (CPSS, 2010).

The move to a centrally cleared market has become a key objective. The recent creation of central counterparty for CDS is designed for transferring counterparty risk to structures

[56] The Big Bang Protocol, the Small Bang Protocol and the convention changes are described in details in Markit (2009a, 2009b).

that can absorb the shock of a default by a major market participant. CCPs also ensure better collateralisation standards by imposing initial and variation margins on a daily or intraday basis. These margin calls are complemented by a clearing fund, which is constituted by the individual contributions of the clearing members and allows risk mutualisation in case of default of one of the members (CPSS, 2007). Four CCPs currently clear CDS contracts. The first was launched in March 2009 by the Intercontinental Exchange (ICE Trust) based in Atlanta, for American CDS indices and single-name contracts. Its subsidiary, ICE Europe, clears European single-name CDS and indices. It went live in July 2009. Two European structures, EUREX Credit Clear and LCH.Clearnet SA, launched in July 2009 and March 2010 respectively, also clear European CDS. Mid-2010, about 6.5 trillion USD notional has been cleared by the four CCPs, of which 97% by ICE Trust and ICE Europe.

Participation to a CCP grants a single framework and reduces legal and operational risks. However, this framework imposes a standardisation of cleared products. On the one hand, it may improve the liquidity of these products, which is a condition for the CCP to ensure efficient hedging and liquidation of its position when a participant defaults. On the other hand, the need for standardisation limits the range of products that a CCP could clear, as a significant number of trades involves CDS with poor liquidity. At the moment, single-name CDS account for only 3% of the notional cleared by the four CCPs.

7. Conclusion

When large financial firms such as Lehman Brothers or Washington Mutual failed, there was much concern about the ability of the CDS market to cope with a shock of that magnitude. In the end, these defaults were settled smoothly through the netting of positions and an auction process introduced in 2005. The netting of market participants' gross positions helped to clean up a situation that started out as a huge tangle of crossed positions. By reducing the number of contracts, the netting drastically reduced participants' exposure to counterparty risk and the amount of protection sold on the defaulting firms. The auction process helped to ensure an orderly process by guaranteeing a single price for all holders of protection on the firms. The smooth running of the auction process has prompted its generalisation by market participants to every settlement since then. Nevertheless, the close examination of several cases shows that the auction process is not completely flawless and can yield to biases in the final price. This points to the limits of the auto-regulation of an OTC market.

More importantly, the concerns raised during the crisis have set in motion a train of reforms. Counterparty risk has become a major threat because of the large amounts involved and the low recovery rates. It is now considered to have been needlessly magnified by interlocking positions on the market. The lack of clarity about positions, owing to the market's OTC nature, has shown the need for reliable statistics on positions. Regulatory measures have already been taken to address these issues, some are still under way. The move to a central counterparty clearing is a pivotal tool to mitigate the risks. The recording of all trades by DTCC is also seen as a key element to provide supervisors with the necessary information on the market evolution.

Chapter III Contagion inside the credit default swap market: The case of the GM and Ford crisis in 2005[*]

Abstract

We study the General Motors (GM) and Ford crisis in 2005 in order to determine if the credit default swap (CDS) market is subject to contagion effects. Has the crisis spread to the whole (CDS) market? To answer this question, we study the correlations between CDS premia, by using a sample of 226 CDSs on major US and European firms. We do evidence a significant rise in correlations during the crisis episode, but little "shift-contagion" as defined by Forbes and Rigobon (2002). When using dynamic measures of correlations (EWMA and DCC-GARCH), we also show that correlations significantly increased during the crisis, especially in the first week.

JEL classification: G01; G15.

Keywords: Credit default swap; Correlation; Contagion.

[*] This is a joint article with Virginie Coudert. Published in the *Journal of International Financial Markets, Institutions and Money* 20 (2010), p. 109-134. Republished in Robert W. Kolb (dir.), Financial contagion: The viral threat to the wealth of nations (forthcoming), John Wiley & Sons. NOTICE: this is the author's version of a work that was accepted for publication in the *Journal of International Financial Markets, Institutions and Money*. Changes resulting from the publishing process, such as peer review, editing, corrections, structural formatting, and other quality control mechanisms may not be reflected in this document. Changes may have been made to this work since it was submitted for publication. A definitive version was subsequently published in the *Journal of International Financial Markets, Institutions and Money*, Vol. 20, (2010), doi:10.1016/j.intfin.2010.01.001.

1. Introduction

Are credit derivatives markets particularly vulnerable to contagion effects? This question is important given that derivatives markets play a key role in asset pricing. The sharp increase in all credit default swap (CDS) premia during the subprime crisis tends to suggest a positive answer. The General Motors (GM) and Ford crisis in 2005 also triggered a surge in all CDS premia, which can be seen now as a premonitory event. Considering this precise crisis has the advantage of being well circumscribed in time, as its origin can be clearly tracked down by the announcement of losses by GM in March 2005, promptly followed by the downgrading of both firms by the major rating agencies. As some time has now elapsed, it is possible to look back on this episode to understand its impact on the whole CDS market.

GM and Ford troubles in 2005 had important repercussions on the credit market due to the huge debt issued by the two leading multinational firms, which reached 3% of the investment grade bond market at that time, and nearly 15% of the high yield market (Packer and Woolridge, 2005); the spillovers were strengthened by the fact that their debt was also included in many Collateral Debt Obligations (CDOs). At the very start of the crisis, in March 2005, the cost of protection against default on the CDS market of both firms surged dramatically (by 260 bp for GM and 110 bp for Ford). This immediately rippled through the whole CDS market, the CDX high yield climbing from 300 to 530 bp. The bond market was also affected (rising by 150 bp in the US high yield segment), though to a lesser extent as short positions are easier to take on the credit derivatives markets than on the cash markets (IMF, 2005).

Contagion on financial markets can be broadly defined by a simultaneous fall in asset prices, triggered by an initial drop in one specific market. More restrictive views may confine contagion to crisis periods, or limits the phenomenon to “shift-contagion”, corresponding to falls in asset prices exceeding the usual co-movements observed in tranquil periods (Forbes and Rigobon, 2002). There are many rationales for financial contagion, which have been abundantly studied in the economic literature (for a review see Pericoli and Sbracia, 2003). Three main strands of literature can be distinguished depending on which market contagion occurs (Huang and Xu, 2000; Pritsker, 2001): speculative attacks ending up in currency crises spreading over to different countries; banking crises in dominos, stemming from the linkages between financial institutions; contagion in financial markets. The first strand has been particularly developed in order to understand the 1997 "Asian crisis" (Baig and Goldfajn, 2002; Corsetti *et al*., 1999; Kaminsky and Reinhart, 2000; Masson, 1998).

However, most studies on currency crises point to channels of contagion that can also apply to financial markets; the LTCM crisis for example was analysed with similar perspective (Pritsker, 2001). The same thing can be said of some models concerning banking crises, though to a lesser extent. Consequently, to take stock of all the existing literature, it seems more useful to focus on transmission channels rather than on markets. In this perspective, we see four broad categories of transmission channels of crises that could be observed on financial markets: (i) simultaneous selloffs due to investors' liquidity problems; (ii) the updating of investors' beliefs and preferences; (iii) herding behaviour and (iv) counterparty risk.

A first channel of contagion goes through investors' liquidity problems in case of crisis. Contagion is then based on investors' reaction when incurring heavy losses on one market in an environment of highly diversified portfolio management. The diversification of investors' assets across markets may pave the way to a "common creditor effect": in case of a sharp fall in one market, investors have to put up with a reduction of wealth and tend to withdraw their funds from other risky assets (Schinasi and Smith, 2001; Goldstein and Pauzner, 2004; Caramazza *et al*., 2004). This may happen even if agents are rational and in markets without imperfections. Some studies have focused on the specific role of financial intermediaries in this type of contagion, as banks' liabilities overlapping across countries may bring about more vulnerability (Allen and Gale, 2000). The drying up of liquidity during crises also concerns money managers, who are pressed into promptly liquidating their position on other markets. As they all do it simultaneously, this results in firesale prices spreading the crisis over to other markets. Convergence traders could be particularly affected and forced to liquidate their portfolios (Kyle and Xiong, 2001; Xiong, 2001); arbitrageurs too can be involved in these liquidations through their constrained access to liquidity (Gromb and Vayanos, 2007). The selloff pressures are intensified by margins calls in leveraged positions (Calvo, 1999). As well, fund managers may want to reduce their value-at-risk, by selling other risky assets, triggering crises in other markets. More generally, marked to market valuation of assets by financial institutions may incite them to liquidate assets in order to meet risk measurement constraints (Schnabel and Shin, 2004; Shin, 2008). As financial intermediaries are key participants in financial markets, their risk management system tends to feedback with asset prices, and propagates contagion (Adrian and Shin, 2008).

A second contagion channel goes through the updating of judgements and preferences. As a crisis bursts on one market, investors suddenly realize the riskiness of other financial assets and revise their risk assessments upwards. This may trigger a surge of risk premia, mirrored by a fall in prices of risky assets. It can occur in the circumstances described above but also without any drying up in investors' liquidity. A sheer rise in uncertainty is able to make investors move from risky to safe assets. This "flight to quality" may happen without liquidity shock, liquidity then hoarding in uncontingent assets. In Caballero and Krishnamurthy's models (2005, 2007), this mechanism takes place through financial intermediaries. Kumar and Persaud (2002) point to a sudden drop in investors' risk appetite, which makes investors require higher excess returns for all risky assets and spread the crisis. This is confirmed by empirical studies analysing risk aversion indicators around crisis periods (Dungey *et al.*, 2003; Coudert and Gex, 2008). As risky assets are also characterized as less liquid than the safe ones, in some cases, a "flight to liquidity" can be involved, although it is tricky to disentangle it from a mere "flight to quality" (Vayanos, 2004).

A third type of contagion is related to herding behaviour (for a survey, see Bikhchandani and Sharma, 2000). Herding occurs as soon as agents are influenced in their investment choice by the choices made by others. It is basically linked to the uncertainty about the fundamental value of financial assets and stems from various reasons. Market participants may believe that private information on future returns is revealed by the trading behaviour of other participants; in this case, information may be conveyed in cascades through market prices. Herding can concern rational agents when they are faced with high information costs (Calvo, 1999; Calvo and Mendoza, 2000); asymmetric information can also increase countries' vulnerability to crises through investors' cross-market rebalancing (Kodres and Pritsker, 2002). Another reason for herding stems from the behaviour of portfolio managers, since imitation is often rewarded by compensation plans (Chakravorti and Lall, 2004); besides conformity generates less adverse reputational effects in case your investment strategy goes wrong (Persaud, 2000). Another reason is that mimetic behaviour is probably an intrinsic feature of human nature, shared by many individuals including financial market participants.

The fourth channel of contagion is through counterparty risk. In the real economy, counterparty risk arises as soon as a firm's financial distress has adverse effects on other firms, because of their business relationships. Strong reliance on a distressed firm as a supplier or as a consumer may lead to heavy losses for other firms. Hence, default intensities of interdependent firms are linked together, pushing their credit spreads to co-move during crises. Market participants are able to anticipate these difficulties, and may bid down prices of a whole range of bonds, just after the announcement of a bankruptcy. This type of counterparty risk has been formalized and precisely measured in the pricing of bonds and credit derivatives such as CDS by Jarrow and Yu (2001).

Importantly, Jorion and Zhang (2007) have provided empirical evidence on these effects on the CDS market. They showed that intra-industry firms are generally negatively affected by a Chapter 11 bankruptcy, therefore suffering from contagion effects, whereas they could be favourably impacted by Chapter 7 bankruptcies. In the latter case, the liquidation of one competitor could result in favourable competitive effects, able to wipe off the contagion effects, as shown by Lang and Stulz (1992). Another kind of counterparty risk, that is also present in the CDS market, is the risk of a CDS seller to fail. This type of risk has seriously risen since Lehman Brothers bankruptcy in September 2008. As Lehman Brothers was a major counterparty on this market, its failure has immediately raised concerns about the possibility of other CDS sellers not to honour their contracts. Jorion and Zhang (2009) provide evidence of this type of contagion by showing that bankruptcy announcements may have an impact on CDS premia.

In this paper, we aim at determining if any of these contagion channels were at stake on the CDS market during theMay2005 episode. Acharya et al. (2008) investigated the impact of the same crisis on the liquidity of CDS market. They consider that GM and Ford's difficulties set off an exogenous liquidity shock on this market, that increased counterparty and inventory risks. To demonstrate this hypothesis, they use a sample of firms in the auto and financial industry and try to isolate the components of their CDS returns that cannot be attributed to the default risk. Consequently, they focus on the CDS "innovations", calculated as residuals of a regression including stock returns as explanatory variables. They find an increase in the correlations of these innovations with those of GM and Ford during the crisis, which points to a liquidity shock. Here, taking stock of this former work, we try to investigate all possible forms of contagion that could have played a role in this crisis. To do that, we take a larger sample of firms in all range of industries and consider the correlations between their whole CDS premia and those of GM and Ford, not only their innovations. As a matter of fact, this shock has certainly reduced the level of liquidity, as suggested by Acharya *et al*. (2008), as financial intermediaries were confronted to rising margin calls and a worsening of their risk management ratios. However, contagion could have spread through other channels. First, as these two flagship firms were suddenly viewed as possible defaulters, agents might have updated their judgement on the probabilities of default of other firms, considered as safe assets until that time. Second, herd behaviour could have taken place, just as in any other crisis. Third, counterparty risk could have played a role, not only for financial firms, but also for other firms, as a possible bankruptcy of GM and Ford may have had damaging effects on them. In particular, it is worth to analyse the effects on the automobile sector, to determine if contagion or competitive effects were involved.

Whatever the theoretical mechanisms at stake, contagion phenomena are generally characterized by increased co-movements in the returns of risky assets. Actually, the rise in correlations is often considered as the key symptom of contagion (Baig and Goldfajn, 2002; De Gregorio and Valdès, 2001). A number of empirical methods have been developed to measure co-movements appropriately (for a survey see Dungey *et al*., 2003). The most straightforward methods consist in comparing correlations during crisis and the period just before. As crises tend to generate strong volatility, correlations may be adjusted of a possible bias (Boyer *et al*., 1999), which allows to gauge if price transmission mechanisms were shifted by the crisis, a phenomenon called "shift-contagion" by Forbes and Rigobon (2002). Another strand of methods focuses on co-movements when asset returns are extreme (Hartmann *et al*., 2001; Bae *et al*., 2003). This latter method would not be appropriate here, as we want to study a given period of crisis, which is exogenously defined, not all extreme returns of a sample.

That is why we set out to test the hypothesis of an increase in correlations between the CDSs during the GM and Ford crisis. To do so, we construct a sample of 224 CDSs of European and US firms included in the major indices (CDX and iTraxx). We calculate correlations using different methods in order to cross-check the results. First, we compare the correlations during the crisis period with those during a reference period, by adjusting them to take account of the rise in volatilities, as recommended by Boyer *et al*. (1999) and Forbes and Rigobon (2002). This method gives a first insight, but has its limitations. The crisis period under review must be long enough to include a sufficient number of observations, whereas the CDS market's response to the GM and Ford crisis was very prompt. Second, we calculate conditional correlations by using Exponentially Weighted Moving Averages (EWMA) and Dynamic Conditional Correlation Generalized Autoregressive Conditional Heteroskedasticity (DCC-GARCH). Then we test for their increase in the crisis period and during the first week.

The remainder of the paper is organised as follows. Section 2 identifies the crisis period on the CDS market and presents the data. Section 3 checks for an increase in the correlations during the crisis period. Section 4 studies the daily dynamics of correlations and tests the impact of the crisis. Section 5 concludes.

2. The GM and Ford crisis and the CDS market

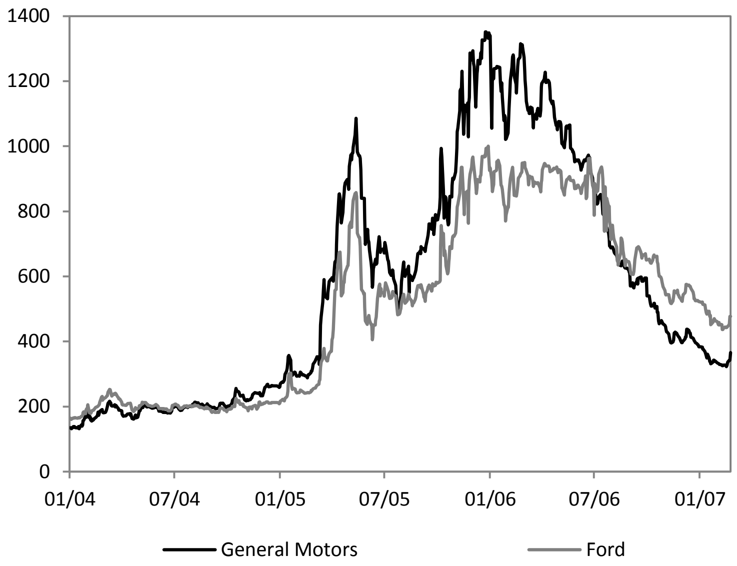
2.1. Stylised facts

The difficulties encountered by GM started to raise concerns in March 2005. On 16 March, GM announced a profit warning for the first quarter, forecasting a loss of roughly USD 850 million, compared to a previous target of breakeven. This would reduce the earnings per share to USD 2, i.e. half what had been forecasted (USD 4 to USD 5). On 8 April, Ford also announced a profit warning, revising its annual earnings expectations down by 25% compared to forecasts i.e. USD 2.5 billion instead of USD 3.4 billion.

Consequently, as early as March 2005, investors started to expect major difficulties for GM. In retrospect, these concerns were justified since the recorded loss reached USD 1.1 billion for the first quarter of 2005 (published on 19 April), and 8.6 billion for the whole year, compared with a net profit of USD 2.8 billion in 2004. As a matter of fact, in March 2005, market participants reassessed both firms' default risk and were expecting a downgrading by rating agencies, before the latter took any decision. As a result, the CDS premium of GM climbed from 304 to 567 bp in March 2005, while that of Ford rose from 244 to 357 bp (Chart III.1). The ratings of both firms were successively downgraded by the three major rating agencies between 5 May and 19 December 2005 (Table III.1). The downgrading was particularly harsh since the two firms were downshifted from investment grade to speculative grade. GM and Ford CDS premia continued to increase over this period.

Given the importance of these two firms, financial stress rippled over the whole CDS market. Contagion went through the usual channels reviewed in the introduction but was also reinforced by specific phenomena. (i) As GM and Ford were no longer investment-grade, dedicated investment grade investors started to sell both firms' bonds and bought protection to hedge their former positions, which contributed to the rise in the cost of protection. (ii) There was an inverse movement between GM bonds and stocks, which adversely affected a number of hedge funds that had arbitraged on GM capital structure. The value of GM debt sharply fell because of the downgrading, whereas the price of GM stocks surged because of a tender offer made by Kirk Kerkorian on 4 May. That day, GM equity appreciated by 18%; the day after, S&P downgraded GM and its bond price fell

Chart III.1: CDS premia, GM and Ford (in basis points)



Sources: Bloomberg.

Table III.1: Dates of rating downgrades for GM and Ford (dates of downgrades from investment to speculative grade are in bold)

High yield ratings are shaded in grey. The ratings by S&P goes from AAA, AA+ ,AA, AA-, A+, A, A-, BBB+, BBB, to BBB- for investment grade and from BB+, BB, BB-, B+, B, B-, CCC+, CCC, CCC- to CC for speculative grade (high yield); those by Fitch are the same, except for the ratings beginning by C which are grouped in a single category CCC. For Moody's, the ratings are Aaa, Aa1, Aa2, Aa3, A1, A2, A3, Baa1, Baa2, Baa for the investment grade, and Ba1, Ba2, Ba3, B1, B2, B3, Caa1, Caa2, Caa3, Ca for the speculative grade.

	General Motors			Ford		
Date	S&P	Moody's	Fitch	S&P	Moody's	Fitch
Prior to January 2004	BBB	Baa1	BBB+	BBB-	Baa1	BBB+
13 October 2004			BBB			
14 October 2004	BBB-					
4 November 2005		Baa2				
16 March 2005			BBB-			
5 April 2005		Baa3				
5 May 2005	BB			BB+		
12 May 2005					Baa3	
19 May 2005						BBB
24 May 2005			BB+			
20 July 2005						BBB-
24 August 2005		Ba2			Ba1	
26 September 2005			BB			
10 October 2005	BB-					
1 November 2005		B1				
9 November 2005			B+			
12 December 2005	B					
19 December 2005						BB+
5 January 2006				BB-		
11 January 2006					Ba3	
21 February 2006		B2				
13 March 2006						BB
29 March 2006		B3				
8 June 2006						B+
20 June 2006		Caa1				
28 June 2006				B+		
14 July 2006					B2	
18 August 2006						B
19 September 2006				B	B3	
27 November 2006		Caa1			Caa1	

Sources: Fitch, Moody's, Standard and Poor's.

markedly. These abnormal price evolutions brutally hit a number of hedge funds that had taken long positions in GM bonds by financing them with short equity position. Both legs of their strategy being affected, those hedge funds suffered losses and tried to hedge themselves by bidding up the cost on GM protection (Packer and Woolridge, 2005; Venizelos, 2005). (iii) The price of equity tranches in the CDS indexes increased relatively to the other tranches, which had adverse effects on other hedge funds, holding long equity and short mezzanine positions (Beinstein *et al*., 2005).

At any rate, all of the CDS market was immediately affected: index premia almost doubled in March 2005 (Charts III.2 and III.3). After having reached a peak on 18 May, the CDS indices started to decline, which suggests that the market had managed to absorb the shock.

Chart III.2: Premia for investment grade CDS indexes, CDX NA IG and iTraxx Europe Main (in basis points)

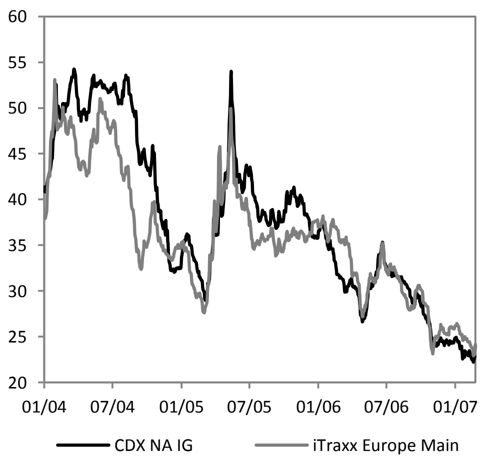
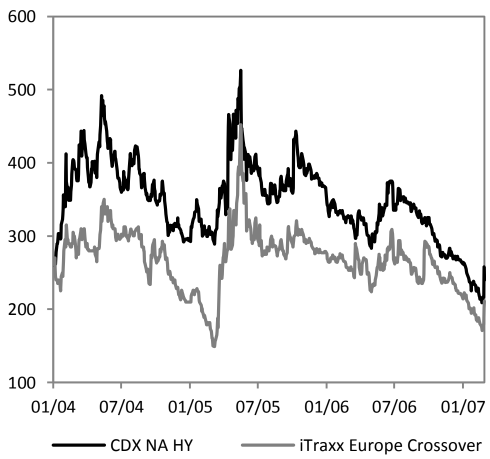


Chart III.3: Premia for high yield CDS indexes, CDX NA HY and iTraxx Europe Crossover (in basis points)



Sources: Bloomberg, J.P. Morgan.

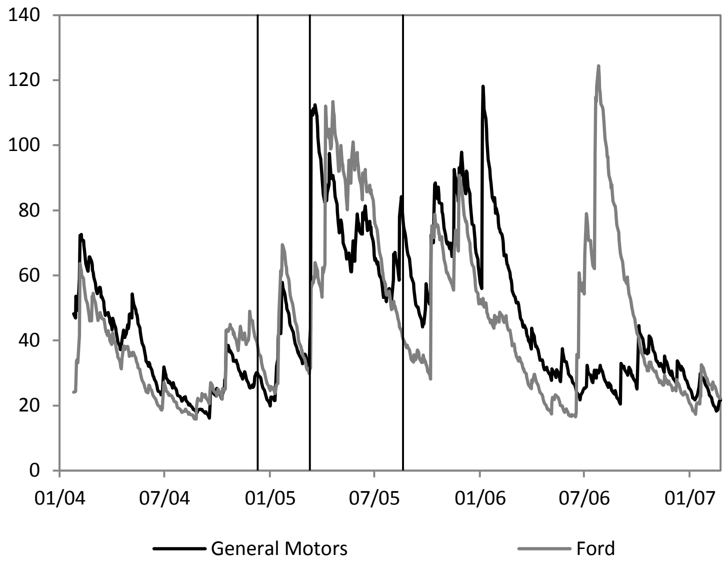
2.2. *Identification of the crisis period*

Because financial crises are generally characterized by a rise in volatility, we check for the volatility of CDS premia for GM and Ford around this episode in order to identify the crisis period more accurately. We use an EWMA volatility (Exponentially Weighted Moving Average), defined as a weighted sum of the quadratic CDS yields with exponentially decreasing weightings.1 The results show a sudden jump in volatility on the 16th of March 2005 (Chart III.4). CDS volatility was multiplied by a factor of 3.5

between 15 and 18 March in the case of GM (jumping from 32% to 110%) and almost twofold in the case of Ford (climbing from 30% to 56%). Volatility remained high until end-August 2005.

Chart III.4: Volatility of GM and Ford's CDS premia (in percentage)

Vertical lines stand for the three periods (12/15/04 to 03/15/05; 03/16/05 to 08/24/05; 08/25/05 to 02/28/07).



Sources: Bloomberg,. Author's calculations.

We consider that the crisis corresponds to this period of high volatility. Its beginning is dated by the jump in volatility on the 16th of March 2005, which exactly matches the profit warning announced by GM. It ends on the 24th of August 2005, when both firms were downgraded by Moody's and when volatility had already notably decreased.

This definition of the crisis period differs from that of Acharya *et al*. (2008), who saw the crisis start as early as October 2004, when GM was downgraded to BBB− by S&P. However, it seems appropriate for several reasons. (i) In January and February 2005, bond spreads and CDS premia were at historically low levels, as well as their volatility; even for GM, the CDS premia were moderate (200 bp) and their volatility low. Hence, it seems difficult to include this period in the crisis. This situation dramatically changed in March 2005, after GM announced its loss: the cost of protection on GM promptly surged to more than 1000 bp. (ii) The beginning of the crisis in March 2005 matches the analyses made by the major institutions supposed to scrutinize financial markets, such as the IMF (2005) or the BIS (Packer and Woolridge, 2005). (iii) The volatility of GM CDS more than tripled in March 2005, which did not occur before.

Consequently, it is possible to split the sample into three sub-periods:

- a reference period just before the crisis,when premia and volatility were particularly low. This period is defined as running from 15 December 2004 to 15 March 2005 (3 months). The small size of this reference period meets the requirements of Dungey (2001), as correlations tests might be biased by too large reference periods;
- the crisis period, from 16 March to 24 August 2005;
- the post-crisis period, running from August 2005 to February 2007, i.e. prior to the turbulences of summer 2007.

2.3. The sample used

The sample contains daily data on the CDSs present in the four North-American and European 5-year CDS indices, that are highly traded and represent benchmarks for the markets:

- the CDX NA IG, for North-American investment grade (IG hereafter) firms;
- the iTraxx Europe Main, for European investment grade firms;
- the CDX NA HY, for US speculative grade, or high yield, firms (HY hereafter);
- the iTraxx Europe Crossover, for European speculative grade firms.

These CDS indices are equally weighted baskets made up of a number of CDSs, 125 in the case of the CDX NA IG and the iTraxx Main, 100 for the CDX NA HY and 30 for the iTraxx Crossover. On the whole, 380 CDSs are included in these four indices. Every 6months, a new updated index is launched, including the most liquid CDSs. The new series (the “on-the-run” series) replaces the old one (the “off-the-run” series), which continues to be traded until its component CDSs reach maturity.

We start by collecting data on all these 5-year CDS on the period running from 6 January 2004 to 28 February 2007. A number of entities are eliminated because of unavailable or missing data, in the Bloomberg and Datastream databases over the period. Moreover, we select the entities that appeared in the on-the-run indices throughout the period under review, for they are supposed to be more representative (for more detail, see Appendix A). We end up with a sample of 224 CDSs, broken down among the different indices as shown in Table III.2. The CDSs of GM and Ford are added to the list. The 224 companies in the sample are shown in Tables A1 and A2 in Appendix A.

Table III.2: Number of CDS in the indices and in the sample

	Index	Sample
CDX NA IG	125	93
Consumers	24	21
Energy	14	13
Financial	25	22
Industrials	20	23
TMT	22	14
iTraxx Main	125	84
Consumers	30	22
Energy	20	16
Financial	25	14
Industrials	20	11
TMT	20	13
Autos	10	9
CDX NA HY	100	34
iTraxx Crossover	30	13
Total	380	224

As entities that go bankrupt or break the threshold of the speculative grade are removed from the on-the-run indices, this sample selection could have induced a possible "survivorship" bias, if it were conducted over a long period of time. However, there are few of such events over the considered period, because (i) it is relatively short (4 years) and (ii) it does not contain big economic turmoil, except the crisis under review. Only 4 firms in the 380 present in the index at the beginning went bust (Delphi in the CDX NA IG; Dana, Dura and Millennium in the CDX NA HY); 15 out of 380 were downgraded from investment grade to high yield (8 in the CDX NA and 7 in the iTraxx), apart from GM and Ford, that are obviously included in the sample, despite belonging to this category.

2.4. *Description of the data*

Most of the CDS premia in the sample have a unit root, as evidenced in Tables A1 and A2 in Appendix A. Therefore, for calculating volatility and correlations, we make them stationary by using their log first differences x_t^i:

$$x_t^i = \log(c_t^i) - \log(c_{t-1}^i) \tag{III.1}$$

where c_i^t is the CDS premium of firm $i, i = 1, \ldots, 224$ in period t. The resulting x_t^i series are stationary and comparable to financial asset returns. This is the method used by Acharya and Johnson (2007)[57], Jorion and Zhang (2007) and Scheicher (2009).

During the reference period, i.e. just before the crisis (15 December 2004 – 15 March 2005), CDS premia were particularly low and stable: 33 bp on average for the CDS IG index and 73 bp for our global index (Table III.3). At that time, default rates were low and investors' risk appetite was high. Then, during the crisis, CDS premia posted a sharp increase in all sectors, reaching 94 bp in the case of the global index. CDS volatility rose sharply during the crisis, jumping on average from 42% to 60%. The whole automotive industry was affected, with volatility increasing threefold between the first two periods. The European and US high yield segments were also impacted.

Table III.3: Mean and volatility of CDS premia (sample of 226 firms)

	Mean (in basis points)			Volatility (in %)		
	Period 1 *(pre-crisis)*	Period 2 *(crisis)*	Period 3 *(post-crisis)*	Period 1 *(pre-crisis)*	Period 2 *(crisis)*	Period 3 *(post-crisis)*
CDX NA IG	32.9	40.6	31.4	44.8	66.2	55.4
Consumers	31.8	38.8	30.1	50.7	65.8	56.1
Energy	35.4	42.1	32.4	42.2	65.3	48.4
Financials	31.6	36.6	23.7	41.4	60.1	57.3
Industrials	30.5	41.7	32.2	38.8	77.0	53.1
TMT	38.4	46.3	43.0	53.7	59.3	61.3
CDX NA HY	233.1	297.6	268.9	65.1	81.8	64.4
iTraxx Main	32.97	38.7	31.5	28.9	44.7	31.8
Autos	35.92	51.0	39.8	20.0	63.3	30.8
Consumers	43.69	51.2	38.4	32.5	46.9	32.0
Energy	23.46	27.6	21.7	21.0	32.8	28.5
Financials	18.57	21.5	14.3	30.5	38.6	36.2
Industrials	31.12	40.8	35.2	36.8	46.8	32.0
TMT	35.25	39.3	42.6	30.0	48.0	31.5
iTraxx Crossover	211.0	302.4	224.9	39.0	62.5	37.8
Global index[a]	73.3	94.1	78.7	41.6	60.3	46.9
General Motors	297.1	698.8	814.1	39.0	80.2	49.3
Ford	239.7	541.2	734.3	40.8	79.6	50.4

[a] Index composed by all the CDS in the sample except GM and Ford (224).
Note: Period 1: from 12/15/04 to 03/15/05; period 2: from 03/16/05 to 08/24/05; period 3: from 08/25/05 to 02/28/07.

2.5. Intra-sectoral correlations between CDSs

CDS premia generally fluctuate in line with each other, which results in positive correlations. A positive correlation suggests that the market is underpinned by common

[57] Acharya and Johnson (2007) then regress these series on their lagged values and stock prices (in a linear and non-linear manner), in order to get the "innovations" on the CDS market as the residuals of the regression. This allows them to test for insider trading in the CDS market, using the stock market as a benchmark for public information.

dynamics, which are likely to generate contagion effects in the event of a crisis. The correlation coefficient is 0.14, on average for the 224 firms in the whole sample (Table III.4, last column, last line). This figure is not particularly high, when compared to the correlation obtained on the equity market for the same sample (0.18). Like on other financial markets, correlations are stronger within each sector than for the global index. Intra-sectoral correlations increased during the crisis; and then decline back to around their initial level in the following period.

Table III.4: Intra-sectoral correlations between CDS premia
(average correlations between the CDS of firms within index and sector)

	Period 1 *(pre-crisis)*	Period 2 *(crisis)*	Period 3 *(post-crisis)*	Period 1 to 3
CDX NA IG	0.087	0.175	0.064	0.092
Consumers	0.073	0.119	0.093	0.094
Energy	0.102	0.315	0.131	0.179
Financials	0.076	0.242	0.078	0.117
Industrials	0.205	0.255	0.104	0.159
TMT	0.166	0.324	0.124	0.157
CDX NA HY	0.051	0.124	0.102	0.091
iTraxx Main	0.189	0.422	0.187	0.254
Autos	0.459	0.791	0.374	0.581
Consumers	0.280	0.561	0.259	0.353
Energy	0.315	0.556	0.355	0.393
Financials	0.180	0.380	0.319	0.314
Industrials	0.286	0.559	0.278	0.331
TMT	0.522	0.706	0.399	0.503
iTraxx Crossover	0.248	0.437	0.316	0.354
Global index [a]	0.096	0.238	0.097	0.136

[a] Index composed by all the CDS in the sample except GM and Ford (224).

Note: Period 1: from 12/15/04 to 03/15/05; period 2: from 03/16/05 to 08/24/05; period 3: from 08/25/05 to 02/28/07.

3. Correlations between firms' CDSs and those of GM and Ford during the crisis

We now calculate the correlations between the CDSs of the 224 firms and those of the two originators of the crisis, GM and Ford, and compare them between the reference period and the crisis period. If they rise significantly during the crisis, we can conclude to contagion effects. We also test for "shift-contagion", as we take stock of the works by Forbes and Rigobon (2002), that recommended adjusting the correlation coefficients for changes in volatility.

3.1. *Adjusting correlation and "shift-contagion"*

If the volatility of one asset increases markedly, its correlation with the other assets will mechanically increase. This may occur even when the underlying linkages between the two assets remain constant (Boyer *et al*., 1999; Forbes and Rigobon, 2002). To illustrate this phenomenon, let us consider a simple model where the returns on two assets are linked. The return on asset 1, x_t, is subjected to random shocks ε_t; the return on asset 2, y_t, to random independent shocks η_t. The return on asset 2 is assumed to be impacted by a fraction β of the shocks affecting asset 1:

$$\left.\begin{array}{c} x_t = \varepsilon_t \\ y_t = \beta x_t + \eta_t \end{array}\right\} \qquad \text{(III.2)}$$

where ε_t and η_t are independent random variables with a zero mean and variances σ_ε^2 and σ_η^2; β is a constant coefficient.

Any return pair (x_t, y_t) with a normal bivariate distribution may be written as model (III.2) (Boyer *et al*., 1999). The correlation coefficient ρ between the two returns is written as follows:

$$\rho = \frac{\beta\sigma_\varepsilon}{\sqrt{\beta^2\sigma_\varepsilon^2 + \sigma_\eta^2}} \qquad \text{(III.3)}$$

If the volatility of shocks affecting the first asset σ_ε^2 increases, σ_η^2 being constant, the correlation coefficient also increases. It tends towards 1 when the volatility of asset 1 is very high.

$$\sigma_\varepsilon^2 \gg \sigma_\eta^2 \Rightarrow \rho \to 1 \qquad \text{(III.4)}$$

Let us now consider a crisis period for asset 1. By definition, the variance of the shocks during the crisis, denoted ${\sigma_\varepsilon^C}^2$, is higher than its usual value σ_ε^2. The conditional correlation ρ^C may be written in the following form, which depends on the ratio of the variances of x_t during the crisis and in normal circumstances:

$$\rho^C = \rho\left[\rho^2 + (1-\rho^2)\frac{\sigma_\varepsilon^2}{{\sigma_\varepsilon^C}^2}\right]^{-\frac{1}{2}} \qquad \text{(III.5)}$$

As the variance of the shocks is greater during the crisis, the correlation coefficient is automatically higher during this period:

$${\sigma_\varepsilon^C}^2 > \sigma_\varepsilon^2 \Rightarrow \rho^C \to \rho \qquad \text{(III.6)}$$

Boyer *et al*. (1999) suggest correcting this bias by calculating an adjusted correlation coefficient ρ^A:

$$\rho^A = \rho^C\left[1 + \delta\left(1 - \rho^{C^2}\right)\right]^{-\frac{1}{2}} \tag{III.7}$$

$$\delta = \frac{\sigma_\varepsilon^{C^2}}{\sigma_\varepsilon^2} - 1 \tag{III.8}$$

When this adjusted correlation coefficient rises, there is “shift-contagion”, according to Forbes and Rigobon (2002). Shift-contagion therefore refers to a disruption in the usual mechanisms of price transmission between assets. This distinction is useful. However, we must keep in mind that all contagion effects do not necessarily go through “shift-contagion”. For example, Forbes and Rigobon (2002) showed that there was no shift-contagion effects at stake in the 1997 Asian crisis. The usual interdependence between asset prices within the area is sufficient to explain why the crisis in Thailand rippled over to the neighbouring countries. Therefore, two types of contagion can be observed. The former is the usual contagion due to interdependence (like in the Asian crisis), that can be assessed by a rise in correlations. The other is shift-contagion, as described above, which can be evidenced by an increase in adjusted correlations.

This adjustment was criticised by Corsetti *et al*. (2005) on the ground that it does not allow to correct the bias on the correlation coefficient if the data generating process includes a common factor (such as a rise in interest rates or in the price of oil, which affects all assets). In this case, the correction to be made should also depend on the common factor.

In our case, the method seems appropriate. On the one hand, the volatility of GM and Ford CDS premia posted a sharp rise during the crisis, which could explain part of the increase in correlations. On the other hand, the initial shock does not come from a common factor affecting the CDS market, but is clearly idiosyncratic, as it stems from the difficulties of two specific firms, in which case the Corsetti’s criticism does not hold. This view of an idiosyncratic shock affecting the market is shared by the IMF (2005) and the BIS (Packer and Woolridge, 2005), when reviewing the corporate debt markets at that time, as well as by market analysts (Venizelos, 2005). Another evidence is provided by the gap between the price of CDO’s equity tranche, that surged, and mezzanine tranches, that remained stable (Beinstein *et al*., 2005; Packer and Woolridge, 2005). A further evidence could be found in the much smaller CDS spreads on all other firms but GM and Ford, even on the other car-makers.

3.2. Plain and adjusted correlations

First, we take a look at the plain correlations between the CDSs of the 224 firms and those of GM and Ford. These correlations notably increased during the crisis, from 9.1% to 25% overall, but also on average for each sector (Table III.5). Investment grade CDSs seem to have been impacted as well as the high yields. More detailed results at a firm-level show that correlations with GM increased for 200 firms out of 224, and with Ford for 179 of them. Secondly, we carry out the adjustment described in Equations (III.7) and (III.8). The adjusted correlations obtained are inevitably lower than those calculated previously (Table III.5). However, there is still some increase in correlation during the crisis, from 9.1% to 13.0%.

Table III.5: Average correlations between the 224 CDS and GM and Ford (by index and sector)

	Period 1 *(pre-crisis)*	Period 2 *(crisis)*		Period 3 *(post-crisis)*
		Correlations	Adjusted correlations	
CDX NA IG	0.071	0.205	0.105	0.058
Consumers	0.060	0.148	0.077	0.061
Energy	0.055	0.249	0.128	0.059
Financials	0.032	0.209	0.107	0.037
Industrials	0.071	0.198	0.102	0.068
TMT	0.163	0.254	0.131	0.068
CDX NA HY	0.067	0.198	0.102	0.065
iTraxx Main	0.115	0.303	0.159	0.071
Autos	0.185	0.422	0.227	0.105
Consumers	0.133	0.336	0.177	0.069
Energy	0.103	0.231	0.118	0.049
Financials	-0.009	0.185	0.094	0.037
Industrials	0.159	0.348	0.183	0.097
TMT	0.153	0.349	0.183	0.099
iTraxx Crossover	0.145	0.356	0.190	0.141
Global index[a]	0.091	0.250	0.130	0.069

[a] Index composed by all the CDS in the sample except GM and Ford (224).

Note: Period 1: from 12/15/04 to 03/15/05; period 2: from 03/16/05 to 08/24/05.

The decomposition by industry enables us to take a closer look at the car-industry in the case of Europe. The increase in correlation was particularly marked in the auto-industry, when considering unadjusted correlations (from 18.5% to 42.2%), although it is much smaller after the adjustment is made (22.7%), evidencing high volatility (Table III.5). Individual results of this sector show that all the auto-firms in the sample had their CDS premia positively correlated with those of GM and Ford during the crisis. This shows that there were no competitive effects inside the auto-industry, as the other carmakers did not benefit from GM and Ford difficulties. Moreover, the adjusted correlations between the

CDS of the car-makers and GM increased for all firms in the sample (although not with Ford).

The financial sector was also impacted through counterparty risk, which confirms results by Acharya *et al*. (2008). Its CDSs were hardly correlated with those of GM and Ford before the crisis (3.2% for the CDX and −0.9% for the iTraxx), but the correlation turned positive during the crisis (20.9% and 18.5%, respectively). However, this impact is not more important than on the other industries. When looking at the second and third columns of Table III.5, we see that the levels of correlations, adjusted or not, with the two distressed firms were higher for other industries than financials.

3.3. *Testing for contagion*

The increase in correlation is not necessarily due to contagion, as it may stem from a random phenomenon. In order to determine whether this movement is significant or not, we carry out a test of equality of correlations. The null hypothesis is the equality of the two correlations in the pre-crisis period ρ and in the crisis period ρ^C:

$$\begin{aligned} H_0 &: \rho^C = \rho \\ H_1 &: \rho^C > \rho \end{aligned} \tag{III.9}$$

The correlation coefficients are transformed according to Fisher's transformation:

$$z(\hat{\rho}) = \frac{1}{2}\ln\frac{1+\hat{\rho}}{1-\hat{\rho}} \tag{III.10}$$

where $\hat{\rho}$ is the estimated correlation coefficient. Under the assumption of the two samples drawn from the same normal bivariate distribution (as Forbes and Rigobon, 2002; or Corsetti *et al*., 2005), the difference between the estimated $z(\hat{\rho})$ in the two samples converges to a normal distribution with mean zero and variance $\left(\frac{1}{n^T-3} + \frac{1}{n^C-3}\right)$, where n^C is the size of the sample for the crisis period and n^T for the tranquil period. Hence, we use the following Student's t-statistic:

$$t = \frac{z(\hat{\rho}_t^C) - z(\hat{\rho}_t^T)}{\sqrt{1/(n^T-3) + 1/(n^C-3)}} \tag{III.11}$$

We consider that contagion took place if we reject the null hypothesis of equality of correlations with a confidence threshold of 90% or 95%.

3.4. Results for contagion

Results show that contagion effects did occur in the CDS market. The GM crisis affected more than half of the CDSs in the sample, as evidenced by the significant rise in correlations (second and third columns of Table III.6). 127 out of 224 firms had their correlations with GM increased significantly at a 90% confidence threshold, and 103 at a 95% threshold. Contagion from Ford is much less marked: 49 firms were impacted with a 90% threshold, and 23 with a 95% threshold (fourth and fifth columns of Table III.6).

On the whole, the CDS market reacted much more to GM difficulties than to those of Ford (Table III.6). It seems rational for two strands of reasons. First, the crisis was much more severe for GM which announced a loss in March 2005, whereas Ford only announced a lower benefit than expected. This is materialised by the more dramatic rise in GM's CDS spread from 304 to 567 bp in March 2005, whereas that of Ford rose from 244 to 357 bp. Second, GM was bigger than Ford, in respect to its consolidated turnover (USD 192.6 billion versus USD 177.1 billion) as well as its total assets (USD 476.1 billion versus USD 269.5 billion for total assets). GM's debt was also much greater than Ford's one (USD 203 billion versus USD 122 billion)[58].

Contagion hit all industries, geographical areas and categories (IG or HY) across the board. American and European firms seem equally affected. This may be due to several factors. (i) A large share of the deals on the CDS market are trades on indices, tranches of indices or synthetic CDOs, and not on individual entities (Fitch, 2007); in these cases, positions are taken or liquidated for a whole range of CDS simultaneously. (ii) The CDS market was highly concentrated around a few large market makers and investors, especially at that time. Consequently, any difficulties supported by market participants were more likely to spread on the whole market. (iii) Both distressed firms are multinationals, able to impact the world economy. European firms even seem to have been more impacted when looking at the sub-indexes, especially because the iTraxx index contains a sub-index of the auto-industry, whereas it is not the case for the North-American index.

The results confirm the previous interpretations made on the rise of correlations. The automotive sector was particularly affected: all the 9 CDSs included in this sub-index are more highly correlated with GM during the crisis. The financial sector was also impacted by contagion, 12 out of 14 firms in Europe, 9 out of 22 in North America. This suggests the same contagion effects as those evidenced by Acharya *et al.* (2008), through liquidity

[58] 2005 figures, source: GM and Ford annual reports.

effects on financial intermediaries. However, the results are broader, since a majority of the firms in the sample are affected in all sectors across the board, not only in the auto and financial industries.

We now apply the same test to adjusted correlations. Similarly, we consider that there was shift-contagion if the null hypothesis of equality of adjusted correlations is rejected. There is little evidence for shift-contagion. After adjusting correlations, only 38 CDSs out of 224 display significantly higher correlations with GM during the crisis period (sixth column of Table III.6), and much fewer with Ford (3). Hence, following the interpretation given by Forbes and Rigobon (2002), the higher correlations observed during the crisis are not due to shifts in transmission mechanisms, but results from the usual interdependence within the CDS market.

Table III.6: Number of CDS affected by contagion from the GM and Ford crisis

	Number of CDS in the sample	Contagion[a] from				"Shift-contagion"[a] from			
		GM		Ford		GM		Ford	
		10%	5%	10%	5%	10%	5%	10%	5%
CDX NA IG	93	36	28	19	7	12	7	1	0
Consumers	21	5	5	5	3	1	0	0	0
Energy	13	5	5	5	2	0	0	0	0
Financials	22	9	9	2	0	2	0	0	0
Industrials	23	6	6	5	2	4	0	0	0
TMT	14	3	3	2	0	0	0	0	0
CDX NA HY	34	14	12	8	3	4	2	1	0
iTraxx Europe	84	66	54	18	10	19	6	1	1
Autos	9	9	9	2	1	1	0	0	0
Consumers	22	17	15	7	6	1	0	0	0
Energy	16	8	6	2	0	0	0	0	0
Financials	14	12	12	2	1	3	0	0	0
Industrials	11	9	6	2	1	0	0	0	0
TMT	12	11	6	3	1	1	0	0	0
iTraxx Crossover	13	11	9	4	3	3	2	0	0
Global Index[b]	224	127	103	49	23	38	17	3	1

[a] Contagion is defined as a significant increase in the non-adjusted correlations between firms CDS premia and those of GM or Ford; "shift-contagion" is defined in the same way, using correlations adjusted for volatility effects.

[b] Index composed by all the CDS in the sample except GM and Ford (224).

4. Effect of the crisis on dynamic correlations

4.1. EWMA conditional correlations

One of the limitations of the previous calculations is to provide correlations for a number of subperiods, without analysing the underlying dynamics within each period. To overcome this problem, we now calculate dynamic correlations between the CDS premia of the two originators and those of the firms in the sample for the entire period. To do so, we use an Exponentially Weighted Moving Average (EWMA). This choice relies on several studies that have concluded that EWMA or GARCH(1,1) models perform better than other complex formulations in forecasting volatility (Beltratti and Morana, 1999; Berkowitz and O'Brien, 2002; Lopez and Walter, 2000; Ferreira and Lopez, 2005). The same type of conclusions could be applied to correlations.

The EWMA variance of an asset return x_t (with zero mean) is a moving average of the quadratic yields weighted with exponentially decreasing weightings:

$$\hat{\sigma}_t^2 = \frac{\sum_{k=1}^{n} \lambda^{k-1} x_{t-k}^2}{\sum_{k=1}^{n} \lambda^{k-1}} \qquad \text{(III.12)}$$

with $0 < \lambda < 1$. When n tends toward infinity, the EWMA variance can be written in an autoregressive form equivalent to an I-GARCH(1,1) model with a zero constant, albeit the decay parameter λ is estimated differently:

$$\hat{\sigma}_t^2 = (1-\lambda) x_{t-1}^2 + \lambda \hat{\sigma}_{t-1}^2 \qquad \text{(III.13)}$$

λ is estimated by optimizing variance forecasts given by Equation (III.13), which is obtained by minimizing the root mean squared errors of forecasts (as J.P. Morgan, 1996). Here, we have found λ equal to 0.94 on our sample of daily CDS premia. This figure matches the one found by J.P. Morgan (1996) on a sample of several financial markets.

The EWMA correlation can be calculated in the same way, with the same decay parameter. We therefore calculate correlations with the 224 CDS of and those of GM and Ford, by applying exponentially decreasing weightings:

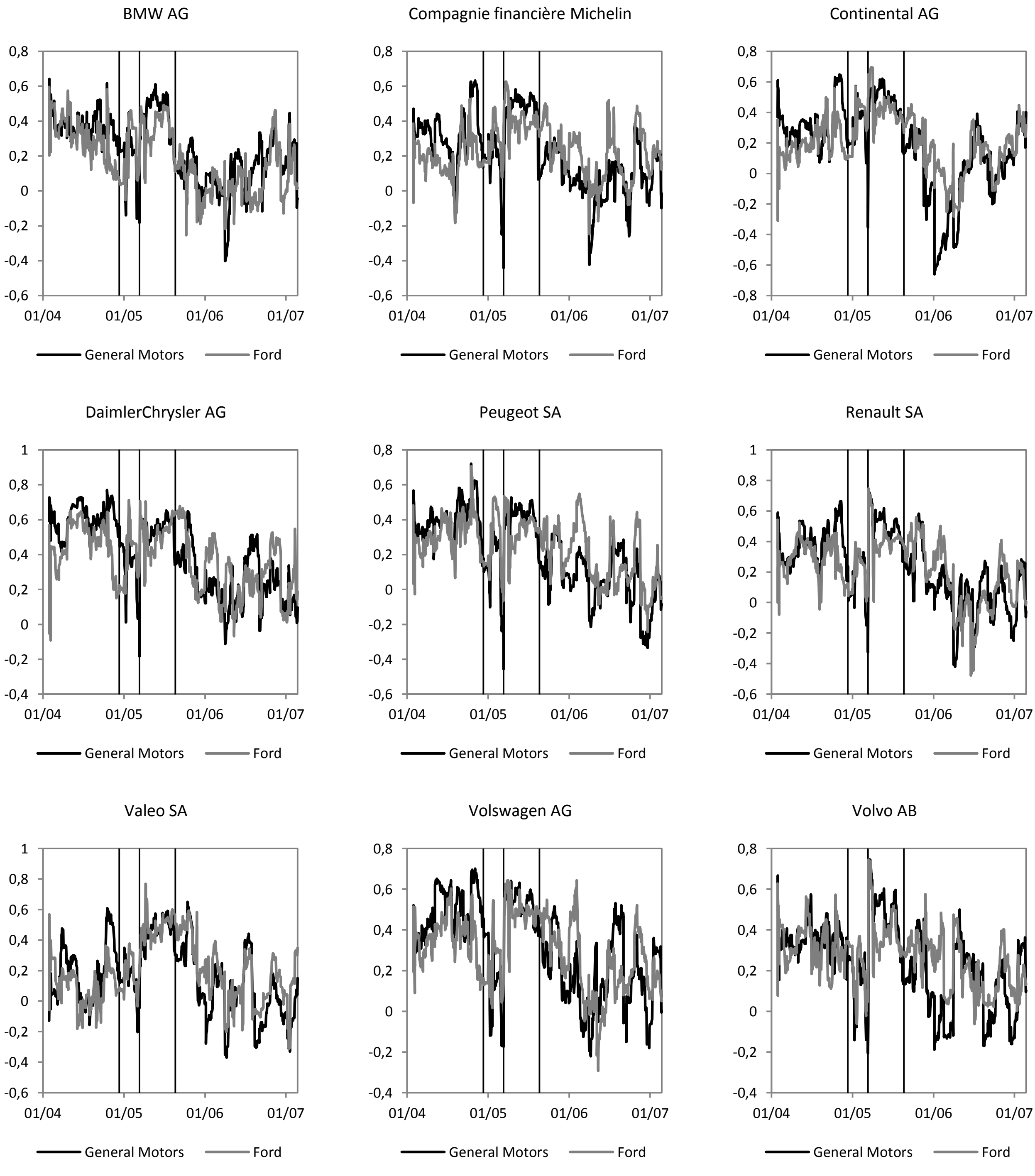
$$\hat{\rho}_t^{Ki} \simeq (1-\lambda) \frac{x_{t-1}^K x_{t-1}^i}{\hat{\sigma}_{t-1}^K \hat{\sigma}_{t-1}^i} + \lambda \hat{\rho}_{t-1}^{Ki} \qquad \text{(III.14)}$$

where K is the originator of the crisis (i.e. GM or Ford); i a given firm in the sample; x_t^i is the log first difference of firm i's CDS premia. Chart III.5 shows the correlations calculated using this method for the automotive sector firms. These correlations increase sharply during several days in March 2005, which coincide with the start of the crisis.

Chart III.6 shows the average correlations between the 224 CDSs and each one of the two originators of the crisis. It also points to an increase in correlations in the first days of the crisis.

Chart III.5: EWMA correlations between the originators' CDS and firms in Autos sector

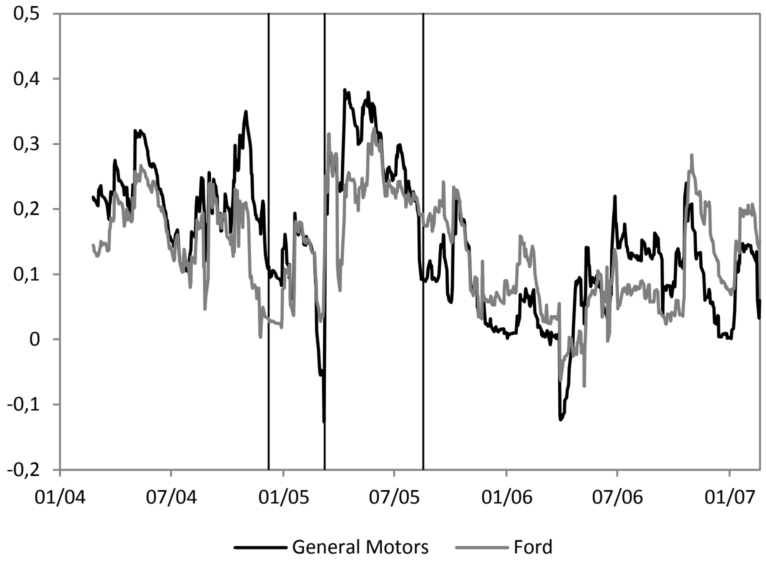
Vertical lines stand for the three periods (12/15/04 to 03/15/05; 03/16/05 to 08/24/05; 08/25/05 to 02/28/07).



Sources: Bloomberg,. Author's calculations.

Chart III.6: Average EWMA correlation between the 224 firms' CDS And the crisis originators (GM and Ford)

Dotted lines stand for the three periods (12/15/04 to 03/15/05; 03/16/05 to 08/24/05; 08/25/05 to 02/28/07).



Sources: Bloomberg,. Author's calculations.

In order to verify this hypothesis econometrically, we test whether the correlations between the CDSs of the originators and those of the other firms in the sample have increased significantly over the crisis period. We define a dummy variable D_t representing the crisis, equal to 1 during the crisis (from 17 March 2005 to 24 August 2005) and 0 before and after the crisis:

$$\begin{cases} D_t = 1 \text{ if } t \in [30/17/2005, 08/24/2005] \\ D_t = 0 \text{ elsewhere.} \end{cases} \quad \text{(III.15)}$$

Like Chiang *et al*. (2007), we estimate an equation linking the correlations to their lagged values and the dummy variable, as follows:

$$\rho_t^{Ki} = cst^{Ki} + a^K \rho_{t-1}^{Ki} + b^K D_t + u_t^{Ki} \quad \text{(III.16)}$$

The regression is run on panel data for the 224 series of correlations successively for each originator. Fixed effects cst^{Ki} are introduced. The results are displayed on the first two rows of Table III.7. They show that the correlations increased significantly by a daily 1 percentage point during the crisis period. When taking into account the autoregressive coefficient of 0.94, we find that the correlations increased by 16.6% at the end of the crisis (this figure being equal to $\frac{0.01}{1-0.94}$).

Table III.7: Panel regressions: 224 EWMA correlations on their lagged values and crisis dummies

Coefficient	General Motors		Ford	
Lagged endogenous variable	0.94*** (1 241.0)	0.94*** (1 246.4)	0.93*** (1 259.0)	0.93*** (1 261.1)
Crisis dummy	0.01*** (23.9)	0.01*** (15.0)	0.01*** (21.9)	0.01*** (17.0)
One-week crisis dummy		0.07*** (41.2)		0.04*** (23.4)
R^2	0.91	0.91	0.91	0.91
F-value	8351.2	8398.9	8302.3	8292.7

Significant at * 10%, ** 5%, *** 1%; Student-t in brackets.

As Charts III.5 and III.6 point to a marked rise in correlations at the very start of the crisis, we verify this econometrically. To do so, we include in Equation (III.16) another indicative variable Dw_t equal to 1 during the week following the first day of the crisis, i.e. from 17 to 23 March 2005, and 0 the rest of the time:

$$\rho_t^{Ki} = cst^{Ki} + \alpha^K \rho_{t-1}^{Ki} + b^K D_t + d^k Dw_t + u_t^{Ki} \quad \text{(III.17)}$$

The last row of Table III.7 shows that the correlations increased significantly more during the first week of the crisis, by an additional 7% on a daily basis in the case of GM, 5% for Ford. Taking account of the auto-regressive form, the correlations of all CDS premia with those of General Motors increased by 35% at the end of the first week of the crisis. They increased by 27% with those of Ford.

These results are confirmed when we estimate Equation (III.17) individually at firm-level, for each one of the 224 firms and the 2 originators, rather than conduct a panel estimation. The correlation with GM increases significantly during the first week of the crisis (at a 10% threshold) for 158 CDSs out of 224, and during the entire crisis period for 34 CDSs. The correlation with Ford increases significantly for 103 firms out of 224 during the first week of the crisis and for 79 firms during the entire crisis period.

Another issue is to find out whether the volatility of correlations is higher during the crisis period. This may occur during crises, as evidenced by Chiang *et al*. (2007) for Asian stock returns in the aftermath of the Asian crisis. We test this hypothesis by estimating a univariate GARCH(1,1) on each correlation, including dummy variables:

$$h_t^{Ki} = \alpha^K h_{t-1}^{Ki} + \beta^K \varepsilon_{t-1}^{Ki^2} + \delta^K D_t + \gamma^K Dw_t + \eta_t^{Ki} \quad \text{(III.18)}$$

where h_t^{Ki} is the volatility of residuals ε_t^{Ki}, linked to correlations. For GM, only 40 out of the 159 convergent estimates (45 out of 186 for Ford) have a significant coefficient on the crisis dummy and only 2 during the first week (12 for Ford). Therefore, we cannot conclude that the volatility of correlations is greater during the crisis, although the correlations themselves are significantly higher.

4.2. DCC-GARCH correlations

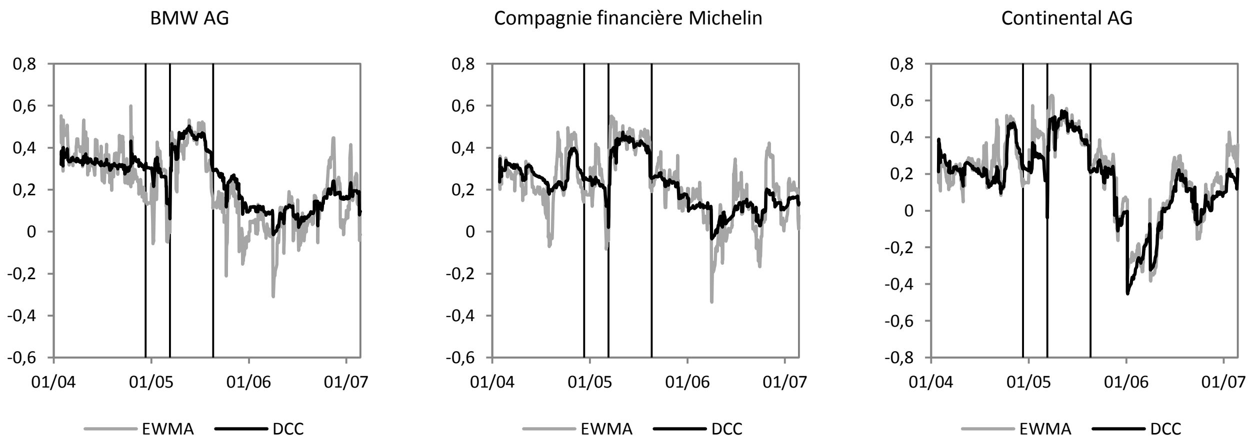
We verify the results presented above by calculating the dynamic correlations by means of a DDCGARCH model (Dynamic Conditional Correlation GARCH), like Engle and Sheppard (2001) and Engle (2002) (see Appendix B). We calculate 448 bivariate DCC-GARCH estimates that correspond to the

224 GM and Ford return pairs. Only 67 estimates out of 448 yield satisfactory results: convergence of the model and significant parameters. The correlations obtained here are not very different from the previous ones[59], as shown in Chart III.7, which represents the two types of correlations EWMA and DCC-GARCH for the automotive sector.

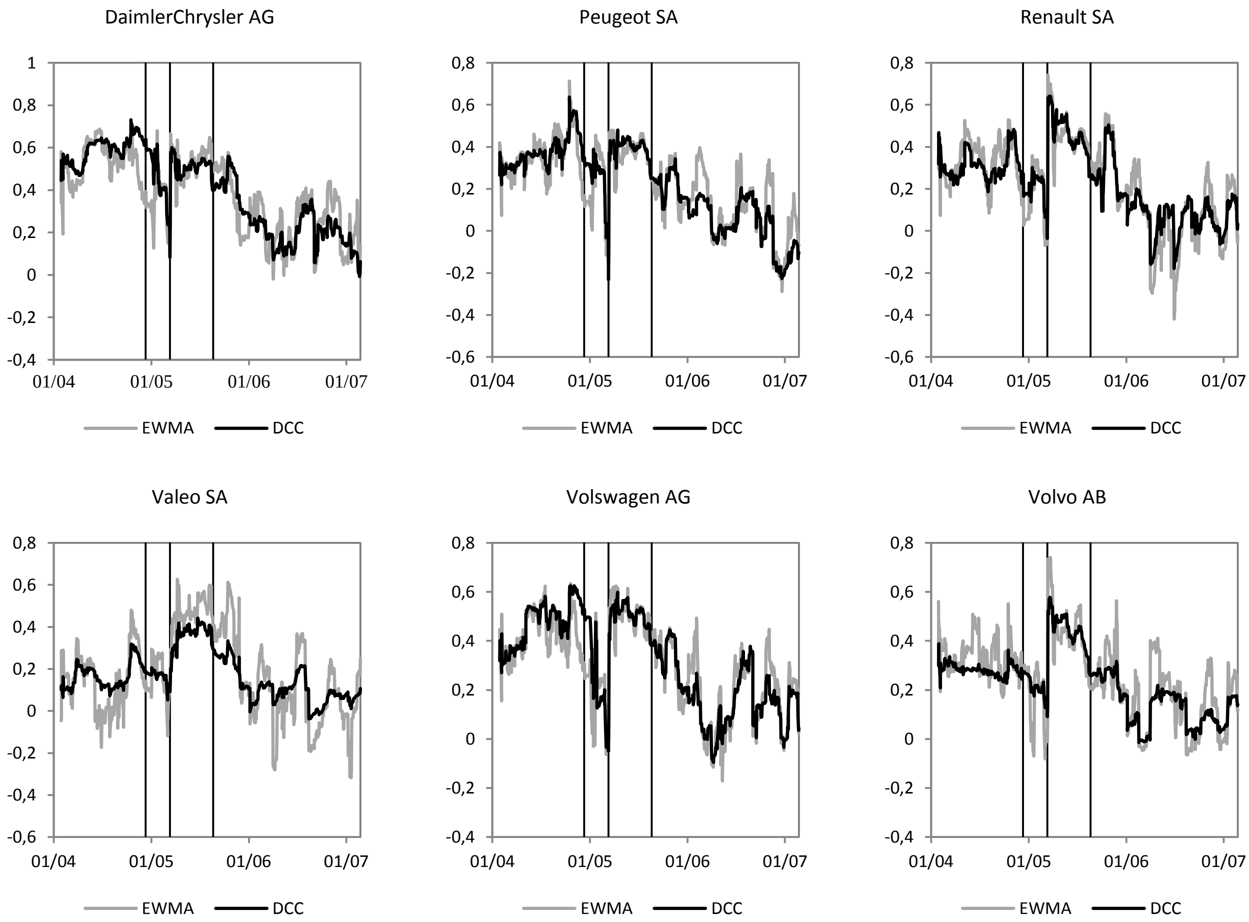
We apply the same regressions as Equations (III.16) and (III.17) on the 67 DCC-GARCH correlations. The results confirm the previous ones, as shown in Table III.8. Correlations rose significantly during the crisis period, by 1%, and especially during the first week, respectively, by 7% and 3% for GM and Ford. Overall, the two methods point to a significant increase in correlations within the CDS market.

Chart III.7: EWMA and DCC correlations between the originators' CDS and firms in Autos sector (average correlation of each firm with GM and Ford)

Vertical lines stand for the three periods (12/15/04 to 03/15/05; 03/16/05 to 08/24/05; 08/25/05 to 02/28/07).



59 This may be due to the fact that the average coefficients that we obtain in the estimation (0.83 on the autoregressive parameter β and 0.06 for the shock parameter α) are not very different from the 0.94 and 0.06 that we used in the EWMA.



Sources: Bloomberg,. Author's calculations.

Table III.8: Panel regressions: 67 DCC correlations on their lagged values and crisis dummies

Coefficient	General Motors		Ford	
Lagged endogenous variable	0.91*** (464.0)	0.92*** (466.4)	0.88*** (226.1)	0.88*** (226.3)
Crisis dummy	0.01*** (13.8)	0.01*** (9.7)	0.01*** (8.0)	0.01*** (7.2)
One-week crisis dummy		0.06*** (19.0)		0.02*** (3.5)
R^2	0.89	0.89	0.84	0.84
F-value	6233.9	6172.7	3986.7	3800.2

Significant at * 10%, ** 5%, *** 1%; Student-t in brackets.

5. Conclusion

In this article, we analyse the possible contagion of the crisis experienced by General Motors and Ford in May 2005 to the whole CDS market. At that time, both firms' CDS premia increased sharply and all other CDS premia rose markedly for US and European firms. As contagion is usually characterized by increasing correlations between risky assets, we study the changes in the correlations between CDS premia around the time of the crisis, by calculating them through different measures. To do so, we construct a sample of 226 CDSs that are representative of the US and European indices (CDX and iTraxx). Correlations between a majority of CDS in the sample and those of GM increased significantly during the crisis. This can be interpreted as a contagion effect.

These results are confirmed, when using dynamic measures, such as EWMA or DCC-GARCH. We also find that average correlations between CDS premia and those of GM and Ford increased significantly (by 17%) during the crisis episode. Nevertheless, there is little “shift-contagion” in the sense of Forbes and Rigobon (2002), as correlations adjusted for biases due to higher volatility are not significantly different. In this sense, the usual price transmission mechanisms within the CDS market were not shifted by the crisis; but the strong interdependence inside the market and the high volatility generated by the crisis were sufficient to significantly raise most correlations. All industries were hit across the board, although auto-makers were particularly affected. Both the US and the European markets were impacted. Their similar response also points to the strong international integration of the credit markets.

Appendix

Appendix A - Construction of the database

The sample is made up of 224 5-year CDS premia, plus CDSs of the two originators of the crisis, GM and Ford over the period 01/06/2004 to 02/28/2007 (Tables III.A1 and III.A2). It contains the most traded 5-year CDSs. In order to have sufficiently liquid and representative CDSs, we chose CDSs belonging to the main CDS IG indices (iTraxx Main for Europe and CDX NA IG for North America) and HY indices (iTraxx Crossover for Europe and CDX NA HY for North America). CDS indices are updated every 6 months: the new series include the most liquid CDSs at the time of issuance. The sample only contains the CDSs present in all the series during the entire period under review.

We draw on two databases, Bloomberg and Datastream. Bloomberg aggregates the prices of several contributors. When the number of contributors displaying a price is insufficient on a given date, Bloomberg does not post up a price on that day. Datastream provides the prices of a single contributor (in the pool of Bloomberg contributors); there are therefore no missing values in the series (the contributor always posts up a price, whether quoted or traded).

The sample is constructed as follows: (i) The CDSs for which the Bloomberg and Datastream series begin after the starting date of our sample are not taken into account. If only one of the two databases provides a series starting before early 2004, we use this database; (ii) The Bloomberg series is used if the proportion of missing values is less than 10% (excl. week-ends and bank holidays) and does not cover more than 5 consecutive days (in this case, the missing values are interpolated); otherwise, the Datastream series is used (provided it exists); (iii) If the Bloomberg series does not meet the conditions mentioned above and the Datastream series does not exist, the CDS is removed from the sample.

The filtered sample is made up of 224 series (i.e. roughly 86% of the 261 series that satisfy the first liquidity criterion), plus the CDSs of the two originators of the crisis, GM and Ford. 179 CDSs are taken from the Bloomberg database, 47 from Datastream. We then reconstitute the sectoral breakdown of the sample, for the IG indices (Tables III.A1 and III.A2)[60]. These new indices are given the same names as the indices on which they are based: CDX NA IG, CDX NA HY, iTraxx Main, iTraxx Crossover.

[60] The sectoral composition of the iTraxx Main is fixed from one roll to the next; on the other hand, the composition of the CDX NA IG may change slightly. The composition shown in Table A1 is that of series 7 and 8.

Table III.A1: North America
Firms included in the sample and order of integration of CDS premia

We use ADF tests. The number of lags is optimized by an Akaike criterion. We test the significance of a trend in the model. For each series, DS stands for difference-stationary; TS, for trend-stationary; S, for stationary time series.

	t-stat	process		T-stat	Process		*t*-stat	process
United States 93 CDS			Countrywide Home Loans Inc	0.47	DS	Interntional Business Machines Corp	-3.66	TS
Consumers 21 CDS			Equity Office Properties Trust	0.06	DS	Motorola Inc	-0.89	DS
Altria Group Inc	-1.20	DS	Fannie Mae	-4.80	TS	Omnicom Group Inc	-3.10	DS
Amgen Inc	-3.33	DS	Freddie Mac	-1.52	DS	Sprint Nextel Corp	-2.35	S
Baxter International Inc	-3.36	DS	General Electric Capital Corp	-4.80	TS	Time Warner Inc	-0.74	DS
Bristol-Myers Squibb Co	-3.30	DS	Hartford Financial Services Group Inc	-3.64	TS	Verizon Global Funding Corp	-3.85	S
Campbell Soup Co	-4.40	TS	International Lease Finance Corp	-3.03	DS	Walt Disney Co	-1.06	DS
Carnival Corp	-10.54	TS	Loews Corp	-3.99	TS	**US HY 34 CDS**		
ConAgra Foods Inc	-0.65	DS	MBIA Insurance Corp/New York	-2.95	S	AES Corp/The	-5.32	TS
Federated Department Stores Inc	-0.32	DS	Metlife Inc	-2.87	DS	AK Steel Corp	-1.61	DS
General Mills Inc	-0.98	DS	Simon Property Group LP	-4.01	TS	Allied Waste North America Inc	-3.14	S
Kraft Foods Inc	-0.85	DS	Washington Mutual Inc	0.33	DS	Bowater Inc	0.07	DS
Kroger Co/The	-0.56	DS	Wells Fargo & Co	-0.71	DS	Chesapeake Energy Corp	-4.45	TS
Marriott International Inc	-0,87	DS	XL Capital Ltd	-0.50	DS	CMS Energy Corp	-4.26	TS
McDonald's Corp	-1,06	DS	*Industrials 23 CDS*			Dillard's Inc	-2.67	S
Newell Rubbermaid Inc	-1,05	DS	Alcan Inc	-0.46	DS	Dole Food Co Inc	0.16	DS
Nordstrom Inc	-0,90	DS	Alcoa Inc	-0.38	DS	Dynegy Holdings Inc	-5.21	TS
Safeway Inc	-0,78	DS	Boeing Capital Corp Ltd	-7.56	TS	Echostar DBS Corp	-3.44	S
Southwest Airlines Co	-3,76	TS	Burlington Northern Santa Fe Corp	-0.46	DS	El Paso Corp	-1.55	DS
Target Corp	-1,57	DS	Caterpillar Inc	-4.31	TS	Forest Oil Corp	-3.12	S
Wal-Mart Stores Inc	-4,52	TS	Centex Corp	0.09	DS	Houghton Mifflin Co	-3.71	S
Whirlpool Corp	-3,07	S	CSX Corp	0.01	DS	IKON Office Solutions Inc	-3.47	S
Wyeth	-1,18	DS	Deere & Co	-4.00	TS	KB Home	-2.96	S
Energy 13 CDS			Dow Chemical Co/The	-0.67	TS	Lyondell Chemical Co	-1.21	DS
American Electric Power Co Inc	-1,24	DS	Eastman Chemical Co	-0.92	DS	Navistar International Corp	-0.79	DS
Anadarko Petroleum Corp	-4,17	S	Goodrich Corp	-5.50	TS	Nortel Networks Corp	-0.58	DS
ConocoPhillips	-0,97	DS	Honeywell International Inc	-1.02	DS	Owens-Illinois Inc	-4.93	S
Constellation Energy Group Inc	-0,56	DS	Ingersoll-Rand Co Ltd	-2.65	S	Parker Drilling Co	-4.00	TS
Devon Energy Corp	-0,76	DS	International Paper Co	-0.78	DS	PolyOne Corp	-2.98	S
Dominion Resources Inc/VA	-0,56	DS	Lockheed Martin Corp	-3.42	TS	Pride International Inc	-0.98	DS
Duke Energy Corp	-1,31	DS	MeadWestvaco Corp	-0.66	DS	Rite Aid Corp	-3.64	S
FirstEnergy Corp	-3,63	S	Norfolk Southern Corp	-0.48	DS	Royal Caribbean Cruises Ltd	-1.62	DS
Nat. Rural Utilities Coop. Finance Corp	-3,79	TS	Northrop Grumman Corp	-5.10	TS	Saks Inc	-0.52	DS
Progress Energy Inc	-2,62	DS	Pulte Homes Inc	-0.03	DS	Sinclair Broadcast Group Inc	-3.58	TS
Sempra Energy	-0,75	DS	Raytheon Co	-1.60	DS	Six Flags Inc	-2.94	S
Transocean Inc	-0,88	DS	Rohm & Haas Co	-3.75	TS	Smithfield Foods Inc	-4.94	S
Valero Energy Corp	-1,25	DS	Union Pacific Corp	-2.97	S	Solectron Corp	-0.68	DS
Financials 22 CDS			Weyerhaeuser Co	-0.87	DS	Standard-Pacific Corp	-2.99	S
ACE Ltd	-3,32	DS	*TMT 14 CDS*			Tembec Industries Inc	-3.26	S
Aetna Inc	-3,09	DS	Arrow Electronics Inc	-1.11	DS	Unisys Corp	-0.49	DS
American Express Co	-2,75	DS	Cingular Wireless LLC	-1.52	DS	United States Steel Corp	-4.54	TS
American International Group Inc	-0,75	DS	Clear Channel Communications Inc	0.20	DS	Xerox Corp	-4.84	TS
Capital One Bank	-4,47	TS	Comcast Cable Communications Inc	-3.68	TS	**Originators 2 CDS**		
Chubb Corp	-4,29	TS	Computer Sciences Corp	-3.04	S	Ford Motor Co	-0.09	DS
Cigna Corp	-3,25	DS	COX Communications Inc	-0.98	DS	General Motors Corp	-0.37	DS
CIT Group Inc	-0,06	DS	Hewlett-Packard Co	-0.83	DS	**Total 129 CDS**		

Table III.A2: Europe
Firms included in the sample and order of integration of CDS premia

We use ADF tests. The number of lags is optimized by an Akaike criterion. We test the significance of a trend in the model. For each series, DS stands for difference-stationary; TS, for trend-stationary; S stationary time series.

	t-stat	process		T-stat	Process		*t*-stat	process
Europe IG 84 CDS			Electricite de France	-1.06	DS	EADS Co NV	-1.29	DS
Autos 9 CDS			EnBW Energie Baden-Wuert. AG	-2.26	S	Imperial Chemical Industries PLC	-1.26	DS
Bayerische Motoren Werke AG	-1.75	DS	Endesa SA	-1.15	DS	Lafarge SA	-1.27	DS
Compagnie Financiere Michelin	-0.76	DS	Enel SpA	-3.31	DS	Siemens AG	-0.80	DS
Continental AG	-0.41	DS	Energias de Portugal SA	-2.35	DS	Stora Enso Oyj	-0.17	DS
DaimlerChrysler AG	-0,95	DS	Fortum Oyj	-4.84	TS	UPM-Kymmene Oyj	-0.60	DS
Peugeot SA	-1,27	DS	Iberdrola SA	*-0.45*	*S*	*TMT 12 CDS*		
Renault SA	-0,96	DS	National Grid PLC	-1.09	DS	Bertelsmann AG	-1.08	DS
Valeo SA	0,32	DS	Repsol YPF SA	-0.65	DS	British Telecommunications PLC	-0.30	DS
Volkswagen AG	-4,16	TS	RWE AG	-1.38	DS	Deutsche Telekom AG	-1.05	DS
Volvo AB	-0,71	DS	Suez SA	-1.72	DS	France Telecom SA	-1.46	DS
Consumers 22 CDS			Union Fenosa SA	-2.05	S	Hellenic Telecom. Organization SA	-3.64	TS
Accor SA	-1,19	DS	United Utilities PLC	-0.51	DS	Reuters Group PLC	-1.59	DS
Alliance Boots PLC	0,67	DS	Vattenfall AB	-4.00	TS	Royal KPN NV	-0.14	DS
British American Tobacco PLC	-1,09	DS	Veolia Environnement	-1.50	DS	Telecom Italia SpA	-2.67	S
Cadbury Schweppes PLC	0,22	DS	*Financials 14 CDS*			Telefonica SA	-0.38	DS
Carrefour SA	0,37	DS	Aegon NV	-2.60	DS	Vodafone Group PLC	-0.35	DS
Compass Group PLC	-0,43	DS	Allianz SE	-3.74	TS	Wolters Kluwer NV	-0.36	DS
Deutsche Lufthansa AG	-3,03	DS	Aviva PLC	-1.20	DS	WPP Ltd	-0.80	DS
Diageo PLC	-3,69	TS	AXA SA	-0.89	DS	**Europe HY 13 CDS**		
DSG International PLC	-0,17	DS	Banca Intesa SpA	-1.58	DS	British Airways PLC	-1.44	DS
Gallaher Group PLC	-2,13	DS	Banca Monte dei Paschi di Siena SpA	-1.33	DS	Cable & Wireless PLC	-0.25	DS
GUS PLC	-2,72	S	Banco Comercial Portugues SA	-1.56	DS	Corus Group PLC	-2.68	S
Imperial Tobacco Group PLC	-0,66	DS	Banco Santander Central Hispano SA	-0.79	DS	EMI Group PLC	-4.52	S
Kingfisher PLC	0,72	DS	Capitalia SpA	-2.07	S	Fiat SpA	-1.23	DS
Koninklijke Philips Electronics NV	-3,21	DS	Commerzbank AG	-1.44	DS	International Power PLC	-0.96	DS
LVMH SA	-1,67	DS	Deutsche Bank AG	-0.47	DS	Invensys PLC	-1.11	DS
Marks & Spencer PLC	-0,94	DS	Hannover Rueckversicherung AG	-6.82	TS	Koninklijke Ahold NV	-1.71	DS
Metro AG	-3,52	TS	Muenchener Rueckversicherungs AG	-3.39	DS	M-real OYJ	-0.01	DS
PPR	-2,18	S	Swiss Reinsurance	-0.87	DS	Rhodia SA	-2.11	S
Sodexho Alliance SA	-3,80	TS	*Industrials 11 CDS*			Scandinavian Airlines System AB	-5.32	TS
Tesco PLC	-0,82	DS	Akzo Nobel NV	-0.36	DS	Sol Melia SA	-6.11	TS
Thomson	-0,25	DS	Arcelor Finance SCA	-1.46	DS	TUI AG	-3.17	S
Unilever NV	-0,19	DS	BAE Systems PLC	-4.26	TS	**Total 97 CDS**		
Energy 16 CDS			Bayer AG	-0.99	DS			
E.ON AG	-0.92	DS	Cie de Saint-Gobain	-0.53	DS			

Appendix B - DCC-GARCH model

Let $x_t = [x_t^1, x_t^2]$ be two asset returns with zero means. The returns are assumed to follow a normal bivariate distribution with conditional variance-covariance H_t:

$$H_t = \begin{bmatrix} \sigma_{1,t}^2 & \rho_t \\ \rho_t & \sigma_{2,t}^2 \end{bmatrix} \tag{III.A1}$$

The log-likelihood of x_t over the sample $i = 1$ to T is:

$$\log L = -\frac{1}{2}\sum_{t-1}^{T} 2\log(2\pi) + \log(|H_t|) + x_t' H_t^{-1} x_t \tag{III.A2}$$

Following Engle and Sheppard (2001) and Engle (2002), the decomposition of the variance-covariance matrix can be written as:

$$H_t = D_t R_t D_t \tag{III.A3}$$

where D_t is the diagonal matrix of the conditional standard deviations and R_t the matrix of the conditional correlations:

$$D_t = \begin{bmatrix} \sigma_{1,t} & 0 \\ 0 & \sigma_{2,t} \end{bmatrix}; \quad R_t = \begin{bmatrix} 1 & \rho_t \\ \rho_t & 1 \end{bmatrix} \tag{III.A4}$$

By replacing H_t with this decomposition in the log-likelihood, Equation (A2) can be written as:

$$\log L = -\frac{1}{2}\sum_{t-1}^{T} 2\log(2\pi) + \log(|D_t|) + \log(|R_t|) + \varepsilon_t' D_t^{-1} R_t^{-1} D_t^{-1} \varepsilon_t \tag{III.A5}$$

The maximisation of the log-likelihood is done in two steps. The first one consists in maximising the likelihood on matrix D_t. To do so, volatilities are estimated through univariate GARCH:

$$D_t = \overline{D}(1 - A - B) + A x_{t-1} x_{t-1}' + B D_{t-1} \tag{III.A6}$$

where A and B are diagonal matrixes. In a second step, the returns x_t are divided by their estimated standard deviations. The reduced returns $\varepsilon_t = D_t^{-1} x_t$ are used to estimate the dynamic correlations:

$$\begin{gathered} Q_t = \bar{Q}(1 - \alpha - \beta) + \alpha \varepsilon_{t-1} \varepsilon_{t-1}' + \beta Q_{t-1} \\ \bar{Q} = \frac{1}{n}\sum_{t-1}^{T} \varepsilon_t \varepsilon_t' \end{gathered} \tag{III.A7}$$

where α and β are matrices with diagonal elements equal to a and b, respectively. To obtain the correlation matrix, the elements of Q_t are normalized by dividing by the standard deviations:

$$R_t = \text{diag}(Q_t)^{-\frac{1}{2}}\, Q_t \, \text{diag}(Q_t)^{-\frac{1}{2}}$$
$$\hat{\rho}_t = \frac{q_{12,t}}{\sqrt{q_{11,t}}\sqrt{q_{22,t}}} \qquad \text{(III.A8)}$$

Chapter IV Disrupted links between credit default swaps, bonds and equity during the GM and Ford crisis in 2005*

Abstract

We analyse the crisis experienced by General Motors (GM) and Ford following the downgrading of their credit ratings in May 2005 and its impact on the financial markets. At that time, the Credit Default Swap (CDS) premia of GM and Ford sharply increased; all other CDS premia also rose markedly, but stock markets hardly reacted. We try to determine if the usual links between CDS, bonds and stocks were affected by the crisis. To answer this question, we consider 5-year maturity CDS premia and stock prices for 120 major US and European firms, and construct a generic 5-year bond for each of these firms. We estimate nonlinear Vector Error-Correction Model (VECM) and Vector Autoregressive (VAR) model at the firm level. First, the results show that the CDS market has a lead over the bond market, confirming previous results by Blanco *et al*. (2005) and Zhu (2006), whereas the stock market tends to lead the CDS market. Second, we show that those markets were somewhat disconnected during the crisis, as their links were significantly loosened.

JEL classification: G01; G14; G15.

Keywords: Credit default swaps; Bonds; Equities; Financial crisis.

---

* This is a joint article with Virginie Coudert. Published in *Applied Financial Economics* (2010). NOTICE: this is a preprint of an article whose final and definitive form has been published in the *Applied Financial Economics* © 2010 [copyright Taylor & Francis]; *Applied Financial Economics* is available online at: http://www.informaworld.com/smpp/content~db=all~content=a929115737~frm=titlelink.

1. Introduction

The surge in credit default swap (CDS) premia in 2007 and 2008 hints at a possible overreaction of credit market derivatives to crises. The over-the-counter nature of these markets as well as their lack of regulation may be at stake, as they tend to exacerbate speculation during crises. However, as CDS do provide trading for default risk, their prices are closely related to bonds. Therefore, it is interesting to know how crises spill over to these two markets. Are the usual links between financial markets upset during episodes of financial turmoil? These questions are important given the huge size of credit derivatives markets, which has long outsized the bond market.

Theoretically, the CDS premium is roughly equal to the bond spread, for the same borrower and maturity (Duffie, 1999; Hull and White, 2000; Hull *et al*. 2004). Actually, the CDS premium is never exactly equal to the bond spread, for a number of reasons (O'Kane and McAdie, 2001; Cossin and Lu, 2004; Blanco *et al*., 2005). Cossin and Lu (2004) find that the major part of this basis is consistent with a liquidity premium. Longstaff *et al.* (2005) also evidenced the key role of liquidity, showing that bond yields include a liquidity premium, which is not present in the CDS market.

Several studies try to explain the determinants of the CDS premium empirically (Aunon-Nerin *et al.*, 2002; Ericsson *et al*., 2004; Houweling and Vorst, 2005). Alexander and Kaeck (2006) study the variations of the sectoral components of the major European CDS index, the iTraxx. They show that these variations can be partly explained by the implied volatility of the DJ Eurostoxx 50. Moreover, according to these authors, the iTraxx is subject to regime switching and is more sensitive to the variations of stock market variables during periods of stress. Andritsky and Singh (2006) also show that the pricing of CDS could be affected by financial turmoil, especially concerning recovery rates, that turn out to be a key determinant in distressed periods. More recently, Papenbrock *et al*. (2009) propose a model of pricing CDS index-tranches taking into account the joint default behaviour in the underlying credits.

Another issue relates to which market has the lead on the other in the price discovery process. The CDS market is generally considered to lead the bond market, as innovations on the CDS market have a greater tendency to spill over to bond spreads than the reverse (ECB, 2004; Blanco *et al*., 2005; Zhu, 2006; Baba and Inada, 2007; Bowe *et al*., 2009). Crouch and Marsh (2005) show that this link is especially strong for the auto sector. According to them, the CDSs of General Motors, Ford and DaimleyChrysler tend to lead their bond spread. These CDS also lead the CDS premia of the other firms of the sector, especially over the periods when the premia of the carmakers globally rise.

The links between CDS and equity are more controversial. A priori, as a rise in a CDS premium is linked to the firm's financial difficulties, it should go with a decline in its stock price, as consistent with the framework of Merton (1974) model. However, some studies find that the equity market has a lead over the CDS (Norden and Weber, 2004; Byström, 2008), although others show mitigated results (Scheicher, 2006).

Although the links between these markets have been extensively studied, there is no study focusing on what happens during crises. That is why this paper tackles this issue of the upset links between markets during crises. We chose to study the GM and Ford crisis in 2005 for several reasons. First, this episode had important consequences on the credit market due to the size of the two leading multinational firms[61]. Second, the crisis is well circumscribed in time: the origin can be clearly identified by the profit warning of GM in March 2005 that announced huge losses, followed by the successive downgrades of the two firms by the three main rating agencies. Third, the crisis can now be seen a precursory event, that hints at the speculative nature of the CDS market. At that time, the CDS premia posted a sharp rise; their bond spreads jumped too, although to a lesser extent. The whole of the CDS market was affected, as well as the bond market. Acharya *et al.* (2008), who also studied this crisis, showed that it triggered a major liquidity shock on the CDS market.

In this paper, to study thoroughly links between markets, we use a large sample containing daily premia of the most liquid 5-year CDSs present in the main European and North-American indexes. We match them with bonds issued by the same entity and on the same 5-year maturity, which we construct by interpolating bonds of close maturities. We end up with a sample of 120 pairs of CDS premia and bond spreads, for main European and US firms. We then add stock prices to study their interactions with CDS premia.

We take stock of the literature on links between markets, which mostly relies on vector error correction models (VECM) and vector auto-regressive (VAR) models. For example, Blanco *et al*. (2005) use them to test the non-arbitrage relationship of Duffie (1999) on a sample of 33 pairs of corporate bonds and CDS for American and European entities. Here, we use either VECMS or VARs according to the statistical properties of the data.

[61] Their long-term debt exceeded USD 325 billons at the end of year 2005, which is a fairly large amount compared to USD 12 000 billions for the US domestic bond market at that time (source: GM and Ford's annual reports and BIS for the bond market).

We then test for disrupted links in VECMs in the spirit of the Gonzalo-Pitarakis (2006) approach of non-linear cointegration systems. For VARs, we compare results obtained in the tranquil period and during the crisis.

The remainder of the paper is organised as follows. Section 2 identifies the crisis period on the CDS market. Section 3 examines the interactions at the firm-level between the CDS and the bond markets. Section 4 investigates the links with the equity market. We set out the conclusion in Section 5.

2. The GM and Ford crisis and the CDS market

2.1. Stylised facts

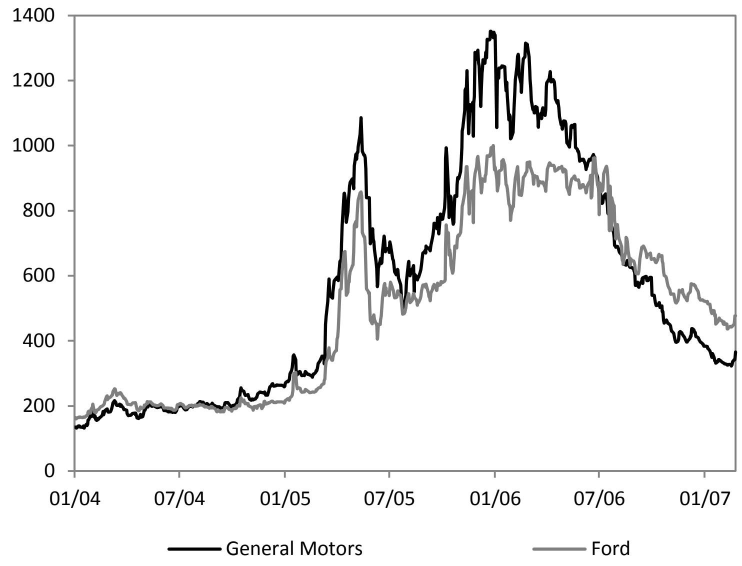
The difficulties encountered by GM and Ford started to raise concerns in March 2005. On 16 March, GM announced a profit warning for the first quarter, forecasting a loss of roughly USD 850 million, compared to a previous target of breakeven. This would reduce the earnings per share to USD 2, i.e. half what had been forecasted (USD 4 to USD 5). On 8 April, Ford also announced a profit warning, revising its annual earnings expectations down by 25% compared to forecasts i.e. USD 2.5 billion instead of USD 3.4 billion.

As a result, investors started to expect major difficulties and reassessed both firms' default risk, in March 2005, before their ratings were actually downgraded by rating agencies[62]. The CDS premium of GM climbed from 304 to 567 bp in March 2005, while that of Ford rose from 244 to 357 bp (Chart IV.1). The ratings of both firms were successively downgraded by the three major rating agencies between 5 May and 19 December 2005 (Table IV.1). The downgrading was particularly harsh since the two firms were downshifted from investment grade to speculative grade. GM and Ford CDS premia continued to increase over this period.

Given the importance of these two firms, investors probably reassessed the risks attached to all borrowers. At any rate, all of the CDS market was affected: index premia almost doubled in March 2005 (Chart IV.2). After having reached a peak on 18 May, the CDS indices started to decline, which suggests that the market had managed to absorb the shock.

[62] This concern was justified since the loss recorded for the first three months, published on 19 April, amounted to USD 1.1 billion. In 2005, total net loss stood at USD 8.6 billion, compared with a net profit of USD 2.8 billion in 2004.

Chart IV.1: CDS premia, GM and Ford (in basis points)



Sources: Bloomberg.

Table IV.1: Dates of rating downgrades for GM and Ford (dates of downgrades from investment to speculative grade are in bold)

High yield ratings are shaded in grey. The ratings by S&P goes from AAA, AA+ ,AA, AA-, A+, A, A-, BBB+, BBB, to BBB- for investment grade and from BB+, BB, BB-, B+, B, B-, CCC+, CCC, CCC- to CC for speculative grade (high yield); those by Fitch are the same, except for the ratings beginning by C which are grouped in a single category CCC. For Moody's, the ratings are Aaa, Aa1, Aa2, Aa3, A1, A2, A3, Baa1, Baa2, Baa for the investment grade, and Ba1, Ba2, Ba3, B1, B2, B3, Caa1, Caa2, Caa3, Ca for the speculative grade.

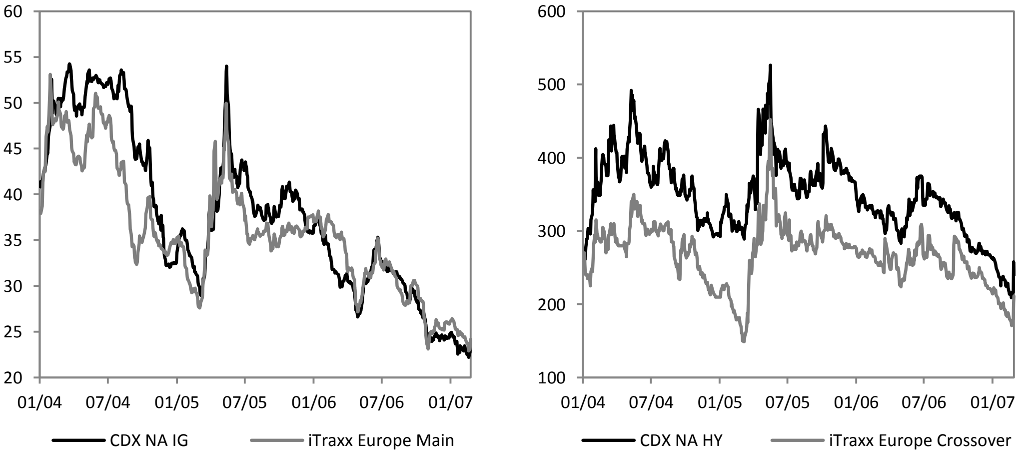
	General Motors			Ford		
Date	S&P	Moody's	Fitch	S&P	Moody's	Fitch
Prior to January 2004	BBB	Baa1	BBB+	BBB-	Baa1	BBB+
13 October 2004			BBB			
14 October 2004	BBB-					
4 November 2005		Baa2				
16 March 2005			BBB-			
5 April 2005		Baa3				
5 May 2005	BB			BB+		
12 May 2005					Baa3	
19 May 2005						BBB
24 May 2005			BB+			
20 July 2005						BBB-
24 August 2005		Ba2			Ba1	
26 September 2005			BB			
10 October 2005	BB-					
1 November 2005		B1				
9 November 2005			B+			
12 December 2005	B					
19 December 2005						BB+
5 January 2006				BB-		
11 January 2006					Ba3	
21 February 2006		B2				
13 March 2006						BB
29 March 2006		B3				
8 June 2006						B+
20 June 2006		Caa1				
28 June 2006				B+		
14 July 2006					B2	
18 August 2006						B
19 September 2006				B	B3	
27 November 2006		Caa1			Caa1	

Sources: Fitch, Moody's, Standard and Poor's.

Chart IV.2: Premia for CDS indexes in North America (NA) and Europe (in basis points)

Investment grade (IG)
CDX NA IG and iTraxx Europe Main

High yield (HY)
CDX NA HY and iTraxx Europe Crossover



Sources: Bloomberg, J.P. Morgan.

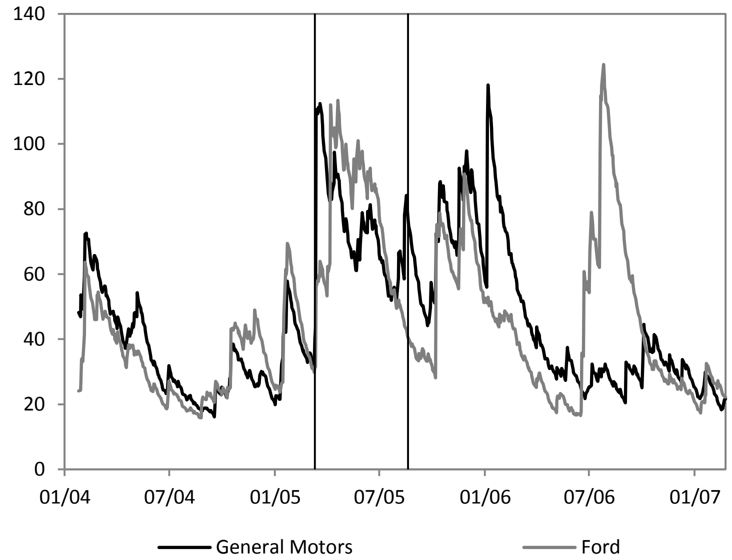
2.2. *Identification of the crisis period*

Financial crises are generally characterised by a rise in volatility. We therefore check that Ford's profit warning on 16 March triggered the crisis by looking at the volatility of CDS premia for GM and Ford around this period. We calculate an EWMA volatility (Exponentially Weighted Moving Average), which is defined as the weighted sum of quadratic yields[63] with exponentially decreasing weightings over time (J.P. Morgan, 1996). The results show a sudden jump in volatility precisely on 16 March 2005 (Chart IV.3). CDS volatility rose by a factor of 3.5 between 15 and 18 March in the case of GM (from 32% to 110%) and almost twofold in the case of Ford (from 30% to 56%). Volatility remained high until end-August 2005. We consider that the crisis period corresponds to this period of pronounced volatility. It started on 16 March 2005 and ended on 24 August 2005, when the two firms were downgraded by Moody's and when volatility had already notably decreased.

[63] The decay parameter is 0.97. As CDS premia have a unit root (see appendix B), CDS "yields" are the log first differences of CDS premia. This is the method used by Scheicher (2006), Jorion and Zhang (2007), and Acharya and Johnson (2007)

Chart IV.3: Volatility of GM and Ford's premia (in percentage)

Vertical lines stand for the crisis period (03/16/05 to 08/24/05).



Sources: Bloomberg,. Author's calculations.

3. The relationship between the CDS market and the bond market

3.1. The theoretical links between the two markets

Theoretically, the CDS premium should be approximately equal to the bond spread for a given entity and a given maturity (Duffie, 1999; Hull and White, 2000; Hull *et al*. 2004; Cossin et Lu, 2005). To see this, let us consider the arbitrages between these two markets: a bond with a yield of y_t and a CDS with a premium of c_t issued by the same entity and with the same maturity T. By purchasing both assets simultaneously, an investor is covered against the default risk linked to the bond; her annual return is $y_t - c_t$. By arbitrage, this return should be roughly equal to the risk-free rate of the same maturity denoted r_t.This means that the CDS premium should be approximately equal to the bond yield minus the risk-free rate.

$$c_t \simeq y_t - r_t \quad \text{(IV.1)}$$

If $c_t < y_t - r_t$, the investor should buy the bond and the CDS by borrowing at a risk-free rate (assuming that she is able to do so). If this strategy is massively adopted, the bond price increases, leading to a fall in its yield and an increase in the price of protection, which ultimately cancels out the observed divergence. Conversely, if $c_t > y_t - r_t$, the investor should sell the bond (assuming that it is possible to have a short position), sell the CDS and invest at a risk-free rate, which ultimately restores equilibrium. In this simplified framework, the bond spread, $s_t = y_t - r_t$ defined as the bond yield less the risk-free rate is therefore equal to the CDS premium: $c_t = s_t$.

In reality, things are much more complex. In particular, Hull and White (2000) and Hull *et al*. (2004) emphasised the role of accrued interests. In case of default, CDS holders can get the par value of the bond but not the accrued interests. The arbitrage relationship must be adjusted for this factor:

$$c_t = \frac{y_t - r_t}{(1 + A^*)} \qquad \text{(IV.2)}$$

where A^* is the expected accrued interest on the par yield bond at the time of the default. For bonds paying coupons twice a year, A^* is equal to $\frac{y}{4}$.

Apart from accrued interests, there are a number of factors that hinder this arbitrage (O'Kane and McAdie, 2001; Bruyère, 2004; Olléon-Assouan, 2004; De Wit, 2006). That is why the "basis", defined as the difference between a bond spread and the CDS premium on the same entity and same maturity, $b_t = c_t - s_t$, is different from zero most of the time.

Some factors make the basis positive.

- In the event of borrower default, the CDS holder may supply the cheapest to deliver bond; the seller therefore ends up with the most discounted securities.
- Short positions are difficult and costly to take on the bond market. If economic agents expect the borrower to default, it is easier to buy CDSs.
- The CDS contract makes a provision for payment in the event that the borrower should default; however, the default may concern only part of the bonds, which implies that the CDS seller is more exposed to risk than the bond holder.
- The strategies adopted by hedge funds or banks may have a positive impact on the basis. For example, hedge funds buy large amounts of convertible bonds at the time they are issued, and, at the same time, hedge against credit risk by buying CDSs. Similarly, banks participating in syndicated loans hedge against risk by buying protection.

Conversely, other factors make the basis negative.

- In the event of default, bond investors often lose the accrued interest while CDS buyers pay the premium up until the default date[64]. This contributes to reducing the basis.
- The CDS buyer is exposed to counterparty risk, if the protection seller defaults; this risk is all the more high as defaults may be correlated, preventing sellers from meeting their payments.
- On the CDS market, investors may sell protection at a price c_t without any initial outlay (apart from margins); this is not the case for an investment on the bond market, which must be financed through a loan. The plain arbitrage described by equations (IV.1) and (IV.2) assumes that investors are able to borrow at risk free-rate. In reality, it depends on the cost of the loan. The higher the cost, the less profitable the investment in bonds. For high yield investors, it is more profitable to sell protection than to buy a bond. The CDS premium should therefore be lower than the bond spread.
- Securitisation via collateralized debt obligation (CDO) issuance encourages banks to sell CDSs, which contributes to reducing the basis.
- CDS are much less affected by liquidity effects than bonds (Longstaff *et al.*, 2005). Indeed, when investor wants to liquidate a CDS position, he usually does not sell it but enters into a new contract in the opposite direction. Therefore, the liquidity of the market is not a problem. Moreover, as CDS contracts can be sold in arbitrarily large amounts, they are not in limited supply like bonds. In addition, the CDS market on a given borrower is not fragmented as the bond market which is made of all its successive issuances. There is also the fact that large number of investors (insurance firms, pension funds) purchase bonds as part of a "buy and hold" strategy, whereas CDS sellers, who benefit from a leverage effect (for example, hedge funds), are more active on the market. Several empirical studies have evidenced that CDS spreads incorporate a lower liquidity premium than bonds (for example, Longstaff *et al.* 2004; Cossin and Lu, 2005; Crouch and Marsh, 2005; Zhu, 2006) [65]. This is especially true for fixed maturity CDSs, in particular 5-year CDSs, and to a lesser extent, 3, 7 and 10-year CDSs. The CDS premium could therefore be lower than the bond spread.

---

64 Hull and White (2000) take account of this effect in their model.

65 As shown by Vaihekoski (2009) for the stock market, the liquidity effect tends to be priced as a systematic source of risk for the whole market.

3.2. The data

The sample contains daily data on CDSs taken from Bloomberg and Datastream databases. These CDS are present in the four North-American and European 5-year CDS indices, that are highly-traded and represent benchmarks for the markets: (i) CDX NA IG, for North-American Investment Grade (IG hereafter) firms; (ii) iTraxx Europe Main for European investment grade firms; (iii) CDX NA HY for US speculative grade, or high yield, firms (HY hereafter); (iv) iTraxx Europe Crossover for European speculative grade firms. After having eliminated numerous entities with missing data, we get 224 CDSs, plus those of GM and Ford.

To study the link between CDSs and bonds, we have to find or construct the yield of a 5-year generic bond for each firm in the previous sample. Most of the time, 5-year bonds are not available. We therefore calculate the yield of a 5-year generic bond by interpolating for each date the yields of two bonds with lower and higher maturities (Hull *et al*, 2004; Norden and Weber, 2004; Blanco *et al.*, 2005; Zhu, 2006)[66]. The exact method is described in Appendix A. However, it is not possible to carry out an interpolation for all borrowers through lack of data. The sample is therefore limited to 120 firms, plus the two originators of the crisis, GM and Ford (see Appendix B). The period considered also needs to be small enough in order to interpolate 2 bonds with a generic maturity of 5 years. It spans from 01/06/2004 to 12/30/2005, which makes 519 observations.

The bond spread is the difference between the bond yield and the risk-free rate. Various risk-free rates are used in the literature (for example, Blanco *et al*., 2005; Longstaff *et al.,* 2005; Zhu, 2006). Houweling and Vorst (2005) especially focused on the issue of the appropriate risk-free rate and conclude that government bond yields are not a good reference, which also matches the results by Longstaff *et al*. (2005). Following Duffie (1999) and Houweling and Vorst (2005), Blanco *et al*. (2005) argue that the recommended risk-free rates are general collateral or repo rates, which are liquid and virtually risk-free. However, as these rates are only available for very short maturities (less than one year), they use swap rates. Zhu (2006) uses two benchmarks for the risk-free rate: the zero coupon Treasury rates and swap rates; he concludes that swap rates are a better proxy as they result in a smaller basis.

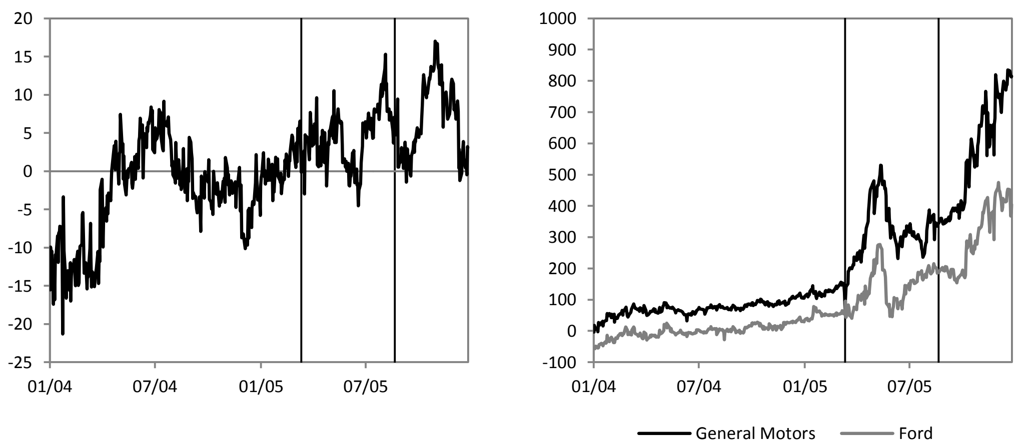
[66] Hull *et al.* (2004) construct a generic 5-year bond by regressing the yield on the residual maturity of the different bonds available at each date.

Therefore, we chose the 5-year swap rate in USD for US entities and euros for European entities[67]. The average basis is very close to zero for the whole sample (1 bp)[68]. Over the periods under review, the basis posted an upward trend (Chart IV.4). This is particularly striking in the case of GM and Ford. Their CDS premia climbed well above their bond spread during the crisis, the basis peaking at around 500 basis points. This means that the crisis mostly affected the CDS market, and had a lesser impact on the bond market.

Chart IV.4: Basis – CDS premium minus bond spread (in basis points)

Vertical lines stand for the start and the end of the crisis period (03/16/05 to 08/24/05).

Average in the 120 firm-sample **General Motors and Ford**



Sources: Bloomberg, Datastream. Authors' calculations.

3.3. The empirical relationship between CDSs and bonds

We now try to highlight the links between the bond and the CDS markets at the firm-level. To do that, we use the general framework of VECMs including the CDS premium and bond spread for each firm. This method has the advantage of estimating the long-term relationship as well as the short-run adjustment between the two markets. It has already been adopted in several studies on the CDS and bond markets (ECB, 2004; Blanco *et al*., 2005; Zhu, 2006; Baba and Inada, 2007).

We start from a general cointegration framework:

[67] We take into account the currency of denomination of the bond. It is generally the USD for US firms and the euro for European firms. There are, however, a few exceptions throughout the sample.

[68] In absolute terms, the average basis is 33 bp, which is higher than the results obtained by Blanco *et al.* (2004) and Houweling and Vorst (2002), i.e. 15 bp and 11 bp respectively. This difference can be attributed to the presence of HY entities in our sample, which is not the case in the other studies. If only IG entities are taken into consideration, the average absolute basis stands at 19 bp.

$$\Delta X_t^i = \mu^i + \Pi^i X_{t-1}^i + \sum_{j=1}^{k} \Gamma_j^i \Delta X_{t-j}^i + u_t^i \quad \text{(IV.3)}$$

where $X_t^i = \left(c_t^i, s_t^i\right)'$ is a 2-dimensional time-series vector made up of the CDS premia c_t^i and spreads s_t^i for firm $i, i = 1, \ldots, 120$; both c_t^i and s_t^i being taken in logarithm. Π^i, Γ_j^i are 2×2 parameter matrices.

For a given firm i, there are four possibilities which determine the method to follow:

(i) both series in $Y_t^i = \left(c_t^i, s_t^i\right)'$ are non-stationary and cointegrated, then matrix Π^i is ranked 1 and the model is a full VECM as in equation (IV.3);

(ii) both series are non-stationary but they are not cointegrated, then Π^{i} is ranked 0 an it boils down to a VAR model in first-difference:

$$\Delta X_t^i = \mu^i + \sum_{j=1}^{k} \Gamma_j^i \Delta X_{t-j}^i + u_t^i \quad \text{(IV.4)}$$

(iii) if both series are stationary, we re-write (3) as a VAR model in level:

$$Y_{\mathrm{t}}^{\mathrm{i}} = \mu^{\mathrm{i}} + \sum_{\mathrm{j}=1}^{\mathrm{k}} \Lambda_{\mathrm{j}}^{\mathrm{i}} \Delta Y_{\mathrm{t-j}}^{\mathrm{i}} + \mathrm{u}_{\mathrm{t}}^{\mathrm{i}} \quad \text{(IV.5)}$$

(iv) if one series is stationary and the other is not, we run a VAR in first difference as in equation (IV.4).

We check for each firm i if the CDS premia and bond spreads have a unit root. This is the case for a majority of them (107 CDSs and 93 bond spreads out of 120), according to the augmented Dickey-Fuller (ADF) tests (Appendix B)[69]. For 85 firms out of 120, both series have a unit root. They are cointegrated in 52 cases, according to Johansen tests[70], which puts them into case (i) for which a VECM can be applied. Other 68 firms will be dealt with VARs.

3.3.1. The VECMs

For 52 firms out of 120, CDS premia and bond spreads are non stationary and cointegrated, which enables to apply a VECM. We can write the cointegration relationship between CDS premia and bond spreads as the following[71]:

---

[69] CDS premia are found to have unit roots in most papers on the subject, previously cited. As we find the same standard results on our sample, we have not investigated the issue further by using other kinds of unit root tests, that may be more robust to breaks.

[70] See note 69.

[71] If the two series c_t^i and s_t^i moved in parallel, α_1^i should be equal to 1. This hypothesis can be tested by imposing a restriction on the cointegrating vector. The results show that this works only for 14 entities out of 52. For these 14

$$c_t^i = \alpha_0^i + \alpha_1^i s_t^i + \varepsilon_t^i \tag{IV.6}$$

The variations on the two markets can be explained by the adjustment to the long-term relationship and the lagged values of the series:

$$\begin{aligned} \Delta c_t^i &= \lambda_1^i \hat{\varepsilon}_{t-1}^i + \sum_{j=1}^{\text{lag}^i} \beta_{1,j}^i \Delta c_{t-j}^i + \sum_{j=1}^{\text{lag}^i} \gamma_{1,j}^i \Delta s_{t-j}^i + u_{1,j}^i \\ \Delta s_t^i &= \lambda_2^i \hat{\varepsilon}_{t-1}^i + \sum_{j=1}^{\text{lag}^i} \beta_{2,j}^i \Delta c_{t-j}^i + \sum_{j=1}^{\text{lag}^i} \gamma_{2,j}^i \Delta s_{t-j}^i + u_{2,j}^i \end{aligned} \tag{IV.7}$$

where $\hat{\varepsilon}_{t-1}^i$ is the estimated residual of equation (IV.6).

For both markets to adjust to their long-term relationship, the coefficients λ_j^i must have the following sign: $\lambda_1^i \leq 0$ and $\lambda_2^i \geq 0$. The number of lags on the coefficients, lag^i, is optimised using the Schwarz criterion.

We then estimate model (IV.7) for the 52 entities for which the series are cointegrated. The estimated coefficients are reported on Table IV.C1 in Appendix C. λ_1^i has a negative sign, as expected, in 44 cases out of 52 and is significantly negative in 36 cases out of 52. λ_2^i is positive in 48 cases out of 52, and significantly positive in 38 cases. Results show that the speeds of adjustment are quite rapid, of 0.06 on average for the negative λ_1^i, which implies a half-life deviation, of around 11 days. This rapid return to equilibrium makes it possible to estimate a relevant cointegration relationship over a short period of time (two years).

3.3.2. The leading market

One important question is to determine how the adjustment takes place. Does the bond market adjust to the CDS market, or vice-versa? The higher the adjustment coefficient λ_i of market i in absolute terms, the more market i will adjust to the other market. The leading market is the market that adjusts the least to its long-term relationship i.e. for which the absolute value of λ_i is the smallest.

The relative adjustment of the two markets is brought to light by the measure proposed by Gonzalo and Granger (1995), that we denote GG^i, which compares the adjustment coefficients λ_1^i and λ_2^i on both markets.

$$GG^i = \frac{\lambda_2^i}{\lambda_2^i - \lambda_1^i} \tag{IV.8}$$

entities, we accept either restriction $[1, -1, \alpha_0^i]$ (7 cases), or restriction $[1, -1, 0]$ (7 cases), which both imply that the basis is stationary.

The first market, i.e. the CDS market in equation (IV.7), is considered to have a lead over the second market if $GG^i > 0.5$. If $\lambda_1^i < 0$ and $\lambda_2^i < 0$, then $0 < GG^i < 1$ and the condition $GG^i > 0.5$ amounts to imposing a greater adjustment speed on the second market, i.e. $|\lambda_2^i| > |\lambda_1^i|$.

Our results show that the CDS market has a lead over the bond market. The Gonzalo-Granger measure is greater than 0.5 in most cases (33 out of 52). This conclusion confirms previous results put forward by Blanco *et al.* (2005), whose study covers a sample of 34 investment grade firms, as well as those of the European Central Bank (2004) and Zhu (2006) for the US market.

3.3.3. The VAR models

Results point to the same direction in the VAR models. They are applied to firms for which the series of CDS premia and bond spreads are not cointegrated (68 cases out of 120). The VAR models are in level for stationary series or in first difference for non-stationary series. We then conduct Granger causality tests (Table IV.C2, Appendix C). The results show that CDS premia more often Granger-cause bond spreads than the reverse. At the 10% confidence level, this is the case for 30 cases out of 68, the reverse causality holding for 23 cases out of 68 and bi-directional causality occurring in 10 cases. This confirms the lead of the CDS market over the bond market.

Another criterion consists in comparing the intensity of relationships in the VAR models. We compare the sum of the coefficients on CDS premia and bond spreads in the two equations. In most cases (48 out of 68), the coefficients of the CDS premia in the bond spread equation are higher than the coefficients of the bond spreads in the CDS premia equation. Then again, the results evidence that bond prices tend to adjust to CDS premia, rather than the reverse.

3.3.4. Changes during the crisis period

We now want to detect possible changes in these relationships during the crisis episode. To do that, we rely on the work by Gonzalo and Pitarakis (2006) on non linear cointegrating relationships.

$$\begin{aligned}\Delta X_t^i = \mu^i + \Pi_1^i X_{t-1}^i I(q_t < \chi) + \Pi_2^i X_{t-1}^i [1 - I(q_t < \chi)] \\ + \textstyle\sum_{j=1}^k \Gamma_j^i \Delta X_{t-j}^i + u_t^i\end{aligned} \qquad \text{(IV.9)}$$

where Π_1^i, Π_2^i, Γ_j^i are 2×2 parameter matrices, I is the indicator function, equal to one when the scalar variable q_t is below a given threshold χ, and 0 otherwise.

Here, we assume that (i) the long-run cointegration relationship is linear [72];(ii) there is a non-linearity in the adjustment process during the crisis; (iii) the indicator function I is defined exogenously by the crisis period.

Indeed, we retain two dummies. The first one (I_t) is equal to 1 during the crisis period (from 17 March 2005 to 24 August 2005) and 0 elsewhere.

$$\begin{gathered} I_t = 1 \text{ if } t \in [03/17/2005, 08/24/2005] \\ I_t = 0 \text{ elsewhere.} \end{gathered} \quad \text{(IV.10)}$$

The second one, denoted Iw_t, is equal to 1 during the first week of the crisis, i.e. from 17 to 23 March 2005, and 0 elsewhere. We have retained this second indicator because we have shown in another study that the CDS market was particularly upset in the first week of the crisis (Coudert and Gex, 2010a), as correlations between all the CDS premia and those of GM and Ford surged under contagion effects.

First, we introduce these indicator variables into the 52 VECM models defined in (IV.7):

$$\begin{aligned} \Delta c_t^i &= \left(\lambda_1^i + \mu_1^i I_t + \nu_1^i Iw_t\right)\hat{\varepsilon}_{t-1}^i + \sum_{j=1}^{\text{lag}^i} \beta_{1,j}^i \Delta c_{t-j}^i + \sum_{j=1}^{\text{lag}^i} \gamma_{1,j}^i \Delta s_{t-j}^i + u_{1,j}^i \\ \Delta s_t^i &= \left(\lambda_2^i + \mu_2^i I_t + \nu_2^i Iw_t\right)\hat{\varepsilon}_{t-1}^i + \sum_{j=1}^{\text{lag}^i} \beta_{2,j}^i \Delta c_{t-j}^i + \sum_{j=1}^{\text{lag}^i} \gamma_{2,j}^i \Delta s_{t-j}^i + u_{2,j}^i \end{aligned} \quad \text{(IV.11)}$$

The results are presented in Table IV.C1 in Appendix C. The coefficients of the dummy variables are not often significant (μ_1 is significant in 19 cases out of 52; μ_2 is significant in 15 cases out of 52). There is no particularly strong reaction during the first week of the crisis (ν_1 is significant in 6 cases out of 52; ν_2 is significant in 15 cases out of 52). The CDS market continues to have a lead over the bond market during the crisis: the number of Gonzalo-Granger measures exceeding 0.5 is exactly the same as before, (33 out of 52).

As the crisis may also have affected the short-term relationships between markets, we also tried to interact the crisis indicator with the short-term returns, as in the following equation:

$$\begin{aligned} \Delta c_t^i &= \lambda_1^i \hat{\varepsilon}_{t-1}^i + \sum_{j=1}^{\text{lag}^i} \beta_{1,j}^i \Delta c_{t-j}^i + \sum_{j=1}^{\text{lag}^i} \left(\gamma_{1,j}^i + \xi_{1,j}^i D_{t-j}\right)\Delta s_{t-j}^i + u_{1,j}^i \\ \Delta s_t^i &= \lambda_2^i \hat{\varepsilon}_{t-1}^i + \sum_{j=1}^{\text{lag}^i} \left(\beta_{2,j}^i + \xi_{2,j}^i D_{t-j}\right)\Delta c_{t-j}^i + \sum_{j=1}^{\text{lag}^i} \gamma_{2,j}^i \Delta s_{t-j}^i + u_{2,j}^i \end{aligned} \quad \text{(IV.12)}$$

The sum of the coefficients on the indicator variables $\sum \xi_{1,j}^i$ turns out to be significant for half of the 52 firms (21 out of 26 being positive), while $\sum \xi_{2,j}^i$ is significant only in 15 cases out of 52 (10 of them being positive). The crisis thus appears to have somewhat

[72] An alternative method would be to use a non-linear cointegration relationship, as Gregory and Hansen (1996), but this seems less suitable here as the crisis period is short.

affected the relationship between the two markets. As $\sum \xi_{1,j}^{i}$ is more often positive than $\sum \xi_{2,j}^{i}$, the CDS premia respond more to bond price changes during the crisis, which suggest a weakening of the lead of the CDS market.

Second, we deal with the 68 firms for which spreads and CDS premia are not cointegrated. Here, results are more clear-cut. For these series, we re-estimate the VAR models only over the crisis period, in order to assess the changes in the causal links between the two markets. The lead of the CDS market appears less pronounced than in the whole period. Bond spreads are Granger-caused by CDSs in 22 cases out of 68 (instead of 33 out of 68 on the whole period); the reverse occurs in 19 cases instead of 23 (Table IV.C3, Appendix C).

4. The equity market

While CDS premia and bond spreads generally co-move, stock prices are expected to move in the opposite direction. When the default risk on a firm rises significantly, the value of its debt decreases, which raises its bond spread (and the CDS premium). Simultaneously, the equity value declines, as in case of default, shareholders are paid after bond-holders. These key features of corporate finance have been highlighted in the framework of Merton's model (1974). They point to a negative relationship between CDS premia and share prices. Chart IV.5 illustrates these evolutions, in putting stock prices with a reversed scale. Broadly speaking, on the whole period, CDS premia and bond spreads in the sample move in parallel, whereas stock prices tend to evolve in the opposite direction. Nevertheless, this relationship seems disrupted during the crisis period.

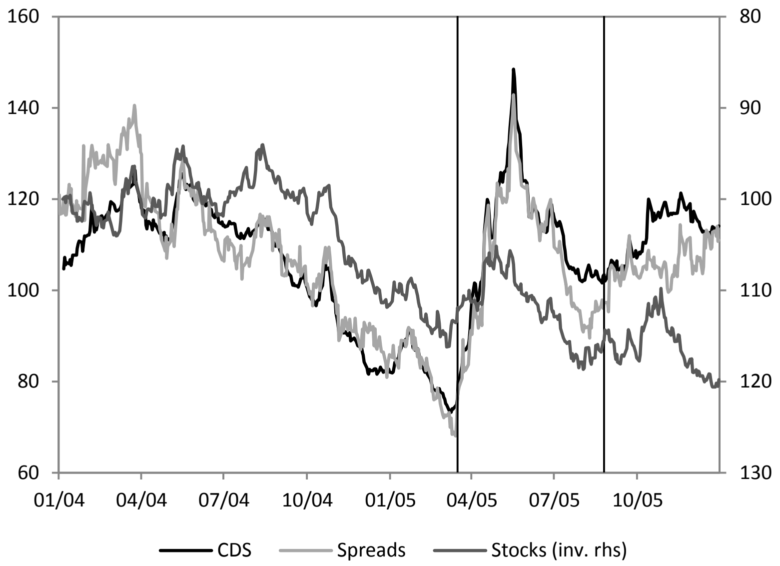
4.1. The stock market during the crisis

The crisis hardly impacted the equity prices of GM and Ford, probably because they had already been falling for a long time. Prices hit a low point on 21 and 22 April 2005 for GM and Ford respectively (Chart IV.6); they then picked up slightly until early May, before dropping again. In the case of GM, prices even rose during the crisis following the tender offer made by Kirk Kerkorian.

While the equity prices of GM and Ford do not seem directly affected by the crisis, their volatility sharply increased at that time (Chart IV.6). In the case of GM, volatility jumped from 19% to 61% in one day at the start of the crisis, on 17 March 2005. In the case of

Ford, volatility peaked at 45% on 5 May, rising up from 16% at the end of the pre-crisis period. On average, volatilities for GM and Ford stock prices increased sharply between the pre-crisis period and the crisis period (from 17% to 46% for GM and 17% to 32% for Ford).

Chart IV.5: CDS premia, stock prices and bond spreads (average for the 120-frim sample)

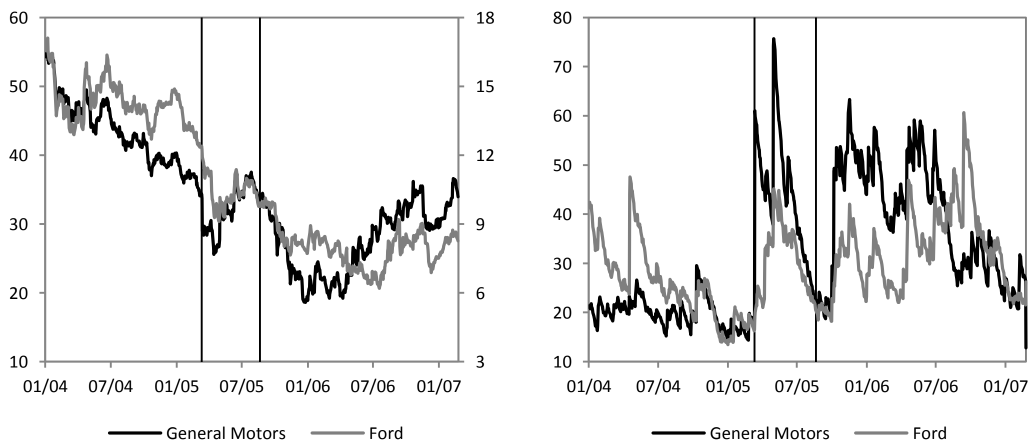


Sources: Bloomberg, Datastream.

Chart IV.6: GM and Ford stock prices and volatilities

Vertical lines stand for the start and the end of the crisis period (03/16/05 to 08/24/05).

Stock prices **Volatility in stock prices**



Sources: Bloomberg, Datastream. Authors' calculations.

As regards to the whole market, stock prices declined at the beginning of the crisis, but quickly rallied within a few weeks (Chart IV.5). On average, they did not decrease during the crisis period, but even posted an average increase of 3%. The volatility of stock prices did rise during the crisis; slightly on average but more sharply for high yield firms. However, it may not be linked to the GM and Ford crisis, as the volatility continued to increase afterwards.

4.2. The empirical relationship between CDSs and stocks

We now study the empirical relationship between CDSs and stocks. For the sake of homogeneity, we use the same method and the same sample of 120 firms as the one used in section 4. 102 stock prices and 107 CDS premia out of 120 have a unit root according to the ADF tests; for 91 entities out of 120, the two series have a unit root (Appendix B). However, among them, only 21 pairs are cointegrated, according to Johansen tests. For these 21 pairs, we define the following long-term relationship and VECM model.

$$a_t^i = \alpha_0^i + \alpha_1^i c_t^i + \varepsilon_t^i \tag{IV.13}$$

$$\begin{aligned} \Delta a_t^i &= \lambda_1^i \hat{\varepsilon}_{t-1}^i + \sum_{j=1}^{\text{lag}^i} \beta_{1,j}^i \Delta a_{t-j}^i + \sum_{j=1}^{\text{lag}^i} \gamma_{1,j}^i \Delta c_{t-j}^i + u_{1,j}^i \\ \Delta c_t^i &= \lambda_2^i \hat{\varepsilon}_{t-1}^i + \sum_{j=1}^{\text{lag}^i} \beta_{2,j}^i \Delta a_{t-j}^i + \sum_{j=1}^{\text{lag}^i} \gamma_{2,j}^i \Delta c_{t-j}^i + u_{2,j}^i \end{aligned} \tag{IV.14}$$

where a_t^i is the stock price of entity i at time t (in logarithm). Contrary to the previous section, α_1^i is expected to have a negative sign, given the negative relationship between equity prices and the firms' probability of default. CDS premia rise when stock prices decline, and vice-versa. The expected sign of λ_1^i is therefore negative, as in the previous section, but also for λ_2^i, which is confirmed by the results. λ_1^i is negative in 16 cases out of 21 and significantly negative in 8 cases; λ_2^i is significantly negative in 19 cases out of 21 (Table IV.C4, Appendix C).

Evidence shows that the equity market has a lead over the CDS market. In the VECM (used in 21 cases out of 120), the Gonzalo-Granger measure is greater than 0.5 in 18 cases out of 21[73]. In the VAR (used in 99 cases out of 120), the test results also show that stock prices Granger-cause CDS premia (56 cases out of 99 incl. GM and Ford) (Table C5, Appendix C). The reverse occurs in only 17 cases out of 99. A two-way linkage exists in the case of 6 entities. The observed causal links do not point to a geographical or sectoral concentration. Our results confirm those found by Byström (2008), who

[73] We modify the Gonzalo-Granger measure to take into account the fact that the two adjustment coefficients λ^i are expected to be negative: $GG^i = \frac{\lambda_2^i}{\lambda_2^i + \lambda_1^i}$.

concluded that information is first embedded into stock prices, using a European sample. However, research on the links between these two markets has yielded mixed results. Scheicher (2006) highlighted the existence of simultaneous linkages between the two markets over a sample of 250 North American and European firms, whereas Acharya and Johnson (2007) concluded that there is a continuous flow of information from the CDS market to the stock market, when analysing a sample of 79 US firms.

To determine whether the relationship between the stock market and the CDS market changed during the crisis, we first introduce the crisis indicator variables defined in equation (IV.12) into the VECM model. The dummy variables are rarely significant neither when interacting with the error correction term, as in equation (IV.11)[74], nor when interacting with the returns like in (IV.13). The relationship between the stock market and the CDS market seems therefore not altered by the crisis. However, this conclusion is limited for it concerns only 21 out of the 120 firms in the sample, for which we performed a VECM.

For the vast majority of firms (99 out of 120), we use VARs and narrow the estimation period down to the crisis period. This results in a strong decline in the number of causal links, especially from stock prices to CDS premia (28, incl. GM and Ford, against 56 on the whole period), and to a lesser extent from CDS premia to stock prices (Appendix C, Table C6). All sectors and geographical areas are concerned. Overall, the CDS market appears to be decoupled from the equity market and driven by autonomous dynamics during the crisis. This is consistent with the stylised facts on the originators, for which equity prices increase during the crisis due to expected mergers and acquisitions. This means that the turmoil on the CDS market during the crisis does not stem from the equity market. The usual relationships between the two markets, which underpin the spread of innovations from the equity market to the CDS market, were therefore disrupted.

5. Conclusion

In this paper, we analyse the links between financial markets around the crisis experienced by General Motors and Ford in May 2005. At that time, both firms' CDS premia increased sharply and all other CDS premia rose markedly for US and European firms. To do so, we construct a sample of 226 CDSs that are representative of the US and European indices (CDX and iTraxx).

[74] μ_1 is significant in 2 cases out of 21, ν_1 in 3 cases, μ_2 in 7 cases, ν_2 in 3 cases.

Usually, CDSs premia are close to bond spreads, but the relationship between the bond market and the CDS market is affected by the crisis. Our results confirm that the CDS market leads the bond market in the price discovery process, which has been evidenced in previous papers. In other words, bond spreads tend to adjust to the innovations on the CDS market, and not the reverse. However, the crisis mitigated this leading position of the CDS market. Especially, GM and Ford's CDS premia surged well above their bond spreads.

The links to the equity market were also disrupted. We find that the two markets are usually linked by a negative relationship, the equity market being the leader. However, they were somewhat decoupled during the crisis. Indeed, many stock prices continued to rise during the crisis, while CDS premia were surging for the same firms. Therefore, contagion seemed confined to the CDS market. The speculative nature of the CDS market may be at stake in this phenomenon.

Appendix

Appendix A - Construction of the database

A.1 CDS premia

We start from a sample of CDS containing the most traded 5-year ones. In order to have sufficiently liquid and representative CDSs, we chose CDSs belonging to the main CDS IG indices (iTraxx Main for Europe and CDX NA IG for North America) and HY indices (iTraxx Crossover for Europe and CDX NA HY for North America). CDS indices are updated every six months: the new series include the most liquid CDSs at the time of issuance. Our sample only contains the CDSs present in all the series during the entire period under review. We draw on two databases, Bloomberg and Datastream. Bloomberg aggregates the prices of several contributors. When the number of contributors displaying a price is insufficient on a given date, Bloomberg does not post up a price on that day. Datastream provides the prices of a single contributor (in the pool of Bloomberg contributors); there are therefore no missing values in the series (the contributor always posts up a price, whether quoted or traded).

The sample is constructed as follows. 1) The CDSs for which neither Bloomberg nor Datastream data are available on the whole period are left out. 2) The Bloomberg series is used if the proportion of missing values is less than 10% (excl. week-ends and bank holidays) and does not cover more than 5 consecutive days (in this case, the missing values are interpolated); otherwise, the Datastream series is used (provided it exists); 3) If the Bloomberg series does not meet the conditions mentioned above and the Datastream series does not exist, the CDS is removed from the sample.

The filtered sample is made up of 224 series (i.e. roughly 86% of the 261 series that satisfy the first liquidity criterion), plus the CDSs of the two originators of the crisis, GM and Ford. 179 CDSs are taken from the Bloomberg database, 47 from Datastream.

A.2 Bond spreads

The sample includes 5-year bond spreads for 120 entities over the period from 01/06/2004 to 12/30/2005. The database is constructed as follows. 1)Bond yields are extracted from the Datastream database for each entity in the sample of 224 CDSs; we select for each date a bond with a maturity of 2.5 to 5 years (lower bound) and a bond with a maturity of 5 to 7.5 years (upper bound). 2) To avoid any measurement errors, the bonds used in the sample must meet the following conditions: they should not include any options, should all be denominated in the same currency, should not be subordinated, structured or collateralised and should be fixed rate bonds. 3) If several bonds meet the conditions mentioned above, we use the two bonds just above and below the 5-year bond. 4) If only one of the two bounds is available (or if the maturity of one of the two bounds is exactly 5 years), this will be used as a proxy for the generic bond yield. 5) An entity that has not issued any bonds or whose bonds do not meet the above-mentioned conditions is withdrawn from the bond database. That is why the number of firms in the sample is drastically reduced. The risk-free rate used to calculate bond spreads is the US or European 5-year swap rate, extracted from the Bloomberg database. For the bonds denominated in pound sterling, we use the 5-year swap rate in the United Kingdom.

A.3 Equity prices

The sample includes the stock prices for the 120 same entities as bonds over the same period from 01/06/2004 to 12/30/2005. They are extracted from the Bloomberg database.

Appendix B - List of the firms in the sample and order of integration of series

We use ADF tests. Firstly we test the significance of a trend in the model. The number of lags is optimized by an Akaike criterion. The table gives the order of integration of the series for the reduced sample of CDS, stocks (St.) and bond spreads (Sp.). A star indicates a trend in the series.

	CDS	St.	Sp.
United-States IG			
Consumers			
Altria Group Inc	1	1	1
Bristol-Myers Squibb Co	1	1	1
General Mills Inc	1	1	1
Kraft Foods Inc	1	1	1
Kroger Co/The	1	1	1
Marriott International Inc/DE	1	1	1
McDonald's Corp	1	1	1
Newell Rubbermaid Inc	1	1	0
Nordstrom Inc	0	1	1
Safeway Inc	1	1	1
Target Corp	1	0	1
Wal-Mart Stores Inc	1	1	1*
Whirlpool Corp	1	1	1
Wyeth	1	1	1*
Energy			
American Electric Power Co Inc	1	1	1
Anadarko Petroleum Corp	1	1	0*
Dominion Resources Inc/VA	1	1	0*
Sempra Energy	0	1	0*
Financials			
American International Group Inc	1	1	1
Capital One Bank	1	1	1
Chubb Corp	0*	1	1*
CIT Group Inc	1	1	1
Countrywide Home Loans Inc	1	1	0
General Electric Capital Corp	1*	1	1
Hartford Financial Services Group Inc	1	1	1
International Lease Finance Corp	1	1	1
Simon Property Group LP	1	1	1
Washington Mutual Inc	1	1	0
Wells Fargo & Co	1*	0	1
Industrials			
Alcan Inc	1	1	1
Alcoa Inc	1	0	1
Boeing Capital Corp Ltd	1	1	1*
Caterpillar Inc	1*	1	1*
Centex Corp	1	1	1
CSX Corp	1	1	1*
Deere & Co	1	1	0
Dow Chemical Co/The	1	1	1
Eastman Chemical Co	1	1	1
Goodrich Corp	1	1	1
Honeywell International Inc	1	0	0
International Paper Co	1	1	1
Lockheed Martin Corp	1	1	1
MeadWestvaco Corp	1	1	1
Union Pacific Corp	1	1	1*
Weyerhaeuser Co	1	1	0
TMT			
Clear Channel Communications Inc	1	1	1
Comcast Cable Communications LLC	1	1	1
Computer Sciences Corp	1	1	1
Hewlett-Packard Co	1	1	1
International Business Machines Corp	1	1	1
Motorola Inc	1	1	1
Verizon Global Funding Corp	1	1	1
Walt Disney Co/The	1	1	1
Etats-Unis HY			
AES Corp/The	1	1	1
AK Steel Corp	1	1	1
Allied Waste North America Inc	1	1	1
Bowater Inc	1	1	1
Dillard's Inc	1	1	1
Dynegy Holdings Inc	1	1	0
Echostar DBS Corp	1	1	1
El Paso Corp	1	1	0*
Forest Oil Corp	1	1	0*
KB Home	1	1	1
Lyondell Chemical Co	1	1	1
Owens-Illinois Inc	1	1	1
Rite Aid Corp	0*	0	1
Royal Caribbean Cruises Ltd	1	1	0
Saks Inc	1	1	1
Six Flags Inc	1	1	1
Smithfield Foods Inc	0	1	0
Standard-Pacific Corp	1	1	1
Tembec Industries Inc	1	1	1
Unisys Corp	1	1	1*
United States Steel Corp	1	1	1
Xerox Corp	1	1	1
Europe IG			
Autos			
Compagnie Financiere Michelin	0	1	1
Renault SA	1	1	1
Volkswagen AG	1*	1	1
Volvo AB	1	0	0*
Consumers			
Alliance Boots PLC	1	1	1
Carrefour SA	1	1	1
Compass Group PLC	1	1	1
Experian Finance PLC	0	1	1
Gallaher Group PLC	1	1	1
Kingfisher PLC	1	1	1
Koninklijke Philips Electronics NV	1	1	1
LVMH SA	0	0	1
PPR	0	0	1
Sodexho Alliance SA	0*	0	1
Tesco PLC	1	0	1
Thomson	1	0	1
Energy			
E.ON AG	1	0	1*
Endesa SA	1	0	1
Enel SpA	0*	1	1
Iberdrola SA	1	0	1
Repsol YPF SA	1	0	1
Suez SA	1	0	1*
Financials			
Allianz SE	1*	0	1*
Banca Monte dei Paschi di Siena SpA	1	0	1
Banco Santander Central Hispano SA	1	1	1*
Capitalia SpA	1	1	1*
Commerzbank AG	1	0	1*
Deutsche Bank AG	1	0	1
Industrials			
Akzo Nobel NV	1	1	1*
Arcelor Finance SCA	1	0	1
Cie de Saint-Gobain	1	0	1*
EADS Co NV	1	0	1*
Lafarge SA	0	1	1
UPM-Kymmene Oyj	1	1	0
TMT			
Deutsche Telekom AG	1	1	1
France Telecom SA	1	1	1
Telecom Italia SpA	0	0	1
Telefonica SA	1	0	1
Vodafone Group PLC	1	0	1
WPP Ltd	1	0	1
Europe HY			
Fiat SpA	1	1	1
Invensys PLC	1	1	1
Rhodia SA	1	1	1
Originators			
Ford Motor Co	1	1	0
General Motors Corp	1	1	0

Appendix C - VECMs and VAR models

C.1 CDS – bond spreads

Table IV.C1: VECMs

Estimation of equations (IV.6), (IV.7) and (IV.11), over the period 06/01/2004 to 30/12/2005 for 52 out of 120 firms. Significantly different from zero at the * 90%, ** 95%, *** 99% confidence levels.

	Model without dummies				Coefficient on dummies			
	α_1	λ_1	λ_2	GG	μ_1	ν_1	μ_2	ν_2
United-States IG								
Consumers								
Bristol-Myers Squibb Co	-2.41	0.00	0.05***	1.10	-0.0017	0.0072	0.0018	-0.0072
Kraft Foods Inc	-0.61	-0.03**	0.06**	0.69	-0.0025	0.0547	-0.1587***	1.5020***
Marriott International Inc/DE	-0.71	0.00	0.05***	1.02	-0.0157	-0.3393	-0.0358	1.3216**
Safeway Inc	-0.63	-0.03*	0.09***	0.76	-0.0387	0.0416	-0.0397	0.3050
Wal-Mart Stores Inc	-0.30	-0.08***	0.09	0.52	-0.0168	-0.1910	-0.2562**	2.3997*
Whirlpool Corp	0.89	-0.03***	-0.01	-0.54	-0.0127	0.0142	-0.0413*	0.0649
Wyeth	-1.68	0.01**	0.03***	1.55	-0.0097	0.0195	-0.0208	0.1715
Energy								
American Electric Power Co Inc	-0.49	-0.03***	0.07***	0.68	-0.0126	0.2517*	0.0543	-0.0350
Anadarko Petroleum Corp	-0.56	-0.06***	0.05**	0.45	0.0091	0.3774	-0.0567	2.6456***
Financials								
American International Group Inc	-0.49	-0.01	0.08***	0.93	-0.0190	0.4755***	0.2317***	-0.1624
Capital One Bank	-1.44	0.00	0.03***	1.06	0.0290	0.0447	0.0694**	-0.0090
CIT Group Inc	-1.42	0.00	0.08***	0.98	-0.0065	0.1350***	0.0474	0.2334*
General Electric Capital Corp	3.76	0.00	-0.04***	1.04	0.0098**	-0.0508***	0.0219	-0.0526
Hartford Financial Services Group Inc	-0.30	-0.02**	0.04***	0.74	0.0029	-0.0459	-0.0213	0.0516
Industrials								
Centex Corp	-0.68	-0.01	0.06***	0.82	0.0042	0.6759**	0.0544	1.5193***
CSX Corp	-0.81	0.00	0.05***	0.93	-0.0066	0.0113	0.0496*	-0.0406
Deere & Co	-0.30	-0.04***	0.00	0.01	0.0005	0.1786	-0.0374	1.3752*
Dow Chemical Co/The	-0.57	-0.02**	0.06***	0.72	-0.1582***	0.1166	-0.0236	1.7581*
Goodrich Corp	-0.67	-0.06***	0.04***	0.39	0.0969**	0.0294	0.0021	-0.1278
International Paper Co	-0.91	-0.01	0.05***	0.86	-0.0664***	0.1957*	-0.0222	0.0510
Weyerhaeuser Co	-0.78	-0.02*	0.05***	0.68	-0.0483*	0.1617	-0.0455	0.1809
TMT								
Clear Channel Communications Inc	-0.60	-0.03**	0.04**	0.57	-0.0869***	0.0481	-0.0020	0.1948
Computer Sciences Corp	-0.93	-0.03**	0.01	0.17	0.0392	0.1386	0.0433	0.2181
Hewlett-Packard Co	-0.63	0.00	0.06***	1.05	0.0117	0.0037	0.0869***	-0.1817**
Motorola Inc	-0.62	-0.02*	0.07***	0.80	0.0042	0.1485	0.0499	1.4456***
Etats-Unis HY								
AES Corp/The	-0.88	-0.13***	0.01	0.04	0.0330	-0.3194	0.0280	-0.0515
AK Steel Corp	-1.08	-0.08***	0.04**	0.31	-0.1096**	0.1977	-0.0336	0.1566
Allied Waste North America Inc	-2.19	-0.04***	0.01*	0.21	-0.0623*	-0.3477	-0.0222	0.1723
Bowater Inc	-1.03	-0.03	0.07***	0.72	-0.0214	0.1484	0.1328**	-0.1862
Dillard's Inc	-1.02	-0.02	0.05***	0.74	0.0428	0.0616	0.0236	-0.1169
Dynegy Holdings Inc	-1.12	-0.09***	0.00	0.00	-0.1131*	-0.2223	-0.0088	0.2679**
El Paso Corp	-1.04	-0.24***	0.01	0.02	-0.1307*	-0.4459	-0.0283	0.3519
Forest Oil Corp	-0.97	-0.07***	0.05***	0.41	0.0083	-0.2186	-0.0675*	0.6103
KB Home	-0.60	-0.09***	0.03	0.27	0.1183**	-0.4094	0.0890	-0.1990
Owens-Illinois Inc	-0.49	-0.12***	0.03*	0.18	-0.0698	0.2375	-0.1240**	-0.5385*
Royal Caribbean Cruises Ltd	-1.09	-0.06***	0.09***	0.60	-0.0381	0.0278	0.0090	0.7506
Saks Inc	-1.29	-0.04**	0.06***	0.58	0.0086	0.0339	-0.0104	0.0090
Standard-Pacific Corp	-0.82	-0.24***	0.04*	0.15	-0.1034	0.1264	0.0899	-0.2198
Tembec Industries Inc	-0.14	-0.01*	-0.06***	1.23	0.0004	0.0593	0.0506	-0.1829
Unisys Corp	-1.03	-0.12***	0.04*	0.26	-0.1849**	0.7553	-0.1083*	1.0618***
United States Steel Corp	-1.30	-0.1***	0.01	0.08	-0.0035	0.0803	-0.0154	0.1223
Xerox Corp	-0.84	-0.12***	0.01	0.06	-0.1829**	0.2754	0.2315**	-0.2196
General Motors Corp	-2.39	0.02**	0.03***	2.73	-0.0457**	-0.0235	-0.0169	0.0542
Europe IG								
Autos								
Renault SA	-0.35	-0.03***	0.04*	0.59	-0.0281	-0.0251	-0.1258***	-0.2417
Volkswagen AG	-2.11	0.01***	0.02***	2.40	0.0175*	0.1050	-0.0143	0.0863
Consumers								
Carrefour SA	-0.33	-0.04***	0.07*	0.65	-0.0854**	0.1313	-0.1094	-0.6547
Koninklijke Philips Electronics NV	-0.92	-0.02***	0.07***	0.78	0.0336**	0.2133	-0.0721	0.1801
Industrials								
Akzo Nobel NV	-0.79	-0.02**	0.05***	0.75	-0.0124	-0.0070	0.1555*	-0.3186*
TMT								
France Telecom SA	-1.17	0.01	0.19***	1.03	-0.0091	-0.0017	-0.0873	-0.0646
Europe HY								
Fiat SpA	-0.73	-0.04***	-0.03**	-2.42	-0.0552**	-0.0604	0.0114	-0.0453
Invensys PLC	-0.98	-0.07***	0.08***	0.53	0.1701***	0.3381	0.1678***	0.5142*
Rhodia SA	-1.05	-0.08***	0.01	0.12	0.0486	-0.1925	0.0681	-0.1165

Table IV.C2: VAR models

Estimation over the period 06/01/2004 to 30/12/2005 for 68 out of 120 firms.

	H_0 : no-causality from bond spread to CDS			H_0 : no-causality from CDS to bond spread		
	Sum coeff.	F-stat	Signif.	Sum coeff.	F-stat	Signif.
United States IG						
Consumers						
Altria Group Inc	0.87	46.03	0.00	0.10	1.89	0.13
General Mills Inc	0.01	0.55	0.58	0.15	0.90	0.41
Kroger Co/The	0.09	9.40	0.00	0.08	1.52	0.22
McDonald's Corp	-0.01	0.35	0.55	0.03	0.05	0.82
Newell Rubbermaid Inc	0.01	0.17	0.68	0.11	1.28	0.26
Nordstrom Inc	0.01	0.16	0.69	0.12	0.99	0.32
Target Corp	0.00	0.00	0.96	0.03	0.04	0.83
Energy						
Dominion Resources Inc/VA	-0.01	0.11	0.74	0.14	3.30	0.07
Sempra Energy	-0.01	0.09	0.77	0.57	29.39	0.00
Financials						
Chubb Corp	0.01	0.52	0.60	0.85	8.12	0.00
Countrywide Home Loans Inc	0.05	4.46	0.04	0.09	1.12	0.29
International Lease Finance Corp	0.00	0.01	0.99	-0.15	2.20	0.11
Simon Property Group LP	0.07	4.46	0.04	0.02	0.16	0.69
Washington Mutual Inc	0.02	0.93	0.33	-0.03	0.13	0.72
Wells Fargo & Co	0.02	6.05	0.01	0.05	0.09	0.77
Industrials						
Alcan Inc	0.03	0.36	0.70	0.20	2.04	0.13
Alcoa Inc	0.02	0.19	0.83	0.21	1.91	0.15
Boeing Capital Corp Ltd	0.01	0.04	0.84	0.16	5.92	0.02
Caterpillar Inc	-0.01	0.84	0.43	0.05	2.94	0.05
Eastman Chemical Co	0.02	0.25	0.62	0.10	2.21	0.14
Honeywell International Inc	0.03	3.65	0.06	0.06	0.38	0.54
Lockheed Martin Corp	0.00	0.00	0.99	-0.12	1.75	0.19
MeadWestvaco Corp	0.01	0.18	0.67	0.44	22.00	0.00
Union Pacific Corp	0.02	0.23	0.63	-0.02	0.19	0.67
TMT						
Comcast Cable Communications LLC	0.01	0.05	0.82	0.14	15.01	0.00
International Business Machines Corp	0.00	0.25	0.78	-0.52	1.01	0.36
Verizon Global Funding Corp	0.10	3.17	0.04	0.30	5.85	0.00
Walt Disney Co/The	0.01	0.45	0.50	0.15	1.73	0.19
Etats-Unis HY						
Echostar DBS Corp	-0.05	0.51	0.47	0.05	3.36	0.07
Lyondell Chemical Co	0.27	34.61	0.00	0.07	3.29	0.07
Rite Aid Corp	0.06	7.30	0.00	0.00	1.25	0.29
Six Flags Inc	0.21	11.98	0.00	-0.03	0.74	0.39
Smithfield Foods Inc	0.71	5.18	0.00	-0.03	0.42	0.86
Ford Motor Co	0.08	1.64	0.20	0.32	53.74	0.00

	H_0 : no-causality from bond spread to CDS			H_0 : no-causality from CDS to bond spread		
	Sum coeff.	F-stat	Signif.	Sum coeff.	F-stat	Signif.
Europe IG						
Autos						
Compagnie Financiere Michelin	0.02	1.24	0.27	0.42	23.11	0.00
Volvo AB	0.00	0.10	0.75	0.06	0.24	0.62
Consumers						
Alliance Boots PLC	0.10	3.20	0.07	0.11	5.28	0.02
Compass Group PLC	0.12	6.47	0.01	0.35	35.68	0.00
Experian Finance PLC	-0.13	1.30	0.27	0.27	8.91	0.00
Gallaher Group PLC	-0.07	3.32	0.07	0.20	14.92	0.00
Kingfisher PLC	0.03	1.98	0.16	0.12	1.71	0.19
LVMH SA	0.01	2.98	0.08	0.06	4.91	0.03
PPR	0.06	14.48	0.00	0.03	1.99	0.16
Sodexho Alliance SA	0.03	16.38	0.00	0.01	0.23	0.63
Tesco PLC	0.01	0.56	0.46	-0.03	0.02	0.90
Thomson	-0.05	0.88	0.42	-0.12	1.55	0.21
Energy						
E.ON AG	-0.01	2.12	0.12	1.00	5.11	0.01
Endesa SA	-0.02	0.84	0.43	0.80	9.02	0.00
Enel SpA	0.01	1.00	0.32	0.10	0.73	0.39
Iberdrola SA	0.00	0.02	0.90	-0.06	0.01	0.92
Repsol YPF SA	0.10	3.24	0.04	0.35	4.76	0.01
Suez SA	0.00	0.12	0.73	0.18	1.95	0.16
Financials						
Allianz SE	0.00	0.01	0.93	0.38	5.71	0.02
Banca Monte dei Paschi di Siena SpA	0.03	2.81	0.02	1.19	1.88	0.10
Banco Santander Central Hispano SA	0.00	0.02	0.89	0.14	0.55	0.46
Capitalia SpA	-0.01	0.28	0.76	-0.59	1.20	0.30
Commerzbank AG	-0.03	0.77	0.51	0.94	2.83	0.04
Deutsche Bank AG	0.00	0.19	0.83	-0.42	0.98	0.38
Industrials						
Arcelor Finance SCA	0.47	19.63	0.00	0.22	6.90	0.00
Cie de Saint-Gobain	0.01	0.85	0.36	0.46	12.70	0.00
EADS Co NV	0.03	4.14	0.04	0.13	1.27	0.26
Lafarge SA	0.02	0.99	0.32	0.35	12.76	0.00
UPM-Kymmene Oyj	0.02	0.95	0.33	0.38	20.77	0.00
TMT						
Deutsche Telekom AG	0.06	4.39	0.04	0.30	17.86	0.00
Telecom Italia SpA	-0.02	3.43	0.06	0.04	8.77	0.00
Telefonica SA	0.04	0.74	0.48	0.25	2.03	0.13
Vodafone Group PLC	0.01	0.43	0.51	0.46	11.50	0.00
WPP Ltd	0.02	1.42	0.23	0.51	32.00	0.00

Table IV.C3: VAR models (crisis period)

Estimation over the period 16/03/2005 to 24/08/2005 for 68 out of 120 firms.

	H_0: no-causality from bond spread to CDS			H_0: no-causality from CDS to bond spread		
	Sum coeff.	F-stat	Signif.	Sum coeff.	F-stat	Signif.
United States IG						
Consumers						
Altria Group Inc	0.35	3.54	0.02	0.52	1.39	0.25
General Mills Inc	0.02	0.09	0.91	0.37	0.31	0.74
Kroger Co/The	0.19	7.90	0.01	-0.07	0.26	0.61
McDonald's Corp	0.01	0.04	0.84	-0.03	0.05	0.83
Newell Rubbermaid Inc	0.13	2.88	0.09	-0.10	0.88	0.35
Nordstrom Inc	0.00	0.00	0.95	0.07	0.08	0.78
Target Corp	-0.01	0.05	0.83	0.04	0.03	0.86
Energy						
Dominion Resources Inc/VA	0.10	5.06	0.03	0.30	2.83	0.10
Sempra Energy	0.06	1.55	0.22	0.92	45.17	0.00
Financials						
Chubb Corp	0.06	4.74	0.01	1.45	5.70	0.00
Countrywide Home Loans Inc	0.10	5.39	0.02	-0.11	0.33	0.56
International Lease Finance Corp	-0.12	0.54	0.58	-0.29	5.51	0.01
Simon Property Group LP	0.09	2.42	0.12	0.03	0.06	0.81
Washington Mutual Inc	0.03	0.33	0.57	-0.26	3.43	0.07
Wells Fargo & Co	0.04	5.43	0.02	-0.40	0.85	0.36
Industrials						
Alcan Inc	0.09	0.28	0.76	0.31	2.96	0.06
Alcoa Inc	0.03	0.09	0.91	0.26	1.74	0.18
Boeing Capital Corp Ltd	0.00	0.00	0.96	-0.15	0.61	0.43
Caterpillar Inc	0.09	0.56	0.57	0.11	0.79	0.46
Eastman Chemical Co	0.09	1.06	0.31	-0.06	0.36	0.55
Honeywell International Inc	0.11	5.63	0.02	0.12	0.44	0.51
Lockheed Martin Corp	0.13	2.16	0.14	-0.17	3.41	0.07
MeadWestvaco Corp	0.02	0.56	0.46	0.88	15.73	0.00
Union Pacific Corp	0.05	0.31	0.58	-0.11	2.24	0.14
TMT						
Comcast Cable Communications LLC	0.06	6.44	0.01	0.66	3.89	0.05
International Business Machines Corp	0.03	0.83	0.44	-0.88	1.08	0.34
Verizon Global Funding Corp	0.09	1.84	0.16	0.19	1.25	0.29
Walt Disney Co/The	0.14	5.13	0.03	-0.11	0.72	0.40
Etats-Unis HY						
Echostar DBS Corp	0.08	0.08	0.77	0.05	1.96	0.16
Lyondell Chemical Co	0.32	5.47	0.02	0.06	0.82	0.37
Rite Aid Corp	0.13	7.12	0.00	-0.08	5.57	0.00
Six Flags Inc	0.47	18.43	0.00	-0.09	1.35	0.25
Smithfield Foods Inc	0.71	3.76	0.00	-0.09	1.52	0.18
Ford Motor Co	0.04	0.07	0.79	0.48	17.43	0.00

	H_0: no-causality from bond spread to CDS			H_0: no-causality from CDS to bond spread		
	Sum coeff.	F-stat	Signif.	Sum coeff.	F-stat	Signif.
Europe IG						
Autos						
Compagnie Financiere Michelin	0.07	0.75	0.39	0.42	12.83	0.00
Volvo AB	0.00	0.00	1.00	-0.11	0.71	0.40
Consumers						
Alliance Boots PLC	0.21	3.68	0.06	0.06	0.26	0.61
Compass Group PLC	0.01	0.00	0.95	0.30	2.53	0.11
Experian Finance PLC	-0.35	1.60	0.19	0.21	2.68	0.05
Gallaher Group PLC	-0.13	1.44	0.23	0.10	1.27	0.26
Kingfisher PLC	0.03	0.19	0.67	0.15	1.17	0.28
LVMH SA	-0.01	0.03	0.87	0.23	9.28	0.00
PPR	0.05	0.72	0.40	0.06	1.14	0.29
Sodexho Alliance SA	0.14	1.75	0.19	0.18	3.05	0.08
Tesco PLC	-0.02	0.58	0.45	-0.20	0.36	0.55
Thomson	-0.12	0.93	0.40	-0.34	1.34	0.27
Energy						
E.ON AG	-0.05	0.95	0.39	-0.06	0.43	0.65
Endesa SA	-0.20	3.75	0.03	0.58	2.51	0.09
Enel SpA	-0.04	3.80	0.05	0.19	0.20	0.65
Iberdrola SA	-0.01	0.41	0.52	-0.28	0.19	0.66
Repsol YPF SA	-0.21	3.02	0.05	0.31	1.76	0.18
Suez SA	0.00	0.01	0.92	-0.04	0.03	0.85
Financials						
Allianz SE	-0.05	1.04	0.31	0.25	1.69	0.20
Banca Monte dei Paschi di Siena SpA	0.08	1.24	0.30	0.62	0.51	0.77
Banco Santander Central Hispano SA	-0.01	0.06	0.80	0.12	0.08	0.78
Capitalia SpA	-0.01	1.15	0.32	-0.93	4.14	0.02
Commerzbank AG	0.02	0.31	0.82	0.60	1.44	0.24
Deutsche Bank AG	0.00	0.08	0.92	0.49	1.73	0.18
Industrials						
Arcelor Finance SCA	1.22	13.93	0.00	0.12	1.51	0.23
Cie de Saint-Gobain	-0.03	0.41	0.52	0.41	3.46	0.07
EADS Co NV	0.02	0.12	0.73	-0.07	0.15	0.70
Lafarge SA	-0.02	0.06	0.80	0.10	0.69	0.41
UPM-Kymmene Oyj	0.04	0.22	0.64	0.33	8.82	0.00
TMT						
Deutsche Telekom AG	-0.01	0.01	0.92	0.39	7.45	0.01
Telecom Italia SpA	0.01	0.10	0.75	0.13	3.81	0.05
Telefonica SA	0.06	0.11	0.90	-0.01	0.76	0.47
Vodafone Group PLC	-0.01	0.07	0.80	0.19	0.58	0.45
WPP Ltd	0.05	0.81	0.37	0.59	13.66	0.00

C.2 Stocks – CDS

Table IV.C4: VECMs

Estimation of equations (IV.13), (IV.14); dummies introduce as in model (IV.11) over the period 06/01/2004 to 30/12/2005 for 21 out of 120 firms. Significantly different from zero at the * 90%, ** 95%, *** 99% confidence levels.

	Model without dummies				Dummies			
	α_1	λ_1	λ_2	*GG*	μ_1	ν_1	μ_2	ν_2
United-States IG								
Consumers								
Safeway Inc	-1.02	-0.02**	0.03***	3.13	-0.0072	-0.0043	-0.0132	-0.0086
Target Corp	1.62	0.00	-0.02***	0.82	0.0315*	0.0602	0.0189**	-0.0155
Wyeth	0.24	-0.05***	0.00	-0.03	-0.0490	0.0115	0.0174	0.0017
Financials								
American International Group Inc	1.94	0.01	-0.02***	1.73	0.0083	0.1392***	-0.0301**	-0.1633***
Capital One Bank	0.49	-0.05***	-0.05**	0.52	0.0149	-0.1189	-0.293***	-0.3862
General Electric Capital Corp	1.24	-0.03***	-0.02**	0.42	0.0266	-0.2452	0.0296*	-0.3299
Hartford Financial Services Group Inc	1.91	0.00	-0.02***	0.91	-0.0281	0.0913**	0.0132	-0.0232
Simon Property Group LP	2.47	0.00	-0.01***	1.16	0.0103	-0.0050	0.0136	-0.0227
Wells Fargo & Co	0.55	-0.04***	-0.03***	0.39	-0.0114	0.1534	-0.0023	-0.1609**
Industrials								
Caterpillar Inc	4.16	0.00	-0.01***	1.02	0.0161	0.0597	-0.0020	-0.0035
Dow Chemical Co/The	0.83	-0.02	-0.04***	0.67	-0.0367	0.0490	-0.1173***	0.1843*
MeadWestvaco Corp	0.38	-0.02*	-0.05***	0.74	-0.0210	-0.8232	-0.0356	-0.1204
Etats-Unis HY								
AES Corp/The	0.34	-0.02**	-0.36***	0.96	-0.0059	0.5367*	0.3906**	-1.7870
AK Steel Corp	0.25	-0.02	-0.5***	0.96	0.0645**	-0.0269	0.2185	-0.1704
Allied Waste North America Inc	0.27	0.01	-0.48***	1.02	-0.0027	0.0491	0.1696	-0.0060
Lyondell Chemical Co	0.23	-0.01	-0.3***	0.96	0.0413	-0.2429	0.0279	-1.5453
Owens-Illinois Inc	0.53	-0.01	-0.3***	0.98	0.0200	0.0179	-0.0170	0.2415
Six Flags Inc	0.25	0.00	-0.24***	0.98	0.0176	0.1494	-0.0187	0.3374
Tembec Industries Inc	1.24	0***	-0.01**	1.73	0.0019	0.0122	-0.0002	-0.0124
United States Steel Corp	0.31	0.00	-0.36***	0.99	0.0275	0.0099	-0.0893	0.4369
Europe IG								
Autos								
Volkswagen AG	1.59	-0.01**	-0.03***	0.67	-0.0019	-0.0029	-0.0625***	-0.0116

Table IV.C5: VAR models

Estimation over the period 06/01/2004 to 30/12/2005 for 99 out of 120 firms.

	H_0 : no-causality from stock to CDS			H_0 : no-causality from CDS to stock		
	Sum coeff.	F-stat	Signif.	Sum coeff.	F-stat	Signif.
United-States IG						
Consumers						
Altria Group Inc	0.01	0.68	0.41	-1.28	87.58	0.00
Bristol-Myers Squibb Co	-0.05	1.65	0.20	-0.12	5.26	0.02
General Mills Inc	-0.06	3.48	0.06	-0.04	0.59	0.44
Kraft Foods Inc	-0.09	2.77	0.10	0.00	0.01	0.93
Kroger Co/The	0.03	0.66	0.42	-0.02	0.10	0.75
Marriott International Inc/DE	-0.08	2.10	0.15	-0.08	4.73	0.03
McDonald's Corp	0.06	0.83	0.36	-0.01	0.23	0.63
Newell Rubbermaid Inc	0.03	0.54	0.46	-0.06	1.74	0.19
Nordstrom Inc	0.03	0.31	0.58	-0.02	0.43	0.51
Wal-Mart Stores Inc	-0.10	0.52	0.67	-0.04	1.34	0.26
Whirlpool Corp	0.02	0.73	0.39	-0.09	0.93	0.34
Energy						
American Electric Power Co Inc	0.02	0.14	0.71	-0.11	8.11	0.00
Anadarko Petroleum Corp	0.00	0.02	0.90	-0.18	12.86	0.00
Dominion Resources Inc/VA	-0.01	0.09	0.76	-0.11	4.68	0.03
Sempra Energy	0.01	0.88	0.42	0.00	0.57	0.57
Financials						
Chubb Corp	-0.14	2.41	0.09	-0.16	9.94	0.00
CIT Group Inc	0.01	0.04	0.85	-0.14	19.98	0.00
Countrywide Home Loans Inc	0.03	0.27	0.61	-0.10	11.44	0.00
International Lease Finance Corp	-0.06	1.44	0.23	-0.20	27.84	0.00
Washington Mutual Inc	0.01	0.03	0.86	-0.09	4.43	0.04
Industrials						
Alcan Inc	0.06	0.36	0.70	-0.16	6.88	0.00
Alcoa Inc	0.04	0.42	0.52	-0.07	3.74	0.05
Boeing Capital Corp Ltd	-0.02	0.20	0.65	-0.14	12.81	0.00
Centex Corp	0.02	0.49	0.61	-0.25	14.08	0.00
CSX Corp	-0.03	0.52	0.47	-0.08	2.12	0.15
Deere & Co	0.11	1.58	0.21	-0.01	0.18	0.67
Eastman Chemical Co	0.13	3.75	0.02	-0.30	15.09	0.00
Goodrich Corp	-0.01	0.67	0.41	-0.08	0.53	0.47
Honeywell International Inc	-0.06	0.65	0.42	-0.03	0.95	0.33
International Paper Co	-0.01	0.18	0.67	-0.22	8.52	0.00
Lockheed Martin Corp	0.03	0.52	0.47	0.03	0.27	0.60
Union Pacific Corp	0.03	1.18	0.28	-0.31	17.46	0.00
Weyerhaeuser Co	0.01	0.70	0.55	0.12	4.17	0.01
TMT						
Clear Channel Communications Inc	-0.02	0.85	0.36	-0.31	8.01	0.00
Comcast Cable Communications LLC	-0.02	1.18	0.28	-0.10	1.07	0.30
Computer Sciences Corp	-0.01	0.43	0.51	0.40	13.37	0.00
Hewlett-Packard Co	-0.01	0.01	0.91	-0.03	0.80	0.37
International Business Machines Corp	-0.04	0.26	0.61	-0.08	9.11	0.00
Motorola Inc	-0.14	4.45	0.04	-0.05	2.30	0.13
Verizon Global Funding Corp	0.04	2.86	0.09	-0.09	1.23	0.27
Walt Disney Co/The	-0.06	1.71	0.19	0.08	3.24	0.07
Etats-Unis HY						
Bowater Inc	-0.01	0.64	0.42	-1.01	17.33	0.00
Dillard's Inc	-0.01	1.53	0.22	-0.74	3.62	0.03
Dynegy Holdings Inc	0.00	0.00	1.00	-1.47	10.98	0.00
Echostar DBS Corp	0.01	2.38	0.12	-0.24	0.90	0.34
El Paso Corp	0.00	0.84	0.36	-1.05	7.90	0.01
Forest Oil Corp	-0.01	0.45	0.50	-0.22	0.99	0.32
KB Home	-0.01	1.36	0.24	-0.13	0.56	0.46
Rite Aid Corp	0.00	0.49	0.62	-0.79	1.04	0.35
Royal Caribbean Cruises Ltd	0.00	0.04	0.85	-0.55	10.02	0.00

	H_0 : no-causality from stock to CDS			H_0 : no-causality from CDS to stock		
	Sum coeff.	F-stat	Signif.	Sum coeff.	F-stat	Signif.
Saks Inc	0.01	0.44	0.51	0.14	0.29	0.59
Smithfield Foods Inc	0.00	0.72	0.63	-0.06	1.86	0.09
Standard-Pacific Corp	0.01	0.80	0.45	-0.84	2.56	0.08
Unisys Corp	0.00	0.43	0.51	-1.52	20.66	0.00
Xerox Corp	-0.01	2.56	0.03	-1.23	1.21	0.30
Ford Motor Co	0.00	0.23	0.63	-2.33	30.15	0.00
General Motors Corp	0.01	2.52	0.11	-3.75	67.75	0.00
Europe IG						
Autos						
Compagnie Financiere Michelin	-0.10	3.43	0.06	0.01	0.02	0.88
Renault SA	-0.09	2.13	0.14	-0.06	4.46	0.04
Volvo AB	-0.26	11.83	0.00	-0.01	0.15	0.70
Consumers						
Alliance Boots PLC	0.02	0.41	0.52	0.22	8.54	0.00
Carrefour SA	-0.07	1.01	0.39	-0.06	1.67	0.17
Compass Group PLC	-0.03	0.79	0.37	-0.16	8.30	0.00
Experian Finance PLC	-0.03	0.58	0.45	-0.02	0.14	0.70
Gallaher Group PLC	0.07	1.54	0.21	-0.06	3.12	0.08
Kingfisher PLC	-0.03	0.67	0.41	0.04	0.74	0.39
Koninklijke Philips Electronics NV	-0.08	0.73	0.39	-0.05	7.38	0.01
LVMH SA	-0.09	1.22	0.27	-0.03	1.55	0.21
PPR	0.02	0.90	0.34	-0.21	5.79	0.02
Sodexho Alliance SA	0.00	0.00	0.95	-0.02	0.30	0.59
Tesco PLC	-0.20	2.06	0.15	0.00	0.01	0.93
Thomson	0.03	0.18	0.84	-0.04	0.22	0.81
Energy						
E.ON AG	0.02	0.03	0.86	0.00	0.01	0.91
Endesa SA	-0.10	1.79	0.18	-0.07	7.42	0.01
Enel SpA	-0.13	4.14	0.04	0.00	0.01	0.93
Iberdrola SA	0.16	4.62	0.03	0.00	0.00	0.99
Repsol YPF SA	-0.09	5.37	0.02	-0.07	1.94	0.16
Suez SA	-0.03	0.08	0.78	-0.05	7.04	0.01
Financials						
Allianz SE	0.00	0.00	0.97	-0.04	6.40	0.01
Banca Monte dei Paschi di Siena SpA	0.10	0.45	0.50	-0.02	1.78	0.18
Banco Santander Central Hispano SA	-0.01	0.01	0.92	-0.03	2.24	0.13
Capitalia SpA	-0.04	1.36	0.26	-0.04	3.44	0.03
Commerzbank AG	0.03	0.05	0.82	-0.03	6.22	0.01
Deutsche Bank AG	-0.04	0.05	0.82	-0.03	8.85	0.00
Industrials						
Akzo Nobel NV	0.08	1.23	0.27	0.00	0.00	0.99
Arcelor Finance SCA	-0.05	2.82	0.09	-0.18	6.45	0.01
Cie de Saint-Gobain	-0.10	1.32	0.25	0.01	0.21	0.65
EADS Co NV	-0.03	0.10	0.75	-0.03	2.80	0.09
Lafarge SA	-0.07	1.38	0.24	-0.05	2.93	0.09
UPM-Kymmene Oyj	-0.10	3.14	0.08	-0.07	4.28	0.04
TMT						
Deutsche Telekom AG	-0.01	0.10	0.76	-0.09	2.93	0.09
France Telecom SA	0.02	0.18	0.67	-0.09	5.46	0.02
Telecom Italia SpA	-0.05	2.74	0.10	-0.06	0.80	0.37
Telefonica SA	-0.09	3.07	0.08	-0.07	3.67	0.06
Vodafone Group PLC	0.03	0.10	0.76	-0.02	1.10	0.29
WPP 2005 Ltd	0.00	0.01	0.94	-0.06	3.42	0.07
Europe HY						
Fiat SpA	-0.01	2.51	0.11	-1.21	21.48	0.00
Invensys PLC	0.00	0.15	0.86	-1.55	8.25	0.00
Rhodia SA	-0.04	8.65	0.00	-1.12	7.91	0.00

Table IV.C6: VAR models (crisis period)

Estimation over the period 16/03/2005 to 24/08/2005 for 99 out of 120 firms.

	H_0 : no-causality from bond spread to CDS			H_0 : no-causality from CDS to bond spread		
	Sum coeff.	F-stat	Signif.	Sum coeff.	F-stat	Signif.
United-States IG						
Consumers						
Altria Group Inc	-0.02	0.74	0.39	-0.06	0.03	0.86
Bristol-Myers Squibb Co	-0.05	0.81	0.37	-0.04	0.09	0.77
General Mills Inc	-0.12	4.24	0.04	0.10	0.42	0.52
Kraft Foods Inc	-0.08	0.44	0.51	0.02	0.07	0.80
Kroger Co/The	0.07	1.09	0.30	-0.07	0.29	0.59
Marriott International Inc/DE	-0.04	0.16	0.69	-0.04	0.17	0.68
McDonald's Corp	0.09	1.02	0.31	0.13	2.14	0.15
Newell Rubbermaid Inc	0.13	4.81	0.03	-0.11	0.68	0.41
Nordstrom Inc	-0.04	0.21	0.64	-0.04	0.12	0.73
Wal-Mart Stores Inc	-0.75	1.85	0.14	0.00	1.83	0.15
Whirlpool Corp	0.03	0.29	0.59	0.16	0.69	0.41
Energy						
American Electric Power Co Inc	0.11	1.94	0.17	-0.39	12.69	0.00
Anadarko Petroleum Corp	-0.04	0.64	0.43	-0.17	1.30	0.26
Dominion Resources Inc/VA	0.13	1.59	0.21	-0.22	6.45	0.01
Sempra Energy	0.01	0.61	0.54	-0.11	4.23	0.02
Financials						
Chubb Corp	0.11	0.53	0.59	-0.02	0.94	0.40
CIT Group Inc	0.00	0.00	0.98	-0.21	9.60	0.00
Countrywide Home Loans Inc	-0.07	0.73	0.40	-0.03	0.08	0.78
International Lease Finance Corp	-0.10	1.79	0.18	-0.35	9.47	0.00
Washington Mutual Inc	-0.01	0.03	0.87	-0.14	1.07	0.30
Industrials						
Alcan Inc	0.11	0.82	0.44	-0.49	6.36	0.00
Alcoa Inc	0.06	0.81	0.37	-0.35	5.85	0.02
Boeing Capital Corp Ltd	0.01	0.01	0.91	-0.01	0.02	0.88
Centex Corp	0.00	0.04	0.96	-0.53	6.70	0.00
CSX Corp	-0.06	1.10	0.30	-0.14	0.79	0.38
Deere & Co	0.25	3.73	0.06	-0.02	0.13	0.72
Eastman Chemical Co	0.22	3.19	0.04	-0.32	5.87	0.00
Goodrich Corp	0.02	0.22	0.64	-0.13	0.75	0.39
Honeywell International Inc	0.03	0.06	0.81	0.10	1.76	0.19
International Paper Co	-0.02	0.25	0.62	-0.51	3.64	0.06
Lockheed Martin Corp	0.02	0.25	0.62	0.17	0.58	0.45
Union Pacific Corp	0.07	2.37	0.13	-0.86	22.66	0.00
Weyerhaeuser Co	0.01	0.61	0.61	0.68	6.27	0.00
TMT						
Clear Channel Communications Inc	-0.01	0.70	0.40	-0.65	1.65	0.20
Comcast Cable Communications LLC	-0.14	1.79	0.18	-0.10	1.39	0.24
Computer Sciences Corp	-0.14	5.51	0.02	-0.07	0.29	0.59
Hewlett-Packard Co	0.08	0.79	0.37	0.08	0.70	0.41
International Business Machines Corp	0.07	0.24	0.62	-0.10	2.27	0.13
Motorola Inc	0.03	0.08	0.77	-0.37	17.22	0.00
Verizon Global Funding Corp	0.04	1.11	0.29	-0.06	0.08	0.77
Walt Disney Co/The	0.09	1.41	0.24	-0.01	0.00	0.96
Etats-Unis HY						
Bowater Inc	0.01	0.12	0.73	-1.45	8.45	0.00
Dillard's Inc	0.01	0.11	0.90	-0.52	0.18	0.84
Dynegy Holdings Inc	0.00	0.03	0.87	-0.77	0.34	0.56
Echostar DBS Corp	0.01	3.20	0.08	0.18	0.02	0.88
El Paso Corp	0.00	0.38	0.54	-0.96	0.59	0.44
Forest Oil Corp	0.01	0.08	0.78	-0.71	4.04	0.05
KB Home	0.00	0.01	0.91	-0.73	5.60	0.02
Rite Aid Corp	-0.02	0.78	0.46	-0.45	0.53	0.59
Royal Caribbean Cruises Ltd	0.02	1.90	0.17	-0.43	0.45	0.50

	H_0 : no-causality from bond spread to CDS			H_0 : no-causality from CDS to bond spread		
	Sum coeff.	F-stat	Signif.	um coeff.	F-stat	Signif.
Saks Inc	0.00	0.15	0.69	1.01	1.54	0.22
Smithfield Foods Inc	0.01	1.20	0.31	0.01	1.13	0.35
Standard-Pacific Corp	0.02	0.84	0.43	-2.96	11.06	0.00
Unisys Corp	-0.02	2.52	0.11	-1.23	3.19	0.08
Xerox Corp	0.07	2.25	0.05	-0.62	0.25	0.94
Ford Motor Co	-0.01	1.02	0.31	-3.65	9.15	0.00
General Motors Corp	0.01	0.51	0.47	-4.36	25.58	0.00
Europe IG						
Autos						
Compagnie Financiere Michelin	-0.07	1.34	0.25	0.20	2.14	0.15
Renault SA	0.01	0.02	0.90	-0.02	0.04	0.85
Volvo AB	-0.21	3.44	0.07	0.01	0.01	0.91
Consumers						
Alliance Boots PLC	0.01	0.26	0.61	0.48	2.09	0.15
Carrefour SA	0.57	2.44	0.07	0.04	0.58	0.63
Compass Group PLC	-0.10	6.72	0.01	0.24	1.13	0.29
Experian Finance PLC	0.00	0.00	0.99	-0.01	0.01	0.93
Gallaher Group PLC	0.06	0.51	0.48	-0.02	0.05	0.83
Kingfisher PLC	-0.04	0.47	0.49	0.26	2.61	0.11
Koninklijke Philips Electronics NV	-0.39	3.30	0.07	-0.09	4.47	0.04
LVMH SA	-0.16	2.02	0.16	-0.05	0.34	0.56
PPR	0.04	1.01	0.32	0.26	1.42	0.24
Sodexho Alliance SA	-0.05	0.42	0.52	0.25	3.80	0.05
Tesco PLC	0.13	0.37	0.55	0.00	0.00	0.97
Thomson	0.09	0.36	0.70	-0.30	1.81	0.17
Energy						
E.ON AG	0.10	0.11	0.74	0.00	0.00	0.98
Endesa SA	0.09	0.83	0.36	0.07	0.54	0.46
Enel SpA	-0.18	0.39	0.53	-0.03	1.31	0.26
Iberdrola SA	0.28	4.09	0.05	0.03	0.25	0.62
Repsol YPF SA	-0.01	0.00	0.96	-0.03	0.25	0.62
Suez SA	0.29	2.24	0.14	-0.09	4.78	0.03
Financials						
Allianz SE	-0.06	0.14	0.70	-0.04	0.63	0.43
Banca Monte dei Paschi di Siena SpA	0.31	0.65	0.42	-0.01	0.05	0.83
Banco Santander Central Hispano SA	0.07	0.05	0.82	-0.05	3.35	0.07
Capitalia SpA	0.07	1.13	0.33	-0.02	0.78	0.46
Commerzbank AG	0.01	0.00	0.97	-0.10	8.23	0.00
Deutsche Bank AG	-0.30	1.82	0.18	-0.13	12.90	0.00
Industrials						
Akzo Nobel NV	0.15	1.35	0.25	-0.03	0.18	0.67
Arcelor Finance SCA	-0.02	0.22	0.64	-0.52	3.76	0.06
Cie de Saint-Gobain	-0.18	1.08	0.30	0.02	0.10	0.75
EADS Co NV	0.24	2.20	0.14	0.00	0.00	0.94
Lafarge SA	-0.02	0.03	0.85	-0.10	0.89	0.35
UPM-Kymmene Oyj	-0.17	4.58	0.03	-0.15	2.28	0.13
TMT						
Deutsche Telekom AG	-0.03	0.29	0.59	0.04	0.08	0.78
France Telecom SA	0.07	1.14	0.29	-0.08	0.46	0.50
Telecom Italia SpA	-0.08	2.63	0.11	0.13	0.54	0.46
Telefonica SA	-0.05	0.47	0.49	-0.18	1.80	0.18
Vodafone Group PLC	-0.25	2.25	0.14	-0.01	0.07	0.80
WPP 2005 Ltd	0.02	0.05	0.82	-0.15	2.54	0.11
Europe HY						
Fiat SpA	-0.01	1.11	0.29	-1.20	3.18	0.08
Invensys PLC	-0.01	0.22	0.80	-1.74	1.64	0.20
Rhodia SA	-0.04	1.85	0.16	0.76	0.66	0.52

Chapter V The sovereign CDS market: What the failure of Lehman Brothers changed[*]

Abstract

The crisis of 2007-2009 considerably altered investors' perception of sovereign risk. By intervening to salvage the financial system, governments created new links between the financial and public spheres. This development contributed to arousing market participants' interest in CDSs on government debt. We use econometric methods for measuring causality to identify the presence of such relations in the case of a sample of sovereign CDSs of euro area countries. The dynamic approach selected reveals that the markets became more strongly interrelated following the failure of Lehman Brothers. Unlike what has been observed on the other segments of the CDS market, the price discovery process takes place on the bond market. A significant result is that this relation tends to be reversed from the start of 2010.

JEL classification: E44; G01; G15.

Keywords: Risk transfert; Sovereign credit default swaps; Causality.

[*] I thank Céline Bazard and Virginie Coudert for helpful remarks.

1. Introduction

During the crisis of 2007-2009, the governments went to the rescue of their national banking systems which were on the verge of collapse. The situation became critical following the failure of Lehman Brothers, after which the US government, and the governments of other developed countries, decided to intervene massively. This resulted in a drastic and lasting deterioration in the public finances of most countries, further heightened by the subsequent recession. The sovereign risk of developed countries, which had up until then been considered as negligible, was suddenly revalued by the markets. This led to an increase in the cost of financing and credit default swap (CDS) premia for the most exposed countries, such as Ireland and Greece.

Past experience reminds us that both emerging and developed sovereign borrowers can be subject to default. History is punctuated by such events, as shown by Reinhart and Rogoff (2009). These defaults most often take the form of debt restructuring. More exceptionally, sovereign default may have been caused by debt repudiation, like in Russia in 1917, or by a moratorium on debt, like in Mexico in 1982. In the case of the euro area, fears of default may have been fueled by the no bailout clause in the Maastricht Treaty, which stipulates that neither the European Union nor EU Member States are liable for the commitments of other Member States, nor should they assume such liabilities.

The recent deterioration in public finances of euro area countries and of the most advanced OECD countries has fostered trading activity in the sovereign CDSs of these countries. These instruments have emerged as a new measure of market sentiment. The recent emergence of the market for sovereign CDSs of developed countries thus explains why there have so far been few studies on the subject. The spectacular growth of this new segment of the CDS market, which increased by 29% in 2009, may have altered the financial environment, given that trading in sovereign CDSs of developed countries has impacted the dynamics of the sovereign debt market in general (Boone *et al*., 2010). According to Duffie (2010), speculative strategies have, however, not led to an increase in the cost of financing of euro area Member States.

The exceptional volatility of developed countries' sovereign CDS premia observed from the summer of 2007, together with the extremely high premium levels compared with those recorded in the first half of 2007, suggests that this market segment may have overreacted. This intuition echoes the conclusions of Andritzky and Singh (2005), who already in the mid-2000s were questioning the pertinence of the level of sovereign CDS premia in the case of emerging countries.

The CDS market may have been considered as the cause of the movements observed on the underlying debt market. Theoretically, the bond spread should move in parallel with the CDS premium of a given entity. Divergences between these two series may, nevertheless, be observed for various reasons linked to the specificities of both markets. This implies that one may expect the asset price discovery process to take place predominantly on one of these two markets, rather than on the other.

Several studies have sought to identify which one of these markets tended to have a lead over the other. These studies, which use vector models and are based on the notion of causality, initially focused on companies and financial institutions. This focus can be explained by the considerable liquidity of the CDS market relative to that of corporate bond issuance. The European Central Bank (ECB, 2004), Blanco *et al*. (2005) and Zhu (2005), amongst others, thus concluded that, in the case of corporate CDSs, innovations on the CDS market had a greater tendency to spill over to bond spreads than the reverse. Baba and Inada (2007) come to the same conclusion using a sample of Japanese banks. The results are less clear-cut in the case of sovereign CDSs of emerging countries. Thus, while Bowe *et al*. (2009) conclude that the asset price discovery process takes place on the market for foreign currency denominated government bonds, Ammer and Cai (2007) note, for a different sample of countries, that when the bond market is relatively illiquid, the CDS market tends to dominate the underlying market. Coudert and Gex (2010a) have sought to determine how the asset price discovery process took place over the period from early 2007 to end-March 2010. In the case of the sovereign CDSs of the main European countries, they observe that the bond market has a lead over the CDS market, both during the calm period before the crisis and during the financial turbulences following the rescue of Bear Sterns. It appears, however, that this lead declines during the crisis and is less pronounced for those governments considered as the most fragile.

In this paper, we seek to determine (i) the links between the default risk of banks and governments and the extent to which the deterioration in the situation of the financial system has altered the perception of governments' default risk; (ii) the causal links between the CDS and sovereign bond markets and the direction of this causality. To this end, we study the causal links between these markets in the case of 8 euro area countries, chosen for the liquidity of their sovereign CDSs, and highlight the changes in these links during the crisis. We have a sample of 8 pairs of series of CDS premia and bond spreads for the 5-year maturity, which is the most traded maturity for CDSs.

We also construct an equivalent sample for the 10 year maturity, which is generally the maturity for government bonds.

Our study differs from the previous studies on two points. First, over the period from early 2007 to end-September 2010, we adopt a dynamic approach by allowing the coefficients of our vector model to vary thanks to the integration of an estimation by a Kalman filter. This method enables us to identify the presence of a causal link for each date, conditional on past information, and avoids us having to determine a precise event as the potential trigger of a change in market relations. We are thus able to ascertain whether one or several events in particular have contributed to distorting market relations, and how. We then integrate for each country a bank CDS index, when it is possible to construct one. This enables us to gauge to what extent public interventions, which have led to a transfer of risk from banks to governments, have contributed to altering these relations.

The study is structured as follows. Part 2 presents the characteristics of CDS contracts on sovereign reference entities and the specificities of sovereign CDS contracts of developed countries. Part 3 describes the different events that are likely to affect the impact and the role of sovereign CDSs of developed countries. Part 4 examines the changes in trading activity on this market during the different episodes of the crisis by looking at several measures of liquidity. Part 5 presents a statistical analysis of the links between markets. Part 6 concludes.

2. Characteristics of sovereign CDS contracts

The first CDS contracts were signed on sovereign entities following the series of crises that hit emerging countries in the 1990s. Their purpose was to provide protection against the risk of a credit event that could affect an emerging country. These contracts were then extended to corporate debt. Corporate CDSs now account for the lion's share of this market.

The development of developed sovereign CDS contracts is a recent phenomenon. A sovereign CDS has similar characteristics to a contract on non-sovereign reference entities. Two parties are involved: on the one hand, a protection buyer, which wishes to obtain protection against the risk of a credit event that may affect the reference entity; on the other, a protection seller, which, against payment, will reimburse the protection buyer the par value of the bond should a credit event occur[75]. The reference entity is the sovereign whose credit event will trigger the CDS, i.e. the reimbursement of the protection buyer by the protection seller. The reference entity is not a party to the contract and the protection buyer and the protection seller are under no obligation to notify it of the existence of the contract.

2.1. Documentation of the contracts

As for most CDS contracts signed between a protection buyer and a protection seller, a sovereign CDS is governed by a Master Agreement, which is a framework agreement defined by the International Swaps and Derivatives Association (ISDA). The Master Agreement specifies the conditions for all the CDSs between the buyer of protection and the seller of protection, which are generally large banks. It is a relatively flexible contract, which enables both parties to add specific conditions in the annex to the contract (Credit Support Annex – CSA).

The ISDA Master Agreement relating to sovereigns distinguishes between reference entities according to their geographical location. The Sovereign Master Credit Derivatives Confirmation Agreement put forward by the ISDA in 2004 makes the following distinction: Asian countries; European, Middle Eastern and Latin American emerging countries; Western Europe (the United States is included in this categorie); Japan. The characteristics of the contracts thus differ between developed and emerging reference entities. Contracts on emerging reference entities cover a wider range of credit events and restrict the type of underlying securities concerned by the occurrence of such a credit event (Table V.1).

Given that the emergence of the CDS market is a recent phenomenon, relatively few sovereign reference entities have, up until now, defaulted thereby triggering a CDS[76]. However, the few credit events that have occurred have contributed to improving the functioning of the CDS market in general. Russia’s default in 1998, following the restructuring of its domestic currency-denominated debt and the breaking off of transactions in government securities, brought to light the lack of documentation on CDS contracts and led to the provision of specific details on the identity of the issuer, subordination clauses and the status of creditors. The moratorium on Argentina’s debt at end-2001 was an opportunity to clarify the definition of credit events and the types of

[75] For a presentation of the default settlement procedure see, for example, Coudert and Gex (2010b).

[76] The most recent case of sovereign debt default is that of Ecuador. At end-2008, the government announced that it would not pay the remaining interest on its bonds maturing in 2012, 2012 and 2030.

deliverables. It was also the first credit event for which the default settlement on the CDS market was partly conducted in cash (Olléon-Assouan, 2004).

Table V.1: Characteristics of sovereign CDS contracts by type of underlying security

	Western Europe and Japan	European, Middle Eastern and Latin American emerging countries
Credit event	Failure to pay Moratorium / repudiation Restructuration	Failure to pay (extension of grace period) Acceleration Moratorium / repudiation Restructuration
Debt category	All forms of debt (bond or loan)	Bonds only
Recovery rate hypothesis	40%	25%
Characteristics of debt insturment	None	Not subordinated, not domestic currency denominated, not issued domestically or not domectic law listed

Source: ISDA.

2.2. *Strategies*

As a general rule, CDSs, like all derivatives, are used as a portfolio management instrument[77]. They are designed to hedge the credit risk of a given reference entity. These counterparty agreements reduce the credit exposure in terms of counterparty risk on this entity. In addition, hedging loans by purchasing CDSs saves on regulatory capital by reducing the capital charges linked to hedging (BCBS, 2006).

However, CDS premia are generally higher than the credit margin generated by the loan. The teams in charge of managing a financial institution's credit portfolio will "remodel" the credit portfolio in order to make this transaction financially attractive.

Assume that bank B wishes to grant a loan to company X but has reached its limit in terms of counterparty risk on company X. A solution would be for bank B to buy protection on company X in order to reduce its exposure to counterparty risk on X. Because this is costly for B, the bank will simultaneously sell protection on Y, a company in the same sector of activity and with a similar level of risk but which is not a client of B. The cost of buying protection on X will thus be offset by the premium paid on the sale of a CDS on Y. As the CDS premia on X and Y are supposed to be of the same amount and highly correlated, the transaction will be financially neutral and bank B will be able to maintain its business relations with X.

[77] For a review of credit derivative strategies see, for example, Chaplin (2005) and Das (2005)

Equivalent strategies may be put in place in the case of sovereign CDSs. For emerging countries, banks determine an overall amount per country, i.e. a limit to the banks' commitments in a given country. When a bank wishes to grant a loan to a company in an emerging country, but has already reached its limit, it may buy protection on this country. This protection does not have any regulatory value because it is considered as imperfect hedging and may therefore not be taken into account in the calculation of capital requirements. However, this transaction enables the bank to reduce its overall risk vis-à-vis the emerging country and to carry on with its lending activities.

Because banks do not set any limits to their exposure on developed countries, trading in sovereign CDSs of these entities is mainly aimed at reducing the cost of hedging counterparty risk. In the case mentioned above, bank B, which wishes to reduce the cost of hedging its exposure on X, may choose to sell protection on the sovereign country where X is established. The hedging cost will be partly offset by the profits derived from the sale of sovereign CDSs. In addition, because the risk of the sovereign is lower than that of X, the risk weighting of the new exposure will be limited. This type of strategy, which can also be applied to emerging countries, is especially effective when the sovereign CDS premium and that of the corporate CDS are correlated, i.e. in particular for public or predominantly State-owned enterprises.

However, the liquidity of the CDS market is mainly provided by trading activities. For example, an investor that anticipates an increase in a CDS premium can buy protection on the reference entity concerned, then sell protection on this same entity when the rise occurs. This will generate a profit until the CDS reaches maturity through the perception of a premium linked to the sale of protection that is greater than the premium paid following the purchase of protection. Relative value strategies may also be implemented. An investor that deems the hierarchy of CDS premia of two entities to be unusual will buy the CDS with the lowest premium and finance this position by selling the CDS with the highest premium. Once the premium inversion has disappeared, the investor will unwind its two positions by conducting a reverse transaction and make a profit on both CDSs. These arbitrages may also be made on the CDS curve, by betting on the steepening or the flattening of the curve of CDS premia[78]. Lastly, market participants may carry out basis trading strategies. These consist in simultaneously investing in a CDS and in the underlying debt security, by betting on the joint development of the CDS premium and the credit spread.

78 It is also possible to take positions on an implied forward CDS for a given reference entity. For example, an investor may create a 5-year maturity in 5 years, by combining a position on the 5-year CDS with one on the 10-year CDS.

As a result of the strong pressures experienced by sovereigns during the crisis, market participants decided to include developed sovereign CDSs in these different types of strategies (see Appendix A). To a lesser extent, sovereign CDSs have also been used to offer structured products with a government debt exposure, such as, for example, the construction of baskets of sovereign CDSs.

3. The behaviour of the sovereign CDS market during the crisis

3.1. Data

To study the behaviour of the developed sovereign CDS market over a sufficiently long period, we construct a composite index using the CDS premia in both indices. We calculate this composite index for the 5-year maturity, which is the benchmark maturity on the CDS market. We adopt the market's practice applied to all CDS indices by giving an equal weighting to the series within the composite indices. Our composite index is composed for the period from early 2007 to end-2009 of the CDS premia of the following 10 countries: Germany, Austria, Belgium, Spain, France, Greece, Italy, Japan, Portugal, Netherlands; we then add the CDS premia of Denmark, the United States, Ireland, the United Kingdom and Sweden (the construction of the index is explained in Appendix B).

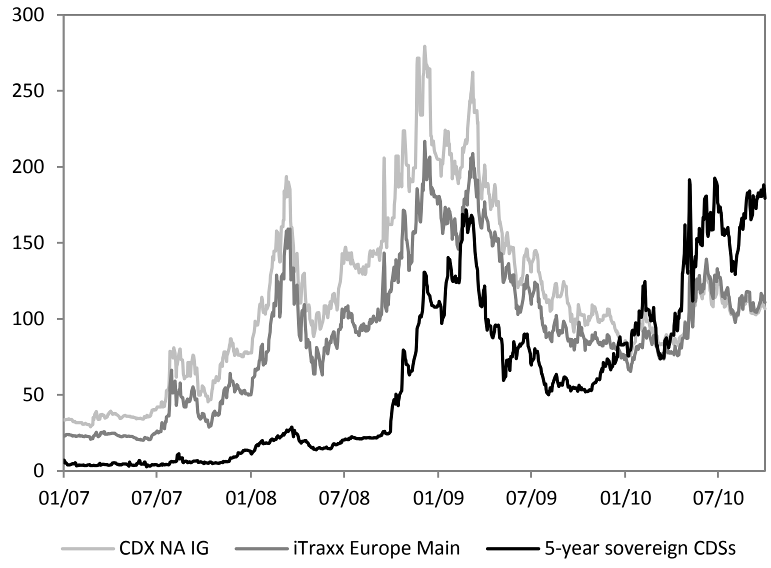
To analyse the behaviour of the sovereign CDS segment compared to the rest of the CDS market, we use the US CDX and the European iTraxx, which are benchmark indices for corporate CDSs (Chart V.1).

3.2. The first pressures on the financial institutions

Up until end-July 2007, the level of the composite index of sovereign CDSs and the 5-year market indices remained stable. The period of financial turmoil that followed was caused by the bursting of the subprime bubble, which was triggered by the collapse in house prices and the rise in interest rates, previously at historically low levels (Frank *et al*., 2008). Following the announcement by Bear Stearns on 18 July 2007 that two of its funds were encountering difficulties in meeting margin calls, investors became aware of the uncertainty regarding the valuation of structured products held by banks.

Indeed, an increase in the use of securitisation had led issuers to ease their credit standards and loan monitoring standards. This decline in credit quality as a result of the acceleration in securitisation is shown empirically by Keys *et al*. (2008). The rate of delinquencies and defaults on the underlying loans, mainly mortgage loans, in this type of

Chart V.1: CDS premia of the main market indices and of the 5-year sovereign CDS composite index (in basis points)



Sources: Bloomberg, Datastream.

instrument increased considerably from February 2007, as shown by the rise in the ABX index, which reflects the cost of insurance against default of a basket of mortgage loans for a given rating (Fender et Scheicher, 2008). From then on, the succession of negative announcements, such as the drying up of the Asset-Backed Commercial Papers (ABCP) market, both financial and non-financial, and the freezing up of the money market (Brunnermeier, 2009), triggered an upward movement in CDS premia, fuelled by the announcement of banks' bad results in the fourth quarter of 2007[79].

Between end-July 2007 and mid-March 2008, the main indices of corporate CDSs, the US CDX and the European iTraxx, more than tripled, rising by around 150 basis points and 130 basis points respectively. This episode also corresponds to a first break in the growth of sovereign CDSs. The sovereign CDS index remained relatively stable until the summer of 2007, at around 4 basis points. Following the announcement of the difficulties encountered by Bear Stearns, it increased to a maximum of around 30 basis points in March 2008, i.e. a rise of more than 600%. This increase can partly be ascribed to the revaluation of recovery rates conducted by market participants during the periods of financial turmoil (Andritzky and Singh, 2006; Singh and Spackman, 2009).

[79] Citigroup reported a record loss of USD 9.83 billion in the fourth quarter of 2007 and asset write-downs of USD 18.1 billion. On 15 February, UBS announced a loss of USD 7.8 billion in the last three months of 2007. Société Générale recorded losses of EUR 4.9 billion following the fraud committed by one of its traders, Jérôme Kerviel, on 24 January. Northern Rock was nationalized by the British government on 17 February.

The successive interventions of the Federal Reserve, which started setting up new facilities on 10 March to help investment banks and pursued its policy of rate cuts, as well as the implementation of additional measures by central banks helped to temporarily curb this increase in corporate CDS premia[80]. As Acharya *et al*. (2009) point out, the setting up by the Federal Reserve of the Term Securities Lending Facility (TSLF)[81] and the Primary Dealer Credit Facility (PDCF)[82] is the most radical change in US monetary policy since the Great Depression. In particular, Frank and Hesse (2009) show that the impact of the introduction by the Federal Reserve of the Term Auction Facility (TAF)[83], as well as the liquidity injections by the ECB through supplementary 90-day Long Term Refinancing Operations (LTRO) in the Euro area, contributed to reducing tensions, especially on the money market.

On 24 March, J.P. Morgan acquired Bear Stearns with the help of the Federal Reserve, which granted it a USD 30 billion loan to facilitate this takeover. At end-April, corporate CDS indices stood at less than 100 basis points.

Corporate CDS premia then posted a new increase, reflecting the deterioration in the situation of several financial institutions whose rating was reviewed downward by rating agencies. Between 1 May 2008 and 12 September 2008, the CDX and iTraxx indices were up by 61 and 34 basis points respectively. Over this same period, the composite index remained stable at around 20 basis points from June to September.

3.3. The bankruptcy of Lehman Brothers and government responses

From the summer 2007, the investment bank Lehman Brothers started to accumulate considerable losses as a result of large exposures on high-risk products. Between its high point in February 2007, at USD 85.6, and 12 September 2008, the stock price of the bank dropped by 73%, to USD 3.7. In the absence of a government rescue scheme, the bank was compelled to file for Chapter 11 bankruptcy protection on 14 September 2008. According to certain interpretations, the Federal Reserve considered itself unable to grant a loan to Lehman Brothers because the investment bank could not provide the required assets as collateral (Cassidy, 2008). Investors then became aware that the role of lender of

---

80 See for example Federal Reserve Bank of New York (2010) for a detailed chronology of the international responses to the crisis.

81 The TSLF, organized in the form of auctions, allowed primary dealers to borrow Treasury securities from the Federal Reserve by pledging a wide range of eligible collateral.

82 The PDCF, the equivalent of a discount window for investment banks, provided central bank liquidity to primary dealers in exchange for investment grade collateral subject to an appropriate haircut.

83 The TAF allows the Fed to auction collateralised loans to commercial banks; eligible collateral is the same as that accepted for discount window loans.

last resort of the Federal Reserve, together with the additional mechanisms for giving investment banks access to liquidity set up following the collapse of Bear Stearns, would not give rise to unconditional and unlimited support (Acharya *et al*., 2009).

The bankruptcy became effective on 15 September and represented an unprecedented shock for markets from a general point of view. The change in macroeconomic and financial conditions following the bankruptcy of Lehman Brothers brought about a change in the nature of financial turmoil and the responses of public authorities. Prior to 15 September 2008, the subprime crisis was characterised by the predominance of central bank measures whose objective was to contain the confidence crisis linked to counterparty risk. After this date, the crisis became global and the international response took the form of measures aimed at restoring financial stability and preventing a global economic depression (Aït-Sahalia *et al*., 2009).

The CDS market was particularly hit by the failure of Lehman Brothers. Lehman Brothers was indeed very active on this market and one of the dealers on this type of product, i.e. one of the counterparties that investors needed to speak to in order to trade CDSs (Yelvington and Taggert, 2008). The collapse of Lehman Brothers led market participants to reconsider their perception of counterparty risk. Up until then, this risk was considered as negligible, since financial institutions intervening on the CDS market were considered to be reliable.

There were also fears that the failure of Lehman Brothers would lead to the collapse of the entire market (Coudert and Gex, 2010d). Indeed, the involvement of Lehman Brothers on the CDS market was twofold. First, Lehman Brothers was a reference entity on which a large number of CDSs had been traded. On this point, given that the CDS market is an over-the-counter (OTC) market, it was difficult to estimate the amounts to be traded that the failure of Lehman Brothers would generate in the framework of the settlement of contracts (Gerson Lehrman Group, 2008). Second, because Lehman Brothers was a major dealer, the question arose as to the unwinding of CDS in which the bank was a counterparty, i.e. a buyer or seller of protection. This was a particular problem for investors who had bought protection from Lehman Brothers for hedging purposes.

There then followed a second break in the growth of sovereign CDS premia. This corresponds to the time when several European countries decided on a first wave of measures designed to rescue the financial system, which had been put under strain by the deterioration in financial conditions as a result of the bankruptcy of Lehman Brothers, by acquiring stakes in the capital of their main banks and guaranteeing private individuals' deposits:

- On 28 September, Belgium, the Netherlands and Luxembourg came to the rescue of Fortis, which was faced with a solvency crisis, by partially nationalising it. For a total amount of EUR 11.2 billion, the Belgian government acquired 49% of the bank, and the Dutch and Luxembourg governments took a 49% stake of the subsidiaries on their territory (Fortis Bank Nederland and Fortis Banque Luxembourg);
- On 29 September, the German government, backed by a number of private banks, extended a EUR 35 billion credit line to Hypo Real Estate, the fourth largest bank in the country. The British government nationalized Bradford & Bingley and the Icelandic government nationalised up to 75% the third largest bank in the country, Glitnir;
- On 30 September, the Irish government provided an unlimited two-year guarantee of bank deposits and debts of six major Irish banks (Allied Irish Bank, Bank of Ireland, Anglo Irish Bank, Irish Life and Permanent, Irish Nationwide Building Society, Educational Building Society). Belgium, France and Luxembourg injected EUR 6.4 billion into Dexia via a capital increase.

In the United States, the Emergency Stabilization Act was passed on 3 October. It granted the US Treasury broader powers through the Troubled Asset Relief Program (TARP). It authorised the purchase and insurance of up to USD 700 billion of banks' toxic assets in order to stabilise financial markets, support the real estate and mortgage markets and minimise the cost borne by taxpayers (Aubuchon, 2009).

Government rescue packages for banks consist in a risk transfer from banks to governments (Ejsing and Lemke, 2009). These announcements triggered a sudden increase in sovereign CDS premia in early October 2008. Between 26 September and 10 October, the sovereign CDS index was up by 91%, from 25 basis points to 47 basis points.

The fears surrounding the possible systemic impact of the collapse of one or more banks exerted strong pressures on the entire CDS market. However, all the measures taken by governments to support the economy through substantial recovery plans[84] led to a decline in corporate CDSindices.

At the same time, the rise in sovereign risk resulting from these public commitments and the resulting transfer of risk to governments led to an almost continuous rise in sovereign CDS premia over 5 months. At the end of February 2009, the composite index peaked at 172 basis points, reflecting investors' concerns over the sustainability of government debt.

All CDS premia then started to decline. Between 24 February and 4 August 2009, the sovereign CDS index dropped by 71 basis points. The CDX and iTraxx indices also recorded a fall, with premia decreasing by 48% and 51% respectively over the same period. This first improvement in market conditions can be ascribed to the continued intervention of public authorities, both through further monetary policy easing and additional aid packages to the banking sector[85].

3.4. The deterioration of public finances

The measures taken by public institutions to support the financial sector are divided into two categories, direct and indirect measures (IMF, 2009a, 2009b). Direct measures are those that have an impact on the government deficit. This category includes loans to financial institutions and equity purchases of these institutions, capital injections and purchases of risky assets. It also covers transactions conducted by central banks that require Treasury financing and do not appear on public accounts. One example is the Special Liquidity Scheme (SLS) of the Bank of England. The SLS was in place between 21 April 2008 and 30 January 2009. It enabled British banks to trade, over a 1 to 3-year period, high quality assets accepted as collateral after application of a haircut (for example the AAA-rated RMBS) against government securities. The latter were provided by the Debt Management Office of the British Treasury for a total amount of GBP 185 billion (Bank of England, 2009).

Indirect measures may have a high fiscal cost but do not have an impact on the government deficit. These include public interventions by entities other than the

[84] The European recovery plan approved by the European Heads of State on 2 December amounts to EUR 200 billion, i.e. 1.5% of the euro area GDP.

[85] This downward movement was, however, adversely affected by the publication of banks' results for 2008, which were particularly bad. On 3 March, the CDX and iTraxx indices posted a new high following the announcement of a record annual loss of USD 99.3 billion by AIG. Indeed, as AIG's rating was downgraded by rating agencies, the counterparties of the insurance company demanded more collateral to cover their positions on CDS sold by AIG. The insurance company was unable to meet these margin calls (Weistroffer, 2009). The US Treasury bailed out AIG by injecting USD 30 billion and by organising its restructuring. This episode shows that the market remained fragile and sensitive to negative announcements despite the aid packages.

government that do not have an impact on public accounts (mainly the provision of exceptional liquidity by central banks), and guarantees provided by governments or central banks.

First, governments have strengthened the protection of creditors to prevent a confidence crisis vis-à-vis the banking sector, by improving the coverage of deposits and guaranteeing debt issuance of financial institutions. Second, the direct measures taken immediately after the failure of Lehman Brothers were massive capital injections. The G20 governments injected a total of USD 384 billion between September 2008 and February 2009. Recapitalisations then continued at a slower pace. By mid-2009, an additional USD 75 billion had been injected into the financial system (Group of Twenty, 2009).

By mid-April 2009, the direct measures taken by developed countries accounted for 5.3% of these countries' GDP in 2008. This percentage climbs to 32.3% if one takes into account indirect measures (IMF, 2009a). The most significant direct measures were taken by the United Kingdom (20.2% of GDP), via the SLS and the Asset Purchase Facility (APF). This facility, which has been in place since 25 March 2009, has enabled the Bank of England, via an ad hoc subsidiary, to inject money into the economy by purchasing high-quality assets (mainly commercial paper, non-speculative grade corporate bonds and British government bonds) with a Treasury guarantee[86]. In addition, Northern Rock (GBP 99 billion) and Bradford & Bingley (GBP 50 billion) were nationalised.

Indirect interventions came to substantial amounts, in particular in the case of Ireland, where a guarantee arrangement to safeguard all deposits, covered bonds, senior debt and subordinated debt of Irish banks totalled an estimated amount of EUR 485 billion, i.e. 257% of the country's GDP in 2008 (IMF, 2009b).

The deterioration in sovereigns' tax receipts and the cost of interventions caused a sharp rise in government debt. In developed countries, the ratio of government debt to GDP was close to the level observed after the Second World War. The great majority of European Union countries no longer met the Maastricht criteria (Table V.2). Between 2007 and 2009, the ratio of government debt to GDP was up by 12.7 percentage points, from 66.0% to 78.7% in the case of the euro area, and by 14.8 percentage points, from 58.8% to 73.6% in the EU-27. At end-2009, 12 Member States out of 27 showed a government debt ratio above 60%, among which Italy (115.8%), Greece (115.1%), Belgium (96.7%),

[86] Initially set at GBP 75 billion, the amount of assets purchased under the APF was subsequently raised on a regular basis (Benford *et al*., 2009).

France (77.6%), Portugal (76.8%), Germany (73.2%), the United Kingdom (68.1%), Austria (66.5%), Ireland (64.0%) and the Netherlands (60.9%), present in the composite index. In the case of the United States, the ratio of debt to GDP rose by 19.4% percentage points, from 48.4% to 67.7%.

Table V.2: Government debt and deficit as a % of GDP

	Government debt (as % of GDP)			Government deficit (-) / surplus (+) (as % of GDP)		
	2007	2008	2009	2007	2008	2009
Euro area	66.0	69.4	78.7	-0.6	-2.0	-6.3
European Union	58.8	61.6	73.6	-0.8	-2.3	-6.8
Austria	59.5	62.6	66.5	-0.4	-0.4	-3.4
Belgium	84.2	89.8	96.7	-0.2	-1.2	-6.0
Denmark	27.4	34.2	41.6	4.8	3.4	-2.7
France	63.8	67.5	77.6	-2.7	-3.3	-7.5
Germany	65.0	66.0	73.2	0.2	0.0	-3.3
Greece	95.7	99.2	115.1	-5.1	-7.7	-13.6
Ireland	25.0	43.9	64.0	0.1	-7.3	-14.3
Italy	103.5	106.1	115.8	-1.5	-2.7	-5.3
Netherlands	45.5	58.2	60.9	0.2	0.7	-5.3
Portugal	63.6	66.3	76.8	-2.6	-2.8	-9.4
Spain	36.2	39.7	53.2	1.9	-4.1	-11.2
Sweden	40.8	38.3	42.3	3.8	2.5	-0.5
United Kingdom	44.7	52.0	68.1	-2.8	-4.9	-11.5
United States	48.4	56.4	67.7	-2.9	-6.5	-11.1
Japan	156.3	162.2	…	-2.5	-2.1	…

Source : BCE, Eurostat, national.

Lower potential growth had an adverse impact on debt dynamics and was accompanied by a widening of government deficits (Table V.2). At end-2009, the following countries in our sample showed the largest deficit to GDP ratios: Ireland (-14.3%), Greece (-13.6%), United Kingdom (-11.5%), Spain (-11.2%), Portugal (-9.4%) and France (-7.5%). Over the same year, no EU Member State recorded a government surplus. This deterioration was also particularly pronounced in the United States, where the budget balance reached -9.9% in 2009 against -1.1% in 2007.

3.5. *The change in the perception of sovereign risk*

In the case of the euro area, this new upward movement in sovereign CDS premia and bond spreads occurred after a significant narrowing of spreads and a low differentiation between Monetary Union Member States, which had raised doubts as to markets' ability to correctly assess the pertinence of euro area governments' fiscal policy (Garzarelli and Vaknin, 2005; Debrun *et al*., 2008; Attinasi *et al*., 2009). From the end of 2008, it appears that markets progressively took into account the impact of this deterioration in the fiscal position of these governments (Sgherri and Zoli, 2009).

Membership of a monetary area is a specificity that influences markets' perception of the credit risk of the euro area Member States. According to article 125 of the Lisbon Treaty (former article 103 of the EC Treaty), neither the European Union nor EU Member States are liable for the commitments of other Member States, nor should they assume such liabilities, except for specific projects[87].

This provision, known as the no-bailout clause, aims at neutralising the moral hazard effect of belonging to a monetary area: if the European Union had established an automatic support mechanism, EU Members would have had less incentive to reduce their deficits. Even if such a mechanism existed, there would still be the question of its implementation, as neither the European Commission nor the Member States have any expertise in the matter or the necessary resources (Pisani-Ferry and Sapir, 2010).

In the case of sovereign CDSs, fears over the explosion of the euro area raised the question of the triggering of CDSs. According to the ISDA definitions (2009), a restructuring credit event consists in a reduction in the principal amount or interest payable, a postponement of payment or a change in the payment currency. Concerning this last point, an exception is made if the debt is redenominated in the currency of a G7 country or any country belonging to the OECD, provided that the long-term debt of the government conducting the restructuring be rated AAA by one of the three main rating agencies, Standard and Poor's, Moody's or Fitch. Technically, if a Member State rated less than AAA were to leave Monetary Union and adopt a domestic currency, this would trigger the sovereign CDS (Mahadevan *et al*., 2010). In practice, given that the debt of the monetary union countries is predominantly denominated in euro, adopting a domestic currency, much weaker than the euro, would very likely lead the sovereign to default, which would in fine trigger the CDS[88].

[87] "The Union shall not be liable for or assume the commitments of central governments, regional, local or other public authorities, other bodies governed by public law, or public undertakings of any Member State, without prejudice to mutual financial guarantees for the joint execution of a specific project. A Member State shall not be liable for or assume the commitments of central governments, regional, local or other public authorities, other bodies governed by public law, or public undertakings of another Member State, without prejudice to mutual financial guarantees for the joint execution of a specific project" (article 125 of the Lisbon Treaty).

[88] A CDS is not necessarily triggered by an aid package in the form of a loan by another government or an international organisation such as the IMF. Indeed, a restructuring credit event triggers the CDS if the situation of the creditors of the entity concerned has deteriorated. If the loans granted in the framework of an IMF programme, for example, are considered as "super senior", the seniority of the old creditors would indeed deteriorate. In practice, they often have the

The confidence crisis vis-à-vis euro area countries led to a deterioration in the rating of several countries in the region over the period under review, which naturally fuelled further concerns. At the start of 2009, Standard & Poor’s downgraded the rating of Spain, which had up until then been AAA-rated, the best agency rating, as well as those of Portugal and Greece (Table V.3). Between end-March and early July 2009, the difficulties encountered by Ireland led the three main rating agencies, Fitch, Moody’s and Standard & Poor’s, to downgrade the country’s debt rating, which had previously been AAA-rated.

Fears of a European sovereign defaulting also raised the question of the management of such an event. Indeed, market participants had in mind the case of Argentina in 2001 and the cost that a badly managed default could generate for several years afterwards (Beattie, 2010).

In September 2009, Greek authorities reported a government debt of EUR 297.9 billion, almost entirely denominated in euro. The tight fiscal position of Greece led the three rating agencies to downgrade the countries’ rating between mid-October and mid-December 2009. This raised the question of the eligibility of Greek government bonds for ECB refinancing (Cailloux *et al.*, 2009; Menuet and Schmieding, 2009). Under the broader monetary policy framework put in place during the crisis, BBB-rated securities became eligible as collateral. Greece’s rating came dangerously close to this limit (two notches)[89]. Year 2010 was characterized by growing concerns about the sustainability of Member States’ budget, especially regarding Southern Europe countries and Ireland. Further downgrades of Greece by the major rating agencies led the ECB to suppress temporarily its rating threshold; moreover Greek sovereign bonds were removed from the main benchmark indices following these downgrades. From April 2010 onwards, in order to help to most fragilised countries, the European Union, in partnership with the IMF, implemented several programmes[90]. Additionally, the ECB, as well as other major central banks, decided to postpone possible exit strategies from the exceptional monetary policy frameworks implemented during the crisis.

same rank as the other creditors of the sovereign (like in Latvia and Hungary). Because of reputational risk, the sovereign will prefer to default on the rest of its debt rather than on the IMF loan.

89 In normal circumstances, the ECB limits eligible collateral to A- -rated securities. According to Fitch’s rating, Greek government bonds would no longer be eligible as collateral should the situation return to normal.

90 The European plan, adopted on 9 May 2010, totalising 750 billion EUR, consists of a 60 billion EUR credit line financed by the European Commission, a IMF loan of 250 billion EUR and an amount of 440 billion EUR hosted by of the European Financial Stability Fund (EFSF), a structure which would grant loans on a 3-year horizon to European Monetary Union Member States. In addition, under the Securities Markets Programme (SMP), established on 14 may 2010, allows the ECB to purchase “(a) on the secondary market, eligible marketable debt instruments issued by the central governments or public entities of the Member States whose currency is the euro; and (b) on the primary and secondary markets, eligible marketable debt instruments issued by private entities incorporated in the euro area” (OJEU, 2010).

Table V.3: Ratings of sovereigns by the three major rating agencies

The ratings of Standard and Poor's are AAA, AA+, AA, AA-, A+, A, A-, BBB+, BBB, BBB- for the non-speculative grade category, BB+, BB, BB-, B+, B-, CCC, CCC-, CC for the speculative grade category. The ratings of Fitch are similar, with the exception of the ratings starting with C, which are grouped under a single category CCC. The ratings of Moody's are Aaa, Aa1, Aa2, Aa3, A1, A2, A3, Baa1, Baa2, Baa3 for the non-speculative grade category, Ba1, Ba2, Ba3, B1, B2, B3, Caa1, Caa2, Caa3 for the speculative grade category.

	Date	Moody's	Standard & Poor's	Fitch
Austria	03/01/2007	Aaa	AAA	AAA
Belgium	03/01/2007	Aa1	AA+	AA+
Denmark	03/01/2007	Aaa	AAA	AAA
France	03/01/2007	Aaa	AAA	AAA
Germany	03/01/2007	Aaa	AAA	AAA
Greece	03/01/2007	A1	A	A
	09/01/2009		A-	
	22/10/2009			A-
	08/12/2009			BBB+
	16/12/2009		BBB+	
	22/12/2009	A2		
	09/04/2010			BBB-
	22/04/2010	A3		
	27/04/2010		BB+	
	14/06/2010	Ba1		
Ireland	03/01/2007	Aaa	AAA	AAA
	30/03/2009		AA+	
	08/04/2009			AA+
	08/06/2009		AA	
	02/07/2009	Aa1		
	04/11/2009			AA-
	19/07/2010	Aa2		
	24/08/2010		AA-	
Italy	03/01/2007	Aa2	A+	AA-
Japan	03/01/2007	Aaa	AA-	AA-
	23/04/2007		AA	
	02/04/2009	Aa3		
	18/05/2009	Aa2		
Netherlands	03/01/2007	Aaa	AAA	AAA
Portugal	03/01/2007	Aa2	AA-	AA
	20/01/2009		A+	
	24/03/2010			AA-
	27/04/2010		A-	
	13/07/2010	A1		
Spain	03/01/2007	Aaa	AAA	AAA
	19/01/2009		AA+	
	28/04/2010		AA	
	28/05/2010			AA+
	30/09/2010	Aa1		
Sweden	03/01/2007	Aaa	AAA	AAA
United Kingdom	03/01/2007	Aaa	AAA	AAA
United States	03/01/2007	Aaa	AAA	AAA

Sources: Fitch, Moody's, Standard & Poor's.

The deterioration in the fiscal position of developed sovereigns, together with the fears as to their ability to obtain short-term refinancing and consequently their medium term solvency, resulted in a rise in CDS premia. This increase was particularly pronounced in Southern Europe. During the last period, the CDS premium of Greece jumped by 673% to 775 basis points, exceeding 1,000 basis points on several occasions, while that of Portugal surged by 817% to 409 basis points. At the same time, the sovereign CDS premium climbed by 259%. On 30 September 2010, the sovereign CDS indice stood at 179 basis points, 72 basis points above the CDX premium (107 basis points) and 68 basis points above that of iTraxx (111 basis points).

The period under review can be divided into five sub-periods that reflect the developments in sovereign CDS premia and correspond to certain events that altered investors' perception of sovereign default risk:

(1) from 01/01/2007 to 18/07/2007: calm period preceding the start of the financial crisis;

(2) from 19/07/2007 to 12/09/2008: first pressures on financial institutions following the difficulties encountered by Bear Stearns;

(3) from 15/09/2008 to 24/02/2009: the bankruptcy of Lehman Brothers triggered a phase of strong pressures; market indices, in particular bank CDS premia, reached historic levels, prompting governments to set up rescue packages for financial institutions;

(4) from 25/02/2009 to 04/08/2009: improvement in market conditions thanks to the rescue packages;

(5) from 05/08/2009 to 30/09/2010: deterioration in investors' perception of sovereign risk caused by the worsening of sovereigns' fiscal position and the fears surrounding the sustainability of their debt.

4. Changes in market activity and practices during the crisis

Because the CDS market is an OTC market, it is difficult to observe its activity. However, based on the data on the 15 sovereign CDSs of developed countries in the basket that makes up the composite index, we have a number of elements that point to an increase in activity, associated with a rise in market liquidity, since the start of the crisis.

4.1. Number of transactions

In order to obtain a first measure of market activity, we extracted the veracity score calculated by CMA, Datastream's supplier of CDS data. This veracity score shows how the price displayed every day was calculated. It is expressed on a scale from 1 to 7 (Table V.4). A veracity score of 1 indicates actual trade. A veracity score of 2 or 3 indicates that the price was posted by at least one market maker, with or without a firm commitment to trade. When the veracity score is above 3, the premium is calculated using bond market data and not a market quote.

Table V.4: Veracity score scale

Veracity score	Description
1	Actual trade
2	Firm quote
3	Quote
4	Interpolation of term structure, same credit instrument type
5	Interpolation of term structure, same issuer, different credit instrument type
6	Same issuer, calibrated structural model
7	Interpolation of sector-ratings term structure

Source: CMA.

In the first half of the 2000s, the big majority of CDS transactions concerned non-sovereign reference entities. Furthermore, sovereign CDS transactions were largely focused on emerging reference entities (Dages *et al*., 2005). In 2003, Packer and Suthiphongchai (2003) showed that 90% of all sovereign CDS contracts were linked to emerging market sovereign credits. They also observed that few quotes on CDS corresponded to actual transactions.

During the period that preceded the difficulties encountered by Bear Stearns, at end-July 2007, and for CDSs, few transactions were conducted on the reference entities in the sample (Table V.5). Italy is the only exception: 45% of the daily premia corresponded to actual transactions. This is also the case, but to a lesser extent, for Greece and Portugal, i.e. the euro area countries perceived by investors as more fragile[91]. Nevertheless, market makers posted daily quotes for almost all CDSs available during this period.

During the second period, which runs up to the failure of Lehman Brothers on 15 September 2008, activity increased significantly, with most countries conducting a transaction every two to three days on average. After the failure of Lehman Brothers, almost 90% of daily premia corresponded to actual transactions, with the exception of Japan (42%) and, to a lesser extent, the United States (76%). Furthermore, market makers started posting daily quotes for all of the countries in the sample.

[91] From 2003, Italy and Portugal were among the 25 most traded reference entities according to Fitch (2004).

The level of activity remained unchanged until the end of the period under review: during the last two periods, at least one transaction per day was conducted for all the countries in the sample, with the exception of Japan, which showed a lower level of activity albeit higher than in the second period.

From the start of the crisis, activity on developed sovereign CDS is close to, and in some cases higher than that on emerging sovereign CDS. Indeed, in a sample of six 5-year CDS of emerging countries chosen for their liquidity, Bowe *et al*. (2009) observe, between 2004 and 2006, around 20 CDS quotes per month, i.e. roughly 200 quotes per year.

Table V.5: Proportion of 5-year CDS premia corresponding to transactions

For each country, we calculate the ratio of the number of days for which the Datastream price data correspond to at least one actual transaction, i.e. a veracity score of 1. The presence of bank holidays, which are incorporated into the database such as to always obtain 5-day weeks, and to which Datastream applies the previous day's value with a veracity score of 2, explains why it is not possible to obtain a ratio of 100%. The percentage in italics is the ratio of the number of days for which a price is displayed, with or without a firm commitment to trade and with or without an actual transaction taking place, i.e. a veracity score of up to 3.

	Period 1	Period 2	Period 3	Period 4	Period 5
	(from 01/01/2007 to 18/07/2007)	(from 19/07/2007 to 12/09/2008)	(from 15/09/2008 to 24/02/2009)	(from 25/02/2009 to 04/08/2009)	(from 05/08/2009 to 30/09/2010
Austria	3% *100%*	47% *88%*	91% *100%*	97% *100%*	97% *100%*
Belgium	11% *100%*	54% *98%*	91% *100%*	97% *100%*	97% *100%*
Denmark		45% *100%*	90% *100%*	97% *100%*	97% *100%*
France	1% *100%*	48% *100%*	91% 100%	97% *100%*	97% *100%*
Germany	11% *100%*	44% *99%*	89% *100%*	97% *100%*	97% *100%*
Greece	28% *100%*	59% *100%*	91% *100%*	97% *100%*	97% *100%*
Ireland		83% *99%*	91% *100%*	97% *100%*	97% *100%*
Italy	45% *100%*	60% *100%*	91% *100%*	97% *100%*	97% *100%*
Japan	0% *100%*	7% *84%*	42% *100%*	78% *100%*	90% *100%*
Netherlands	0% *82%*	32% *90%*	90% *100%*	97% *100%*	97% *100%*
Portugal	24% *100%*	56% *100%*	91% *100%*	97% *100%*	97% *100%*
Spain	0% *31%*	60% *97%*	91% *100%*	97% *100%*	97% *100%*
Sweden		52% *99%*	91% *100%*	97% *100%*	97% *100%*
United Kingdom		54% *100%*	89% *100%*	97% *100%*	97% *100%*
United States		22% *96%*	76% *100%*	97% *100%*	96% *100%*

Source: Datastream.

In the second half of 2009 and the first quarter of 2010, aggregate data calculated by DTCC show that the average number of daily transactions on the CDS in our sample is higher than that on other types of CDS. The average number of transactions on the CDS of a given developed sovereign is 10 transactions per day, with an average daily trade volume of USD 217 million. This number is 8 for all sovereign CDSs, with a trade volume of USD 119 million, and 4 for corporate CDSs, with a trade volume of USD 34 million. Trading activity is particularly strong in the case of Southern European countries, with 27 transactions per day for Greece, 26 for Spain, 18 for Italy and 15 for Portugal (Table V.6).

Table V.6: Daily notional amounts and average number of transactions per day

The data are derived from aggregate data calculated by DTCC over the 9-month period from 20 June 2009 to 19 March 2010. The "sample" category corresponds to the average of sovereign CDS data listed in the table. The "sovereign and quasi-sovereign category" corresponds to the measure made by DTCC for the CDSs of this type of reference entity. The "single name CDS" category corresponds to the 1,000 CDSs with the highest gross notional amounts over the period under review by DTCC.

	Average daily notional amount (USD millions)	Average number of transaction per day
Sample :	**217**	**10,2**
Austria	200	9
Belgium	100	4
Denmark	25	1
France	200	7
Germany	225	9
Greece	450	27
Ireland	150	8
Italy	575	18
Japan	100	9
Netherlands	75	3
Portugal	325	15
Spain	500	26
Sweden	50	3
United Kingdom	200	12
United States	75	2
Sovereigns and quasi-sovereigns	**119**	**8,0**
Corporates	**34**	**4,1**
Single-name CDS	**39**	**4,3**

Source: DTCC.

Similar results are obtained using the sample of 10-year CDSs (see Appendix C, Table V.C1). However, the increase in activity in the second period was more pronounced for CDSs with longer maturities (more than 90% of premia in Ireland and the United Kingdom corresponded to transactions). This results from the fact that investors showed a greater interest in CDSs corresponding to the most common and most significant issues of underlying sovereign debt, i.e. 10-year maturities. The growth in trading in 5-year CDSs confirms the hypothesis that sovereign CDSs were greatly used, following the sudden rise in their premia at end-September 2008, in the framework of relative value strategies. Indeed, these strategies, which consisted in taking positions simultaneously on sovereign and corporate CDSs, were easier to put in place for the most common CDS maturity, i.e. the 5-year maturity.

4.2. Volumes

In order to facilitate the recording and electronic confirmation of contracts, a bank consortium set up a common repository in 2006. This Trade Information Warehouse (TIW) is operated by the Depository Trust and Clearing Corporation (DTCC) based in New York. The recent crisis has shown that public authorities had little information on the risk transfers at play on the CDS market and on OTC derivatives markets in general. Faced with the pressures exerted by banking supervisors and, in particular, the Federal Reserve, DTCC accepted to provide the public with a certain amount of CDS market data. According to DTCC, the TIW covers almost all single name CDS transactions conducted between dealers. This is confirmed by an exercise carried out at end-2008 by the Bank for International Settlements on the basis of a comparison between the data drawn from its own statistics, obtained from the voluntary reporting by banks from participating countries, and recordings by the DTCC (CGFS, 2009). At present, DTCC data do not capture a significant share of transactions conducted between dealers and non-dealers, for which there is no systematic electronic recording, and less standardized transactions, which cannot be recorded electronically.

Given that sovereign CDSs are predominantly traded between large financial institutions, which act as dealers, we consider that DTCC data constitute reliable information on volumes traded. These data are only available as from 30 October 2008; they therefore do not cover the entire period under review. We use the data of 30 October as a reference and observe market developments at the end of periods 3 to 5 (Table V.7).

The gross notional amount is a measure of the amount traded on a given name, it is used to assess market activity[92]. This activity remained stable for all single name CDSs recorded by DTCC (around USD 15 trillion). However, purchases and sales of protection on sovereign and quasi-sovereign CDSs were up by 18%, climbing from USD 1.7 to 2.0 trillion between 30 October 2008 and end-September 2010. This increase was actually fuelled by developed sovereign CDSs. Over this same period, the gross notional amount of the 15 CDSs in the sample surged by 129%, from USD 410 to 941 billion, while that of the other sovereign and quasi-sovereign CDSs decreased by 19%. The rise was the

[92] For a detailed presentation of the definitions of CDS used by the existing statistical sources, see ECB (2009) and Duquerroy et *al*. (2009).

most pronounced during the fourth period (+30% compared to the end of the third period), i.e. during the phase of declining sovereign CDS premia, which ran from end-February to early August 2009.

Thus, the share of the 15 sovereign CDSs of the sample represented 48% of the notional amount recorded for all sovereign and quasi sovereign CDSs at end-September 2010, compared with 25% on 30 October 2008, showing a steady increase, in contrast to the developments on the rest of the CDS market.

Table V.7: Changes in notional amounts

The data are drawn from the league table of DTCC, available since 30 November 2008 on a weekly basis. This league table lists the 1,000 reference entities showing the highest gross notional amounts in a given week. It presents, in USD equivalent, the gross and net notional amounts, as well as the number of contracts in force for these 1,000 entities. The category "sovereign CDS in the sample" includes the following countries: Germany, Austria, Belgium, Denmark, Spain, United States, France, Greece, Ireland, Italy, Japan, Netherlands, Portugal, United Kingdom and Sweden. The category "sovereign and quasi-sovereign CDSs" corresponds to the amount calculated by DTCC for this type of entities. The category "Single name CDSs" corresponds to the total volume for the 1,000 CDSs in the league table at a given date.

	Period 3 (week of 30/10/2008)	End of period 3 (week of 27/02/2009)	End of period 4 (week of 07/08/2009)	End of period 5 (week of 01/10/2010)
Gross notional amount (USD billion):				
Sovereign CDS sample (1)	410	474	617	941
Sovereign and quasi-sovereign CDSs (2)	1,668	1,692	1,860	1,966
Single-name CDS (3)	15,381	14,609	15,172	15,361
(1) / (2)	25%	28%	33%	48%
(2) / (3)	11%	12%	12%	13%
Net notional amount (USD billion):				
Sovereign CDS sample (4)	97	88	100	131
Single-name CDS (5)	1,756	1,403	1,365	1,205
(4) / (1)	24%	19%	16%	14%
(5) / (3)	11%	10%	9%	7%
Number of contracts (thousands):				
Sovereign CDS sample	11	14	19	41
Sovereign and quasi-sovereign CDSs	130	134	137	144
Single-name CDS	2,147	2,025	2,040	2,093

Source: DTCC.

The interlocking of positions, which results from the OTC nature of the CDS market, plays a part in increasing the number of contracts. If an economic agent wishes to liquidate a position, he will generally find it difficult to resell it or cancel it. He will need to enter into a CDS contract in the opposite direction with another counterparty (Longstaff *et al*., 2005). This contributes to increasing the number of participants and artificially inflates the size of the market (Coudert and Gex, 2010d). The net notional amount is obtained by subtracting these operations. It measures the amounts that sellers of protection will have to pay to buyers of protection should a credit event occur on a given reference entity, under the assumption of a zero recovery rate and an absence of collateralisation of positions. It thus measures the exposure of sellers of protection.

For all single-name CDSs recorded by DTCC, the notional amount declined by 31% between 30 October 2008 and end-September 2010. Investors' real exposure relative to the size of the market, measured by the ratio of the net notional amount over the gross notional amount, dropped from 11% to 7%. This decrease can be attributed to the use of portfolio compression. This technique, implemented by Markit and TriOptima, consists in eliminating, within a portfolio, the CDSs that have been neutralised by entering into a new CDS contract in the opposite direction (Duquerroy *et al*., 2009).

In the sovereign CDS sample, the increase in activity resulted in a rise in investors' exposure, with the net notional amount climbing from USD 97 billion at end-October 2008 to USD 131 billion at end-September 2010. However, the strong decline in the ratio of the net notional amount over the gross notional amount, from 24% to 14% over the same period, shows that investors took substantial speculative positions to take advantage of the sharp fluctuations, both upward and downward, in their premia following the failure of Lehman Brothers. This is confirmed by the increase in the number of contracts signed on the reference entities of the sovereign CDS sample, which surged by 268%, compared with a decrease of 15% for the other sovereign and quasi-sovereign reference entities and a decrease of 3% for all the reference entities recorded by DTCC.

4.3. Relative bid-ask spread

In order to assess to what extent this increase in activity was accompanied by a decline in transaction costs, we estimate, for each period and each country, the relative bid-ask spread, which is calculated as the ratio of the bid-ask spread over the mid price (Table V.8). As shown by Fleming (2003) on the US Treasuries market, the bid-ask spread is a good measure of liquidity, easy to implement.

Although the relative bid-ask spread is much higher than for the underlying market, it declined in all of the countries in the sample over the entire period under review. The volatility of the relative bid-ask spread also decreased in all five periods, with the exception of the second period for certain countries.

While the relative bid-ask spread ranges from 1.46 for the Netherlands to 0.18 for Italy in the first period, it is below 0.10 for all countries in the last period, with the exception of the United States (0.14). These developments are consistent with the changes in the volumes of DTCC. Indeed, the lowest relative bid-ask spreads at end-September 2010 concern the most traded reference entities or those whose gross notional amount has posted a sharp increase, in particular Spain, Greece, Ireland, Italy and Portugal. These countries recorded the strongest deterioration in their fiscal position, which strengthened incentives for implementing speculative strategies betting on the developments in CDS premia.

Table V.8: Average relative bid-ask spread of 5-year sovereign CDSs by period and country

The relative bid-ask spread is measured for each country and data as: [ask price – bid price] / mid price. The table shows the average bid-ask spread for each period. The standard deviation is in brackets.

	Period 1 (from 01/01/2007 to 18/07/2007)	Period 2 (from 19/07/2007 to 12/09/2008)	Period 3 (from 15/09/2008 to 24/02/2009)	Period 4 (from 25/02/2009 to 04/08/2009)	Period 5 (from 05/08/2009 to 30/09/2010
Austria	0.66 (0.33)	0.46 (0.34)	0.12 (0.05)	0.06 (0.02)	0.06 (0.01)
Belgium	0.63 (0.20)	0.34 (0.30)	0.14 (0.04)	0.09 (0.03)	0.07 (0.02)
Denmark		0.28 (0.09)	0.15 (0.05)	0.11 (0.02)	0.10 (0.02)
France	0.55 (0.26)	0.39 (0.32)	0.15 (0.05)	0.11 (0.03)	0.07 (0.03)
Germany	0.52 (0.26)	0.49 (0.36)	0.15 (0.05)	0.11 (0.03)	0.08 (0.02)
Greece	0.23 (0.12)	0.15 (0.12)	0.10 (0.04)	0.05 (0.02)	0.03 (0.01)
Ireland		0.11 (0.04)	0.09 (0.03)	0.05 (0.02)	0.04 (0.02)
Italy	0.18 (0.10)	0.13 (0.10)	0.07 (0.03)	0.05 (0.01)	0.04 (0.01)
Japan	0.32 (0.14)	0.44 (0.31)	0.21 (0.10)	0.13 (0.04)	0.06 (0.03)
Netherlands	1.46 (0.46)	0.47 (0.34)	0.19 (0.06)	0.11 (0.03)	0.09 (0.02)
Portugal	0.31 (0.13)	0.16 (0.13)	0.09 (0.03)	0.07 (0.02)	0.05 (0.02)
Spain	0.69 (0.27)	0.18 (0.16)	0.09 (0.03)	0.06 (0.02)	0.04 (0.01)
Sweden		0.27 (0.10)	0.18 (0.05)	0.19 (0.06)	0.09 (0.03)
United Kingdom		0.19 (0.07)	0.12 (0.04)	0.08 (0.02)	0.05 (0.01)
United States		0.27 (0.10)	0.18 (0.05)	0.19 (0.06)	0.13 (0.03)

Source: Datastream.

Similar results are obtained for 10-year sovereign CDSs (see Appendix C, Table V.C2). However, the relative bid-ask spread posted a more pronounced fall in the case of 10-year CDSs than for 5-year CDSs in the second period. This is consistent with the results obtained for the share of CDS premia corresponding to actual transactions.

5. Empirical study of market behaviour

5.1. Relationships between sovereign CDSs and government bonds

Theoretically, in the absence of arbitrage opportunities, a CDS premium should be approximately equal to the bond spread on the reference entity (Duffie, 1999; Hull and White, 2000; Hull *et al*. 2004; Cossin and Lu, 2005). In practice, several factors explain why the basis, which is defined as the differential between the CDS premium and the bond spread, is different from zero.[93] In the case of sovereign CDSs, two factors in particular can account for the presence of a positive basis.

Faced with the deterioration of their fiscal positions, developed sovereigns may be forced to restructure their debt. In the case of euro area countries, expectations regarding a possible break-up of the monetary area have made restructuring the most likely credit event to trigger CDSs for investors. The valuation of member countries' CDSs is therefore highly dependent on the conditions under which a restructuring is carried out (Mahadevan *et al*., 2010).

The ISDA's Master Agreement stipulates that developed countries' sovereign CDSs should include an Old Restructuring (Old-R) clause. Under this clause, no maturity limit is set on securities delivered in settlement of a credit event.[94] Given that the protection buyer has an interest in delivering the cheapest-to-deliver (CTD) bond, this is determined by the level of interest rates across the whole of the yield curve.[95] The protection seller is therefore liable to receive a greatly depreciated bond and therefore demands a higher CDS premium, which pushes the basis up.

The differences in terms of liquidity between the sovereign CDS market and the underlying bonds also tend to create a positive basis (Coudert and Gex, 2010c). In the case of bonds issued by corporates, their relative illiquidity justifies a high liquidity premium for this type of asset. In comparison, the corporate CDS market is more liquid, particularly for 5-year CDSs, which are those that are traded most (Longstaff *et al*., 2005;

---

93 For a review of the factors explaining the existence of a basis, see O'Kane and McAdie (2001), Bruyère (2004), Hull *et al*. (2004), Olléon-Assouan (2004), De Wit (2006).

94 Old-R restructuring, which corresponds to the ISDA's 1999 definitions, is also used for contracts involving emerging and Japanese entities. The other restructuring clauses are the Modified-Restructuring (Mod-R or MR) and Modified-Modified-Restructuring (Mod-Mod-R or MMR) clauses. Mod-R restructuring applies mainly to US contracts. Under this clause, deliverable obligations must have a minimum limited maturity between: (i) the final maturity date of the longest restructured security and (ii) 30 months after the date of restructuring. Mod-Mod-R restructuring mainly applies to European contracts. In this case, deliverable obligations must have a minimum limited maturity between: (i) the maturity date of the CDS and (ii) 60 months after the date of restructuring for restructured securities, 30 months for other deliverable obligations.

95 Blanco *et al*. (2005) have inferred the presence of a CTD option in corporate CDSs. Ammer and Cai (2007) arrive at the same conclusion for emerging countries' CDSs.

Cossin and Lu, 2005; Crouch and Marsh, 2005; Zhu, 2006). As a result, in the case of corporate CDSs, the lower liquidity premium contributes to lowering the basis.[96]

Disparities can be observed between countries. Thus, among the countries in our sample, the ratio between the gross national amount of sovereign CDSs and outstanding negotiable public debt varies between 2.9% for France, which has a large debt market, and 33.0% for Portugal, which in comparison has a small debt market, with CDSs actively traded (Table V.9).

Lastly, the crisis led to an increase in the correlation between banks' credit risk measures and risk aversion (Brunnermeier, 2009). Up until the collapse of Lehman Brothers, the sub-prime crisis alerted people to the risks linked to bank portfolios that were largely unrelated to developments in the real economy. Following this event, fears about an imminent recession, pointing to a further deterioration in credit portfolios, affected the whole of the financial system (Eichengreen *et al*., 2009). The implementation of rescue packages for the financial sector, while helping to reduce pressures on markets and the risk perception of financial institutions through a fall, at least a temporary one, in their CDS premia (Panetta *et al*., 2009), may have contributed to changing relations between markets.

Table V.9: Gross notional amounts of CDSs and outstanding negotiable government debt at end-2009

Gross notional amounts of CDSs were taken from DTCC the week of 25/12/2009. The ranking of the gross notional amount in the league table of the 1,000 reference entities with the highest gross notional amounts is given in brackets. Outstanding negotiable debt comes from OECD data at end-2009.

	(1) CDSs: gross notional amount (USD billions)	(2) Government bonds: negociable debt outstanding (USD billions)	Ratio: (1) / (2)
Austria	39.4 (*55*)	232.7	16.9%
Belgium	27.1 (*143*)	419.6	6.5%
France	47.2 (*38*)	1,632.7	2.9%
Greece	69.3 (*14*)	410.7	16.9%
Italy	222.5 (*1*)	2,083.3	10.7%
Netherlands	14.4 (*347*)	393.3	3.7%
Portugal	53.3 (*30*)	161.4	33.0%
Spain	94.3 (*6*)	682.7	13.8%

Source: DTCC, OCDE.

96 At end-December 2009, the corporate CDS market totalled a gross notional amount of USD 8.8 trillion, close to outstanding underlying bond debt, which stood at USD 10.1 trillion. By contrast, the notional amount of CDSs on sovereign and quasi-sovereign entities stood at USD 2.1 trillion compared with USD 36.4 trillion in outstanding government bonds (*sources*: DTCC for CDSs; Bank for International Settlements statistics (BIS, 2010) for bonds).

5.2. Construction of the sample

To study the relations between the developed sovereign CDS market and the underlying bond market, we construct a sample of series for CDS premia and spreads on government bonds of the same maturity.

In order to calculate the bond spread, defined as the differential between the interest rate on a given bond and the risk-free rate, the question arises of which rate to choose as the risk-free rate. When calculating a spread on corporate bonds, some studies take the rate on US government bonds as the risk-free rate (e.g. Longstaff *et al*., 2003). Other studies use the swap rate with the same maturity as the bond under review (e.g. Blanco *et al*., 2005). The basic intuition justifying this choice is that traders operating on derivatives markets and working for large financial institutions use the swap rate in their models to determine asset prices, as this rate is close to the cost of capital for these institutions (Hull *et al*., 2004). Empirically, the approaches of Houweling and Vorst (2005), and Hull *et al*. (2004) conclude that the swap rate is closer to the risk-free rate used by the market than the government bond rate.

In the case of developed countries' sovereign issues, and the use of a swap rate leads to negative bonds spreads in most cases, which reflects the low risk (theoretically risk-free) nature of issues by developed countries. It seems consistent to choose as a risk-free rate for a sovereign in a given geographical region the bond rate of the country in the region regarded as being the safest. This approach has been used by a large number of studies investigating developments in the sovereign spreads of emerging countries, such as McGuire and Schrijvers (2003), Sy (2001, 2003), Hartelius *et al*. (2008) and Hilscher *et al*. (2010) or the relations between the emerging sovereign CDS market and the underlying government bonds, such as Chan-Lau and Kim (2004), Andritzky and Singh (2005, 2006) and Powell and Martinez (2008). These different studies use the EMBI spreads provided by JP Morgan and calculated using benchmark sovereign bond rates for the geographical region concerned. Otherwise, on a sample of emerging economies, Ammer and Cai (2007) use the bond spread calculated by Bloomberg.

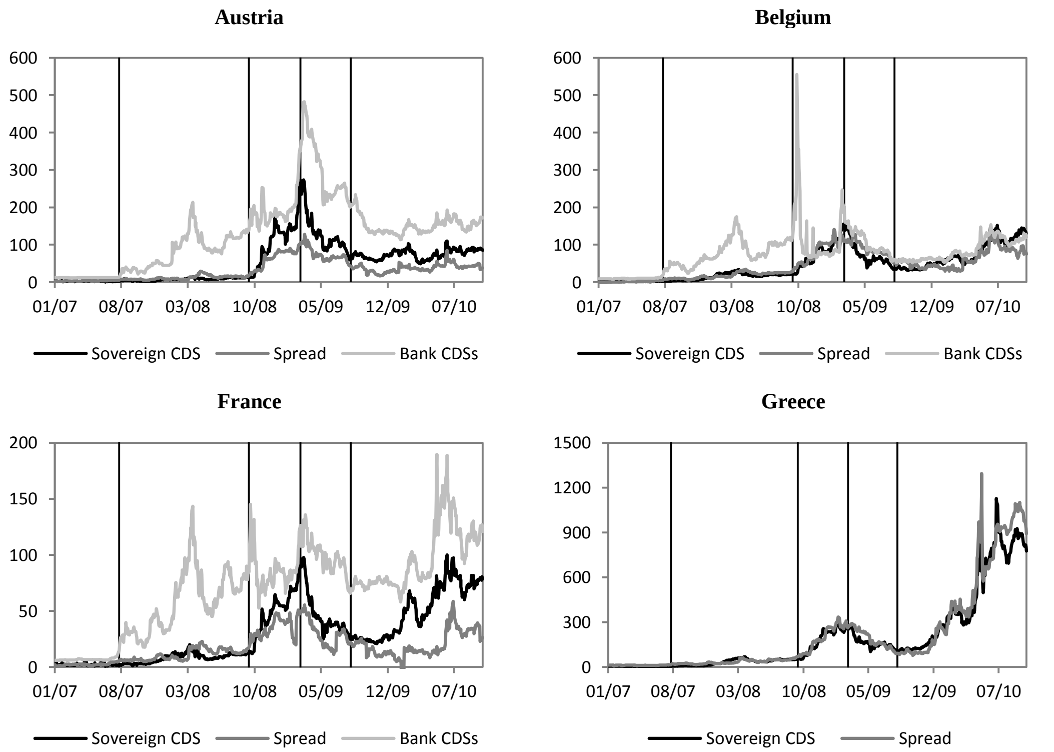
So as to be able to estimate a bond spread, we restrict our sample to European countries, excluding Germany. This allows us to use the rate on the German Bund, which is the benchmark rate for the region. We calculate this spread for the same maturity as that of the most extensively traded CDSs, i.e. 5 years, as the differential between the rate on the government bonds of a given country in the region and the Bund rate.

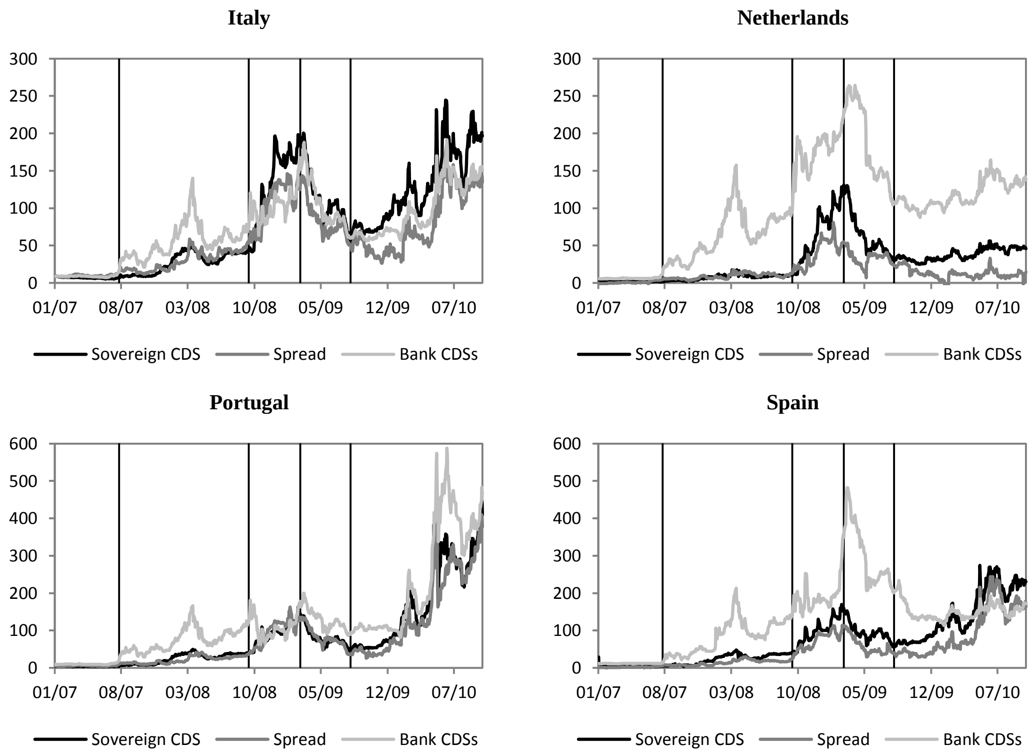
Furthermore, we exclude from the sample the countries where we consider that sovereign CDSs do not display sufficient liquidity (Appendix A provides details of the construction of the database). Our sample is thus made up of eight pairs of sovereign CDSs and underlying bond issues over a period starting on 1 January 2007 and ending on 30 September 2010. The following European countries are included in the sample: Austria, Belgium, France, Greece, Italy, the Netherlands, Portugal and Spain.

In order to measure the impact of the pressures experienced by financial institutions and the effect of the transfer of risk from banks to governments, we take, from Bloomberg, the 5-year CDS premia of the major banks in each country of the sample. For a given country, when we have sufficiently liquid series, we construct an index calculated in the same way as market indices, i.e. as the equally weighted average of available bank CDSs (see Appendix A). We obtain an index of bank CDSs for all of the countries apart from Greece. Chart V.2 shows the data series obtained for the different countries that make up the sample.

Chart V.2: Sovereign CDS premia, government bond spreads and 5-year bank CDS indices (in basis points)

The vertical lines delimit the different periods. Period 1: 01/01/07 – 18/07/07; Period 2: 19/07/07 – 12/09/08; Period 3: 15/09/08 – 24/02/09; Period 4: 25/02/09 – 04/08/09; Period 5: 05/08/09 – 30/09/10.





Sources: Bloomberg, Datastream.

In the same way, we construct a sample of eight pairs of sovereign CDSs and bonds spreads with a 10-year maturity. Given that bank CDSs with this maturity are less liquid, we only obtain a bank CDS index for the following countries: France, Italy, the Netherlands, Portugal and Spain.

5.3. Developments in relations between markets and links of causality

5.3.1. Correlations between markets

As a first approach, we calculate for each country the correlation coefficient between sovereign CDS premia and 5-year bond spreads for the different periods that make up our sample, as well as the correlation coefficient between sovereign CDS premia and the bank CDS index (Table V.10).

Whereas the correlations between sovereign CDS premia and bond spreads are weak and rarely significant during the first period, they increase sharply following the difficulties encountered by Bear Stearns and all become significant at the 10% threshold. In the last period, which saw a sharp deterioration in the perception of sovereign risk, co-movements between the two markets are again significantly less pronounced in the case of France, as well as Austria and the Netherlands, whose correlation coefficient is no longer significant. By contrast, the correlation continues to increase for Southern European countries, which are those that have been weakened most by the deterioration in their fiscal position. These findings can be compared with those of Longstaff *et al*. (2010), who highlight the dependence of emerging sovereign CDS premia on developments in global macroeconomic variables.

In parallel, the correlations between sovereign CDS premia and bank CDS indices display fluctuating developments. For most countries, they are not significant in the first period. They increase strongly following the first tensions observed on the markets (Period 2). They remain strong when all of the packages to support the economy were put in place and a significant proportion of the risk borne by financial institutions was transferred to national governments (Periods 3 and 4); also during the phase of increasing sovereign risk (Period 5), which casted doubt about a possible quick economic recovery.

Table V.10: Correlation of sovereign CDSs with bond spreads and bank CDS indices

The simple correlation coefficient is measured for each country and each period using first differences. A Student test is carried out for each correlation coefficient. ***, **, * indicate a correlation coefficient significantly different from zero at the 1%, 5% and 10% thresholds.

	Period 1 (from 01/01/2007 to 18/07/2007)	Period 2 (from 19/07/2007 to 12/09/2008)	Period 3 (from 15/09/2008 to 24/02/2009)	Period 4 (from 25/02/2009 to 04/08/2009)	Period 5 (from 05/08/2009 to 30/09/2010
Correlations between sovereign CDSs and bonds spreads:					
Austria	0.06	0.09^{*}	0.13^{*}	0.37^{***}	0.37^{***}
Belgium	0.14^{**}	0.26^{***}	0.42^{***}	0.17^{**}	0.59^{***}
France	-0.02	-0.11^{**}	0.16^{**}	0.31^{***}	0.31^{***}
Greece	0.04	0.25^{***}	0.27^{***}	0.64^{***}	0.81^{***}
Italy	0.18^{**}	0.28^{***}	0.29^{***}	0.49^{***}	0.75^{***}
Netherlands	-0.03	-0.08^{*}	0.31^{***}	0.18^{**}	0.25^{***}
Portugal	0.01	0.15^{***}	0.18^{**}	0.41^{***}	0.78^{***}
Spain	0.06	0.11^{**}	0.27^{***}	0.26^{***}	0.78^{***}
Correlations between sovereign CDSs and bank CDS indices:					
Austria	-0.18^{**}	0.02	0.43^{***}	0.51^{***}	0.41^{***}
Belgium	-0.11^{*}	0.36^{***}	0.03	0.51^{***}	0.52^{***}
France	-0.02	0.13^{**}	0.32^{***}	0.61^{***}	0.66^{***}
Italy	0.05	0.38^{***}	0.37^{***}	0.65^{***}	0.62^{***}
Netherlands	0.09	0.53^{***}	0.25^{***}	0.42^{***}	0.61^{***}
Portugal	0.10	0.44^{***}	0.39^{***}	0.75^{***}	0.72^{***}
Spain	0.05	0.19^{***}	0.48^{***}	0.67^{***}	0.77^{***}

5.3.2. Vector model

The relations between the three types of series therefore changed over the whole of the period under review. We attempt to estimate to what extent the daily variations in one of the series can be explained by movements in the other two series. To study the links between the different series, we estimate for each country a vector model including the sovereign CDS and the 5-year bond spread. We incorporate the bank CDS index when it is available. We denote as $c_{i,t}$and $s_{i,t}$ the sovereign CDS premia and bond spread series for country i. When the 5-year bank CDS index of country i is available, we denote it as $b_{i,t}$.

The period under review is a very eventful one so that we use a dynamic approach in order to estimate to what extent links between markets were distorted. To do this, we first estimate a vector model for the period from 1 January to 31 May 2007, i.e. five months. The Augmented Dickey-Fuller (ADF) test shows that all the series in level terms display a unit root over this period; they are therefore stationarised by the calculation of first differences. Johansen tests lead to the rejection of cointegration for the same period. The use of a first difference Vector Autoregressive (VAR) is therefore justified.

We estimate a trivariate VAR model:

$$\Delta X_{i,t} = \alpha_i + \sum_{j=1}^{k} \Gamma_{i,j} \Delta X_{i,t-j} + \mu_{i,t} \tag{V.1}$$

where $X_{i,t} = (c_{i,t}, s_{i,t}, b_{i,t})$ the three dimensional vector is composed of time series of the sovereign CDS $c_{i,t}$, the bond spread $s_{i,t}$and the bank CDS index $b_{i,t}$. $\Gamma_{i,j}$is the 3 × 3 matrix of the model's parameters. α_i denotes country i's intercepts, and $\mu_{i,t}$ is the vector of errors[97]. The number of lags k is optimised using a Schwarz criterion on the whole period under review.

We then use a Kalman filter, which allows for variable parameters over time, to update the results of the chosen model on a daily basis.[98] The measurement equation of the Kalman filter is derived from Model (V.1):

$$\Delta X_{i,t} = \alpha_{i,t} + \sum_{j=1}^{k} \Gamma_{i,j,t} \Delta X_{i,t-j} + \mu_{i,t} \tag{V.2}$$

Let $A_{i,j,t} = (\alpha_{i,t}, \Gamma_{i,j,t})$ be the matrix containing the model's variable coefficients over time. The transition equation that allows for changes in these coefficients is expressed as:

$$A_{i,j,t} = A_{i,j,t-1} + \epsilon_{i,t} \tag{V.3}$$

Estimating the model over five months allows us to set the parameters. Each time the parameters are updated by the Kalman filter, we carry out a Granger causality test. To do this, we estimate a constrained model which one by one excludes each coefficient and its lags. We compare the constrained model to the unconstrained model using a Fisher test.

97 In the case of Greece, as the bank CDS index is not available, we use a bivariate VAR that comprises CDS premia and sovereign bond spreads only.

98 The details of estimation using the Kalman filter are given by Cuthbertson *et al*. (1992) and Hamilton (1994).

When the presence of the coefficient of the explanatory variable tested significantly improves the explanatory power of the constrained model, we conclude that there is Granger causality from the explanatory variable tested to be explained variable. This type of test has already been used in different studies to determine whether the price discovery process occurs on the CDS market or the bond market (e.g. ECB, 2004; Blanco *et al*., 2005; Zhu, 2006; Baba and Inada, 2007).

In this vein, Coudert and Gex (2008) look at the changes to the price discovery process linked to the turmoil triggered by the downgrading of General Motors and Ford to speculative grade in May 2005. The episode considered in this study can be characterised relatively easily. In our case, the crisis covers large part of the period under review; the markets concerned were affected by the events that succeeded one another between the start of the second period, i.e. the difficulties encountered by Bear Stearns, and the end of the sample, in particular the collapse of Lehman Brothers and the role of sovereigns in supporting the financial sector. The use of a Kalman filter makes it possible to observe changes in relations of causality over the whole of the period under review.

For a country i, we attempt to measure the extent to which the increase in risk observed on one of the three assets, sovereign CDSs, bond spreads or bank CDS indices spread to the other assets. To do this, we note for each variable and its lags the dates on which: (i) the Granger causality test is significant at at least the 10% threshold; (ii) the sum of the coefficient tested and its lags is positive. We thereby obtain for each date a measure of conditional causality from one type of asset to another when the coefficients have the expected positive sign.

In all of the tests carried out Granger causality is detected for 49% of the dates at the 10% threshold. Moreover, when a link of causality is detected, the coefficient tested has a positive sign in 81% of cases. The difficulties encountered by Bear Stearns and the collapse of Lehman Brothers changed the dynamics linking the three asset classes under review. These events appear to be decisive in developments in the sovereign CDS market.

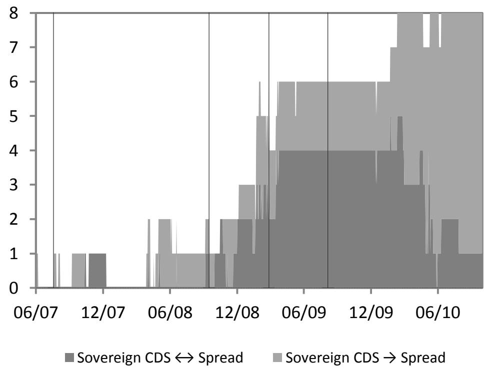
In order to interpret the results synthetically, we count for each day and each relation of the VAR model used, the number of countries for which Granger causality is detected. Detailed results are presented in Appendix D. The distortion of relations between markets is visible in the third period, which goes from the collapse of Lehman Brothers to end-September 2009 (Charts V.3 to V.5). In the two last periods in the sample, the number of countries for which there is a link of causality remains stable.

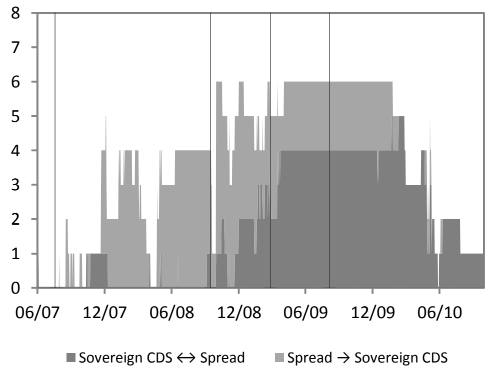
5.3.3. Causality between the sovereign CDS market and the underlying market

Up until the collapse of Lehman Brothers, when a causal relation is detected, the price discovery process mainly occurs on the bond market rather than on the sovereign CDS market for the five-year maturity (Chart V.3).

Chart V.3: Conditional causality between sovereign CDS premia and 5-year government bond spreads

Each chart shows the number of countries for which Granger causality is detected at the 10% threshold for a given date. In the captions to the charts, → denotes unidirectional causality, ↔ bidirectional causality. The vertical lines delimit the different periods. Period 1: 01/01/07 – 18/07/07; Period 2: 19/07/07 – 12/09/08; Period 3: 15/09/08 – 24/02/09; Period 4: 25/02/09 – 04/08/09; Period 5: 05/08/09 – 30/09/10.





This conclusion is in line with Coudert and Gex (2010b), who show that CDS premia in European countries tend to adjust to the government bond spread. The results obtained for developed sovereign CDSs therefore differ from the conclusions reached by research carried out on other categories of CDSs. Using corporate CDS data, Blanco *et al*. (2005), who studied a sample made up of 34 non-speculative grade companies and the European Central Bank (ECB, 2004) and Zhu (2006), who looked at the US market, conclude that the CDS market has a leading role. Baba and Inada (2007) arrive at the same conclusion for a sample of Japanese banks.

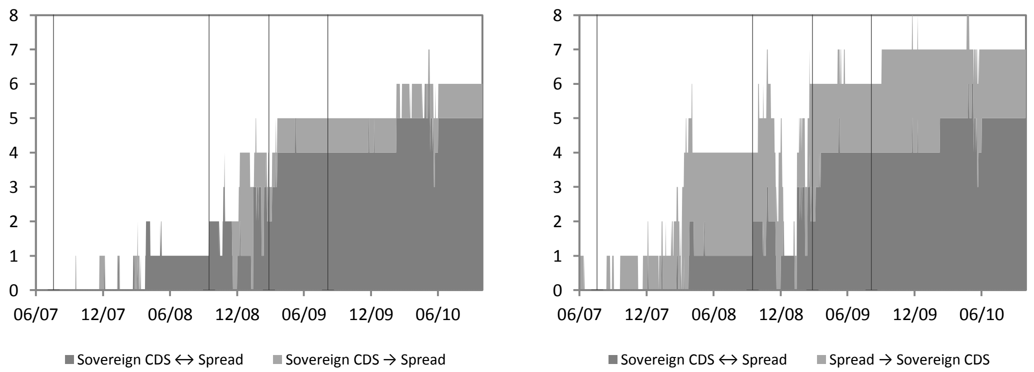
The results obtained on emerging sovereign CDSs are less clear-cut. On a sample of eight emerging economies for the period from January 2003 to September 2006, Bowe et al. (2007) conclude that the price discovery process occurs on the foreign currency denominated government bond market. On a sample of seven different emerging economies for the period from February 2001 to March 2005, Ammer and Cai (2007) find that when the bond market is relatively illiquid, the CDS market tends to lead the underlying market.

However, if we include the last months in the period under review, the number of countries for which causality is observed from sovereign CDSs to spreads becomes preponderant. From February 2010 onwards, the eight countries in the sample display causality from sovereign CDSs to bond spreads; in parallel, the number of countries for which bidirectional causality decreases rapidly. From mid-May on, only one or two causality links from spreads to sovereign CDSs are detected. This change in the relations between sovereign CDSs and bond spreads during the crisis is consistent with the findings of Boone *et al*. (2010), who posit that the growth in sovereign CDS trading has affected the dynamics of the sovereign bond market in general. The results are also in line with those of Coudert and Gex (2010a) indicating that the 2007-2009 crisis resulted in the reversal of relations between the markets in the Southern European countries.

To assess how the differences of liquidity between the markets may have impacted causal relations, we estimate the same models using sovereign CDS and 10-year spread data. Although the links between sovereign CDSs and bond spreads were also strengthened following the failure of Lehman Brothers, the price discovery process mainly occurs on the bond markets on the long maturity (Chart V.4). Contrary to the short maturity sample, it is not possible to conclude to a clear lead of one market on the other on Periods 4 and 5. The fact that the liquidity of CDSs is concentrated on the 5-year maturity may have contributed to these divergences. This interpretation is in line with the findings of Ammer and Cai (2007) regarding emerging market CDSs and of Chakravaty *et al*. (2004), who find that in the case of equity markets the contribution of options to the price discovery process is greater when they are more liquid than the underlying equities.

Chart V.4: Conditional causality between sovereign CDS premia and 10-year government bond spreads

See note to Chart V.3.



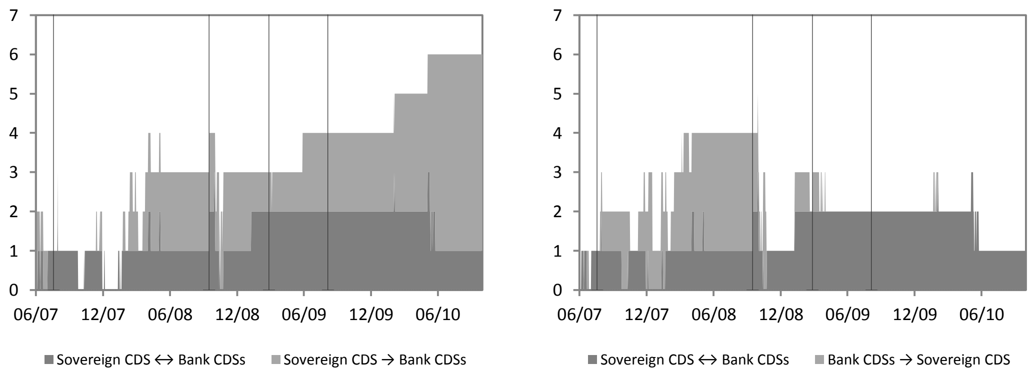
5.3.4. Impact of bank CDS premia on the perception of sovereign risk

Causality between bank CDS premia and sovereign CDS premia

Causality from sovereign CDSs to bank CDSs is detected after the difficulties experienced by Bear Streans (Chart V.5). This suggests that market participants anticipated public assistance in the event of systemic risk linked to the systemic nature of the largest financial institutions ("too big to fail"), which are included in our bank CDS indices. Morevover, the number of causality increases from Period 3 to the end of Period 5. From May 2010 onwards, causality from sovereign CDSs to bank CDSs is detected for all the countries in the sample (expect one) which reflects the news links created between banks and sovereigns, as well as the potential impact of the increasing sovereign risk on the domestic financial systems.

Chart V.5: Conditional causality between bank CDS premia and 5-year sovereign CDSs premia

See note to Chart V.3.



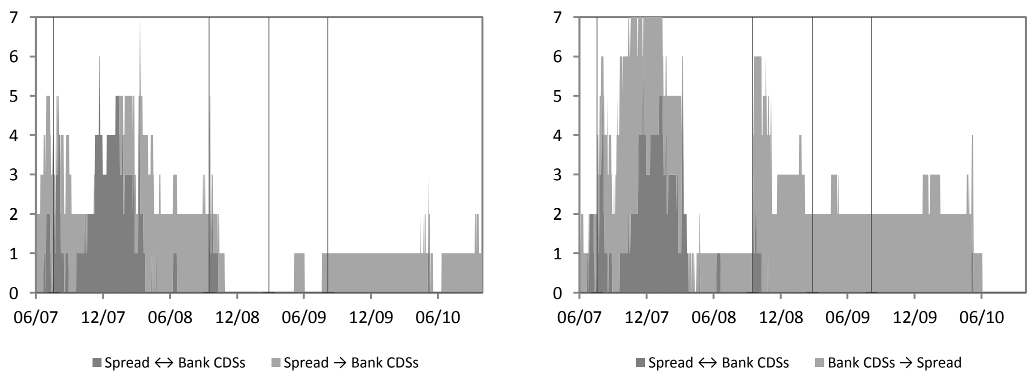
From the difficulties experienced by Bears Stearns onwards, causal relations in the opposite direction are detected. However, this concerns a small number of countries. This finding is in line with the conclusions of Ejsing and Lemke (2009). On a sample of European sovereign CDS premia and those of the major national banks of the countries concerned, these authors find that the correlation with the iTraxx non-financials, regarded as a common factor capturing developments in the macroeconomic environment, decreases for bank CDSs and increases for sovereign CDSs following the implementation of rescue packages in October 2008. They conclude that these rescue packages helped to reduce the pressure on bank CDS premia while prompting an increase in the sensitivity of sovereign risk premia to a possible worsening of the crisis. Developments in credit risk perceived through bank CDS premia appear therefore to have had little impact on developments in sovereign CDS premia following Lehman Brothers' failure, with market participants having focused their attention on changes in sovereign risk linked to the public assistance measures. This seems to confirm the hypothesis that investors quickly anticipated and factored in that the role of central banks as the most likely lenders of last resort, then that of governments, would be decisive.

Causality between bank CDS premia and bond spreads

The number of causal relations between bond spreads and bank CDSs is much greater between the difficulties experienced by Bear Stearns and Lehman Brothers' bankruptcy (Chart V.6). Bank CDS premia were therefore more sensitive to changes in government bond spreads than to variations in sovereign CDS premia until Lehman Brothers' banruptcy. After that episode, the influence of bond spreads on bank's CDS premia disappeared for almost all the countries in the sample. This result is homogenous with the conclusion regarding the relationship between sovereign CDSs and sovereign spreads which points to an increasing role of sovereign CDSs after Lehman Brothers' failure. From that event on and the implementation of most of the rescue packages, sovereign CDS premia therefore became a leading source for investors in estimating developments in developed sovereign risk.

Chart V.6: Conditional causality between bank CDS premia and 5-year government bond spreads

See note to Chart V.3.



Causality from bank CDSs to sovereign bond spreads is detected for most countries just after the announcement of the difficulties encountered by Bear Stearns and the collapse of Lehman Brothers. On the one hand, this is justified by the increase in correlations linked to the generalised increase in asset price volatility during periods of marked tension (Forbes and Rigobon, 2002). On the other hand, this rise reflects agents' perception of the systemic risk linked to the shock affecting all of the domestic financial sectors and the expectation of a response from the public authorities. This echoes the conclusions of Eichengreen *et al*. (2009), who find that the importance of the common component in bank CDS premia increases following the rescue of Bear Stearns. However, causal links disappear from June 2010 onwards. This suggests that investors were increasingly factoring in the economic risk related to each sovereign into bank CDS premia, assessed by the evolution of sovereign CDS premia more than by the evolution of bond spreads.

In the same way as above, we carry out estimates for the long maturity – where a 10-year CDS bank index is available – for five countries[99]. Comparable findings to those obtained for the shorter maturity emerge, in particular the lead of sovereign CDSs over bank CDSs after Lehman Brother's bankruptcy, resulting from the transfer of risk from banks to governments.

6. Conclusion

The emergence of the sovereign CDS market for developed countries is relatively recent and can be largely attributed to the financial crisis in 2007-2009, as well as to the increase in pressures on sovereigns linked to the deterioration in public finances caused by the introduction of rescue packages for the financial sector and the economy. On a sample of CDS premia for 15 developed countries, including the main European countries, the United States and Japan, we observe a substantial increase in activity on this segment of the credit derivatives market, estimated by different measures, mainly following the difficulties encountered by Bear Stearns and the collapse of Lehman Brothers.

In order to estimate how this development may have had an impact on relations between markets, we investigate whether the price discovery process takes place on the government debt market or if it tends to occur on the derivatives market. We use the methods for detecting Granger causality previously used to study the relations between CDS premia and bond spreads for corporate and emerging CDSs. We adopt a dynamic approach by means of a recursive VAR model incorporating a Kalman filter for a sub-sample of countries selected for the liquidity of their CDSs over a period from the start of 2007 to end-September 2010. To take account of the specific links created by the crisis between sovereigns and banks via the transfer of risk from financial institutions to governments as a result of the rescue plans, we include a bank CDS index in the model where this is possible.

[99] France, Italy, the Netherlands, Portugal and Spain.

It emerges that the causal relations between variations in sovereign CDS premia, government bond spreads and bank CDSs strengthened following the collapse of Lehman Brothers and the intervention of the public authorities, as well as following the bailout of Bear Stearns, although to a lesser degree. At the start of the period, causal relations are rarely detected prior to the collapse of Lehman Brothers. Following Lehman Brothers' failure, the price discovery process occurs more on the bond markets than on the sovereign CDS market. However, this causality tends to be reversed when the start of 2010 is included in the estimate, for all of these countries in the sample. The emergence and the development of the market for developed sovereign CDSs, linked to the new relationships between markets due to the rescue plans, has thus modifies the traditional referentials used to assess credit risk. This evolution may have consequences for portfolio management strategies, as well as on the ongoing reforms of OTC derivatives and the possible regulatory requirements which could be applied to sovereign CDSs.

Appendix

Appendix A - Illustration of a directional strategy

The market value of a long or short position on a CDS contract varies with the performance of the reference entity. Thus, if the bond spread on the reference entity widens or its rating is downgraded, the CDS premium should increase. If this happens, the protection seller suffers a mark-to-market loss as the rise in the premium reflects an increase in the probability of default. As for the protection buyer, she records a mark-to-market gain.

A.1 Putting the directional strategy in place

Let us consider the case of an investor who at the start of 2009 anticipated a rise in the CDS premium on the United States. On 2 January 2009, he buys protection for a 70 bp premium maturing on 2 January 2014 on an amount of USD 10 million. The premium, paid on a quarterly basis, that he has to pay to the protection seller amounts to USD 25,000. The first payment will be made on 2 May 2009.

A.2 Unwinding of the position

On 1 February, the CDS premium on the United States is 100 bp. The investor wishes to unwind his position and realise his gain. To do this, he sells protection on the US government for the same maturity date, i.e. 2 January 2014.

The investor, as the buyer of protection, has to pay to the protection seller the interest accrued between 2 January 2009 and 1 February 2009: $\text{Interest accrued} = \text{Notional amount} \times \text{Premium (as a \%)} \times \frac{\text{Number of days}}{360} = \text{USD } 10{,}000{,}000 \times 0.7\% \times \frac{30}{360} = \text{USD } 5{,}833.33$.

As the protection seller, he will in addition receive the present value of 30 bp (130 bp premium -100 bp) a year on the notional amount of USD 10 million up to maturity, i.e. 2 January 2014: $\text{Present value} = \text{Notional amount} \times 0.3\% \times$ PV01. PV01 measures the sensitivity of the CDS's value to a 1 bp increase in the bond spread. Bloomberg gives a PV01 of USD 4, which results in a current value of: USD $10{,}000{,}000 \times 0.3\% \times 4 = \text{USD } 120{,}000$.

A.3 Limitations of the strategy

We postulated that the investor had the option of selling protection on a maturity of 4 years and 11 months. In general, the CDS market is only liquid on some maturities (5 years in particular). In practice, the investor will therefore have to unwind his first contract by selling 5-year protection. He will therefore not be covered during the month of January 2014: during this period he will be a protection seller only.

Moreover, if the investor has used different dealers to execute the two previous operations, there is always counterparty risk (if one of the two dealers defaults, one of the contract's “legs” becomes null and void).

Appendix B - Database for the empirical study

B.1 Composite sovereign CDS index

The CDS premia for the countries in Markit's G-7 and Western Europe indices are taken from Datastream. We exclude Finland's CDSs as the premium is only available from 14 May 2008 onwards, as well as Norway's because of issues regarding data reliability.

For the period from 1 January 2007 to 31 December 2009, the composite index is made up of the 10 following CDSs: Austria, Belgium, France, Germany, Greece, Italy, Japan, the Netherlands, Portugal, and Spain. We add the premia for Denmark, Ireland, Sweden, and the United Kingdom and the United States from 1 January 2008 onwards, as these series are not available for 2007 (United Kingdom and United States) or are not reliable prior to 2008 (Denmark, Ireland and Sweden).

The index is calculated as the simple average of the different CDS premia. This choice of an equal weighting of the premia is in line with the mode of calculation of the G-7 and Western Europe indices. It is also used for all of the corporate CDS indices such as the iTraxx and CDX families of indices (European and Asian and US and emerging market indices respectively).

B.2 Database for the empirical study

Sovereign CDS premia and bond spreads

We extract from Datastream the sovereign CDS premia, for 5-year and 10-year maturities, on the European countries included in the Western Europe CDS index administered and calculated by Markit. We exclude series for which data are only available from 1 January 2008.

To ensure that we use sufficiently liquid CDSs in our empirical study, we apply the following data filter: (i) the number of days showing a quote (i.e. a veracity score of 3 or below) must be greater than 80%; (ii) the number of days on which at least one order was executed (a veracity score of 1) must be greater than 60%.

5-year and 10-year sovereign bond yields are extracted from Bloomberg. We use the benchmark rate given by Bloomberg if it is available over the whole period. When this is not the case (the Netherlands for the 5-year maturity and Ireland for 5-year and 10-year maturities), we construct a synthetic bond. To do this, we adopt the approach used by Hull *et al*. (2004), Norden and Weber (2004), Blanco *et al*. (2005) and Zhu (2006). We select two bonds, one with a longer maturity than the maturity sought, the other with a shorter maturity. For each date, we use these two bonds to calculate the yield of a bond on a maturity of exactly 5 or 10 years by means of linear interpolation.

The bond spread is then calculated as the differential between the yield on the bond and that on the Bund with the same maturity. The choice of the German rate as the risk-free rate for European countries results in Germany being excluded from the sample.
This leads us to retain pairs consisting of CDS premia and bond spreads for the nine following countries: Austria, Belgium, France, Greece, Ireland, Italy, the Netherlands, Portugal and Spain.

Bank CDS premia

The bank CDS premia series are taken from Bloomberg. We extract the senior CDS premia of banks resident in one of the aforementioned countries available in Bloomberg. We exclude bank CDSs whose liquidity levels we deem to be insufficient. To do this, we apply the following filters: (i) the proportion of missing values over the period under review must be less than 10% (excluding weekends and public holidays); (ii) the number of consecutive missing values must not exceed 20 days.

For the 5-year maturity, we have at least one sufficiently liquid bank CDS for each country in the sample except for Greece. When we have more than one bank CDS, we construct a 5-year index, calculated in the same way as for market indices, i.e. the equally weighted average of the bank CDSs available. Given that 10-year bank CDSs are traded less, we only obtain a sample of bank CDSs that meet our liquidity criteria for five countries: France, Italy, the Netherlands, Portugal and Spain.

In the same way as for the 5-year maturity, we construct for each of these countries a 10-year bank CDS index when we have more than one bank CDS.

Table B1 gives the list of the banks whose CDSs were selected.

Table V.B1: Composition of bank CDS indices

	5-year CDSs	10-year CDSs
Austria	Erste Bank	
Belgium	Fortis Bank	
France	BNP Paribas	BNP Paribas
	Société Générale	Société Générale
	Crédit Agricole	
Italy	Banca Monte dei Paschi di Siena	Banca Monte dei Paschi di Siena
	Banca Nazionale del Lavoro	Banca Nazionale del Lavoro
	Banca Popolare di Milano	Banca Popolare di Milano
	Intesa Sanpaolo	Intesa Sanpaolo
	UniCredito Italiano	UniCredito Italiano
Netherlands	ABN Amro Bank	ABN Amro Bank
	ING Bank	ING Bank
	Rabobank Nederland	Rabobank Nederland
	SNS Bank	
Portugal	Banco Comercial Português	Banco Comercial Português
	Banco Espirito Santo	
Spain	Banco Bilbao Vizcaya Argenteria	Banco Bilbao Vizcaya Argenteria
	Banco Santander Central Hispano	Banco Santander Central Hispano

Appendix C - Activity on the 10-year sovereign CDS market

Table V.C1: Proportion of 10-year CDS premia derived from transactions

See note to Table V.5.

	Period 1 (from 01/01/2007 to 18/07/2007)	Period 2 (from 19/07/2007 to 12/09/2008)	Period 3 (from 15/09/2008 to 24/02/2009)	Period 4 (from 25/02/2009 to 04/08/2009)	Period 5 (from 05/08/2009 to 30/09/2010)
Austria	7% *100%*	62% *88%*	92% *100%*	97% *100%*	95% *100%*
Belgium	7% *100%*	70% *98%*	91% *100%*	97% *100%*	96% *100%*
Denmark		85% *100%*	91% *100%*	97% *100%*	95% *100%*
France	1% *100%*	71% *100%*	91% 100%	97% *100%*	96% *100%*
Germany	20% *100%*	70% *99%*	91% *100%*	97% *100%*	93% *100%*
Greece	5% *100%*	74% *100%*	92% *100%*	97% *100%*	95% *100%*
Ireland		95% *99%*	93% *100%*	97% *100%*	95% *100%*
Italy	9% *100%*	79% *100%*	91% *100%*	97% *100%*	96% *100%*
Japan	0% *100%*	6% *84%*	7% *100%*	3% *100%*	2% *100%*
Netherlands	24% *60%*	54% *87%*	91% *100%*	97% *100%*	95% *100%*
Portugal	5% *100%*	74% *100%*	92% *100%*	97% *100%*	95% *100%*
Spain	7% *91%*	75% *97%*	91% *100%*	97% *100%*	97% *100%*
Sweden		85% *98%*	91% *100%*	97% *100%*	94% *100%*
United Kingdom		91% *99%*	91% *100%*	97% *100%*	95% *100%*
United States		46% *93%*	79% *100%*	97% *100%*	82% *100%*

Source: Datastream.

Table V.C2: Relative bid-ask spread on 10-year CDSs by period and country

See note to Table V.8.

	Period 1 (from 01/01/2007 to 18/07/2007)	Period 2 (from 19/07/2007 to 12/09/2008)	Period 3 (from 15/09/2008 to 24/02/2009)	Period 4 (from 25/02/2009 to 04/08/2009)	Period 5 (from 05/08/2009 to 30/09/2010)
Austria	0.52 (0.39)	0.24 (0.18)	0.11 (0.04)	0.06 (0.02)	0.06 (0.01)
Belgium	0.71 (0.24)	0.14 (0.08)	0.13 (0.04)	0.09 (0.03)	0.07 (0.02)
Denmark		0.16 (0.04)	0.14 (0.04)	0.11 (0.02)	0.10 (0.02)
France	0.73 (0.34)	0.19 (0.13)	0.13 (0.04)	0.11 (0.03)	0.07 (0.02)
Germany	0.69 (0.49)	0.19 (0.11)	0.13 (0.04)	0.11 (0.03)	0.09 (0.02)
Greece	0.18 (0.04)	0.06 (0.03)	0.07 (0.03)	0.06 (0.02)	0.04 (0.02)
Ireland		0.08 (0.02)	0.09 (0.03)	0.06 (0.02)	0.05 (0.02)

Table V.C2 – cont.	Period 1	Period 2	Period 3	Period 4	Period 5
Italy	0.21 (0.05)	0.06 (0.03)	0.07 (0.03)	0.05 (0.02)	0.04 (0.02)
Japan	0.29 (0.12)	0.30 (0.19)	0.18 (0.08)	0.12 (0.04)	0.06 (0.03)
Netherlands	0.78 (0.54)	0.28 (0.23)	0.17 (0.05)	0.12 (0.03)	0.09 (0.02)
Portugal	0.30 (0.10)	0.07 (0.03)	0.09 (0.03)	0.08 (0.02)	0.06 (0.02)
Spain	0.13 (0.12)	0.08 (0.05)	0.09 (0.04)	0.06 (0.02)	0.05 (0.02)
Sweden		0.16 (0.04)	0.14 (0.04)	0.09 (0.02)	0.09 (0.02)
United Kingdom		0.13 (0.04)	0.11 (0.03)	0.08 (0.02)	0.06 (0.01)
United States		0.21 (0.06)	0.18 (0.05)	0.19 (0.06)	0.12 (0.03)

Source: Datastream.

Appendix D - Conditional causality by country

The charts below investigate the six possible relations of causality between the three different financial series: sovereign CDS premia, government bond spreads calculated with reference to the German Bund of the same maturity and the bank CDS index.

Each chart shows the dates for which the Fisher test indicates Granger causality and has the expected positive sign. A → B denotes Granger causality from the series A to series B. The light grey shading indicates a significant test at the 10% threshold, and the dark grey shading a significant test at the 5% threshold. The black vertical lines delimit the different periods. Period 1: 01/01/07 – 18/07/07, Period 2: 19/07/07 – 12/09/08, Period 3: 15/09/08 – 24/02/09, Period 4: 25/02/09 – 04/08/09 and Period 5: 05/08/09 – 30/09/10.

Chart V.D1: Conditional causality by country between sovereign CDS premia and 5-year government bond spreads

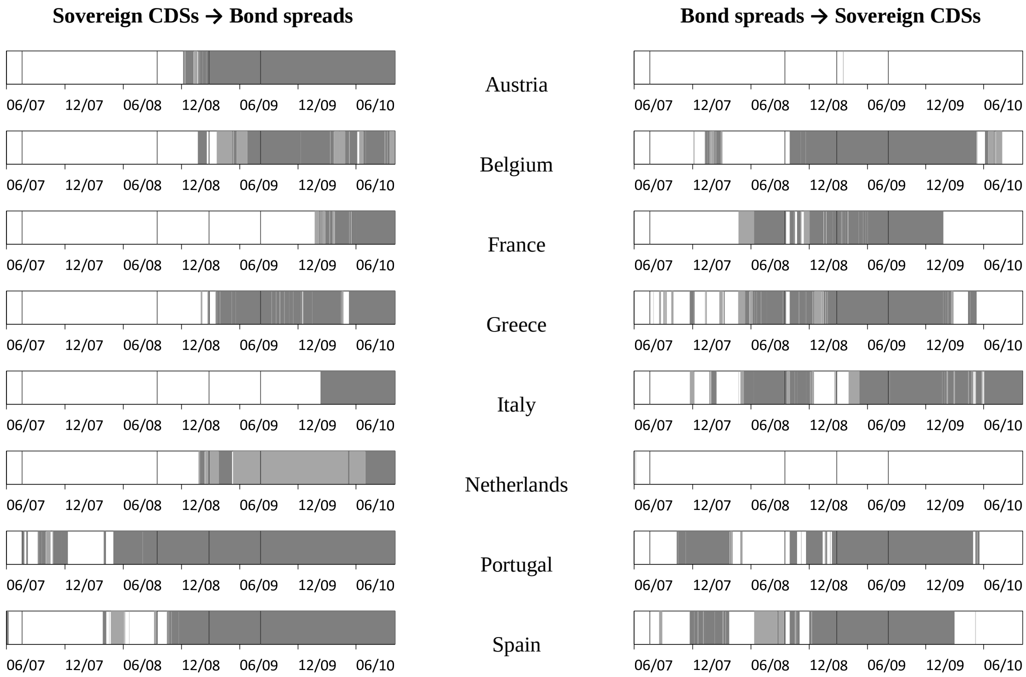


Chart V.D2: Conditional causality by country between sovereign CDS premia and 5-year bank CDS indices

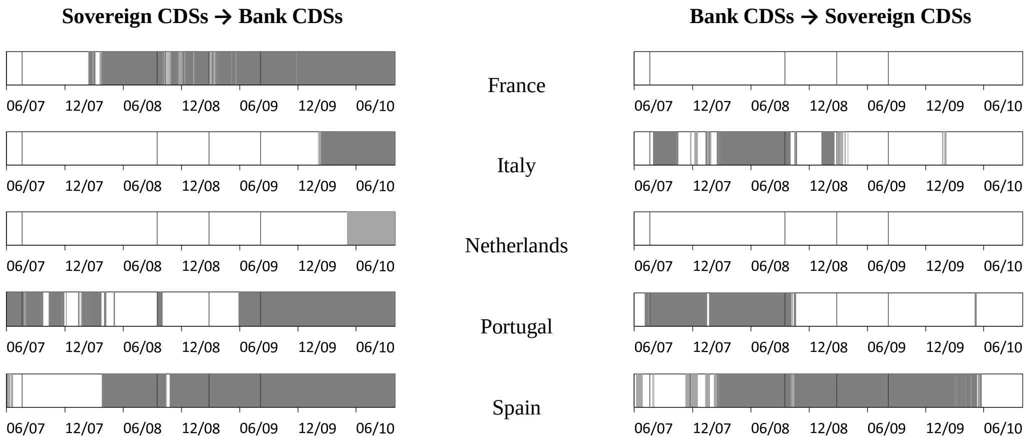


Chart V.D3: Conditional causality by country between government bond spreads and 5-year bank CDS indices

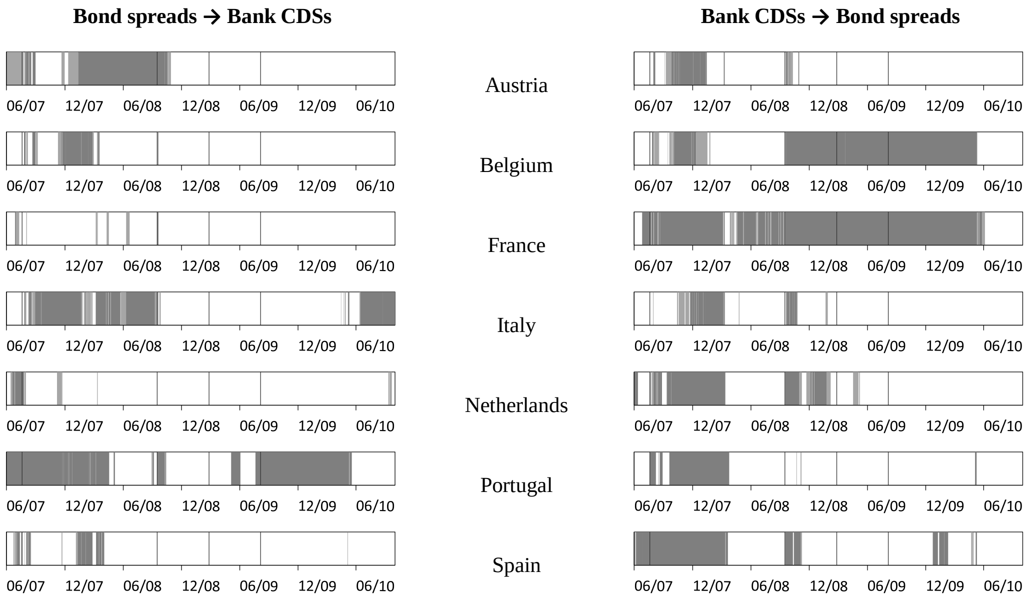
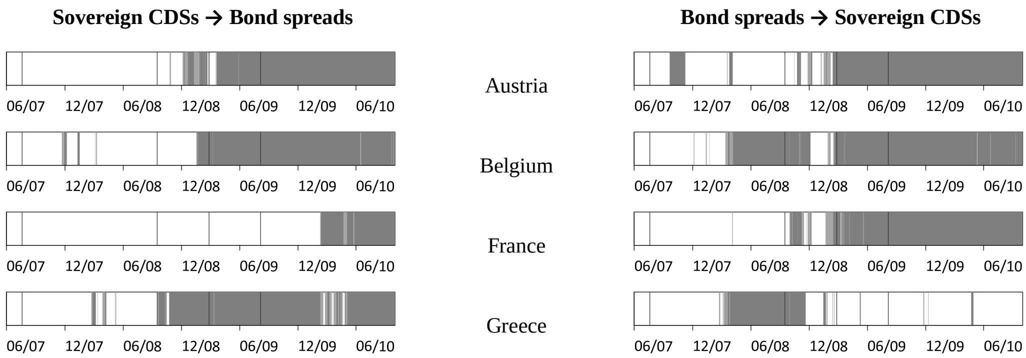


Chart V.D4: Conditional causality by country between sovereign CDS premia and 10-year government bond spreads



Sovereign CDSs → Bond spreads | **Bond spreads → Sovereign CDSs**

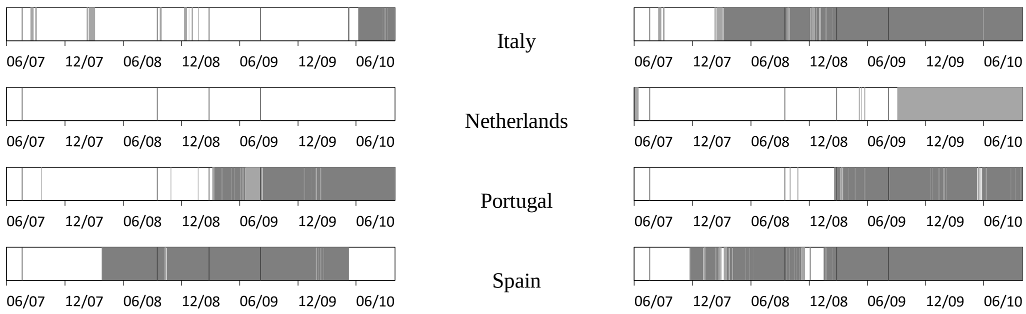


Chart V.D5: Conditional causality by country between sovereign CDS premia and 10-year bank CDS indices

Sovereign CDSs → Bank CDSs | **Bank CDSs → Sovereign CDSs**

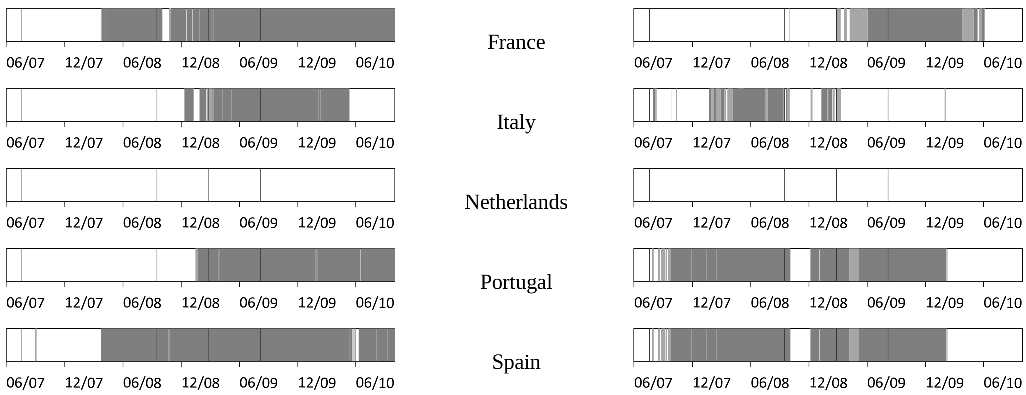
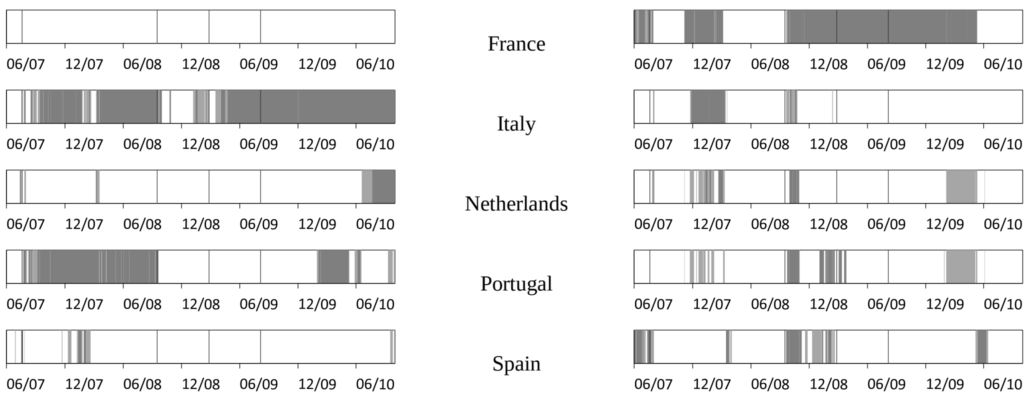


Chart V.D6: Conditional causality by country between government bond spreads and 10-year bank CDS indices

Bond spreads → Bank CDSs | **Bank CDSs → Bond spreads**



Conclusion générale

Cette thèse a permis d'étudier la dynamique du marché des CDS et de ses relations avec les autres marchés, en particulier durant les épisodes de crise.

Le marché des CDS a connu un développement vigoureux depuis son émergence, au milieu des années 90. Comme l'a détaillé l'introduction générale, les volumes de contrats de CDS échangés ont augmenté à un rythme rapide, ce marché a ainsi connu le développement le plus rapide parmi les dérivés OTC. Fin 2009, le montant brut de CDS était de 33 trillions USD. Ce développement a accompagné celui de la finance structurée, les CDS ayant servi de support à de nombreux produits comme les CDO. Les participants de marché, principalement les grandes banques, ont su tirer parti des possibilités offertes par les outils de transfert de risque qui leur ont permis tout d'abord, de disposer d'instruments novateurs de protection contre le risque de crédit, mais aussi d'assurer l'expansion de leur activité d'intermédiation du crédit tout en optimisant les exigences en capital.

L'émergence de cette nouvelle catégorie de produits dérivés a conduit les participants de marché à renforcer les dispositifs utilisés pour traiter ce type de contrats. Ainsi, depuis le début des années 2000 et l'occurrence de nombreux événements de crédit, les intervenants ont progressivement précisé les définitions nécessaires à la rédaction des contrats et ont réduit le risque opérationnel lié à ces outils, en particulier grâce à la migration de la confirmation des contrats vers des plateformes électroniques. Le développement des techniques de compression des portefeuilles de CDS a également permis de diminuer de manière substantielle les montants de CDS en supprimant le nombre de CDS redondants, liés à l'empilement des positions.

Cette rationalisation progressive du fonctionnement du marché des CDS a effectué une avancée majeure au cours de l'année 2009. La mise en place du *Big Bang Protocol* pour les CDS américains, puis du *Small bang Protocol* pour les CDS européens, ont conduit à une standardisation accrue des procédures de négociation et de règlement des CDS, l'objectif étant à terme de faciliter le recours à des chambres de compensation. L'utilisation systématique d'une procédure d'enchère pour gérer le règlement des événements de crédit permet par ailleurs de garantir un traitement équitable des cocontractants en cas de déclenchement du CDS et vise à assurer une cohérence entre le taux de recouvrement et les prix observés sur le marché secondaire de la dette sous-jacente.

Apport de la thèse

Bien que le fonctionnement du marché des CDS ait connu une amélioration depuis le début des années 2000, plusieurs éléments mettent en doute l'hypothèse d'un marché efficient et résilient aux périodes de crise. Comme l'a montré le chapitre II, la collatéralisation des contrats, permettant aux acheteurs de CDS de se prémunir contre le risque de contrepartie, ne fournit qu'une protection partielle. Par ailleurs, le marché est resté très concentré. Les institutions financières sont à la fois les principaux acheteurs et vendeurs de protection. De plus, la protection négociée par les différents acteurs concerne très souvent des entités de référence financières. Le transfert de risque que le marché des dérivés de crédit était censé opérer en permettant une dilution du risque sur un grand nombre d'acteurs ne s'est en réalité pas produit. Au contraire, ces instruments ont conduit à une plus grande concentration du risque de crédit, tout en diminuant les incitations des acteurs à effectuer un contrôle rigoureux des conditions d'octroi des crédits. De même, l'étude détaillée du processus d'enchère utilisé pour assurer le règlement des CDS lors du défaut de l'entité sous-jacente montre que dans le cas de certains règlements de défauts de grande taille, les prix finaux présentaient un écart substantiel avec les prix des obligations livrables observés sur le marché secondaire.

Ces incertitudes importantes concernant le fonctionnement du marché soulèvent la question de la résilience du marché des CDS, les niveaux de primes constatés sur ce marché dès le début des années 2000, ainsi que leur volatilité, ayant conduit à s'interroger sur une surréaction possible de ce marché, favorisée par son caractère fortement spéculatif. Cette question est d'autant plus importante que l'évolution des primes de CDS a pu influencer les prix d'autres actifs, en particulier celui des *spreads* obligataires sous-jacents. L'existence de phénomènes de contagion, aussi bien au sein du marché, qu'entre primes de CDS et prix d'autres d'actifs, ne peut être écartée. Le développement du marché des CDS a pu ainsi participer à modifier les conditions de financement des entreprises et, d'une manière plus générale, de l'économie.

La crise de 2005 a permis de détecter de tels effets de contagion, bien qu'elle fût d'une ampleur nettement plus faible que celle des *subprimes*. Cette crise trouve son origine dans la dégradation en catégorie spéculative de GM et Ford, entreprises américaines majeures et importants émetteurs de dette. L'avantage de cet épisode est qu'il est bien circonscrit dans le temps et que nous disposons d'un certain recul pour pouvoir l'analyser. Le chapitre III a ainsi montré que des phénomènes de contagion ont pu être observés durant cette crise. En effet, l'ensemble des corrélations entre les primes de CDS de GM et Ford et celles des CDS les plus négociés, au Etats-Unis comme en Europe, ont augmenté significativement, en particulier pendant la première semaine de la crise. Cependant, les mécanismes de transmission des prix à l'intérieur du marché des CDS n'ont pas été modifiés durant cette phase de crise, la hausse de la volatilité ayant été suffisante pour provoquer une augmentation significative des corrélations pour l'ensemble des entreprises de l'échantillon.

Le chapitre IV a montré que ces phénomènes de contagion n'étaient pas confinés à l'intérieur du marché des CDS. Plusieurs éléments portent à croire que les mouvements des primes de CDS ont un impact sur d'autres prix d'actifs. Premièrement, la nature OTC et le manque de régulation de ce marché ont pu renforcer les incitations à mettre en place des stratégies spéculatives pendant les périodes de crise. Deuxièmement, comme les CDS sont un moyen de négocier le risque de défaut, leur prix est fortement lié à celui des obligations sous-jacentes. Troisièmement, si l'on se réfère au modèle de Merton (1974), une augmentation de la prime de CDS est liée aux difficultés financières d'une entreprise et devrait aller de pair avec une baisse du prix de son action. Le chapitre IV contribue ainsi aux travaux étudiant la manière dont se déroule le processus de découverte des prix d'actifs entre le marché des CDS, le marché obligataire sous-jacent et le marché boursier. Ce chapitre a confirmé le caractère *leader* des primes de CDS sur les *spreads* obligataires, déjà détecté par plusieurs études. Le développement des CDS n'a donc pas été sans conséquence pour le marché du crédit. En effet, les primes de CDS sont devenues une source d'information privilégiée et le marché des CDS celui sur lequel les investisseurs tendront à intervenir d'abord, ce qui peut être justifié par la plus grande facilité à négocier des CDS plutôt que les titres de dette sous-jacents. Par ailleurs, la relation habituelle entre les deux marchés est modifiée par la crise. Durant la crise de GM et Ford, les primes de CDS s'accroissent plus que les *spreads* obligataires, les investisseurs renchérissant le prix de la protection. Ceci peut être dû à la nature spéculative du marché. De même, la relation entre prix des actions et primes de CDS est perturbée lors des épisodes de crise : bien que la réaction du marché des actions précède celle du marché des CDS, les actions de GM et Ford n'ont pas baissé continûment pendant la crise, comme on pouvait s'y attendre, malgré une forte augmentation de leur volatilité.

A partir de mi-2007, le développement de la crise des *subprimes* a placé à nouveau les CDS au centre des préoccupations. Les primes de CDS ont atteint des niveaux record après la faillite de Lehman Brothers, en particulier dans le cas des CDS de pays développés. La mise en place de plans d'aide massifs par les Etats a profondément dégradé les finances publiques et conduit les participants de marché à réévaluer leur perception du risque souverain. L'évolution de la crise financière en crise des finances publiques a créé de fortes incitations à la négociation des CDS de pays développés. Ce segment du marché est ainsi devenu l'un des plus actifs. Malgré tout, les volumes de CDS négociés sur ces entités de référence restent faibles en comparaison de la taille du marché des titres de dette publique. Cette situation a étendu les interrogations sur les conséquences du développement rapide du marché des CDS au cas des souverains : l'émergence des CDS souverains de pays développés, jusqu'alors très peu négociés, a pu avoir un impact sur les *spreads* sous-jacents et *in fine* sur le financement des Etats. Comme l'a montré le chapitre V dans le cas des pays appartenant à la zone euro, les *spreads* obligataires ont été la source privilégiée des investisseurs pour évaluer l'évolution du risque souverain jusqu'à la faillite de Lehman Brothers. Les investisseurs ont donc rapidement anticipé et intégré le rôle déterminant des banques centrales, en tant que prêteur en dernier ressort le plus probable, ainsi que celui des Etats. Cependant, suite à l'implémentation des plans d'aide, l'influence de ces *spreads* sur les CDS des principales banques nationales a diminué. A l'inverse, le rôle des primes de CDS souverains dans le processus de découverte des prix actifs s'est accru. L'influence du marché des CDS souverains, aussi bien sur les *spreads* obligataires sous-jacents que sur les primes de CDS bancaires, a donc significativement augmenté avec les tensions subies par les Etats ; ceci en dépit des faibles montants notionnels de CDS souverains comparativement aux encours de titres de dette publique sous-jacente.

L'étude de ces deux phases de crise a donc montré que le développement du marché des CDS a participé à modifier les relations entre marchés, les investisseurs ayant fait des primes de CDS une source d'information privilégiée pour évaluer le risque de crédit. En effet, les travaux empiriques menés tout au long de cette thèse ont montré que ce marché est devenu progressivement le lieu où tendait à se dérouler le processus de découverte des prix. Bien que cette évolution trouve un certain nombre de justifications dans le cas des sous-jacents *corporates*, elle reste beaucoup plus sujette à caution dans le cas des CDS souverains. Les vulnérabilités du marché des CDS en général, renforcées par des effets de contagion déjà à l'œuvre lors de l'épisode de crise de 2005, ont soulevé un certain nombre d'inquiétudes. La crainte d'un effondrement du système financier mondial suite à la crise des *subprimes,* dont le marché des CDS aurait pu être un catalyseur, a montré la nécessité de réguler davantage les outils de transfert du risque de crédit et, d'une manière plus générale, les dérivés OTC.

Les enjeux actuels

Un chantier majeur pour mieux maîtriser les risques liés au marché des CDS est la compensation centralisée des contrats. L'objectif est de transférer le risque de contrepartie à des chambres de compensation, structures à même d'absorber le défaut d'un acteur majeur du marché. Le recours à des contreparties centrales (CCP – *central counterparties*) assure un meilleur niveau de collatéralisation des contrats en imposant des marges initiales et des appels de marge sur une base intra-journalière. Ces marges sont par ailleurs complétées par un fond de compensation auquel contribuent les membres de la CCP qui garantit une mutualisation des risques en cas de défaut d'un des membres (CPSS, 2007). A l'heure actuelle, quatre CCP sont actives sur les CDS : la chambre américaine lancée par l'Intercontinental Exchange (ICE Trust) ainsi que sa filiale européenne ICE Europe, Eurex Credit Clear et LCH.Clearnet SA. Cependant, la concurrence entre ces CCP a déjà conduit au retrait d'Eurex Credit Clear qui n'est pas parvenue à attirer suffisamment d'activité (Cameron, 2010).

Malgré tout, la compensation centralisée des CDS ne pourra résoudre l'ensemble des problèmes que le développement du marché a provoqué. En effet, la participation à une CCP nécessite un cadre de fonctionnement unique qui permet de réduire les risques légaux et opérationnels. Par conséquent, seuls des contrats suffisamment standardisés peuvent être compensés. Cette restriction présente l'avantage d'améliorer la liquidité de ces contrats, condition qui permet aux CCP de couvrir facilement leurs positions et les liquider aisément en cas de défaut d'un participant. Cependant, un grand nombre de contrats non suffisamment standardisés ne pourront être compensés. Le choix d'imposer la compensation des contrats sous peine d'exigences en capital réglementaire fortement défavorables est une solution qui inciterait les participants de marché à se focaliser sur des contrats standardisés. Par delà l'inadéquation de ces contrats standardisés à certaines activités de couverture, raison d'être des marchés dérivés, cette option pose également la question des conséquences d'un *clearing* généralisé des CDS et, plus généralement, de l'ensemble des dérivés OTC.

Par ailleurs, comme le note Singh (2010), une compensation centralisée diminuera les possibilités de réhypothécation des contrats. Cette technique, que les banques manipulent très bien, autorise la contrepartie recevant des titres en collatéral à les réutiliser à d'autres fins. Le recours à une CCP imposant la couverture des expositions, le collatéral est alors « verrouillé » par la CCP et ne peut être réutilisé. Le passage de la majorité des produits dérivés sur des CCP aura ainsi pour conséquence un coût élevé pour les banques et une augmentation substantielle de leurs besoins en termes de détention de titres sûrs, éligibles au collatéral des CCP, comme des titres de dette publique des pays les mieux notés. In fine, cette situation pourra exercer une forte pression sur les taux des souverains, renforcée par les exigences attendues de Bâle 3, impliquant pour les banques de détenir dans leur bilan des montants plus importants de titres liquides, c'est-à-dire des obligations émises par ces mêmes souverains.

Enfin, la concentration du risque de contrepartie sur un nombre réduit d'entités soulève la question de la création de nouvelles institutions systémiques et impose de mettre en place des garanties suffisantes pour assurer la stabilité des CCP (voir, par exemple, Avellaneda *et al*., 2010 ; Cont, 2010). Les conséquences du défaut d'une CCP sont difficiles à évaluer, un tel événement ne s'étant pour l'instant jamais produit.

Les réunions du G20 de 2009 et 2010 ont mis l'avenir des marchés dérivés OTC au cœur des préoccupations des régulateurs. Le marché des CDS, souvent accusé d'avoir, sinon provoqué, du moins attisé la crise est ainsi le premier dont l'activité a été plus fortement encadrée. A plus long terme, les différentes autorités nationales devront faire face au délicat arbitrage entre la préservation d'incitations à recourir aux marchés dérivés, l'existence de ces derniers trouvant une rationalité économique, et un environnement financier suffisamment sûr pour maîtriser au mieux les risques qui y sont liés, en particulier le risque systémique. Comme le note Tett (2009), dans son ouvrage retraçant l'émergence des dérivés de crédit et les excès liés à leur utilisation, le mot crédit vient du latin *credere*, croire. Rétablir la confiance dans les instruments de crédit après la plus importante crise économique depuis la Grande Dépression dès années 30 en améliorant la transparence des marchés dérivés OTC et en assurant un meilleur contrôle des risques pris par les intervenants de marché est un enjeu majeur.

References

Acharya, V., T. Philippon, M. Richardson and N. Roubini, 2009, "The financial crisis of 2007-2009: Causes and remedies", Financial Markets, Institutions & Instruments 18, pp. 89-137.

Acharya, V. V., S. Schaefer and Y. Zhang, 2008, "Liquidity risk and correlation risk: a clinical study of the General Motors and Ford Downgrade of May 2005", BNP Paribas Hedged Fund Centre, Working Paper Series, HF-029.

Acharya, V. V. and T. C. Johnson, 2007, "Insider trading in credit derivatives", Journal of Financial Economics 84, pp. 110-141.

Ades, A. and M. Fuentes, 2003, "Risk aversion", Goldman Sachs Foreign Exchange Market, pp. 28-31, October.

Adrian, T. and A. Shin, 2008, "Liquidity and financial contagion", Banque de France, Financial Stability Review 11, pp. 1-7.

Aït-Sahalia, Y., J. Andritzky, A. Jobst, S. Nowak and N. Tamirisa, 2009, "How to stop a herd of running bears? Market response to policy initiatives during the financial crisis", IMF Working Paper 09/204.

Akerlof, G., 1970, "The market for 'lemons': Qualitative uncertainty and the market mechanism", Quarterly Journal of Economics 89 (3), pp. 488-500.

Alexander, C. and A. Kaeck, 2006, "Regimes in CDS spreads: A Markov switching model of iTraxx Europe indices", ICMA Centre Discussion Paper in Finance DP2006-08.

Allen, F. and D. Gale, 2000, "Financial contagion", Journal of Political Economy 108, pp. 1-33.

Ammer, J. and F. Cai, 2007, "Sovereign CDS and bond pricing dynamics in emerging markets: Does the cheapest-to-deliver option matter", Board of Governors of the Federal Reserve System, International Finance Discussion Paper 912.

Andritzky, J. R. and M. Singh, 2005, "Overpricing in emerging market CDS contracts: some evidence from recent distress cases", IMF Working Paper 05/125.

Andritzky, J. R., and M. Singh, 2006, "The pricing of credit default swaps during distress", IMF Working Paper 06/254.

Attinasi, M. G., C. Checherita and C. Nickel, 2009, "What explains the surge in euro area sovereign spreads during the financial crisis of 2007-09?", ECB Working Paper 1131.

Aubuchon, C. P., 2009, "What's under the TARP?", Federal Reserve Bank of Saint Louis, Economic Synopsis 20.

Aunon-Nerin, D., D. Cossin, T. Hricko and Z. Huang, 2002, "Exploring for the determinants of credit risk in default swap transaction data: Is fixed-income markets' information sufficient to evaluate credit risk?", FAME Research Paper 65.

Avellaneda, M., R. Cont and J. Zhang, 2010, "Risk management for central counterparties", Working Paper, University of Columbia.

Baba, N. and M. Inada, 2007, "Price discovery of credit spreads for Japanese mega-banks: Subordinated bond and CDS", Bank of Japan, Institute for Monetary and Economic Studies Discussion Paper 2007-E-6.

Bae, K.-H., G. A. Karolyi and R. M. Stulz, 2003, "A new approach to measuring financial contagion", Review of Financial Studies 16 (3), pp. 717-763.

Baek, I., A. Bandopadhyaya and C. Du, 2005, "Determinants of market-assessed sovereign risk: economic fundamentals or market risk appetite?", Journal of International Money and Finance 24 (4), pp. 533-548.

Baig, T. and I. Goldfajn, 2002, "Monetary policy in the aftermath of currency crises: The case of Asia", Review of International Economics 10 (1), pp. 92-112.

Bank for International Settlements (BIS), 2009, Quarterly Review, December.

Bank for International Settlements (BIS), 2010, Quarterly Review, March.

Bank of England, 2009, "Special Liquidity Scheme", Market notice, 3 February, http://www.bankofengland.co.uk/markets/marketnotice090203c.pdf.

Basel Committee on Banking Supervision (BCBS), 2006, "International convergence of capital measurement and capital standards", Bank for International Settlements, June.

Beattie, A., 2010, "State of bankruptcy", Financial Times, 1 August.

Beinstein, E., C. Pedersen and B. Graves, 2005, "Quantitative strategy: dislocations in tranched DJ CDX.NA.IG market may present opportunities", J.P. Morgan, Credit Derivatives and Quantitative Strategy, 11 May.

Beltratti, A., Morana, C., 1999. Computing value at risk with high frequency data. Journal of Empirical Finance 6, 431–455.

Benford, J., S. Berry, K. Nikolov and C. Young, 2009, "Quantitative easing", Bank of England, Quarterly Bulletin, volume 49, no. 2, pp. 90-100.

Berg, A. and C. Pattilo, 1999, "Are currency crises predictable? A test". IMF Staff Paper, vol. 46-2.

Berkowitz, J. and J. O'Brien, 2002, "How accurate are value-at-risk models at commercial banks?", Journal of Finance 57 (3), pp. 1093-1111.

Bikhchandani, S. and S. Sharma, 2000, "Herding behavior in financial markets: A review", IMF Working Paper 00/48.

Blanco, R., S. Brennan and I. W. Marsh, 2005, "An empirical analysis of the dynamic relationship between investment grade bonds and credit default swaps", Journal of Finance 60 (5), pp. 2255-2281.

Bliss, R. and N. Panigirtzoglou, 2004, "Option-implied risk aversion estimates", Journal of Finance 59 (1), pp. 407-446.

Boone, L., L. Fransolet and S. Willemann, 2010, "Euro public debt and the markets: Sovereign fundamentals and CDS market dynamics", Banque de France, Financial Stability Review 14, pp. 19-26.

Boucher, C., 2004, "Identification et comparaison des crises boursières", *in* Boyer, R., M. Dehove, and D. Plihon (eds.), Les crises financières, Conseil d'Analyse Economique, report, vol. 50, pp. 375-396.

Bowe, M., A. Klimavicienne and A. Taylor, (2009). "Information transmission and price discovery in emerging sovereign credit risk markets" Presentation at the Mid-West Finance Association Annual Conference, Chicago.

Boyer, B., H., M. S. Gibson and M. Loretan, 1999, "Pitfalls in test for changes in correlations", Board of the Governors of the Federal Reserve System, International Finance Discussion Paper 597.

Brettell, K., 2009, "Strong bank bid could squeeze CIT's CDS auction", Reuters, 18 November.

Brunnermeier, M., K., 2009, "Deciphering the liquidity and credit crunch 2007–2008", Journal of Economic Perspectives 23 (1), pp. 77-100.

Bruyère, R., 2004, Les produits dérivés de crédit, 2ème éd, Economica, Paris.

Burkart, O. and V. Coudert, 2002, "Leading indicators of currency crises for emerging countries", Emerging Markets Review 3 (2), pp. 107-133.

Bussière, M. and M. Fratzscher, 2006, "Towards a new early warning system of financial crises", Journal of International Money and Finance 25 (6), pp. 953-973.

Byström H., 2008, "Credit default swaps and equity prices: The iTraxx CDS index market" *in* N. Wagner (éd), Credit risk – Models, derivatives, and management, Chapman & Hall.

Caballero, R. and A. Krishnamurthy, 2005, "Financial system risk and flight to quality", NBER Working Paper 11834.

Caballero, R. and A. Krishnamurthy, 2007, "Collective risk management in a flight to quality, episode", Journal of Finance 63, pp. 2195-2230.

Cailloux, J., H. Sian and S. Peruzzo, 2009, "Greek confidence crisis", Royal Bank of Scotland, European Economics and Strategy, 10 December.

Calvo, G., 1999, "Contagion in emerging markets: When Wall Street is a carrier", University of Maryland Working Paper.

Calvo, G. and E. Mendoza, 2000, "Rational contagion and the globalization of securities markets", Journal of International Economics 51 (1), pp. 79-113.

Cameron, M., 2010, "Eurex freezes marketing on CDS clearing", Risk magazine, 10 September.

Campbell, J. and J. Cochrane, 2000, "Explaining the poor performance of consumption-based asset pricing models", Journal of Finance 50 (6), pp. 2863-2878.

Campbell, J., A. Lo and A. MacKinlay, 1997, The Econometrics of Financial Markets, Princeton University Press, Princeton, New Jersey.

Cassidy, J., 2008, "Anatomy of a meltdown", The New Yorker, 1 December.

Caramazza, F., L. Ricci and R. Salgado, 2004, "International financial contagion in currency crises", Journal of International Money and Finance 23, pp. 51-70.

Chakravarty, S., H. Gulen and S. Mayhew, 2004, "Informed trading in stock and option markets", Journal of Finance 59 (3), pp. 1235-1257.

Chakravorti, S. and S. Lall, 2004, "Managerial incentives and financial contagion", IMF Working Paper 04/199.

Chan-Lau J. A. and Y. S. Kim, 2004, "Equity prices, credit default swaps, and bond spreads in emerging markets", IMF Working Paper 04/27.

Chaplin, G., 2005, Credit derivatives: Risk management, trading and investing, John Wiley & Sons.

Chiang, T. C., B. N. Jeon and H. Li, 2007, "Dynamic correlation analysis of financial contagion: evidence from Asian markets", Journal of International Money and Finance 26 (7), pp. 1206-1228.

Chicago Board Options Exchange (CBOE), 2004, "VIX, CBOE volatility index", White Paper.

Cochrane, J., 1996, "A cross-sectional test of an investment-based asset pricing model", Journal of Political Economy 104 (3), pp. 572-621.

Cochrane, J., 2001, Asset Pricing, Princeton University Press, Princeton, New Jersey.

Committee on the Global Financial System (CGFS), 2009, "Credit risk transfer statistics", September.

Cont, R., 2010, "Credit default swaps and financial stability", Banque de France, Financial Stability Review 14, pp. 35-43.

Corsetti, G., P. Pesenti and N. Roubini, 1998, "Paper tigers? A Model of the Asian Crisis", NBER Working Paper 6783.

Corsetti, G., P. Pesenti and N. Roubini, 1999, "What caused the Asian currency and financial crisis?", Japan and the World Economy 11, pp. 305-373.

Corsetti, G., M. Pericoli and M. Sbracia, 2005, "Some contagion, some interdependence: more pitfalls in tests of financial contagion", Journal of International Money and Finance 24, pp. 1177-1199.

Crouch, P. and I. W. Marsh, 2005, "Arbitrage relationships and price discovery in the Autos sector of the credit market", Cass Business School, Working Paper.

Cossin, D. and H. Lu, 2005, "Are European corporate bonds and default swap markets segmented?", Working Paper 153, FAME.

Coudert, V. and M. Gex, 2008, "Does risk aversion drive financial crises? Testing the predictive power of empirical indicators", Journal of Empirical Finance 15 (2), pp. 167-184.

Coudert, V. and M. Gex, 2010a, "Contagion inside the credit default swaps market: The case of the GM and Ford crisis in 2005", Journal of International Financial Markets, Institutions and Money 20, pp. 109-134.

Coudert, V. and M. Gex, 2010b, "Credit default swap and bond markets: Which leads the other?", Banque de France, Financial Stability Review 14, pp. 161-167.

Coudert, V. and M. Gex, 2010c, "Disrupted links between credit default swaps, bonds and equity during the GM and Ford crisis in 2005", Applied Financial Economics, 20 (23), pp. 1769-1792.

Coudert, V. and M. Gex, 2010d, "The credit default swaps market and the settlement of large defaults", International Economics, n° 123.

CPSS, 2007, "New developments in clearing and settlement arrangements for OTC derivatives", Bank for International Settlements, March.

CPSS (2010), "Considerations for trade repositories in OTC derivatives markets", Consultative Report, Bank for International Settlements, May.

Credit Sights, 2008a, "CDS: Guidebook to the upcoming auctions", 1 October.

Credit Sights, 2008b, "CDS: Auctions, exchanges and coming changes", 7 October.

Crouch, P. and I. W. Marsh, (2005), "Arbitrage Relationships and Price Discovery in the Autos Sector of the Credit Market", Working Paper, Cass Business School.

Cuthbertson, K., S. G. Hall and M. P. Taylor, 1992, Applied econometric techniques, Harvester Wheatsheaf, New York.

Dages, B. G., D. Palmer and S. Turney, 2005, "An overview of the emerging market credit derivatives market", Federal Reserve Bank of New York, May.

Das, S., 2005, Swaps and financial derivatives: Products, pricing, applications and risk management, 3rd ed., John Wiley & Sons.

De Gregorio, J. and R. O. Valdès, 2001, "Crisis transmission: evidence from the debt, tequila, and Asian Flu Crisis", The World Bank Economic Review 15 (2), pp. 289-314.

De Wit, J., 2006, "Exploring the CDS-bond basis", Working Paper Research 104, National Bank of Belgium.

Debrun, X., L. Moulin, A. Turrini, J. Ayuso-i-Casals and M. Kumar, 2008, "Tied to the mast? National fiscal rules in the European Union," Economic Policy, 23 (54), pp. 297-362.

Depository Trust and Clearing Corporation (DTCC), 2010, "An introduction to DTCC: Services and capabilities", http://www.dtcc.com/downloads/about/Introduction_to_DTCC.pdf.

Deutsche Bundesbank, 2004, "Indicators of international investors' risk aversion", Monthly Report, vol. 56-10, pp. 69-73.

Deutsche Bundesbank, 2005, "Risk appetite in a dynamical financial market environment", Monthly Report, vol. 57-10, pp. 85-97.

Duffie, D., 1999, "Credit swap valuation", Financial Analysts Journal 55, pp. 73-87.

Duffie, D., 2008, "Innovations in credit risk transfer: Implications for financial stability", BIS Working Paper 255.

Duffie, D., 2010, "Is there a case for banning short speculation in sovereign bond markets?", Banque de France, Financial Stability Review 14, pp. 55-59.

Dungey, M., 2001, "Testing for contagion using correlations: some words of caution", Pacific Basin Working Paper Series 01-09.

Dungey, M., R. Fry, B. González-Hermosillo and V. Martin, 2003, "Characterizing global risk aversion for emerging markets during financial crises", IMF Working Paper 03/251.

Duquerroy, A., N. Gauthier and M. Gex, 2009, "Credit default swaps and financial stability: risks and regulatory issues", Banque de France, Financial Stability Review 13, pp. 75-88.

Eichengreen, B., A. Mody, M. Nedeljkovic and L. Sarno, 2009, "How the subprime crisis went global: Evidence from bank credit default swap spreads", SSRN Working Paper, August.

Ejsing, J. W. and W. Lemke, 2009, "The Janus-headed salvation: Sovereign and bank credit risk premia during 2008-09", ECB Working Paper 1127.

Engle, R. F., 2002, "Dynamic conditional correlation: a simple class of multivariate generalized autoregressive conditional heteroskedasticity models", Journal of Business and Economics Statistics 20 (3), pp. 339-350.

Engle, R. F. and K. Sheppard, 2001, "Theoretical and empirical properties of dynamic conditional correlation multivariate GARCH", NBER Working Paper 8554.

Ericsson, J., K. Jacobs and R. A. Oviedo, 2004, "The determinants of credit default swap premia", CIRANO Working Paper 2004s-55.

European Central Bank (ECB), 2004, "Empirical evidence of price discovery in the CDS and bonds markets", The euro bond market study, 2004.

European Central Bank (ECB), 2009, "Credit Default Swaps and counterparty risk", August.

Eichengreen, B., A. Mody, M. Nedeljkovic and L. Sarno, 2009, "How the subprime crisis went global: evidence from bank credit default swap spreads", NBER Working Paper 14904.

Fama, E. and K. French, 1996, "The CAPM is wanted, dead or alive", Journal of Finance 49 (5), pp. 1579-1593.

Federal Reserve Bank of New York, 2010, "Timelines of policy responses to the global financial crisis", http://www.ny.frb.org/research/global_economy/policyresponses.html.

Fender, I. and M. Scheicher M., 2008, "The ABX: How do the markets price subprime mortgage risk?", BIS Quarterly Review, September, pp. 67-81.

Ferreira, M. A. and J. A. Lopez, 2005, "Evaluating interest rate covariance models within a value-at-risk framework", Journal of Financial Econometrics 3, pp. 126-168.

Fitch, 2004, "Global credit derivatives survey", Special Report, 7 September.

Fitch, 2007, "CDx survey", Special Report, 16 July.

Fleming, M. J., 2003, "Measuring treasury market liquidity", Federal Reserve bank of New York, Economic Policy Review, September, pp. 83-108.

Forbes, K., J. and R. Rigobon, 2002, "No contagion, only interdependence: measuring stock market co-movements", Journal of Finance 57 (5), pp. 2223-2261.

Frank, N. and H. Hesse, 2009, "The effectiveness of Central Bank interventions during the first phase of the subprime crisis", IMF Working Paper 09/2006.

Frankel, J. and A. Rose, 1996, “Currency crashes in emerging markets: empirical indicators”, Journal of International Economics 41 (3-4), pp. 351-366.

Froot, K. and P. O'Connell, 2003, “The risk tolerance of international investors”, NBER Working Paper 10157.

Froot, K., Scharfstein et J. Stein, 1993, “Risk management: coordinating corporate investment and financing policies”, Journal of Finance 48 (5), pp. 1629-1658.

Froot, K. and J. Stein, 1998, “Risk management, capital budgeting and capital structure policy for financial institutions: An integrated approach”, Journal of Financial Economics 47 (1), pp. 55-82.

Gai, P. and N. Vause, 2006, “Measuring investors' risk appetite”, International Journal of Central Banking 2 (1), pp. 167-188.

Garzarelli, F. and M. Vaknin, 2005, “Have bond market vigilantes lowered their guard?,” Goldman-Sachs Global Viewpoint, no. 05/24, 27 July.

Germanier, B, 2003, “Updated risk index”, Foreign exchange note, Union des Banques Suisses. September.

Gerson Lehrman Group, 2008, “Lehman CDS settlement - The dog that didn't bark?” 28 October, http://www.glgroup.com/News/Lehman-CDS-Settlement-%E2%80%93-The-Dog-that-Didnt-Bark--28832.html.

Goldstein, I. and A. Pauzner, 2004, “Contagion of self-fulfilling financial crises due to diversification of investment portfolios”, Journal of Economic Theory 119, pp. 151-183.

Gonzalo, J. and C. Granger, 1995, “Estimation of common long-memory components in cointegrated systems”, Journal of Business and Economic Statistics 13, pp. 27-35.

Gonzalo, J. and J.-Y. Pitarakis, 2006, “Threshold effects in cointegrating relationships”, Oxford Bulletin of Economics and Statistics 68, no. S1, pp. 813-833.

Gregory, A. and B. Hansen, 1996, “Residual-based tests for cointegration in models with regime shifts”, Journal of Econometrics 70, pp. 99-126.

Gromb, D. and D. Vayanos, 2007, “Financially constrained arbitrage and cross-market contagion”, Unpublished Working Paper.

Group of Twenty, 2009, “Global economic policies and prospects”, Meeting of the Ministers and Central Bank Governors, March 13-14, London, http://www.imf.org/external/np/g20/pdf/031909a.pdf.

Gyntelberg, J., K. von Kleist and C. Mallo, 2009, “The size of the global CDS market – BIS and DTCC data”, BIS, Quarterly Review, December, pp. 24-25.

Hamilton, J. D., 1994, “Time series analysis”, Princeton University Press, Princeton.

Hansen, L. and K. Singleton, 1982, “Generalized instrumental variables estimation of nonlinear rational expectations models”, Econometrica 50 (5), pp. 1269-1286.

Hansen, L. and K. Singleton, 1983, “Stochastic consumption, risk aversion, and the temporal behaviour of asset returns”, Journal of Political Economy 91 (2), pp. 249-265.

Hartelius, K., K. Kasiwase and L. E. Kodres, 2008, “Emerging market spread compression: Is it real or is it liquidity?”, IMF Working Paper 08/10.

Hartmann, P., S. Straetmans and C. de Vries, 2001, “Asset market linkages in crisis periods”, Discussion Paper Series 2916, Center for Economic Policy Research.

Helwege, J., S. Maurer, A. Sarkar and Y. Wang, 2009, “Credit Default Swaps Auctions”, Federal Reserve Bank of New York Staff Report no. 372.

Hilscher, J. and Y. Nosbusch, 2010, “Determinants of sovereign risk: Macroeconomic fundamentals and the pricing of sovereign debt”, Review of Finance 14 (2), pp. 235-262.

Houweling, P. and T. Vorst, 2005, "Pricing default swaps: Empirical evidence", Journal of International Money and Finance 24, pp. 1200-1225.

Huang, H. and C. Xu, 2000, "Financial institutions, financial contagion, and financial crises", IMF Working Paper 00/92.

Hull, J., M. Predescu and A. White, 2004, "The relationship between credit default swap spreads, bond yields, and credit rating announcements", Journal of Banking and Finance 28 (11), pp. 2789-2811.

Hull, J. and A. White, 2000, "Valuing credit default swaps I: No counterparty default risk", Journal of Derivatives 8, pp. 29-40.

International Monetary Fund (IMF), 2005, Global Financial Stability Report, September.

International Monetary Fund (IMF), 2008, Global Financial Stability Report, October.

International Monetary Fund (IMF), 2009a, "The state of public finances: Outlook and medium-term policies after the 2008 crisis", Companion Paper, 6 March, http://www.imf.org/external/np/pp/eng/2009/030609.pdf.

International Monetary Fund (IMF), 2009b, "Update on fiscal stimulus and financial sector measures", 26 April, http://www.imf.org/external/np/fad/2009/042609.pdf.

International Swaps and Derivatives Association (ISDA), 2008, "Lehman CDS Protocol", October, http://www.isda.org/2008lehmancdsprot/docs/Lehman-CDS-Protocol.pdf.

International Swaps and Derivatives Association (ISDA), 2009, "2003 ISDA Credit Derivatives Definitions (incorporating the "May 2003 Supplement" and the "July 2009 Supplement")", 14 July.

International Swaps and Derivatives Association (ISDA), 2010, "2010 ISDA Operation Benchmarking Survey", http://www.isda.org/c_and_a/pdf/ISDA-Operations-Survey-2010.pdf.

Inoue, A. and L. Kilian, 2005, "In-sample or out-of-sample tests of predictability: which one should we use?", Econometric Reviews 23 (4), pp. 371-402.

J.P. Morgan, 1996, RiskMetrics Technical Document, 4th ed., J.P. Morgan, New York.

Jarrow, R. and F. Yu, 2001, "Counterparty risk and the pricing of defaultable securities", Journal of Finance 56, pp. 1765-1799.

Jorion, P. and G. Zhang, 2007, "Good and bad credit contagion: evidence from credit default swaps", Journal of Financial Economics 84 (3), pp. 860-883.

Jorion, P. and G. Zhang, 2009, "Credit contagion from counterparty risk", Journal of Finance 64, pp. 2053-2087.

Kamnisky, G., S. Lizondo and C. Reinhart, 1997, "Leading indicators of currency crises", IMF Working Paper 97/79.

Kaminsky, G., L. and C. M. Reinhart, 2000, "On crises, contagion, and confusion", Journal of International Economics 51 (1), pp. 145-168.

Kantor, L. and M. Caglayan, 2002, "Using equities to trade FX: introducing the LCVI", J.P. Morgan Chase Bank, Global Foreign Exchange Research, Investment Strategies, vol. 7.

Kodres, L. E. and M. Pritsker, 2002, "A rational expectations model of financial contagion", Journal of Finance 57 (2), pp. 769-799.

Kumar, M. and A. Persaud, 2002, "Pure contagion and investor's shifting risk appetite: Analytical issues and empirical evidence", International Finance 5 (3), pp. 401-436.

Kyle, A. S. and W. Xiong, 2001, "Contagion as a wealth effect of financial intermediaries", Journal of Finance 56, pp. 1401-1440.

Lang, L. and R. Stulz, 1992, "Contagion and competitive intra-industry effects of bankruptcy announcements", Journal of Financial Economics 8, pp. 45-60.

Lintner, J., 1965a, "The valuation of risky assets and the selection of risky investment in stock portfolios and capital budgets", Review of Economics and Statistics 47 (1), pp. 13-37.

Lintner, J., 1965b, "Security prices and maximal gains from diversification", Journal of Finance 20 (4), pp. 587-615.

Longstaff F., A., S. Mithal S. and E. Neis, 2005, "Corporate yield spreads: Default risk or liquidity? New evidence from the credit default swap", Journal of Finance 60, no. 5, pp. 2213-2253.

Longstaff, F., A., J. Pan, L. H. Pedersen and K. J. Singleton, 2010, "How sovereign is sovereign credit risk?", American Economic Journal, forthcoming.

Lopez, J. A. and C. A. Walter, 2000, "Evaluating covariance matrix forecasts in a value-at-risk framework", Tech. Report 2000-21, Federal Reserve Bank of San Francisco.

Mahadevan, S., A. Musfeldt and P. Naraparaju, 2010, "Sovereign CDS markets – A corporate perspective", Morgan Stanley Research, Credit Derivatives Insights, 29 January.

Mankiw, G. and M. Shapiro, 1986, "Risk and return: consumption versus market beta", Review of Economics and Statistics 68 (3), pp. 452-459.

Markit, 2009a, "The CDS Big Bang: Understanding the changes to the global CDS contract and North American conventions", 13 March.

Markit, 2009b, "CDS Small Bang: Understanding the global contract and European convention changes", 20 July.

Markit and Creditex, 2010, "Credit event auction primer", February, http://www.markit.com/information/affiliations/fixings/auctions/docs/credit_event_auction_primer.pdf.

Martin, B. and T. Lasarte, 2008, "Bye-bye Basis", Credit Strategy Europe, Merrill Lynch, 5 March.

Masson, P., 1998, "Contagion: Monsoonal effects, spillovers, and jumps between multiple equilibria," IMF Working Paper 98-142.

Matthews, D. and B. Yelvington, 2008, "Credit default swaps: Will they change the course of bankrupcy?", Credit Sights, 11 juin.

McGuire, P. and M. Schrijvers, 2003, "Common factors in emerging market spreads", BIS Quarterly Review, pp. 65-78, December.

Menuet, G. and H. Schmieding, 2010, "Greek tragedy? Not quite", Bank of America Merrill Lynch, Economic Analysis, 9 December.

Merriman, J. and J. Baird, 2009, "Thomson CDS auction a good deal for some", Reuters, 22 October.

Merton, R., C., 1974, "On the pricing of corporate debt: The risk structure of interest rates", Journal of Finance 29 (2), pp. 449-470.

Mishkin, F. and E. White, 2002, "US stock market crashes and their aftermath: implications for monetary policy", NBER Working Paper 8992.

Misina, M., 2003, "What does the risk-appetite index measure?", Bank of Canada Working Paper 2003-23.

Misina, M., 2006. Benchmark index of risk appetite. Bank of Canada Working Paper, vol. 2006-16.

Moody's, 2008, "Credit default swaps: Market, systemic, and individual firm risks in practice", Finance & Securities, Special Comment, October.

Nomura, 2004 "Credit default swap primer", Fixed Income Research, 12 May.

Norden, L. and M. Weber, 2004, "The comovement of credit default swap, bond and stock markets: An empirical analysis", CEPR Discussion Paper 4674.

O'Kane, D. and R. McAddie, 2001, "Explaining the basis: Cash versus default swaps", Lehman Brothers Fixed Income Research, May.

Official Journal of the European Union (OJEU), 2010, "Decision of the European Central Bank of 14 May 2010 establishing a securities markets programme" (ECB/2010/5) (2010/281/EU), 20 May.

Olléon-Assouan, E., 2004, "Techniques used on the credit derivatives market: credit default swaps", Banque de France, Financial Stability Review 4, pp. 94-107.

Packer, F. and C. Suthiphongchai, 2003, "Sovereign credit default swaps", BIS, Quarterly Review, December, pp. 79-88.

Packer, F. and P. D. Woolridge, 2005, "Overview: Repricing in credit markets", BIS Quarterly Review, June, pp. 1-13.

Packer, F. and H. Zhu, 2005, "Contractual terms and CDS pricing", BIS, Quarterly Review, March, pp. 89-100.

Panetta, F., T. Faeh, G. Grande, C. Ho, M. King, A. Levy, F. M. Signoretti, M. Taboga and A. Zaghini, 2010, "An assessment of financial sector rescue programmes", BIS Paper no. 48.

Papenbrock, J., S. Rachev, M. Hochstotter and F. Fabozzi, 2009, "Price calibration and hedging of correlation dependent credit derivatives using a structural model with alpha-stable distributions", Applied Financial Economics 19, pp.1401-1416.

Patel, S. and A. Sarkar, 1998. "Crises in developed and emerging stock markets", Financial Analysts Journal 54 (6), pp. 50-59.

Pengelly, M., 2008, "Fannie and Freddie auctions raise questions about CDSs", Risk Magazine, 7 October.

Pericoli, M. and M. Sbracia, 2003, "A primer on financial contagion", Journal of Economic Surveys 17, September, pp. 571-608.

Persaud, A., 1996, "Investors' changing appetite for risk", J.P. Morgan Securities, Global Foreign Exchange Research, July.

Persaud, A., 2000, "Sending the herd off the cliff edge: the disturbing interaction between herding and market-sensitive risk management practices", The Journal of Risk Finance 2 (1), pp. 59-65.

Pindyck, R. and D. Rubinfeld, 1998, Econometric Models and Financial Forecasts, fourth edition. McGraw-Hill, Boston, Massachusetts.

Pisani-Ferry, J. and A. Sapir, 2010, "The best course for Greece is to call in the Fund", Financial Times, 2 February.

Powell, A. and J. F. Martínez, 2008, "On emerging economy sovereign spreads and ratings", Inter-American Development Bank Working Paper 629.

Prat-Gay, X. and J. McCormick, 1999, "Introducing our new 'Liquidity and credit premia update' ", J.P. Morgan Securities, Global FX and Precious Metals Research, August.

Pritsker, M., 2001, "The channels for financial contagion", *in* S. Claessens and K. J. Forbes (eds.), International Financial Contagion, Kluwer Academic Publishers.

Purtle, L. and B. Yelvington, 2008, "CDS: A Market with More Questions than Answers", Credit Sights, 23 September.

Radelet, S. and J. Sachs, 1998, "The east Asian financial crisis: diagnosis, remedies, prospects", Brookings Paper 28 (1), pp. 1-74.

Reinhart, C. M. and K. S. Rogoff, 2009, "This time is different: Eighty centuries of financial folly", Princeton University Press, Princeton.

Reuters, 2008, "WaMu CDS sellers face 43 pct insurance payouts", 23 October.

Rosenberg, D., 2003, "Introducing Merrill Lynch's proprietary weekly indicators", Merrill Lynch, The Market Economist, pp. 4-10. June.

Ross, S., 1976, "The arbitrage theory of capital asset pricing", Journal of Economic Theory 13 (3), pp. 341-360.

Sachs, J., A. Tornell and A. Velasco, 1996, "Financial Crises in Emerging Markets: The Lessons From 1995", Brookings Paper, vol. 27, 1, pp. 147-199.

Scheicher, M., 2003. What drives investor risk aversion? Daily evidence from the German equity market. BIS Quarterly Bulletin, pp. 69–77. June.

Scheicher, M., 2006, "The correlation of a firm's credit spread with its stock price: Evidence from credit default swaps", European Central Bank, Mimeo.

Scheicher, M., 2009, "The correlation of a firm's credit spread with its stock price: evidence from credit default swaps", *in* G. N. Gregoriou (ed.), Stock Market Volatility, Chapman and Hall.

Schinasi, G., J. and R. T. Smith, 2001, "Portfolio diversification, leverage, and financial contagion", *in* S. Claessens and K. J. Forbes (eds.), International Financial Contagion, Kluwer Academic Publishers.

Schnabel, I. and H. S. Shin, 2004, "Liquidity and contagion: The crisis of 1763", Journal of European Economic Association 2 (6), pp. 929-968.

Segoviano, M. and M. Singh, 2008, "Counterparty risk in the over-the-counter derivatives market", IMF Working Paper 08/258.

Sgherri, S. and E. Zoli, 20009, "Euro area sovereign risk during the crisis", IMF Working Paper 09/222.

Sharpe, W., 1964, "Capital asset prices: a theory of market equilibrium under condition of risk", Journal of Finance 19 (3), pp. 425-442.

Shin, H., 2008, "Risk and liquidity in a system context", Journal of Financial Intermediation Volume 17 (3), pp. 315-329.

Singh, M., 2010, "Under-collateralisation and rehypothecation in the OTC derivatives markets", Banque de France, Financial Stability Review 14, pp. 113-119.

Singh, M. and J. Aitken, 2009, "Counterparty risk, impact on collateral flows and role for central counterparties", IMF Working Paper 09/173.

Singh, M. and C. Spackman, 2009, "The use (and abuse) of CDS spreads during distress", IMF Working Paper 09/62.

Sløk, T. and M. Kennedy, 2004, "Factors driving risk premia", OECD Working Paper 385.

Sy, A. N. R., 2001, "Emerging Market Bond Spreads and Sovereign Credit Ratings: Reconciling Market Views with Economic Fundamentals", IMF Working Paper 01/135.

Sy, A. N. R., 2003, "Rating the rating agencies: Anticipating currency crisis or debt crisis", IMF Working Paper 03/122.

Tampereau, Y. and J. Teiletche, 2001, "Comment mesurer l'aversion pour le risque ?", Note Flash 2001-155, CDC Ixis Capital Markets.

Tarashev, N., K. Tsatsaronis and D. Karampatos, 2003. Investors' attitude towards risk: what can we learn from options? BIS Quarterly Bulletin, pp. 59–68. June.

Tett, G., 2006, "The dream machine: invention of credit derivatives", Financial Times, 24 March 2006.

Tett, G., 2009, Fool's gold: How the bold dream of a small tribe at J.P. Morgan was corrupted by Wall Street greed and unleashed a catastrophe, Free Press, New York.

Vaihekoski, M., 2009, "Pricing of liquidity risk: Empirical evidence from Finland", Applied Financial Economics 19, pp. 1547-1557.

Vayanos, D., 2004, “Flight to quality, flight to liquidity, and the pricing of risk”, NBER Working Paper 10327.

Venizelos, G., 2005, “Correlation correction”, Credit in Focus, ABN AMRO, 12 May.

Weistroffer, C., 2009, “Credit default swaps, heading towards a more stable system”, Deutsche Bank Research, Current issues, 21 December.

Wheatley, S., 1988, “Some tests of international equity integration”, Journal of Financial Economics 21 (2), pp. 177–212.

Wilmot, J., P. Mielczarski and J. Sweeney, 2004, “Global risk appetite index”, Credit Suisse First Boston, Global Strategy Research, Market Focus, February.

Xiong, W., 2001, “Convergence trading with wealth effects”, Journal of Financial Economics 62, pp. 247-292.

Yelvington, B. and C. Taggert, 2008, “CDS Auction Madness”, Credit Sights, 10 October.

Zhu, H., 2006, “An empirical comparison of credit spreads between the bond market and the credit default swap market”, Journal of Financial Services Research 29 (3), pp. 211-235.