Les déterminants du choix des instruments de paiement

Bruno Haim Karoubi

UNIVERSITÉ PARIS-EST CRÉTEIL

DOCTORAT DE SCIENCES ECONOMIQUES

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Bruno Karoubi

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Directeur de thèse: François Legendre, Professeur, Université Paris XII

Présidente, Examinatrice : Dorothée Rivaud-Danset, Professeur, Université Paris XII

Rapporteur :Jean-Baptiste Desquilbet, Professeur, Université Lille 1

Rapporteur : Michel Boutillier, Professeur, Université Paris X Nanterre

Examinateur: Régis Chenavaz

Avertissement

"Je me suis dit : laisse,

Et qu'on ne te voit

Et sans la promesse

De plus hautes joies

Que rien ne t'arrête

Auguste retraite."

Arthur Rimbaud.

Abstract

The present dissertation studies the formation of the demand for the main retail payment instruments (cash, bank card, and check). The first chapter presents both a theoretical and empirical analysis using French data. We conclude that charging cash withdrawals at an automated teller machine (ATM) outside the network of the bank reduces the global demand for cash. Using a theoretical model and on the basis of French data, the second chapter concludes, that a seller adjust his prices in order to make the buyers pay cash by making cash payment more convenient, in the sense that the chosen prices limit the number of coins and notes exchanged. We show that convenient prices are more frequent and more frequently paid cash. The third chapter studies the impact of crime as an environmental factor on the preference for cash of merchants, who were asked to rate their appreciation of this payment instrument (this rating is subjective). We show that merchants have a higher appreciation for cash in a department with a high level of financial crime, and a lower appreciation for cash in a department with a high level of violent crime. The fourth chapter studies the impact of crime as an environmental factor on the acceptance level of bank cards (this acceptance level is observed and objective). We show that merchants accept bank card less often in a department with a high level of financial crime. The fifth chapter studies the impact of crime as an environmental factor on the choice of payment instrument by consumers. They are more likely to own a payment card, and the weekly sums withdrawn at ATMs are higher. We find opposite effects for violent crime. Eventually, the sixth chapter studies the impact of perceived risk on the holding and and use of payment instruments. We apply the model of Jacoby and Kaplan (1972) to payment instruments, and we conclude on the basis of an empirical investigation that the risk of unavailability and the risk of time loss have the most cross-cutting effects on the demand for each of the main retail payment instruments.

Résumé

Cette thèse étudie la formation de la demande pour les instruments de paiements. Dans un premier essai, nous montrons à l'aide d'un modèle théorique et d'une étude empirique sur données françaises que la tarification des retraits déplacés réduit la demande pour les espèces. Dans un deuxième essai, nous montrons, également à l'aide d'un modèle théorique et d'une étude sur données françaises, que les marchands ajustent leur prix pour rendre les paiements en espèce plus convénients, au sens où ils mobilisent moins de pièces et billets. Les prix convénients à payer en espèces sont plus fréquents, et ils sont plus fréquemment payés en espèces. Le troisième essai étudie l'impact du crime comme facteur environnemental sur le niveau d'appréciation des espèces par les commerçants (il s'agit d'une appréciation subjective). Nous montrons que ces derniers ont une préférence plus élevée pour les espèces dans un département où la criminalité financière est importante, alors que cette préfèrence est moins élevée dans un département caractérisé par une criminalité violente importante. Le quatrième essai étudie l'impact du crime comme facteur environnemental sur le niveau d'acceptation de la carte bancaire (ce niveau est observé et objectif). Nous montrons que les marchands acceptent moins fréquemment cet instrument de paiement dans un département où la criminalité financière est importante. Les consommateurs possèdent plus souvent une carte bancaire et retirent hebdomadairement des sommes plus élevées aux Distributeurs Automatiques de Billets (DAB). Nous mettons en évidence les effets opposés pour un niveau élevé de criminalité violente, aussi bien pour les consommateurs que pour les marchands. Le cinquième essai étudie l'impact du crime comme facteur environnemental sur le choix de l'instrument de paiement par les consommateurs. Nous montrons que la probabilité de possession d'une carte bancaire ainsi que les sommes retirées hebdomadairement aux DAB sont plus élevées dans un département où la criminalité financière est importante. Nous mettons en évidence les effets opposés pour un département caractérisé par une importante criminalité violente. Enfin, le sixième essai étudie l'influence du risque perçu sur la fréquence de détention et la fréquence d'utilisation des instruments de paiement. Nous appliquons le modèle de Jacoby et Kaplan (1972) au choix de l'instrument de paiement, et nous concluons à partir d'une étude empirique sur données françaises que le risque de manque et le risque de temps ont les effets les plus transversaux sur la demande pour les instruments de paiement.

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Sabrina, procure-toi une guitare basse d'urgence.

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Table des matières

Liste des tables

Introduction générale

Le règlement d'une transaction se caractérise par deux conditions : (1) la propriété du bien est transférée ou bien le service est rendu, (2) le transfert de fonds est effectué au bénéfice du marchand qui est ainsi payé. Le paiement *éteint l'obligation* du payeur vis à vis du payé.

Dans la mesure où la transaction est la principale interaction marchande, les paiements remplissent un rôle critique. On appelle instruments de paiement les outils ou les procédures permettant les paiements.

Les coûts associés à la production et à l'utilisation des instruments de paiement sont immenses. Les coûts sociaux [1] agrégés moyens extrapolés sur l'ensemble des 27 pays de l'union Européenne représentent environ 1% du Produit Intérieur brut, soit environ 130 milliards d'euros selon une étude de la Banque Centrale Européenne (BCE) datée de 2012. Cette estimation ne tient pas compte des coûts subis par les consommateurs (à savoir le risque de pertes et le risque de vol associés à la détention des instruments de paiement, ainsi que le temps passé à payer). Ces coûts sont estimés selon des données partielles danoises et hongroises à hauteur de 0.2% du Produit Intérieur Brut.

Les instruments de paiements ont des coûts et des caractéristiques variables. Les espèces ont de loin les coûts sociaux les plus élevés, puisqu'ils représentent la moitié des coûts sociaux totaux des instruments de paiement (0.49% du Produit Intérieur Brut, contre 0.21% pour la carte bancaire et 0.03% pour le chèque). Ces proportions s'expliquent en priorité par la fréquence élevée des paiements en espèces, puisqu'un paiement en espèces coûte à la société €0,023 par euro payé, alors que les paiements par carte coûtent €0,017 et les paiement par chèque coûtent €0.004. Les chèques sont typiquement utilisés pour des paiements élevés, les cartes bancaires pour des paiements intermédiaires et les espèces pour des paiement de montants faibles (le coût

1. On appelle coût social l'ensemble des coûts supportés par l'ensemble de la société.

moyen par transaction est de €0.41 pour les espèces, €3.86 pour les chèques et €1.34 pour les cartes).

Les paiements constituent donc un enjeu financier majeur, concernant en particulier le consommateur, le marchand et la banque. Les instruments de paiement sont des biens substituts différenciés, et le choix de l'instrument de paiement peut être abordé avec les outils conceptuels des Sciences Économiques et des Sciences de Gestion. Cette thèse comprend cinq essais dont l'objectif est de discuter les déterminants du choix des instruments de paiements de détail hors transferts bancaires directs (virement et débit) [2], c'est à dire à étudier l'arbitrage entre les espèces, le chèque et la carte bancaire.

Nous retraçons d'abord le processus historique d'apparition des instruments de paiement, puis nous présentons la littérature académique traitant des modèles de compétition entre instruments de paiement avant de discuter l'organisation de notre thèse.

0.1 Processus d'apparition des instruments de paiement

0.1.1 Le système de prix

Les échanges dans les sociétés primitives étaient basés sur le système de troc, c'est à dire d'échanges d'objets sans intermédiaire sur accord mutuel des échangeurs. Ce système présente trois défaillances majeures, justifiant a posteriori l'apparition de la monnaie. D'après Aristote dans « Ethique à Nicomaque », les fonctions de la monnaie — venant suppléer aux défaillances du système de troc —- sont les suivantes :

- (1) La préservation de la valeur.
- (2) L'établissement de comptes.
- (3) L'universalité des échanges.

Nous commentons maintenant individuellement ces fonctions. Le point (1) renvoie à la préservation de valeur des biens périssables dans le cadre d'un marché imparfait comprenant des frictions, c'est à dire tel que la mise en contact d'un acheteur et d'un vendeur soit coûteuse. On pense par exemple aux secteurs de l'extraction d'énergie ou à la conservation des denrées

2. Les virement et les débits sont typiquement peu substituables avec les paiements en espèces, en carte bancaire et en chèque, puisqu'ils concernent en général des montants plus élevés. Surtout, ils concernent peu le paiement d'un marchand par un consommateur (cf Snellman *et al.*, 2001).

alimentaires (en particulier, avant la généralisation des techniques de conservation comme la réfrigération ou la salaison dans une moindre mesure).

Le point (2) concerne la standardisation de l'évaluation des biens et la division de la valeur. Dans l'économie detroc, l'échange entre deux biens infiniment divisibles est rare : il y a quasi-systématiquement dans cette mesure un écart à l'optimum théorique dans les quantités échangées. L'introduction de la monnaie est alors justifiée du point de vue de l'efficacité des transactions. Plus trivialement, la monnaie, par le système de prix, permet de construire un ordre sur les valeurs d'échange des biens, qui ne recoupe pas nécessairement les évaluations personnelles des individus (ces dernières pouvant être fortement divergentes en fonction des préférences). Elle substitue une valeur objective (le prix) à un ensemble de valeurs personnelles (l'ensemble des valorisations liées aux fonctions d'utilité personnelles).

Le point (3) renvoie à la valeur universelle de la monnaie. En effet, la condition *sine qua none* du troc est la double coïncidence des désirs : il est nécessaire que chacune des parties valorise plus ce que possède l'autre partie que ce qu'elle possède elle-même. Cette dernière condition n'a plus cours : tous les agents sont censés désirer la monnaie. Notons pour être complet que certains auteurs considèrent que la capacité de la monnaie d'éteindre les dettes ou les obligations, c'est dire son pouvoir libératoire, constitue une quatrième fonction.

La monnaie permet également la centralisation de l'offre et de la demande, ainsi que l'élimination des frictions. Bien que les travaux de Kyotaki et Moore (notamment dans le cadre de l'article de 2002 « Evil is the root of money ») montrent que cette condition n'est pas incontournable, le système de prix centralise l'offre et la demande, et permet en partie de remplir la fonction du crieur Walrasien, c'est dire d'égaliser l'offre et la demande sur les marchés. Par conséquent, l'apparition de la monnaie nécessite l'apparition d'objets sur lesquels se cristallise cette valeur divisible en bijection avec l'ensemble des réels : c'est ce rôle que vient remplir la monnaie, et en particulier les espèces (elles constituent le premier instrument de paiement ; leur valeur faciale, c'est dire leur valeur d'échange étant supérieure à la valeur intrinsèque du matériau à partir duquel elles sont construites).

La généralisation de la monnaie nécessite une masse critique de personnes l'acceptant en échange de biens ou de services, ou du moins la masse critique de personnes ayant confiance dans la persistance de son acceptation universelle. On parle de monnaie fiduciaire, du latin *"fide"* foi ou confiance, parce que l'acceptation est sujette à la croyance de la persistance de la convention qui lui donne sa valeur, c'est à dire dans la capacité du détenteur de monnaie fiduciaire à l'échanger contre des biens ou contre d'autres types de monnaie.

La valeur de la monnaie est en grande partie définie par des *conventions* ; ainsi, une personne ne partageant pas ces dernières s'interrogerait légitimement sur son fondement. On pense par exemple à la Lettre XXIV des lettres persanes de Montesquieu, dans laquelle Rica écrit à Ibben : « [le roi de France] est un grand magicien : il exerce son empire sur l'esprit même de ses sujets ; il les fait penser comme il veut. S'il n'a qu'un million d'écus dans son trésor et qu'il en ait besoin de deux, il n'a qu'à leur persuader qu'un écu en vaut deux, et ils le croient. S'il a une guerre difficile à soutenir, et qu'il n'ait point d'argent, il n'a qu'à leur mettre dans la tête qu'un morceau de papier est de l'argent, et ils en sont aussitôt convaincus. »
C'est à Athènes, pendant l'antiquité, qu'apparaît le premier système monétaire complet. La monnaie athénienne est une *Nomisma*, c'est à dire une règle, au même titre que la loi : elle exprime la puissance de la cité, et représente ses idéaux civilisationnels. C'est un des premiers systèmes dans lequel la valeur d'échange de la monnaie n'est pas indexée sur sa valeur intrinsèque, sa valeur non conventionnelle. Elle a cours légal et peut permettre au citoyen de payer ses impôts aussi bien que les indemnités fixées par les juges. Ce mode de paiement, plus efficace, permet de limiter les cessions de terre et les pensions en nature.

Les travaux de Kyotaki et Moore montrent que la circulation de dettes privées peut annuler le besoin de monnaie pour peu que les dettes privées circulent suffisamment, c'est à dire qu'elle soient échangeables multilatéralement (l'échange bilatéral ne suffit pas) et qu'il n'y ait pas de contrainte de revente, c'est à dire que la dette privée entre deux individus soit parfaitement liquide (tous les agents ont confiance dans la signature du débiteur, et évaluent la dette au même montant).

0.1.2 La monnaie

Depuis la haute antiquité, l'Humanité a souhaité donner aux biens des valeurs abstraites, indépendantes des prix relatifs définis par les marchés et donc fortement variables. La complexité de l'évaluation des marchandises en prix relatifs rend nécessaire la généralisation de points de références communs à toutes les évaluations. Les biens utilisés comme intermédiaires des échanges — c'est à dire qui remplissaient partiellement la fonction de monnaie, désignés dans la suite de cette introduction comme objet-monnaie — devaient avoir deux caractéristiques :

– ils devaient être difficilement reproductibles.

– ils devaient avoir une valeur intrinsèque relativement faible, en dehors de leur valeur d'échange.

La première condition assure que les agents ne peuvent se procurer l'objet-monnaie sans participer aux échanges (si l'objet-monnaie est disponible en abondance il n'est pas nécessaire d'échanger pour l'obtenir). La deuxième condition assure que l'emploi de l'objet-monnaie comme intermédiaire des échanges est efficace (au sens où le coût d'opportunité de cette utilisation est faible).

Ces deux conditions confirment que la valeur de la monnaie est conventionnelle, puisque les théories économiques de formation de la valeur ne s'appliquent pas à la monnaie qui est son étalon. En effet, la théorie de la valeur-rareté impliquerait une valeur importante compte tenu de la première condition, ce qui viendrait en opposition directe avec la deuxième. La théorie de la valeur-travail d'Adam Smith est également prise en défaut, parce que la première condition impliquerait un rôle du travail au mieux secondaire dans le processus de fabrication de cette dernière. Même à considérer, comme John Hicks, que la rareté et le travail incorporé sont comme les deux lames du ciseau, contribuant toutes deux à la création de la valeur, on ne parvient pas à considérer que ces théories s'appliquent aux objets-monnaie.

Néanmoins, en un certain sens, la rareté de la monnaie contribue à la valeur d'une unité monétaire. Cette intuition est développée dans le cadre de la théorie quantitative de la monnaie, proposée pour la première fois par Jean Bodin (1568). L'auteur soutient que la montée du prix au XVI^{ième} siècle est une conséquence de la découverte du Nouveau Monde, et de l'afflux de métaux précieux qui en résulte. La théorie est exposée dans l'ouvrage "Réponse au paradoxe de M. de Malestroict touchant l'enchérissement de toutes choses, et le moyen d'y remédier" . Cette théorie est résumée par l'équation de conservation de la quantité de monnaie échangée dans l'ensemble des transactions proposée par John Hicks. Le produit de la vitesse de circulation de la monnaie (V) et de la quantité de monnaie en circulation (M) est égal au produit du niveau général des prix (P) et du revenu de la nation (Y), $MV = PY$. Les définitions des quantités mises en relation sont intuitives exceptée peut-être la définition de la vitesse de circulation de monnaie qui correspond au nombre moyen de transactions réglées à l'aide d'une unité de monnaie dans la période considérée. Irving Fisher (1911) étudie une version vectorisée de cette égalité, puisqu'il retient deux types de monnaie.

La quantité de monnaie en circulation est donc une fonction croissante du revenu réel (c'est à dire du Produit Intérieur Brut réel) et du niveau général des prix, ainsi qu'une fonction décroissante de la vitesse de circulation de la monnaie.

Les économistes antérieurs aux physiocrates, comme les mercantilistes (et en particulier les bullionnistes) voyaient dans la monnaie l'essence même de la richesse. Un pays serait d'autant plus riche que la monnaie serait abondante. Les physiocrates ainsi que les premiers économistes classiques réservent l'appellation de richesse aux seuls biens réels, et insistent sur le caractères d'intermédiaire des échanges de la monnaie. La loi des débouchés proposés par Jean-Baptiste Say va renforcer cette position, ce dernier allant jusqu'à parler de "monnaie voile" . Dans le traité d'économie politique, Say résume ainsi la loi des débouchés "Il est bon de remarquer qu'un produit terminé offre, dès cet instant, un débouché à d'autres produits pour tout le montant de sa valeur. En effet, lorsque le dernier producteur a terminé un produit, son plus grand désir est de le vendre, pour que la valeur de ce produit ne chôme pas entre ses mains. Mais il n'est pas moins empressé de se défaire de l'argent que lui procure sa vente, pour que la valeur de l'argent ne chôme pas non plus. Or, on ne peut se défaire de son argent qu'en demandant à acheter un produit quelconque. On voit donc que le fait seul de la formation d'un produit ouvre, dès l'instant même, un débouché à d'autres produits" .

Dans le processus décrit par Say, la monnaie n'a que le rôle d'intermédiaire, et n'est jamais désirée pour elle même, puisque « les produits s'échangent contre les produits » . La monnaie est évacuée du champ théorique, considérée comme un faux problème masquant les réalités des problèmes économiques (Karl Marx, considéré comme un économiste classique en particulier dans ces conceptions de la monnaie, dira que cette dernière « masque la réalité des rapports de production »).

Il faut attendre les économistes de l'Ecole de Cambridge (Alfred Marshall, Arthur Cecil Pigou, et plus tard John Maynard Keynes) pour voir apparaître une théorie de la demande de monnaie. Ces économistes proposent une théorie selon laquelle le niveau d'encaisses réelles (c'est à dire la demande de monnaie) est proportionnelle au produit du niveau général des prix et du revenu total de l'économie (ce qu'on interprète comme le produit intérieur brut). La théorie sous-jacente suppose que les agents désirent maintenir la valeur de leurs avoirs monétaires dans le temps pour faire face à un éventuel choc adverse, ce qui est particulièrement rationnel dans le monde radicalement incertain qui retiendra l'intérêt de Keynes.

Keynes reprend la théorie de Marshall et Pigou en la complétant. Dans « La théorie générale de l'emploi, de l'intérêt et de la monnaie », ouvrage publié en 1936, trois motifs expliquent que la monnaie soit désirée pour elle-même à savoir :

– Le motif de transaction : La détention de monnaie pallie la désynchronisation des recettes et des dépenses.
– Le motif de précaution : La détention de monnaie permet de faire face à des dépenses imprévues. C'est la base théorique à l'effet d'encaisses réelles décrit par Marshall et Pigou et décrit plus haut.
– Le motif de spéculation : La monnaie est un actif financier non risqué et non rémunéré, mais permettant d'acheter des obligations. L'arbitrage entre la détention de monnaie et la détention d'obligations est guidé par les anticipations des agents sur l'évolution des variables stratégiques comme le taux d'intérêt. C'est cette dimension d'anticipation qui rend rationnelle la thésaurisation. En effet, selon la théorie quantitative de la monnaie, une diminution de la vitesse de circulation de la monnaie entraîne une diminution du niveau général des prix, et en particulier les prix des biens de capitaux (achetés en priorité par les investisseurs) , ce qui augmente la rentabilité potentielle des investissements (et donc l'incitation à investir).

On constate que la théorie générale s'oppose radicalement à la loi des débouchés, puisque la monnaie n'est plus neutre. Mais il est possible de réconcilier les deux approches. La différence fondamentale réside dans l'hypothèse selon laquelle la monnaie n'est pas désirée pour elle-même pour Say alors que Keynes fait l'hypothèse opposée. Si l'on retient l'hypothèse que la monnaie a une valeur propre, alors la création monétaire est une production comme une autre, et elle appelle de nouveaux débouchés par application de la loi de Say : on retrouve l'idée keynesienne de relance par la création monétaire.

Les économistes monétaristes ont contesté les théories keynesiennes. Pour ces derniers, ce n'est pas directement la quantité de monnaie qui intervient, mais plutôt les anticipations des agents sur ses variations. Par exemple, Friedman (1957) propose la théorie du revenu permanent. Les agents consomment et épargnent en fonction non pas de leur revenu courant, mais de leur revenu moyen anticipé sur une longue période, afin de lisser leur consommation sur leur vie entière. Dans ces conditions la relance par la création monétaire peut réussir à court terme, mais elle ne peut avoir d'impact de long terme puisque les agents anticipent que l'augmentation du niveau général des prix absorbera le pouvoir d'achat supplémentaire. Ils épargnent au lieu de consommer. Cette critique se fera plus encore radicale avec les théoriciens de la nouvelle macroéconomie classique, pour qui les agents font notamment des anticipations rationnelles (concept introduit par John Muth, 1961, et développé par Robert Lucas). Les agents tirent parti de l'ensemble de l'information disponible pour former leurs anticipations, de sorte qu'ils ne font pas d'erreur, à une composante aléatoire près. La relance par la création monétaire n'est efficace ni à court terme, ni à long terme.

0.1.3 Les intermédiaires financiers

Les première théories de l'intermédiation financière considèrent les banques comme des canaux de transmission passifs de la politique monétaire. Jensen et Meckling (1975) soulignent que les intermédiaires financiers, et en particulier les banques, doivent être considérées comme des firmes. Dans cette mesure, la justification économique générale de l'existence des firmes, proposée par Ronald Coase (1937), s'applique ; les banques existent parce qu'elles réduisent les coûts de transaction, c'est à dire « les coûts de fonctionnement du système d'échange, et, plus précisément dans le cadre d'une économie de marché, ce qu'il en coûte de recourir au marché pour procéder à l'allocation des ressources et transférer des droits de propriété ». Les banques assurent le fonctionnement des instruments de paiement, et tiennent les comptes bancaires. Elles internalisent les coûts de transports des consommateurs, et assument le risque de vol ainsi que le risque de perte. Ceci est particulièrement vrai pour les instruments de paiement liés au compte (c'est à dire typiquement la carte bancaire et le chèque). Nous développerons aux chapitres 3 et 4 les conséquences de cette asymétrie de caractéristiques des instruments de paiement.

Les intermédiaires financiers (les banques en particulier) réduisent l'asymétrie d'information entre prêteurs et emprunteurs. En effet, les banques ont accès à un historique relativement complet des agents dont elles tiennent les comptes, et distribuent les prêts de manière informée. Elles contribuent par conséquent à une meilleure allocation des ressources. Dans le cadre d'une concurrence parfaite, l'intermédiation financière permet une allocation efficace des capitaux au sens de l'absence d'arbitrage (c'est à dire au sens de l'impossibilité de réaliser des profits sans risque). Elles permettent également l'efficacité des marchés au sens où les prix reflètent l'ensemble de l'information disponible (Fama, 1970) même si Stiglitz (1981) montre que l'allocation n'est pas nécessairement Pareto-efficace.

Enfin, les intermédiaires financiers fournissent une garantie aux instruments de paiement. La possession d'un instrument de paiement consitue une preuve que la banque le délivrant croit que l'acheteur est solvable. La crédibilité de l'intermédiaire financier se substitue à celle du payeur, de la même manière que l'apparition de la monnaie permet d'apporter la garantie de l'État ou du souverain à la transaction. L'intervention d'une entité ayant une surface financière élevée pour garantir les instruments de paiement renforce la confiance des utilisateurs et donc la fréquence d'utilisation, ce qui permet des externalités positives de réseau croisées entre acheteurs et vendeurs. Plus les marchands sont nombreux à accepter un instrument de paiement, plus les incitations à le détenir sont fortes pour les consommateurs ; réciproquement, plus les consommateurs détiennent un instrument de paiement, plus les marchands sont incités à l'accepter. Les économies d'échelle permettent finalement une diminution du coût d'utilisation de l'instrument de paiement pour les marchands comme pour les consommateurs.

0.1.4 Les instruments de paiement modernes

La monnaie scripturale

Comme son nom l'indique, la monnaie scripturale se présente sous la forme d'un écrit qui précise sa valeur. C'est la première forme alternative de la monnaie. L'origine historique de la monnaie scripturale est relativement incertaine. On pense que les romains, au premier siècle avant l'ère vulgaire, utilisaient des formes primitives de chèque appelées Praetoris. Il est établi que dans l'empire perse Sassanide, les banques émettaient des lettres de crédit appelées Sakks. Les commerçants musulmans ont utilisé les Sakks jusqu'au temps d'Harun Al-Rashid ($9^{ième}$ siècle), pendant le califat Abbaside [3]. Les premières traces d'échanges de chèque entre pays datent du neuvième siècle : un marchand de Bagdad pouvait se faire payer dans son pays un chèque alors que le tiré résidait en Chine. Cette tendance va se renforcer avec l'empire mongol,en particulier durant le treizième et le quatorzième siècles. L'introduction du chèque en Europe semble remonter à l'époque des templiers. Ces derniers auraient mis en place un système de monnaie

3. L'utilisation de chèques est compatible avec la loi musulmane, notamment parce que c'est un actif financier sans taux d'intérêt.

scripturale pour les pèlerins voyageant à Jérusalem et en Europe.

Toutefois, l'introduction du chèque moderne en Europe semble remonter à 1726 en Angleterre. Le monopole de la Banque Centrale d'Angleterre quant à l'émission de billets conduit les marchands à émettre leur propre monnaie scripturale, le chèque. Le chèque primitif était un ordre de paiement au tireur établi nommément par le tiré. Ce chèque primitif était appelé « facture d'échange ». Les chèques primitifs étaient des reconnaissances de dettes bilatérales privées. En particulier, le tireur devait rencontrer le tiré pour se faire payer.

L'introduction de la banque dans le circuit a eu lieu pour renforcer la crédibilité du chèque. L'acceptation universelle du chèque en a été une conséquence, pour les raisons exposées plus haut.

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On insiste ici en particulier sur l'histoire moderne de l'introduction du chèque en France, puisque les études empiriques de notre thèse utilisent des données françaises. L'introduction du chèque en France est un processus en deux étapes. En 1826, la Banque de France émet des "mandats blancs" c'est à dire des écrits servant à retirer des fonds reçus en dépôts sans intérêts par la Banque. Ce n'est qu'avec la loi du 14 juin 1865 que le chèque prend sa physionomie actuelle et que ses critères de validité sont définis (présence des noms du tireur et du tiré, montant de la transaction débité dans la monnaie domestique). Actuellement, avec près de 5 milliards de chèques par an, dont 4 milliards donnent lieu à des échanges interbancaires, la France est l'un des premiers pays utilisateurs de chèques. Notons que les opérations chèques sont aujourd'hui les seules qui ne sont pas transmises intégralement entre banques sous forme dématérialisée. Ainsi, les chèques en francs étaient échangés physiquement dans les 104 chambres de compensation et, pour environ 7% d'entre eux, dans les 9 Centres Régionaux d'Echange d'Images Chèques (CREIC). Des dizaines de milliers de paquets de chèques, classés par catégorie (sur rayon, hors rayon, impayés) s'échangeaient ainsi quotidiennement entre banques. La Convention de Genève de 1931 uniformise la législation autour du chèque, et facilite ainsi leur circulation internationale. La plupart des pays européens a signé cette convention, tout comme le Japon et les anciennes colonies de la Couronne anglaise (anciens pays du Commonwealth). La loi française reprend cette convention en 1935. Elle est ensuite abrogée et reprise au sein du code monétaire et financier.

Les coûts de mise à jour du compte principal sont rapidement devenus prohibitifs. Ils s'ajoutent aux risques importants d'erreur humaine. La mise en place d'un traitement automatisé des chèques permet de limiter les coûts comme les risques. Une Images Chèque est un fichier résumant les principales caractéristiques de la transaction (nom, adresse, coordonnées bancaires du tireur et du tiré, et devise utilisée pour l'échange notamment).

Les Images Chèques ont d'abord été centralisées au niveau régional au sein des Chambres Régionales d'Images Chèque (CREICs), avant d'être déléguées au Groupement pour un Système Interbancaire de Télécompensation (G.S.I.T.) ce dernier ayant été remplacé en 2007 par le systemen CORE (COmpensation REtail) géré par la société STET. Le premier chapitre de la présente thèse, sur lequel nous reviendrons bientôt, exploite des données directement issues de G.S.I.T .

Les instruments de paiement électroniques

En toute rigueur, la monnaie électronique est une des formes de la monnaie scripturale, mais les instruments de paiements électroniques posent des problèmes économiques spécifiques justifiant une présentation séparée. Les instruments de paiement électroniques supposent un développement minimal de l'informatique et des systèmes de télécommunications (il est souvent nécessaire d'interroger un serveur distant pour avoir accès au compte du titulaire de l'instrument de paiement. Ce processus permet une sécurité accrue). On distingue deux instruments de paiement principaux : la carte bancaire et le porte monnaie électronique.

La carte de paiement

La carte de paiement est remise par une banque à un client titulaire d'un compte permettant à ce dernier de retirer ou de transférer des fonds au profit d'un fournisseur de bien ou de service. La première carte de paiement est introduite aux États-Unis, en 1914 par Western Union. Le support est d'abord métallique, puis papier (en 1950, la carte Diner's Club se présente sous la forme d'un petit carnet) et carton. Il faut attendre 1957 pour voir apparaître la première carte plastique. Les cartes permettant les retraits d'espèces aux distributeurs automatiques de billets (DAB) apparaissent en France en 1971. Les premières cartes de retrait d'espèces ne permettent que les retraits dans les distributeurs de la banque émettrice. Il faut attendre 1984 pour la création du protocole "Carte Bleue" (CB) permettant les retraits à n'importe quel DAB. Les cartes prenant en charge le protocole Carte Bleue doivent porter le sigle « CB ». la première carte à puce apparait en 1986. La France est pionnière dans ce domaine : c'est un ingénieur français, Roland Moreno, qui met au point la technologie de la carte à puce en 1974. La France est également en pointe en ce qui concerne la généralisation des standards de qualité, avec notamment l'adoption de la norme EMV (Europay, Mastercard, Visa) en 2001. Le standard précédent « B0 » créé dans les laboratoires de bull CP avait notamment d'importantes faiblesses de sécurité dans le protocole d'authentification du porteur : le code n'était pas chiffré, et n'était pas authentifié par la puce. L'adoption de ce dernier permet techniquement l'introduction de cartes multi-application (par exemple avec option de fidélisation), même si cette possibilité a été relativement peu exploitée à ce jour.

L'introduction progressive à partir du 28 janvier 2008 du Système européen des paiements pourrait précipiter la disparition des systèmes de cartes nationaux au niveau européen, même si le S.T.E.T. affirme que les systèmes de carte nationaux et le système de carte européen pourraient coexister.

Le projet SEPA prévoit à terme l'unification des instruments de paiement dans les 28 États de la communauté européenne, l'Islande, la Norvège, le Liechtenstein, la Suisse et Monaco. D'ores et déjà, les retraits à l'intérieur de la Zone Euro ne sont plus soumis à une tarification spécifique.

Le porte-monnaie électronique

L'introduction du porte-monnaie électronique s'est réalisée de manière dispersée. Il est apparu sous diverses formes dans différents pays du monde (Quick Wertkarte en Autriche, Proton en Belgique et Chipknik au Pays-Bas — où la fonctionnalité est intégrée à toutes les cartes bancaires — Interac au Canada). Certains systèmes sont réservés à des secteurs ou à des transactions spécifiques. Un porte-monnaie électronique permettant de régler des transactions liées à la téléphonie mobile existe au Japon et en Corée. Modeus a permis de régler des titres de transport en France, c'est également le cas d'Octopus à Hong-Kong.

En France, le principal système de porte-monnaie électronique est Moneo. Ce dernier a fusionné avec Modeus et supplanté Mondex (branche française de Mondex International, promu par Mastercard, soutenu en France par le seul Crédit Mutuel). Le déploiement de Moneo a débuté à Tours fin 1999. Le processus a été relancé fin 2005, notamment avec l'adoption de ce moyen de paiement pour les horodateurs de stationnement, puis par l'insertion de dispositifs Moneo dans les cartes d'étudiant de certaines universités françaises. Le système présente nombre d'avantages relativement à l'utilisation des espèces, et permet d'éviter notamment le rendu de monnaie, limitant l'encombrement. Il n'a cependant pas atteint la masse critique d'utilisateurs lui permettant de concurrencer sérieusement, voire de supplanter les espèces. On propose trois pistes d'explication :

- Aucun des deux côtés — utilisateur et marchands — n'a anticipé une diffusion suffisante de l'instrument de paiement chez l'autre, de sorte que chacun reste dans l'expectative. C'est le "Chicken and Egg problem" (problème de l'œuf ou de la poule). Cet argument est notamment développé dans Berentsen (1998).
- Il existe une limite supérieure relativement basse pour les paiements par porte-monnaie électronique (le système Moneo interdit les paiements supérieurs à 30 €) .
- Les coûts de location des terminaux ainsi que les commissions perçues sont souvent trop élevés, et la croissance du nombre d'utilisateurs est trop faible pour réaliser des économies d'échelles significatives entraînant leur diminution.

En France, Moneo reste couramment utilisé dans des cadres spécifiques, notamment dans les restaurants universitaires. On décrit maintenant les caractéristiques économiques des moyens de paiement principaux, permettant de modéliser la concurrence entre instruments de paiement.

0.2 Modèles de compétition entre instruments de paiement

Les instruments de paiements sont des biens substituables différenciés. Ce sont des bien particuliers, en ce sens qu'ils n'ont pas de valeur intrinsèque significative : ils permettent simplement de conduire des transactions. On peut considérer qu'il y a un bénéfice à l'utilisation d'un instrument de paiement plutôt que d'un autre — par exemple en terme de confort et de rapidité — mais l'acte de paiement n'est pas valorisé pour lui même.

Les espèces ont trois caractéristiques particulièrement pertinentes sur le plan économique : elles constituent un instrument de paiement anonyme, immédiat et ayant cours légal. L'anonymat est une caractéristique à double tranchant, elle peut conduire aussi bien à privilégier cet instrument de paiement qu'à l'éviter. En effet, en regard de cette caractéristique, c'est l'instrument privilégié des transactions frauduleuses (trafics illégaux ou plus simplement travail non déclaré, notamment pour motif d'évasion fiscale) et c'est également un instrument de paiement à éviter pour s'assurer contre le vol ou les pertes (les paiements n'étant pas aisément traçables). L'impact du niveau de criminalité sur l'utilisation d'espèces est donc ambivalent, nous aurons l'occasion d'y revenir dans notre thèse.

La deuxième caractéristique, celle de l'immédiateté du paiement, peut conduire un marchand à refuser les moyens de paiement alternatifs afin d'éviter le défaut (en particulier pour éviter les chèques sans provisions). A l'opposé, les consommateurs peuvent privilégier un autre instrument de paiement de manière à disposer d'un délai avant le transfert effectif des fonds. Le chèque, et la carte bancaire dans une moindre mesure [4] peuvent être utilisés comme instrument de gestion de trésorerie contrairement aux espèces.

La dernière caractéristique renvoie *au cours légal* des espèces ; il est imposé aux marchands d'accepter les paiements en espèces au dessous d'un certain seuil de transaction. Un consommateur supporte les coûts de recherche d'un marchand acceptant la carte bancaire ou le chèque, en revanche, il n'a pas à supporter les coûts de recherche d'un marchand acceptant les espèces.

On distingue deux grandes familles de modèles de compétition entre instruments de paiement. Une première famille considère le cas stylisé dans lequel le consommateur a le choix uniquement entre deux instruments de paiement : les espèces ou un instrument de paiement générique lié au compte. Une deuxième famille tient compte des différences entre ces derniers. Elle considère plusieurs instruments de paiement alternatifs pour tenir compte des différences entre les instruments de paiement liés au compte bancaire.

Le modèle de Berentsen (1998), déjà cité, échappe à notre classification, puisqu'il se concentre sur la concurrence entre espèces et porte-monnaie électronique. Berentsen part de la constatation que l'utilisation toujours marginale du porte monnaie électronique ne s'explique dans aucun des

4. La gestion de trésorerie est possible avec les *carte de crédit*, elle est en revanche impossible avec les *carte de débit immédiat*.

cadres jusqu'ici présentés pour mettre en avant la nécessaire interaction entre les marchands et les consommateurs dans le cadre de l'introduction d'un instrument de paiement. La croyance par une masse critique de marchands dans l'utilisation du nouvel instrument par les consommateurs, ainsi que la croyance par une masse critique de consommateurs dans l'acceptation par les marchands est nécessaire pour que le nouvel instrument s'impose. Il en résulte une multiplicité d'équilibres de Nash, et notamment celui dans lequel l'instrument de paiement entrant n'est pas utilisé.

On présente dans un premier temps quelques modèles de choix entre les espèces et un instrument de paiement alternatif. L'analyse micro-économique des paiements s'est beaucoup basée sur la demande de monnaie *à la* Baumol-Tobin. L'article pionnier de Baumol (1952) étudie l'arbitrage entre la détention d'espèces et un actif monétaire lié au compte et rémunéré. La détention d'espèces, non rémunérée, présente un coût d'opportunité proportionnel au taux d'intérêt (évidemment ce coût est également proportionnel au montant des sommes détenues). En revanche, l'actif monétaire a un coût fixe d'utilisation. Par résolution du programme de maximisation du consommateur, on obtient que la détention d'espèces est proportionnelle à l'inverse de la racine carrée du taux de rémunération de l'actif lié au compte, à la racine carrée du revenu par période, et à la racine carrée de la durée de la période de temps considérée (ce résultat est appelé la loi de la racine carrée ou "Square Root Law").

L'étude de Tobin (1956) reprend l'analyse décrite par Baumol, et ajoute à l'analyse le « coût d'usure des chaussures » ("shoe leather cost") correspondant au coût de déplacement devant un distributeur automatique de billets. La loi de la racine carrée démontrée par Baumol, présentée au paragraphe précédent, s'applique également dans ce cadre. la détention d'espèces est maintenant proportionnelle à l'inverse de la racine carrée du « coût d'usure des chaussures ».

La demande de monnaie à la Baumol-Tobin est utilisée notamment dans une note de Whitesell (1989). Dans son modèle les espèces ont un coût d'opportunité directement proportionnel à la valeur de la transaction, mais pas de coût fixe d'utilisation. L'instrument de paiement lié au compte présente à la fois un coût d'utilisation fixe et un coût variable avec le niveau de la transaction (ce coût variable étant inférieur au taux de rémunération de l'actif monétaire). L'auteur dérive un niveau de transaction seuil au dessous duquel un paiement se fait *systématiquement* en espèces, et au dessus duquel un paiement se fait à partir de l'actif lié au compte.

On présente maintenant la deuxième famille de modèles, modélisant le choix entre les espèces et plusieurs instruments de paiement liés au compte bancaire.

Dans le modèle de Santomero et Seater (1996), le consommateur peut détenir quatre types d'actifs, chacun étant associé à un taux de retour par période. Un de ces actifs représente un compte courant non rémunéré (c'est à dire les espèces) et les trois autres sont liés à un compte rémunéré. Bien que le modèle reproduise les principaux résultats des modèles de la première famille — notamment la loi de la racine carrée — il prête le flanc a de nombreuses critiques. Par exemple, les élasticités de substitution entre instruments de paiement ne sont fonction que du taux de retour des instruments de paiement, et du taux de conversion de l'instrument de paiement avec un et un seul actif (appelé l'actif adjacent). Pour fixer les idées, supposons que l'actif A et l'actif B soient adjacents. Il est difficile d'interpréter les raisons pour lesquelles l'élasticité de substitution entre l'actif A et l'actif C (i) ne fait pas intervenir le taux de conversion entre A et C et (ii) fait intervenir le taux de conversion entre A et B.

Shy et Tarrka (2004) posent la question de la coexistence de long terme des espèces et du porte-monnaie électronique. Ils étendent la dimension de l'espace des caractéristiques des instruments de paiement, et tentent de dériver un domaine de transaction pour chacun des instruments de paiement. Tous les instruments de paiement ont une part de marché positive à l'équilibre, mais ceci s'explique par l'introduction d'un paramètre traduisant la méfiance envers les instruments de paiement électroniques. Ce paramètre n'est pas endogénéisé et peu discuté.

Nous présentons maintenant l'organisation de notre thèse.

0.3 Organisation de la thèse

Notre thèse tente d'éclaircir les déterminants du choix entre les principaux instruments de paiement. D'abord, comme nous l'avons vu au début de cette introduction, les espèces sont un instrument de paiement coûteux et inefficace du point de vue social. Les banques souhaitent limiter leur utilisation, parce que c'est également l'instrument de paiement dont le coût privé supporté par les banques est le plus élevé (cf BCE, 2012). La mise en place de la réglementation européenne en juillet 2002 impose l'harmonisation de la tarification bancaire à travers l'Europe. La quasi-totalité des banques françaises a adopté une tarification des retraits déplacés, c'est à dire des retraits à l'extérieur du réseau de la banque tenant le compte du consommateur. En général, ces retraits sont facturés individuellement au prix d'un euro après une franchise de gratuité correspondant à trois ou quatre retraits. Ainsi, l'adoption de cette tarification a été quasiment instantanée par la quasi-totalité des grandes banques françaises. Le mois de juillet 2002 peut être considéré comme une limite séparant deux périodes différentes. Nous nous trouvons ici dans une situation de quasi-expérience naturelle.

Le premier chapitre analyse l'impact de la tarification des retraits déplacés sur la demande d'espèces et sur la demande pour la carte bancaire, en développant un modèle théorique et en vérifiant ses prédictions à l'aide d'une base de données originale provenant de la chambre de compensation française. Nous construisons un modèle théorique, et nous validons empiriquement ses conclusions. Premièrement, nous montrons que l'introduction de la tarification des retraits déplacés a provoqué une diminution du nombre de retraits déplacés, ainsi qu'une substitution partielle des paiements en espèces vers les paiements par carte.

Le deuxième chapitre examine une stratégie permettant d'orienter les choix de l'instrument de paiement du consommateur. Les marchands subissent l'instrument de paiement décidé par les consommateurs pour chaque transaction. Ils peuvent refuser les instruments de paiement alternatifs, mais ces refus peuvent dévier une partie de la demande. Nous examinons dans Dans les marchés imparfaitement concurrentiels, les marchands peuvent ajuster le niveau des prix pour faciliter les paiements en espèces. Par exemple, un prix de 10 euros mobilise un billet unique, alors qu'un paiement de 9.67 euros occasionne 1) si le prix est payé directement un coût cognitif correspondant à la décomposition du prix en pièces et billets 2) s'il y a retour de monnaie, un coût correspondant au transport des pièces reçues en retour. Nous construisons un modèle théorique basé sur ces idées, et nous concluons que toutes choses égales par ailleurs les prix mobilisant moins de pièces et billets pour les paiement en espèces sont plus souvent choisis par les marchands (ils sont plus fréquents dans la distribution des prix). Nous concluons également qu'un prix doit être d'autant plus fréquemment payé en espèces qu'il mobilise peu de pièces ou billets. Nous utilisons une base de données originale issue d'une enquête de terrain comprenant le prix et l'instrument de paiement pour 411 transactions, et nous confirmons nos deux prédictions théoriques.

Les troisième et quatrième chapitres étudient l'impact du crime *en tant que facteur environnemental* sur les paiements. Les indicateurs de crime sont extraits de l'État 4001, un document publié par le Ministère de l'Intérieur et reprenant le compte des plaintes déposées en

Gendarmerie et dans les commissariats de France. Nous retenons les indicateurs de criminalité violente et de criminalité financière, et nous associons à chaque individu le niveau de criminalité de son département. Le troisième chapitre étudie l'impact du crime sur le degré d'appréciation des espèces par les marchands, c'est à dire sur une variable subjective. Le quatrième chapitre étudie l'impact du crime sur l'acceptation de la carte bancaire, c'est à dire sur une variable objective.

Le cinquième chapitre étudie l'impact du crime sur le montant hebdomadaire retiré en espèces ainsi que la décision de possession d'une carte bancaire de paiement. La base de données provient d'une enquête réalisée auprès d'un échantillon représentatif de consommateurs de mars à mai 2005. Elle comprend 1408 observations.

Le sixième chapitre aborde les déterminants psychologiques du choix de l'instrument de paiement en exploitant les modèles de risque perçu de Jacoby et Kaplan (1972). Nous utilisons une base de données originale, constituée à partir de d'un questionnaire en ligne auto-administré. Nous supposons que le risque perçu global peut être additivement séparé en chacune de ses dimensions. Nous retenons les dimensions de risque financier, de risque de performance, de risque social (reprise de Jacoby et Kaplan, 1972) et de risque temporel (repris de Roselius, 1971). Nous étudions l'impact de facteurs contrôlant les dimensions du risque perçu sur la fréquence de détention et sur la fréquence d'utilisation des espèces, de la carte bancaire et du chèque. Nous veillons à tenir compte de la corrélation entre les déterminants de la détention et les déterminants de l'utilisation dans les estimations économétriques. Nous montrons que les équations de détention et d'utilisation ne peuvent être considérés comme indépendantes. Nous montrons également que les principaux effets croisés concernent la carte bancaire et les espèces, confirmant ainsi que ces deux instruments de paiements sont des substituts proches. Nous montrons enfin que le risque dont l'influence est la plus transversale est le risque de manque, suivi du risque associé à la perte de temps.

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Chapter 1

Does The Cost Of Cash Withdrawal Matter? Theory And Evidence

Bruno Karoubi

Abstract

This paper examines whether charging cash withdrawals of non-depositors (a "surcharge") impacts the demand for cash and the demand for card payments. I develop a theoretical model in which payers have three payment options: i) withdrawing cash at ATMs of the network of their bank ii) withdrawing cash at ATMs outside the network of their bank iii) giving up cash withdrawals and pay by card instead. I show that if the price charged is not too extreme compared to the hardness of moving to a home ATM and to the benefit of paying cash rather than paying with card, an increase of surcharges results in a decrease of both the overall number of cash withdrawals and the amount paid with card. Most French banks implemented the surcharge fee in July 2002, immediately after the implementation of the Euro regulation: This process is a quasi natural experiment. I therefore exploit a unique database coming from the French Automated Clearing Housen, using interrupted time series techniques to provide supporting empirical evidence to the theoretical conclusions.

Keywords: Demand for money, Surcharges, Payment Instruments.

JEL Classification: E4.

1.1 Introduction

Payment instruments involve significant private and social costs. Depending on stakeholders considered and on methodology, however, estimates vary. Humphrey *et al* (2003) estimate the costs of making payment instruments to be 3% of the Gross Domestic Product (GDP) in the Netherlands; Gresvik and Owre (2003) estimate banks cost in connection with the production of payment services to be 0.49 % of the GDP in Norway. Banco de Portugal (2007) estimates the corresponding share for Portugal at 0.77%. There is, however, a wide agreement that cash is the most costly payment instrument for most transactions. Humphrey *et al* (2003) estimate that "cash is the most costly payment instrument each time the transaction size is above 11.6 euros." Social costs of cash amount to nearly half of that of all payment instruments (49 %), and total private costs to banks and to retailers are both the highest by far (European Central Bank -hereafter, ECB- 2012). Even though the total costs of cash are high essentially because cash payment is common and typically used for small amounts, the costs of cash per euro of transactions is €0.023 on average, while a check payment costs €0.004 and a payment by debit card costs €0.017. Half of the social costs of cash is incurred by retailers and the other half is borne by banks and infrastructures (ECB- 2012).

Withdrawal costs amounts to half of the costs of cash payment borne by the banks (49%, cf. ECB, 2012). Banks argue that imposing a fee on non depositors who withdraw cash (this fee is a "surcharge") is efficient, since it makes non depositors bear the cost and pay the remuneration of a service (convenient access to money). Moreover, surcharges could *a priori* be used as a strategic tool for large banks to drive away customers from smaller banks (who would like to avoid the payment of the surcharge). Last, increasing the cost of withdrawals should intuitively divert part of the demand for cash to card payments, decreasing the overall amount of cash processed by the banks and therefore the global costs.

In this paper, we analyze the impact of surcharges on the use of cash and cards. To do so, (i) we develop a theoretical model and (ii) we empirically test the most important predictions.

To the best of our knowledge, there is no formalized theoretical framework specifically designed to analyze the question of the impact of surcharges on the use of cash. A straightforward extension of the model of Baumol (1952) and Tobin (1956) supports the assertion that surcharges decrease the total number of withdrawals. Baumol and Tobin's model considers a consumer receiving his income once per period who needs cash continuously to purchase. He faces a trade off between *liquidity* and the value of *foregone interests*. A conclusion of the model is that the number of withdrawals is decreasing with the "shoe leather cost", corresponding to the hardness of moving to an ATM. Surcharges can be considered as an exogenous increase of the monetary cost of withdrawals, and should entail a decrease in the count of external withdrawals if we extend the "shoe leather cost" to the global cost of withdrawing cash (both monetary and non-monetary).

The extension we have just sketched suffers however from three main limitations. First, we do not allow for any outside option, a consumer cannot substitute card to cash payments. Second, extending our conclusions to a macroeconomic framework is not immediate, since the representative agent assumption does not hold: heterogeneity in costs and in preferences is an important part of the problem of the choice of a payment instrument. Third and as corollary, we do not consider the substitutability between cleared withdrawals and withdrawals at ATMs of the bank of the customer ("home withdrawals" from now on). We develop a model taking into account the three dimensions, and we conclude that the count of external withdrawals and the corresponding aggregate amount are decreasing in the level of the surcharge. We also conclude that the aggregate amount of cleared card transactions is an increasing function of the surcharge.

A second contribution of this paper is to test empirically the predictions of the model. We use a unique data set coming from the French Automated Clearing House. The data comprises the monthly count of cleared withdrawals, as well as the corresponding aggregate amount. It also comprises the aggregate amount of cleared card transactions. Series range from January 2001 to December 2008.

Surcharges were implemented almost simultaneously by almost all French banks in July 2002. Indeed, the implementation of the Euro rules has forced banks to undertake a common pricing policy across Member States. French Banks have adapted by charging cleared withdrawals in France to keep charging cleared withdrawals in foreign countries. The quasi-simultaneity, together with the absence of other changes relevant to the choice of payment instrument is precious to the empirical researcher, as it constitutes a typical interrupted time series design.

We examine both theoretically and empirically the three following plausible impact of the charging of foreign withdrawals.

First, we examine whether the count of cash withdrawals at ATMs outside the network of the bank ("external withdrawals" in the remainder of the paper) decreased as a reaction to the surcharges. The assumption that an increase in the monetary costs of external withdrawals reduces demand is natural, but, to the best of our knowledge, it has been examined neither in a dedicated theoretical framework nor empirically. Macroeconomic functions of demand for money neglect withdrawal costs. The implementation of surcharges is a unique opportunity to discuss the assumption, even though the first four or five external withdrawals are not charged and only externals withdrawals are concerned.

Second, we examine whether surcharges resulted in a decrease in the aggregate amount withdrawn at external ATMs. A rational customer could reduce the number of external withdrawals, and increase the average sum withdrawn, while keeping the global amount withdrawn constant. Surcharges would not be a full success regarding cost reduction to the banks, since the global amount of cash processed would not have decreased. More importantly, the strategic effect of driving away non depositors from smaller banks to avoid the surcharge would not be relevant, since the incentive to switch bank would turn out to be too weak (the hardness of moving to a home ATM would be less costly than paying the surcharge). This configuration is not possible if both the count of external withdrawals and the corresponding amount decreased due to the surcharge.

Third, we examine whether surcharges resulted in an increase in the amount of card transactions. The pricing of external withdrawals can be analyzed partly as a strategy to reduce the costs of cash processing for banks by reducing the global demand for cash, since charging withdrawals at external ATMs increase the average cost of cash withdrawals. At a constant volume of transaction, a reduction of the global demand for cash payments is equivalent to an increase in the use of alternative payment instruments. Since bank card has a dominating share among alternative payment instruments, and since other alternative payment instruments are typically not substitutable with cash payments (Snellman *et al*, 2001), card payments should increase.

We conclude that the count of cleared withdrawals, as well as the corresponding aggregate amount decreased as a result of the surcharges. We also show that the amount of cleared credit card transactions increased. Our results are in line with our theoretical predictions. In other words, we show that increasing the direct cost of cash payments provides lever to steer the choice of payment instrument, which has interesting policy implications.

The impact of surcharges on welfare is a complex problem. On the one hand, surcharges boost the deployment of ATMs. On the other hand, surcharges may be used as a strategic tool to build market power, therefore increasing the deadweight loss (the welfare loss due to above marginal cost pricing). Many consumers view surcharge as a "double dip" fee since they pay first to have an account, and then to access to their own money. Empirical facts seem to point out that surcharges indeed boost the deployment of ATMs, although we know of no complete empirical academic studies specifically designed to test this assumption: Prager (2001) notes that Off-premises ATMs increased in the US from 37804 in 1994 to 84000 in 1998 after the surcharges ban lift by Cirrus and Plus in 1996.

Most empirical studies find out that the strategic effect of surcharges is not significant (Hannan, 2007, Prager, 2001 and Kiser, 2000), and empirical studies trying to assess the impact of surcharges on welfare conclude that they are welfare improving, mildly or significantly (Gowrisankaran and Krainer, 2004; Knittel and Stango, 2004). Most theoretical studies draw the same conclusions (Chioveanu et al, 2009) .

Surcharges are considered at least welfare neutral by most studies regardless of the substitution of cash by other payment instruments. Cash is overused relative to the social optimum (ECB, 2012). Since we show that an increase in the cost of withdrawals drives the consumer towards more welfare efficient payment instruments, the social planner would increase welfare by raising the costs of cash supplying, by taxing both cleared and home cash withdrawals.

1.2 Model

Framework

Consider a finite mass of payers. A payer can either (i) withdraw cash at an ATM of his bank (ii) withdraw cash at other ATMs or (iii) pay by card. The three options are mutually exclusive. We consider bank cards as the only alternative payment instrument, because card is dominant among non-cash payment instruments, especially for small value purchases. In the Euro area, the market share of card among alternative payment instruments is more than 80% excluding direct credit transfers, which are typically used for transfers of large sums, and as such not easily substitutable with cash, cf ECB 2010). Moreover, card may be interpreted as a generic payment instrument here, since the substitution pattern between alternative payment instruments is beyond the scope of this paper.

A payer pays the surcharge s each time she withdraws money at an external ATM. Moving to a home ATM costs h more than moving to an external ATM, where h stands for "**h**ardness" or "**h**ome".

b is the additional benefit of paying cash rather than paying with card. It is the monetary sum that the payer is willing to pay to pay cash rather than paying with card. It is the difference between the benefit for cash payments (except withdrawal costs) and the benefit for card payments.

h and b are monetary equivalents; therefore h, b and s are mutually directly comparable.

We consider a two dimension continuum (*i.e.* a rectangle) of payers. payers are heterogeneous in their **h**ardness to move to a **h**ome ATM, h, and in their benefits for cash payments, b. A payer is therefore identified by two coordinate parameters h and b, where (h,b) follows a biuniform distribution, with $h \in I_h = [0;\overline{h}]$ $b \in I_b = [0;\overline{b}]$. A payer earns a stream of income R, which she spends in whole (there is no savings). For the sake of simplicity, we assume that $R = 1$ without loss of generality. This normalization allows us to identify the mass of payers choosing a payment option and the corresponding aggregate amount.

We normalize the incompressible amount of cash held to zero, or equivalently the corresponding withdrawals are performed *ex-ante*. A positive incompressible amount of cash withdrawn would not affect any important outcome, and would make the demand functions more complex to no avail

We make the following assumptions:

(a) $\overline{h} > 0$

(b) $\overline{b} > 0$

(c) $s \in I_s = I_h \cap I_b = [0; min(\overline{b}, \overline{h})]$.

Assumption (a) captures that there are more external ATMs than home ATMs, since there are many banks with a dense network of ATMs (so that the closest ATM is more likely to be external). It also insures that I_h is not degenerated to a point.

Assumption (b) insures that at least a single payer prefers to pay cash all other things being equal. It also insures that I_b is not degenerated to a point.

Assumption (c) insures that I_s is not degenerated to a point, and that $0 \in I_s$ so that we can discuss the implementation of surcharges (which is s changing from 0 to a positive value). Since I model a sudden change of a single parameter (the implementation of surcharges) all other things being equal, I consider a static (or "*one shot*") game.

We first determine the mass of payers choosing each payment option. For cash withdrawing payers, we then discuss the optimal number of withdrawals.

1.2.1 Mass of payers for Each Payment Option

We now provide explicit functions for the total mass of payers performing home and external withdrawals, and an explicit function for mass of payers paying with card.

The program of the payer is

$$\max_{PO \in \{HW\ EW\ Card\}} U(pi) = b\mathbb{1}_{PO \in \{HW,EW\}} - s\mathbb{1}_{\{PO=EW\}} - h\mathbb{1}_{\{PO=HW\}}$$

,

where PO is the Payment Option, HW stands for Home Withdrawals, EW stands for External Withdrawals and Card stands for card payments.

Mass of Card Payments

Proposition 1.1. *The mass of card payments as a function of s is*

$$M_{Card}(s) = -\frac{s^2}{2} + s\overline{h}.$$

The mass of card payments is increasing with the surcharge.

Proof. The proof is in the appendix. □

Mass of External Withdrawals

Proposition 1.2. *The mass of payers performing external withdrawals is*

$$M_{EW}(s) = s - s(\overline{b} + \overline{h}) + \overline{bh}$$

The mass of payers performing cleared withdrawals is decreasing

Proof. The proof is in the appendix. □

Mass of Home Withdrawals

Proposition 1.3. *The mass of payers performing home withdrawals is*

$$M_{HW}(s) = -\frac{s}{2} + s\overline{b}$$

The mass of payers performing home withdrawals is increasing with the surcharge

Proof. The proof is in the appendix. □

To sum up the results, since we assume that $s \in I_s$, **the aggregate amount of card payments and the mass of payers performing home withdrawals both increase when s increases**. The mass of external withdrawals reduces when s increases. Since customers pay either with cash or with card, and since income is constant, an increase in card payments is equivalent to a decrease in the aggregate amount of overall cash withdrawals. The increase in the mass of payers performing home withdrawals does not offset the decrease in the mass of payers performing cleared withdrawals, because some payers performing cleared withdrawals *ex ante* switch to card payments.

Table 1.1 shows the payment behavior of all payers according to their position in the rectangle.

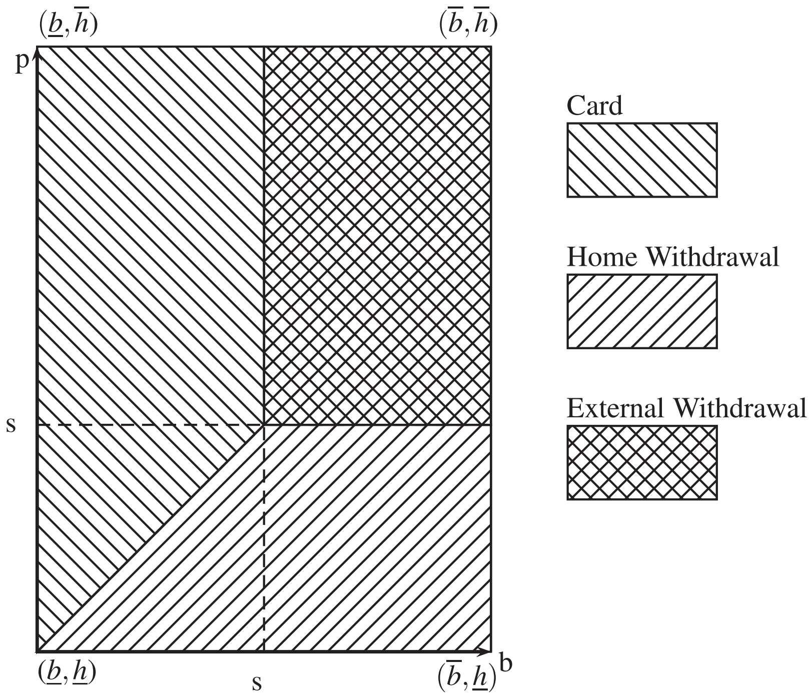
We now determine the optimal number of withdrawals for payers withdrawing cash at home ATMs and payers withdrawing cash at external ATMs.

1.2.2 Optimal Number of Withdrawals

payers have a marginal aversion to average cash holding $\alpha > 0$, because of the risks of loss and theft. The marginal aversion is directly comparable to a monetary sum. payers minimize the loss associated with cash withdrawing $L(n)$ if they withdraw at an external ATM. payers minimize the equivalent loss $L'(n)$ if they withdraw at a home ATM. Therefore,

The program of payer withdrawing at an external ATM is

TABLE 1.1: Map of payer Payment Behavior



$$\min_n L(n) = \alpha * \frac{R}{n} + s * n = \frac{\alpha}{n} + s * n,$$

and the program of a payer withdrawing at a home ATM is

$$\min_n L'(n) = \alpha * \frac{R}{n} + h * n = \frac{\alpha}{n} + h * n.$$

Remark 1.4. A payer withdrawing cash at an external ATM performs n^* withdrawals, with

$$n^*(s) = \sqrt{\frac{\alpha}{s}}.$$

n^* is decreasing in s.

A payer (b,h) withdrawing cash at a home ATM performs n^{**} withdrawals, with

$$n^{**} = \sqrt{\frac{\alpha}{h}}.$$

Proofs of the Remark. The proof is immediate given the program of the payer, considering that $L(n)$ (respectively $L'(n)$) is a continuous concave function of n, and rearranging the first order condition. It is also immediate that n^* is decreasing in s/ □

For a payer withdrawing cash at an external ATM, the optimal number of withdrawal is decreasing in s. Since the mass of such payers is also decreasing in s, we conclude that **the overall number of external withdrawals, and the corresponding aggregate amount decreases when s increases**.

For a payer withdrawing cash at a home ATM, the optimal number of withdrawals is independent of s. Since the mass of such payers is increasing in s, **the overall number of home withdrawals, and the corresponding aggregate amount decreases when s increases**.

1.3 Data

We aim to provide evidence supporting the theoretical propositions. The decrease in the count of external withdrawals and in the corresponding amount (cf Proposition 1.2 and Proposition **??**) can be tested directly, since we observe the count of external withdrawals, the corresponding aggregate amount and the aggregate amount of card transactions between two different banks. The increase in the amount of card transactions (cf Proposition 1.1) can not be tested directly *stricto sensu*, since we do not observe intra-banking transactions. We can test, however, the impact of surcharges on cleared card transactions. They are a vast majority, and can be considered as an excellent proxy for all card transactions.

1.3.1 General Overview of The Dataset

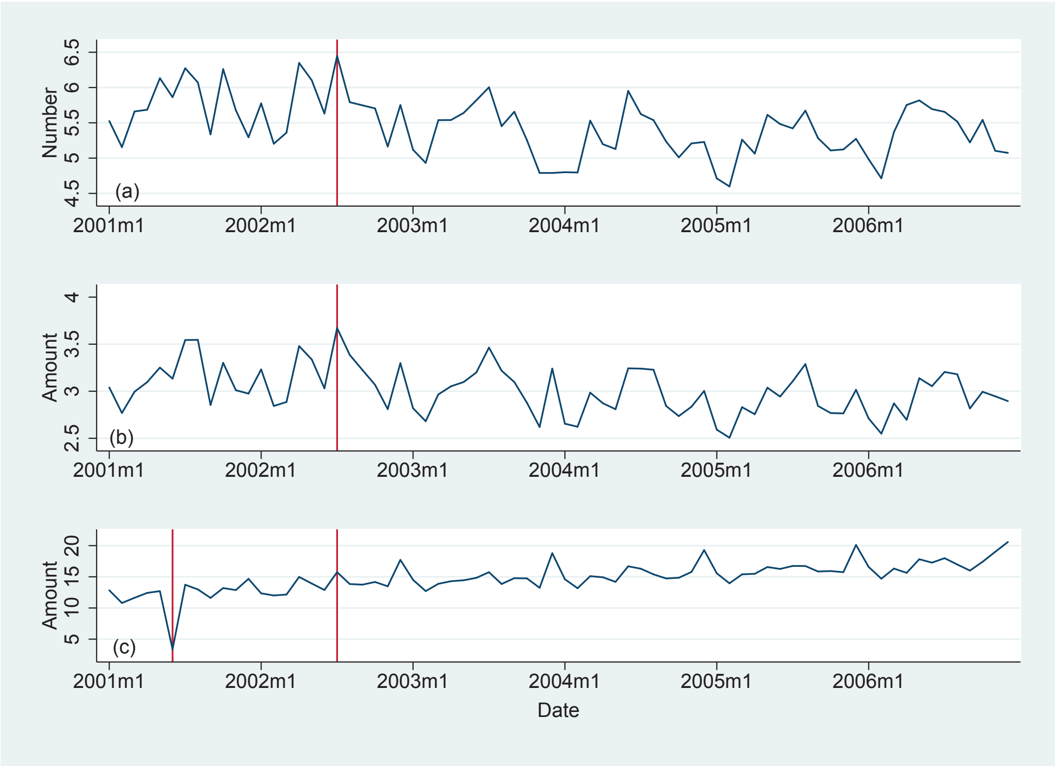
We use a unique database coming from the French Automated Clearing House. [1] Series available ("Payment Series" from now on) are the monthly count of cleared cash withdrawals, the corresponding amount and the amount of bank card mediated cleared transactions. The database also comprises the corresponding amounts. Series range from January 2001 to December 2007, so that there are 72 observations.

There are no significant outliers for all series, except for the month of June 2001 for the amount of cleared card transactions (cf table 1.2). A punctual event accounts for the outlier. Indeed, an individual taking the identity of "Serge Humpich" warned the then president of France, Jacques Chirac by email. "Yescards" — cards enabling transactions whatever the PIN dialed — would

1. The French Automated Clearing House was the S.I.T. (*"Système Interbancaire de Télécompensation"*) at the time the data was collected.

flood the country in a few days. On the 10 of June, the first software allowing the programming of a "Yescard" was online. It did not require any technical skills. The situation resulted in a breach of trust in the safety of the card technology, and the aggregate amount of bank card transactions was reduced by two thirds for the month of June 2002. The Group of Economic Interest "Carte Bleue" that manages the French system of bank cards declared on June 21 that "Yescards" frauds were isolated cases, and as such did not represent a threat to consumers and to buyers (cf for instance Colombani, 2004 for more details). Card transactions resumed to normal levels in July 2002, as we observe in the data.

TABLE 1.2: Graphical Representation of The Evolution of Payment Series Over Time



Notes. (a) represents the count of cleared ATM withdrawals and (b) represents the corresponding amount. (c) represents the amount of cleared card transactions. All amounts are deflated, and given in billion of euros. The count of ATM withdrawals is given in 10 million of euros. The vertical red line on (a) (b) and (c) corresponds to July 2002. The leftmost red line in (c) is the month of June 2001 and corresponds to the "Yescards" crisis.

The following tables displays descriptive statistics.

TABLE 1.3: Descriptive Statistics

	(1)	(2)	(3)
Std Dev	4.15	2.55	2.46
Min	4.6	2.51	3.37
Max	6.45	3.67	20.06
Mean	5.46	3.01	14.9

Notes. Column (1) presents the descriptive statistics for the count of external withdrawals, column (2) is the corresponding amount, and column (3) is the amount of cleared card transactions. The count of cleared withdrawals is given in 10 millions of euros. Amounts are given in billions of euros.

To complete the database, I downloaded the quarterly Gross Domestic Product from the Eurostat website. I linearly interpolated the series to obtain monthly values, since the monthly Gross Domestic Product is not available.

We deflated all nominal series using the monthly Consumer Price Index downloaded from the Eurostat website to get their real equivalent.

1.3.2 Seasonality

Seasonality is usually considered to fall into three categories: stochastic due to the presence of seasonal unit roots, purely deterministic, and stationary stochastic.

The presence of stationarity stochastic seasonality can be tested *a posteriori* by checking for the presence of autocorrelation since both the presence of an autoregressive process and that of a moving average imply autocorrelation in the residual. Therefore, we will use autocorrelation tests to ensure that that the models are correctly specified.

We examine first the presence of a deterministic seasonal pattern, then the presence of a seasonal unit root.

We now turn to examining the presence of a purely deterministic seasonal pattern.

1.3.3 Purely Deterministic Seasonal Pattern

A quick look into the payment series suggests regular spike and gaps at specific months. Indeed, for the count of external withdrawals as well as for the corresponding amount, we observe a significant gap in February each year, which may result from its shorter duration. For the amount of cleared credit card transactions, December corresponds to a spike. We confirmed this graphic intuition by checking that the relevant month to month differences were significantly higher in absolute value around spike and gaps for each year.

Table 1.4 presents the deterministic seasonal pattern.

TABLE 1.4: Deterministic Seasonal Pattern

Pattern	(1)	(2)	(3)
Monthly	February (⇓) December (⇑)	February (⇓) December (⇑)	February (⇓)

Notes. Column (1) presents the patterns for the count of external withdrawals, column(2) presents the patterns for the corresponding aggregate amount, and column (3) presents the pattern for the aggregate amount of cleared card transactions.

1.3.4 Seasonal Unit Root

Preliminary tests for the presence of seasonal unit roots were proposed by Hasza and Fuller (1982) and Hasza, Dickey and Fuller (1984). Strong assumptions are required, however, and in particular the alternative is very restrictive (unit roots are supposed to have the same modulus) .

The framework of Hyllenberg, Engle, Granger and Yo (1990) relaxes the assumption. Their original work deals with quarterly data. Beaulieu and Miron (1993) extend the method and presents a statistical table for monthly data.

Consider the following autoregressive process of order 12:

$$\alpha(L)x_{tm} = v_{tm},$$

where L is the lag operator, v_{tm} is a white noise process ($v_{tm} \rightsquigarrow \text{NID}(0, \sigma)$), and the index "tm" refers to monthly data. A seasonal unit root is a complex root of the polynomial α.

I use the framework provided in Beaulieu and Miron (1993) in order to test for the presence of a seasonal unit root. See that paper for technical details.

I tested credit card and ATM withdrawal series, both in number of transactions and in amount, for the presence of a seasonal unit root.

First, the number of lags included in the Beaulieu-Miron test was chosen, as advised by the authors, by introducing successive lags until the last turned out to be non-significant at the 15% level. The Schwartz criterion was examined but it almost always chose a specification with no lag. The Akaike criterion was considered, but not used, as it is well documented to over-parametrize (Granger and Newbold, 1986).

Second, I included a temporal trend and monthly dummies. Monthly dummies were introduced to control for the deterministic seasonal pattern discussed earlier. As noted by Hylleberg and Al (1990), "the loss of power that results from [the inclusion of seasonal dummies] when unnecessary is insignificant compared to the bias that results from their omission when necessary" .

Table 1.5 sums up the results. Rows y1 to y12 show the t-statistics associated to the corresponding coefficients, and one sided t-statistics are given in rows T(1) to T(3). The distributions of those statistics are not standard. I used the table given in Beaulieu and Miron (1993) to determine critical regions.

For all frequencies except 0, π and $\frac{\pi}{2}$, a particular seasonal unit root is present if and only if both the even and odd coefficients associated are null (note that the alternative of the Student's test for the odd coefficient is its strict negativity, so that the test is one sided). Therefore, F-statistics can be used to test for those seasonal unit roots. For frequencies 0 and π, a unit root is present if and only if the associated coefficient is strictly negative (the corresponding Student's tests are one sided). A seasonal unit root at frequency $\frac{\pi}{2}$ is present if and only if the two corresponding coefficients are null (the alternative of the t-test for the odd coefficient is his strict negativity, so that the test is one sided).

To summarize, we were able to reject the null of a seasonal unit root for all series at all frequencies except three at the 5% level, both using the F- and t-statistics. We can reject neither the presence of a unit root at frequency 0 for the count of external withdrawals nor for the corresponding amount. We can not reject the presence of a unit root at frequency π for the ATM series in amount. The strongest evidence for the presence of a unit root would be at frequency $\frac{5\pi}{6}$ for all series except for the count of external withdrawals: we can not reject the presence of a unit root at a reasonable critical threshold.

We can think of no economic rationale however for the presence of seasonal unit roots for any of the series. Balcombe (1999) states that "if the seasonal unit root is to be treated as a maintained hypothesis, this requires that the existence of a seasonal unit root can be given a sound theoretical footing from an economic point of view". Balcombe also states that given that conventional unit root tests are known to have low power under plausible alternatives, the same may be true of seasonal unit root tests.

Therefore, the presence of a unit root appears seriously questionable for all series. The result is in line with the applied part of Beulieu and Miron (1993) for the GDP series in the United States, as well as Osborn (1990) and Lee and Siklos (1991), for the GDP series in U.K. and Canada respectively.

As a partial conclusion, a seasonal filter is not justified, all the more considering the loss of information associated with filtration in our small sample, and the challenge of interpreting the filtered model.

1.3.5 Stationarity Tests

We used the efficient test proposed by Elliott Rothenberg and Stock (1996), based on the augmented Dickey-Fuller methodology. Since unit root tests are known to have low power (cf for instance Balcombe, 1999), we confirm the results with KPSS tests, because the null is trend stationarity as opposed to Dickey-Fuller type tests.

Choosing the number of lags included in the tests is a crucial issue. Additional lags decreases the power (the null is accepted too often) and a too low number of lags could leave out a significant serial dependency, biasing the results. A preliminary step for choosing the number of lags is choosing the maximum number of lags to be tested.

TABLE 1.5: Seasonal Unit Root: Beaulieu & Miron's Tests

	ATM (Number)	ATM (Amount) C. Card (Amount)	
y1[0]	-1.51	-1.06	-2.22
y2[π]	-3.39	-1.10	-1.77
y3[$\frac{\pi}{2}$]	-3.31	-2.50	-3.11
y4[$\frac{\pi}{2}$]	-0.28	0.91	0.25
y5[$\frac{2\pi}{3}$]	-2.58	-1.29	-0.64
y6[$\frac{2\pi}{3}$]	-1.19	-2.06	-3.58
y7[$\frac{\pi}{3}$]	-2.61	-2.19	-2.75
y8[$\frac{\pi}{3}$]	0.84	1.92	3.79
y9[$\frac{5\pi}{6}$]	-2.27	-1.24	-1.53
y10[$\frac{5\pi}{6}$]	-0.17	-0.30	-0.21
y11[$\frac{\pi}{6}$]	-3.04	-2.68	-6.12
y12[$\frac{\pi}{6}$]	-0.90	-0.59	-0.23
T(1)[0]	1.51	1.06	2.22
T(2)[π]	3.38	1.1	1.77
T(3)[$\frac{\pi}{2}$]	3.31	2.5	3.11
F(3,4)[$\frac{\pi}{2}$]	5.53	3.6	4.85
F(5,6)[$\frac{2\pi}{3}$]	6.04	4.94	9.45
F(7,8)[$\frac{\pi}{3}$]	4.11	4.42	10.7
F(9,10)[$\frac{5\pi}{6}$]	2.63	0.97	1.34
F(11,12)[$\frac{\pi}{6}$]	5.28	5.09	18.9
LM Test	0.43 (0.51)	0.01 (0.91)	0.12 (0.73)
Lags Included	Third only	First and Second	First and Second
Durbin Watson	1.8 (0.18)	0.06 (0.80)	1.80 (0.18)
Breusch-Godfrey	3.23 (0.07)	0.11 (0.73)	3.02 (0.08)
P-values are shown in parentheses			

The various criteria proposed by the literature are ad-hoc (Ng Perron, AIC, SC) and there is no consensus regarding which one to use. The choice of the maximum number of lags must be guided by economic and statistical reasoning. The Schwert (1989) and Final Prediction Error criteria recommend that we include up to 11 lags, which would decrease the power of the unit root test to the point that it would be no longer informative. Both criteria could be misleading in presence of a monthly pattern (i.e. spikes or gaps in specific months) and they are not adapted to medium sized sample — we have 72 observations — like ours (Liew, 2004). The conclusions of the unit root tests are unchanged if we include up to 9 lags, and we consider that 7 is the highest reasonable number for the maximum lag to be tested given the sample size and the loss of power (including more than 7 lag is losing more than 10% of the observations).

We set the exact number of lags to be incorporated using the Ng-Perron criterion, since there is a wide agreement that it is generally to be preferred (see Perron and Ng, 1996 for a compararison of the size adjusted power of different unit tests).

Tests unanimously lead to the conclusion that each payment series is trend stationary, and we cannot reject the absence of serial autocorrelation (of any order) for the residual.

For the real GDP, we can not reject the null of unit root at the 5% level, but since we could reject the null at 10% threshold and since augmented Dickey-Fuller have low power, we confirm the conclusions with other tests. We can not reject the null of unit root for the Philipps-Perron and ERS tests. Moreover, KPSS test rejects without ambiguity the null of trend stationarity. Overall, we conclude that the real GDP has a unit root and a deterministic linear trend (the series is DS(1)+T). Table 1.6 sums up the results. [2]

TABLE 1.6: Conventional Unit Roots: Augmented Dickey-Fuller Tests

	(1)	(2)	(3)	(4)
ADF (tau)	-4.7 ^{a}	-5.2^{a}	-7.0^{a}	-1.4^{d}
KPSS	0.11^{d}	0.06^{d}	0.07^{d}	0.99^{a}
Last lag included	3rd lag	5th lag	No lag	No lag

Notes. ^{a} (p<0.001), ^{b} (p<0.01) , ^{c} (p<0.05), ^{d} (p $\geq$ 0.05). Column (1) shows the results for the count of external withdrawals, column (2) shows the results for the corresponding amount, and column (3) shows the results for the aggregate amount of cleared card transactions. Column (4) shows the results for the real GDP. The distribution of the coefficients for the Augmented Dickey Fuller test is not standard, and the P-values are computed using the tables provided by Elliott, Rothenberg and Stock (1996). Maximum number of lags is 7. The number of lags included is decided by the Ng-Perron criterion.

1.4 Methodology and Results

1.4.1 Econometric Strategy

As a preliminary step, I tested whether the means of the series were significantly different before and after the implementation of surcharges, i.e. after July 2002.

Mean tests

Table 1.7 presents the results.

TABLE 1.7: Mean Tests: T-Statistics

	t
Cleared Withdrawals	*3.7*^{a}
Cleared Withdrawals (Amount)	*2.4*^{b}
Card (Amount)	-6.5^{a}

Notes. ^{a} (p<0.001), ^{b} (p<0.01) , ^{c} (p<0.05), ^{d} (p<0.1), (p $\geq$ 0.1). $t > 0$ means that means before the month of July are higher than means after July; $t < 0$ is interpreted symmetrically. Amounts are deflated.

2. The results of the Breusch-Godfrey tests are not shown here for the sake of conciseness, but they are available upon request to the author.

Means are significantly different and their sense of variation is in line with our theoretical predictions.
For the count of external withdrawals and the corresponding aggregate amount, the greater mean for the first subperiod is in accordance with the expected direction of the implementation of surcharges (cf proposition **??** and proposition 1.2).

For the aggregate amount of cleared card transactions, the greater mean for the second subperiod is in accordance with a partial substitution of external withdrawals by bank card payments and in line with proposition 1.1.

The heuristic approach developed in this section ignores the possibility of a diffusion of the break. Consumers may anticipate the charging of external withdrawals and change their behaviour before the implementation of surcharges, or they may need to experience the charging of external withdrawals before adapting.[3] Moreover, a comparison of means ignores the presence of a possible deterministic time trend in the series. Eventually, we cannot provide evidence that the break is not the consequence of a change of another variable. The significance and direction of the breaks need to be confirmed in a more rigorous setting.

Interrupted Time Series

We aim to show that the implementation of surcharges caused the payment series to vary according to the predictions of the theoretical model. We use an interrupted time series design (ITSD) with non equivalent variable. This can be presented as a two step method. The first step consists in examining the presence of a break in the income variable after the treatment (it would consist here in examining the presence of a break in the payment series after the implementation of surcharges). The second step consists in examining the presence of a break in a related but non equivalent variable. The related variable is chosen so that it is independent of the treatment, and acts as a control group. It is not likely that a factor different from the treatment impacts the series of interest and not the related variable, so that it is reasonable to conclude that the treatment impacted the income variable if we can provide evidence for a break in the income series but not for the related variable (cf for instance May, 2006).

3. Varying the month separating both means is possible, however, discriminating between break points would be difficult, since the tests would yield many false positive: months before and after a true break would still appear eligible.

We retained the real Gross Domestic Product as related variable since it is plausibly independent of the implementation of surcharges, and since it is obviously related to the aggregate amount of payments, itself related to the count of withdrawals.

Note that a test for a break in slopes is not necessary, since the implementation of surcharges is discrete and the mass of consumers choosing each option are all continuous in s.

The internal validity of interrupted time series estimation requires that the seasonal variations be controlled, and that both stochastic and deterministic non stationarity be taken into account in the econometric models. Seasonality should be examined before stationarity, because a seasonal unit root could lead to spurious conclusions regarding the stationarity of the series. Moreover, since we consider the impact of a discrete change, controlling for seasonal variations is critical.

1.4.2 Empirical Results

Payment Series

We estimate the following equation by ordinary least squares, where PS stand for payment series :

$$PS_t = \alpha \mathbb{1}_{T \geq S} + \beta \text{Seasonal dummies} + \gamma t + \delta + u_t, \qquad (1.1)$$

where $\mathbb{1}_{T \geq S}$ is a dummy indicating whether an observation is dated after the potential break due to the implementation of surcharges, u_t is the residual, and other notations are self explanatory. We allowed for a time frame of three months before and after the implementation of surcharges to allow for a potential diffusion of the break, *i.e.* to allow for the possibility that consumers either anticipated or delayed their reaction to surcharges. We tested all months between April and September 2002.

We included dummies for deterministic seasonal variations, corresponding to the patterns discussed in section 1.3.3.

α can be interpreted as the causal effect of the treatment on the income variable. Its statistical significance reveals the presence of an impact of surcharges, and its sign reveals its direction. The endogeneity of α is not a concern here, since the break dummies cannot be correlated

TABLE 1.8: Breusch-Godfrey Tests

	(1)	(2)	(3)	(4)
1st	0.61	1.03	2.95^{d}	0.78
2nd	2.80	1.61	6.41^{c}	3.74
3rd	5.85	2.67	6.46^{d}	5.64

Notes. ^{a} (p<0.001), ^{b} (p<0.01) , ^{c} (p<0.05), ^{d} (p<0.1), (p $\geq$ 0.1). We give the Breusch Godfrey statistic for the four econometric models presented in Table 1.9. Month dummies are present though. Column (1) corresponds to the count of cleared withdrawals, column (2) is the corresponding amount, columnn (3) is the amount of cleared withdrawals, and column (4) is the real Gross domestic Product.

with the residual; indeed, time trends are included in all econometric models estimated, and the dummy depends only on the time trend (its variance is null conditional to the time trend, since it is 1 if the time trend is superior to a certain threshold and 0 otherwise). We cannot exclude with certainty the presence of autocorrelation which would not be strong enough to be detected. First order autocorrelation would introduce the most severe bias. Therefore, we estimated equation 1.1 with robust standard errors. In the same line of thought, we performed Prais-Winsten (1954) estimation to ensure that our estimators are not biased due to autocorrelation.

For the count of external withdrawals and for the corresponding aggregate amount, the only significant break is for the month of September 2002. For the aggregate real amount of cleared card transactions, the only significant break is for the month of April 2002. Serial dependency could bias the standard errors, notably due to the presence of stochastic seasonality which would not be taken into account in the econometric model. Therefore, we took special care to test for the absence of autocorrelation for the residuals using Breusch-Godfrey post-estimation tests. Since we have 72 observations in our sample, testing for higher level of autocorrelations is arguably not reasonable. The conclusions of the tests would appear questionable since we have two few points. [4]

For all payment series, we could not reject the null of absence of autocorrelation up to the third order at the 1% threshold (P-values are given in table 1.8). For the amount withdrawn at external ATMs, we can reject the null at reasonable threshold (5% threshold for the second order and 10% for the first and third order). There is no convincing evidence of misspecification of the econometric model, in particular the presence of stationary stochastic seasonality is dubious, all the more since we fail to see any supporting economic rationale. We use estimation techniques robust to autocorrelation however, to ensure that the standard deviations are correct.

4. Only the integer part of 72/n n-order lags are available at most, and since conclusions regarding the presence of autocorrelation based on less than 30 observations could be considered doubtful.

Non Equivalent Control Variable

Even though we fail to see any month to month relevant varying factor between April and September 2002, we tested for the presence of a break in the real GDP to confirm that the break in payment series can be attributed to the implementation of surcharges.

Since the real GDP series is DS(1)+T (cf table 1.6), we first differentiated the series and included a time trend as regressor.

We estimated the following equation both by ordinary least squares with robust standard errors, and by performing Prais-Winsten estimation :

$$RGDP_t - RGDP_{t-1} = \alpha \mathbb{1}_{T \geq S} + \beta t + u_t, \tag{1.2}$$

where $RGDP_t$ is the Real Gross Domestic Product, and the other notations are the same as for equation 1.1.

We could not evidence the presence of a significant break between April and September 2002, since α in equation 1.2 was not significant. While this is not surprising for a break dummy corresponding to a month beginning a calendary quarter (values are linearly interpolated inside a quarter), we also fail to provide evidence of a break in months ending calendary quarters (two consecutive values with the first one corresponding to a month ending a quarter are not interpolated).

Results are shown in table 1.9.

As a partial conclusion, we show that all payment series exhibit a break in a short time window around the implementation of surcharges, but not the real Gross domestic product.

1.5 Discussion

The evidence is fully compatible with the theoretical model. The implementation of surcharges resulted in a decrease in the number of external withdrawals and in the corresponding aggregate amount, as well as an increase in the total deflated value of cleared card transactions.

TABLE 1.9: Break Equation Estimation by Robust OLS and Prais Winsten

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Break: September	-0.38 ^{b}	-15.4^{d}			-0.36 ^{c}	-15.4		
	(0.14)	(9.16)			(0.16)	(10.8)		
Trend	-0.002	-0.22	6.43 ^{a}	0.13	-0.002	-0.22	6.49^{a}	0.13
	(0.003)	(0.17)	(0.69)	(0.09)	(0.003)	(0.23)	(0.85)	(0.1)
February	-0.66^{a}	-39.4 ^{a}	-138^{a}		-0.54 ^{a}	-31.1 ^{a}	-139 ^{c}	
	(0.06)	(3.60)	(36.5)		(0.13)	(8.53)	(54.6)	
December	-0.24 ^{d}	6.30	341 ^{a}		-0.09	15.1 ^{d}	340 ^{a}	
	(0.14)	(7.85)	(24.7)		(0.13)	(8.60)	(54.5)	
Break: April			122 ^{d}	-0.42			119 ^{b}	-0.47
			(66.3)	(4.84)			(43.8)	(5.31)
N		72		71		72		71
R^2	0.45	0.35	0.74	0.05	0.42	0.35	0.80	0.04

Notes. ^{a} (p<0.001), ^{b} (p<0.01) , ^{c} (p<0.05), ^{d} (p<0.1), (p $\geq$ 0.1). Standard errors are given below the coefficients. Column (1) gives the results of the estimation for the count of external withdrawals, column (2) gives the results for the corresponding real aggregate amount, column (3) gives the results for the real aggregate amount of cleared card transactions. Column (4) presents the estimation with the real Gross Domestic Product; since the break was not significant for all months tested, the dummy included in the results shown is for the month of April, the most likely break.

The evidence also pleads for a sequential reaction of consumers. They first substituted card to cash payments, and they decreased the count of cleared withdrawals six months later. The average sum withdrawn did not increase enough to offset this decrease. We can plausibly assume that consumers first substituted card to cash payments, then substituted home to external withdrawals. The perceived cost of moving to a home ATM may be overestimated before experiencing the trip.

The increase in cleared card transactions can be considered as an excellent proxy of global bank transactions, since acquiring banks are numerous and the market is diluted. Moreover, since check payments represent roughly 15% of the aggregate amount of payments, and since the global amount withdrawn at external ATMs decreased, a reduction of the aggregate amount paid cash is almost certain. Only the configuration in which the increase of the total amount withdrawn at home ATMs would have offset the decrease in the total amount withdrawn at external ATMs, and in which the whole increase in card payments would result from a substitution from check payments would be not imply a reduction of the amount of cash payments. This is highly unlikely, since the share of check payments in amount is relatively modest (15 % according to ECB, 2012), and since check payments are typically made to delay actual payments and for frequent transactions like paying a rent, and for high transaction sizes. Check payments are also often made because they can be send through Postal mail (Humphrey *et al.*, 2000) and are typically not substitutable with cash or card payments (Humphrey *et al.*, 2001).

As stated earlier, cash is overused from the viewpoint of the benevolent planner, because it has by far the highest social costs per euro of transaction among the main retail payment instruments (cf for instance ECB, 2012 and Turján et al, 2011). Moreover, the decrease in the count of external withdrawals is also beneficial to the banks, since cash has also by far the highest private costs for the banks and since withdrawal cost account for half (ECB 2012).

Therefore, we make the following policy recommendation. Since we show that the demand for cash is decreasing with the costs of withdrawal, a tax on all withdrawals should increase welfare. The harm to consumers is capped by the difference between the preference for cash and the preference for card payments, which is markedly inferior to the welfare gain of other actors (see for instance Bergman et al., 2007 or Gresvik and Haare, 2009).

1.6 Conclusion

Surcharges have decreased the count of external withdrawals as well as the corresponding aggregate amount. They also increased the aggregate amount of card transactions.

We show the two assertions in a theoretical framework and provide supporting empirical evidence.

The model involves two axis of heterogeneity for consumers: the hardness of moving to a home ATM and the preference for cash payments (in other words, a consumer is identified to a point in a rectangle). They choose between three options: (i) drawing cash at a home ATM (ii) drawing cash at an external ATM or pay by credit card. We provide explicit functions for the aggregate amount paid by credit card, and for the aggregate amounts withdrawn at home and external ATMs.

We use a unique database from the French Automated Clearing House to provide empirical evidence to these theoretical conclusions. We observe the aggregate value of all credit card cleared transactions, the count of external withdrawals and the corresponding aggregate amount. Since the implementation of surcharges in France occurred in July 2002, we are able to assess the impact of the charging of external withdrawals using an interrupted time series design. Empirical results are fully compatible with theoretical conclusions.

Consumers anticipated the pricing of surcharges and first decreased the proportion of cash transactions in their spending in April 2002. Six months later, in September, and three months after the implementation of surcharges, consumers also substituted home to external withdrawals.

We provide strong evidence that the demand for cash is decreasing in the monetary costs of getting cash. Therefore, increasing the cost of withdrawing cash, both at external and home ATMs, should increase global welfare since the social costs of cash per euro of transaction are the highest, and since most academic studies conclude that surcharges are at least welfare neutral, regardless of the welfare efficiency of payment instruments. [5] We propose that all withdrawals be taxed. Since banks have an interest in reducing total cash processed, their cooperation towards the implementation of the tax is likely.

5. For a more complete discussion, cf for instance Chioveanu et al., 2009.

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Appendix: Proofs

In what follows, I note $(x)^+ = max(x,0)$.

Proof of proposition 1.1. Payer (b,h) pays with card if and only if his benefit to pay cash b is lower than both the hardness to move h and the surcharge s, i.e $b < \min(h,s)$. The demand for card payments M_{Card} is

$$\begin{aligned}
M_{Card}(s) &= \int\int_{D=b\leq min(h;s))} db.dh \\
&= \int\int_{D_1=b\leq h, h\leq s))} db.dh + \int\int_{D_2=b\leq s, s\leq h))} db.dh \\
&= \int_0^{min(s;\overline{b};\overline{h})} (\int_0^b dh)\,db + \int_s^{\overline{h}} (\int_0^s db)\,dh \\
&= \int_0^{min(s;\overline{b};\overline{h})} dh + (\int_s^{\overline{h}} dh)^+ \\
&= \frac{min(s;\overline{b};\overline{h})}{2} + s(\overline{h}-s)^+
\end{aligned}$$

Since we assume that $s \in I(s)$, we have $M_{Card}(s) = \frac{s}{2} + s(\overline{h}-s)$. $M_{Card}(s)$ is a trinomial in s, and is increasing if and only if its derivative is positive, *i.e.* $s < \overline{h}$. □

Proof of proposition 1.2. Payer (b,h) withdraws cash at an external ATM if and only if the surcharge s is lower than the preference for cash b and lower than the hardness to move h, i.e. $s < \min(h,b)$. The mass of consumers withdrawing at an external ATM $M_{EW}(s)$ is

$$M_{EW}(s) = \int\int_{D'=s<\min(h,b)} db.dh$$

$$\begin{aligned}
&= (\int_s^{\overline{b}} (\int_s^{\overline{h}} db)^+ dh))^+ \\
&= (\int_s^{\overline{b}} (\overline{h}-s)^+ dh)^+ \\
&= (\overline{b}-s)^+(\overline{h}-s)^+
\end{aligned}$$

Since we assume that $s \in I(s)$, we have $M_{EW}(s) = s - s(\overline{b} + \overline{h}) + \overline{bh}$. The proposition is immediate, given that $M_EW(s)$ is a trinomial in s. □

Proof of proposition 1.3. Payer (b,h) draws cash at an ATM of his bank if his hardness to move h is lower than both the surcharge s and his preference for cash b, i.e $h < \min(b,s)$. Therefore, the mass of consumers withdrawing money at an ATM of their banks ("Home Withdrawals") M_{HW} is

$$
\begin{aligned}
M_{HW}(s) &= \int_0^s (\int_s^{\overline{b}} db)^+ dh + \int_0^{min(s;\overline{b};\overline{h})} (\int_0^h db)\, dh \\
&= \int_0^s (\overline{b} - s)^+ dh + \int_0^{min(s;\overline{b};\overline{h})} h\, dh \\
&= s(\overline{b} - s)^+ + \frac{min(s;\overline{b};\overline{h})}{2}
\end{aligned}
$$

Since we assume that $s \in I(s)$, $M_{HW}(s) = -\frac{s}{2} + s(\overline{b}$. The conclusion is immediate since $M_{HW}(s)$ is a trinomial in s.

□

Note that we can further make a probabistic interpretation if we normalize the mass of consumers to one (*i.e.* $\int_0^{\overline{h}} \int_0^{\overline{b}} = 1$, or equivalently $\overline{h} = \frac{1}{\overline{b}}$). Each mass of consumers can be interpreted as the probability that a representative consumer chooses the corresponding payment option. The normalization of the mass of consumers yields a simpler expression for the probability that the representative consumer chooses to withdraw at an external ATM P_{EW}:

$$
P_{EW}(s) = M_{EW}(s) = s - s(\overline{b} + \frac{1}{\overline{b}}) + 1 = s - s(\overline{h} + \frac{1}{\overline{h}}) + 1
$$

Chapter 2

Do Sellers Adjust Prices to Be Paid Cash?

Bruno Karoubi and Régis Chenavaz

Abstract

A transaction between a seller and a buyer incurs a payment cost. The payment cost is mainly borne by the seller, depending on the payment instrument the buyer chooses, such as cash or card. Card payment is more costly than cash payment, so the seller prefers that the buyer pays cash. But she cannot force him to pay cash, nor can she pass the cost of card payment on him. In this paper, we study the strategy of the seller that sets a convenient price to push the buyer to pay cash. At a theoretical level, we model this strategy in a game theory setting. We derive that (1) the seller is more likely to set a more convenient price and (2) the buyer is more likely to pay a more convenient price in cash. At the empirical level, using an original data set based on a field inquiry, we give support to both theoretical propositions. Thus sellers adopt a strategy of convenient prices, which can successfully push buyers to pay cash.

Keywords: Convenient price, Pricing, Payment Instrument.

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2.1 Introduction

Frictionless markets, if they exist at all, are rare. A particular transaction cost is the payment cost that depends on the payment instrument, cash or card. Setting a different price according to the payment instrument is forbidden in most countries (Australia is an exception). Because of this *no surcharge rule*, the seller bears the payment cost even though the payment instrument is chosen by the buyer; she prefers him to pay with the less costly payment instrument.

For the seller, a cash payment causes few direct monetary costs (Lee, 2009), and the indirect costs, such as the storage costs, risks of loss, or theft tend to be underestimated (Hanemann, 1991; Robinson and Hammitt, 2011). Card payments instead are costly due to the cost of the terminal and the transaction fees paid to the network. The seller thus perceives a cash payment as less costly than a card payment (Bearing Point, 2009) and prefers a cash payment.

Yet the seller has limited options for encouraging a buyer to pay cash. If the seller refuses card payment, she may lose a sale or harm her reputation. Instead, the seller could set prices strategically, to make it more convenient for a buyer to pay cash. Consider for example a round price of €10. A buyer can easily pay this price with a single €10 note. An odd price of €9.99 also requires a single €10 note, though the seller returns a coin of ¢1 in this case. In contrast, a price of €10.03 requires one €10 note, a ¢2 coin and a ¢1 coin. Therefore, €10 is more *convenient* than €9.99, which in turn is more convenient than €10.03. Following Cramer (1983) and Knotek (2008, 2011), we refer to price as more convenient if a cash payment of this price involves fewer tokens (coins or notes). As such, a more convenient price makes the cash payment relatively less costly than the card payment for the buyer. Accordingly, setting a convenient price may be an option for the seller to foster cash payment by the buyer.

This paper addresses the question of convenient prices from the perspectives of both the seller and the buyer. Do sellers adjust their prices to make them more convenient? If so, do buyers pay more convenient prices in cash? In other words, is there a strategy of price convenience, and is this strategy successful?

The literature bases the convenience of a price on the (minimum) number of tokens required to pay it cash. Cramer (1983) defines as an *efficient payment* a payment which involves that number of tokens. This number of tokens is a good approximation of the cash payment behaviour (Franses and Kippers, 2007), which supports the *least effort principle*. The number of tokens is called *relative inconvenience* by Knotek (2008, 2011). On that basis, we define *objective convenience* and its monetary equivalent, namely *subjective convenience*.

In this paper, we contribute to extend the literature at both theoretical and empirical levels. Theoretically, we offer a micro-foundation to the perceived cost of the seller and buyer towards paying with cash or by card. To our knowledge, this article is the first source of testable analytical results, linking price stickiness to the perceived cost of different payment instruments. In a two-stage sequential game setting, we derive two testable propositions. First, the seller is more likely to set a more convenient price. Second, the buyer is more likely to pay cash a more convenient price. Empirically, we analyse an original data set, which we derive from a field inquiry. The analysis reveals that more convenient prices are more often set and more often paid by cash; the theoretical propositions are verified. Therefore, sellers apply a convenient price strategy, and this strategy is successful in encouraging buyers to pay cash.

We further establish that convenient prices, which reflect sellers' preference to be paid cash, constitute an overall category of psychological prices that include as special cases round and odd prices. In this sense, convenient prices are complementary to other approaches, such as menu costs as explanations of price stickiness. Price stickiness is an issue in itself, because of its effects on business cycles and monetary policies (Carlton, 1986; Levy *et al.*, 1997; Erceg *et al.*, 2000; Clarida *et al.* , 2001).

Moreover, as other measures based on the number of tokens used to pay a price, objective convenience is limited to positive integers. But subjective convenience, economically the monetary equivalent of objective convenience and mathematically a strictly increasing transformation of objective convenience, extends into positive reals. Therefore, by assessing subjective convenience, we can replicate and understand a wider range of price distributions.

2.2 Measures of Convenience

Define $Den = \{0.01, 0.02, 0.05, 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200, 500\}$, the set of facial values of euro tokens. Tokens from 1¢ to €2 are coins; tokens from €5 to €500 are notes. If a buyer pays cash for a product priced at €1, he may simply offer a €1 coin; if he pays cash €1.10, he may give a €1 coin and a 10¢ coin. The price of €1, paid with one coin, thus is said to be more *convenient* than the price of €1.10, paid with two coins. For brevity, we omit the monetary unit in the remainder of the theoretical section. For a more precise measure of convenience, we define in the next two subsections *objective convenience* and *subjective convenience*.

2.2.1 Objective Convenience

We define here objective convenience. Following the principle of least effort, the buyer and the seller exchange the minimum number of tokens required to pay a given price (Cramer 1983, Franses and Kippers 2007). Consider a few examples. First, a price of 10 requires that the buyer gives a 10 note. One token is involved: a note of 10. Second, a price of 10.10 implies a 10 note and a 0.10 coin. Two tokens are involved: a note of 10 and a coin of 0.10. Third, a price of 9.90 implies a return from the seller, to minimise the number of exchanged tokens. The buyer thus gives a 10 note, and the seller returns a 0.10 coin. Two tokens thus are involved: a note of 10 and a coin of 0.10. The number of tokens exchanged is computed using the direct and indirect greedy algorithms.

In the direct greedy algorithm, each step represents a token handed by the buyer to pay the exact sum asked by the seller. The buyer gives the highest token whose face value is equal or inferior to the price, then the token with highest face value equal or inferior to the residual price, and so on until the whole price is paid. In the first and the second examples, the direct greedy algorithm computes an exchange of one token and two tokens.

In the indirect greedy algorithm, the first step represents the initial token handed by the buyer, and subsequent steps correspond to the change returned. The buyer hands over the lowest token equal or superior to the price, then the seller returns change by applying the direct greedy algorithm to the difference between the token provided and the price. In the third example, the indirect greedy algorithm computes an exchange of two tokens.

Formally, the number of steps in the direct greedy algorithm is $DG(p)$ with $DG : \mathbb{R}^+ \to \mathbb{N}^+$, and the number of steps in the indirect greedy algorithm is $IG(p)$, with $IG : \mathbb{R}^+ \to \mathbb{N}^+$.

We call objective inconvenience the constrained minimum of number of tokens exchanged to pay the price. Depending on the cognitive ability of the buyer and seller, and on the tokens available for both sides, the constraints can be more or less strong. The theoretical model we now present is compatible with any definition of objective inconvenience. We only assume that the objective inconvenience is a strictly positive integer.

We consider the following measure of objective convenience for the empirical part and for the examples provided in the main body of the paper. The buyer compares the number of tokens exchanged if he pays the price with a minimum of tokens, but without change returned, and the number of tokens involved if he hands a single token and the seller returns change efficiently. He then pays with the method requiring a minimum number of tokens. This measure of convenience assumes that the buyer has a limited rationality (since he may exchange a non-minimal number of tokens with the seller, even though the number is a good approximation of the minimum). We therefore call this measure of convenience "Limited Rationality Objective Inconvenience" and we note it "LROI". $LROI(p)$ is the minimal number of steps between the direct and indirect greedy algorithms, $LROI(p) = \min\{DG(p); IG(p)\}$. In the remainder of the paper the notation $OI(p)$ is short for $LROI(p)$. "Objective Inconvenience function" refers to the "Limited Rationality objective function" in the examples and in the empirical tests presented in the remainder of the paper. We define however other possible Objective Inconvenience functions in the appendix. The measures and the relative algorithms are presented in the appendix(2B).

Let us give several examples. First, a price of 10 euros requires that the buyer gives a 10 euros note. One token is involved: a note of 10 euros. Second a price of 9.90 euros implies a return from the seller to minimise the number of exchanged tokens. The buyer gives a 10 euros note and the seller returns a 10 cents coin. Two tokens are involved: a note of 10 euros and a coin of 10 cents.

The objective inconvenience function $OI(p)$, with $OI : \mathbb{R}^+ \to \mathbb{N}^+$, is the minimal number of steps between the direct and indirect greedy algorithms, $OI(p) = \min\{DG(p); IG(p)\}$. Objective inconvenience increases with the number of tokens used to pay a transaction. Objective convenience function $OC(p)$, with $OC : \mathbb{R}^+ \to \mathbb{N}^-$, is the opposite of the objective inconvenience function: $OC(p) = -OI(p)$. The more tokens used to pay in a transaction, the lower is the objective convenience. This modelling preserves the intuitive economic interpretation that objective convenience increases with a more convenient price. Recalling the three examples, $OI(10) = 1$, $OI(10.10) = 2$, and $OI(9.90) = 2$. Therefore, $OC(10) = -1$, $OC(10.10) = -2$, and $OC(9.90) = -2$. The price 10 is objectively more convenient than 9.90 and 10.10 because $-1 > -2$.

Let S be the set of prices with positive demand and $\mathscr{P}(S)$ be the power set of S. The class of prices with the same objective convenience as price p is $Cl(p)$, with $Cl : \mathbb{R}^+ \to \mathscr{P}(S)$. A price p is said to be i-convenient if $OC(p) = -n$. If p is i-convenient, $Cl(p)$ refers to the set of i-convenient prices and $Cl(p) = \{z \in S \text{ such that } OC(z) = OC(p)\}$. Define Cl_i the class of i-convenient prices, $Cl_i = \{z \in S \text{ such that } OC(z) = -i\}$. Recalling the examples, 10 is a 1-convenient price, whereas 10.10 and 9.90 are 2-convenient prices. As such, $10 \in Cl_1$ and $(9.90, 10.10) \in Cl_2^2$.

2.2.2 Subjective convenience

Before to study subjective convenience, we define the subjective inconvenience function $SI(p)$, with $SI : \mathbb{R}^+ \to \mathbb{R}^+$. Subjective inconvenience is the monetary equivalent of the objective inconvenience OI, determined according to the difficulty of decomposing price p into tokens (because of cognitive costs), handing them to the seller, and carrying the change. Objective inconvenience increases with the number of tokens used to pay a transaction. Subjective convenience function $SC(p)$, with $SC : \mathbb{R}^+ \to \mathbb{R}^-$, is the opposite of the subjective inconvenience function: $SC(p) = -SI(p)$. The more tokens used in a transaction, the lower the subjective convenience. Following the intuition, subjective convenience increases with a more convenient price.

We assume that $\forall (p_A, p_B, p_C) \in S^3$,

$$OC(p_A) > OC(p_B) \Rightarrow SC(p_A) > SC(p_B), \tag{2.1a}$$

$$OC(p_A) = OC(p_B) \Rightarrow SC(p_A) = SC(p_B). \tag{2.1b}$$

Equation (2.1a) states that subjective convenience is strictly increasing with objective convenience (strictly decreasing in the number of tokens). Equation (2.1b) implies that two different prices with the same objective convenience have the same subjective convenience. For example, the buyer is indifferent between paying 1 with one coin or 10 with one note.

2.3 Model

2.3.1 Setting

In the setting, there are two players, a seller and a buyer. First, the seller sets a price p according to her market power $\overline{p}$ and the probability that the buyer pays p with cash or by card. The price is such that the buyer is willing to pay. Second, the buyer chooses to pay with cash or with card.

2.3.1.1 The Seller (he)

We study the seller's strategy of price adjustment. The production cost is normalised to zero. Let an *admissible price* be a price that the buyer is willing to pay. Let S be the set of admissible prices. The set S is compact with a lower bound 0 and an upper bound $\overline{p}$, $S = [0, \overline{p}]$. The maximum price $\overline{p}$ increases with her market power. The profit is null for $p = 0$ and demand vanishes for $p > \overline{p}$. In a competitive market (no market power), $\overline{p} = 0$; the seller must set $p = 0$ and makes no profit. In a monopolistic market (with market power), $\overline{p} > 0$; the seller can set $p = \overline{p}$ and still earn profit.

If the product is paid cash, the cost of cash management is $s_{cash} \in \mathbb{R}^+$. The parameter s_{cash} captures the cost in time, as required to sort tokens and move them to the bank, as well as storage costs, loss risks, and theft risks. It also comprises the cognitive cost associated with the decomposition of price into tokens. If the product is paid by card, the relevant costs are the direct transaction costs, denoted $s_{card} \in \mathbb{R}^+$. The s_{card} parameter represents the cost of buying a terminal, plus the payments to the card network. The parameters s_{cash} and s_{card} are drawn from two uniform distributions, $s_{cash} \in [\underline{s}_{cash}, \overline{s}_{cash}]$ and $s_{card} \in [\underline{s}_{card}, \overline{s}_{card}]$.

The net cost of card management for the seller is $s = s_{card} - s_{cash}$. If $s > 0$, the card cost s_{card} is higher than the cash cost s_{cash}. As the difference between two uniform variables, s is also a uniform variable. We thus have $s \in [\underline{s}_{card} - \overline{s}_{cash}, \overline{s}_{card} - \underline{s}_{cash}] = [\underline{s}, \overline{s}]$. We normalise $[\underline{s}, \overline{s}]$ so that $\overline{s} - \underline{s} = 1$ for a probabilistic interpretation.

2.3.1.2 The Buyer (he)

The buyer accepts the price set by the seller, though this assumption also may be partially relaxed. We only require that the subjective inconvenience effect does not exclude the buyer; the buyer always would prefer to pay with card rather than not purchase the product at all. Thus, the buyer chooses between paying cash or with credit card. Regardless of the subjective inconvenience, the cost of the cash payment is $b_{cash} \in \mathbb{R}^+$ and the cost of card payment is $b_{card} \in \mathbb{R}^+$. The parameters b_{cash} and b_{card} are drawn from uniform distributions, $b_{cash} \in [\underline{b}_{cash}, \overline{b}_{cash}]$ and $b_{card} \in [\underline{b}_{card}, \overline{b}_{card}]$.

The net cost of card payment for the buyer is $b = b_{card} - b_{cash}$. If $b > 0$, the card cost b_{card} is higher than the cash cost b_{cash}. Because it reflects the difference of two uniform variables, b is a uniform variable. Therefore, $b \in [\underline{b}_{card} - \overline{b}_{cash}, \overline{b}_{card} - \underline{b}_{cash}] = [\underline{b}, \overline{b}]$ and we normalise $[\underline{b}, \overline{b}]$ such that $\overline{b} - \underline{b} = 1$, which yields a probabilistic interpretation.

To exclude singular cases and prove Proposition 2.3 in Appendix A, we make the following technical assumption: For all $(p_A, p_B) \in S^2$ and $p_A \neq p_B$, we have

$$\max\left(\frac{SC(p_A) - SC(p_B)}{p_A - p_B}\right) > \max(\overline{s}; -\frac{1}{E(s)}). \tag{2.2}$$

2.3.1.3 Timing of the Game

The timing of the game is sequential as follows: First, the seller sets a price $p \in [0, \overline{p}]$ that the buyer accepts to pay. Second, observing the price p and according to his subjective convenience $SC(p)$, the buyer decides to pay with cash or by card. We look for the subgame perfect equilibrium of this game.

2.3.2 Resolution

We solve the game by backwards induction, starting with the last stage.

2.3.2.1 The Buyer: Choice of Payment Instrument (Stage 2)

The buyer minimises the cost of the transaction payment *Cost* by choosing payment instrument I (*cash* or *card*), given the net cost of card $b = b_{card} - b_{cash}$ and the price p. The cost of paying cash is $b_{cash} - SC(p)$ (recall that $SC(p) < 0$ for all p), and the cost of paying by card is b_{card}.

The buyer pays cash if the cost of paying by card is higher than the cost of paying cash, $b_{card} > b_{cash} - SC(p)$. This is equivalent to $b_{card} - b_{cash} = b > -SC(p)$, such that he pays cash if b_{card} is high enough relative to b_{cash} to compensate for the subjective convenience effect. In contrast, the buyer pays by card if $b_{cash} - SC(p) > b_{card}$, that is $b < -SC(p)$, which indicates that b_{cash} is high relative to the subjective effect $SC(p)$ and to b_{card}. The cost of paying by card is b_{card}. Cash is the default payment instrument.

The program of the buyer is

$$\min_{I \in \{cash, card\}} Cost(I) = (b_{cash} - SC(p))\mathbb{1}_{\{b+SC(p) \geqslant 0\}} + b_{card}\mathbb{1}_{\{b+SC(p)<0\}},$$

where $\mathbb{1}_{condition}$ is an indicator variable that equals 1 if *condition* is true and 0 otherwise.

Let $P(p,I)$ be the probability that the buyer pays the price p with the payment instrument I. The buyer pays by card if the price is not subjectively convenient enough and with cash if the price is subjectively convenient enough. Because b follows a uniform distribution,

$$P(p,card) = \int_{\underline{b}}^{-SC(p)} du, \; P(p,cash) = \int_{-SC(p)}^{\overline{b}} du, \tag{2.3}$$

with the probability that the buyer pays either by card or with cash $P(p, card \cup cash) = \int_{\underline{b}}^{\overline{b}} du = \overline{b} - \underline{b} = 1$.

2.3.2.2 The Seller: Choice of Price p (Stage 1)

The seller maximises the expected profit $E(\pi)$ by choosing the price p. The program of the seller is

$$\max_{p \in S} E(\pi(p)).$$

If the buyer pays by card, $\pi = p - s$. If the buyer pays cash, $\pi = p$. Therefore,

$$\begin{aligned} E(\pi(p)) &= (p-s)P(p,card) \; + pP(p,cash) \\ &= (p-s)\int_{\underline{b}}^{-SC(p)} du \; + p\int_{-SC(p)}^{\overline{b}} du \\ &= (p-s)(-SC(p)-\underline{b}) + p(\overline{b}+SC(p)) \\ &= p(\overline{b}-\underline{b}) + s(SC(p)+\underline{b}) \\ &= p + s(SC(p)+\underline{b}). \end{aligned}$$

If subjective convenience does not into play, $SC = 0$. If it does, $SC < 0$. Let p_0 be the profit-maximising price with $SC(p_0) = 0$ (the subjective convenience does have an effect). Let p^* be the profit-maximising price, with $SC(p^*) < 0$ (subjective convenience exerts an effect). We note $F(p) = \bigcup_{i=OC(p)}^{-1} \max_{m \in Cl_i} m$. $F(p)$ is the set of maximum prices of each convenience class for which objective convenience is superior or equal to the objective convenience of p. For example, 10.10 is 2-convenient (because $OC(10.10) = -2$). The highest 2-convenient price inferior or equal to 10.10 is 10.10. The highest 1-convenient price inferior or equal to 10.10 is

10 (because $OC(10) = -1$). Thus, $F(10.10) = \{10; 10.10\}$. Let a *candidate price* be a price with a positive probability to be set; the seller may set a price only if it is a candidate price.

Lemma 2.1.

$$p^* = \arg\max_{p \in S} \pi(p) = \arg\max_{p \in F(p_0)} \pi(p).$$

The profit-maximising price if subjective convenience comes into play p^* is the highest admissible price in a convenience class Cl_i. Because p_0 is the profit-maximising price if subjective convenience does not play, $F(p_0)$ is the set of candidate prices.

Proof. The proof is in Appendix A. □

If p_0 is i-convenient, there are at most $n = Card(F(p_0))$ prices with a positive probability to be set by the seller. The highest price in the objective convenience class is set, $P(p \notin F(p)) = 0$ (in particular $P(p_0) = 0$). Candidate prices are strictly ordered with regard to objective convenience.

Assume for example that the seller has enough market power to sell at 10.10, such that 10.10 belongs to the set of admissible prices S. Then Lemma 2.1 states that the seller would rather set a price of 10.10 than a price of 9.90, because $OC(10.10) = OC(9.90) = -2$ and $10.10 > 9.90$.

We note $J_{\varepsilon,\phi} = \{[p_0 - \varepsilon; p_0 + \phi]$ such that for all $i \in [\![OC(p_0), -1]\!]$, there exists $p_i \in [p_0 - \varepsilon; p_0 + \phi]$, $OC(p_i) = -i\}$. We also note $J(p_0) = \bigcap_{\varepsilon \in \mathbb{R}^+, \phi \in \mathbb{R}^+} J_{\varepsilon,\phi}$. Let $p_i^{max} = \max_{m \in Cl_i \cap S} m$ be the highest i-convenient admissible price. Then, we have

Lemma 2.2.

$$p^* \in J(p_0).$$

The profit-maximising price if subjective convenience comes into play p^* belongs to $[\underline{p}^*, \overline{p}^*]$, with $\underline{p}^* = \min_i p_i^{max}$ and $\overline{p}^* = \max\{\max_i p_i^{max}; p_0\}$. The profit-maximising price if subjective convenience does not come into play p_0 belongs to that interval.

Proof. The proof is in Appendix A. □

By Lemma 2.2, the assumption that the buyer accepts any price $p \in J(p_0)$ is equivalent to the assumption that the buyer accepts any price $p \in [0; \overline{p}]$. It is also equivalent to the assumption that the buyer accepts any price $p \in J(\underline{p}^*)$ if the probability of acceptance is inelastic to the price.

Assume for example that p_0, the profit-maximising price if $SC = 0$, is 9.97, and $\overline{p}$, the maximum admissible price, is 10. The prices 9.97 and 10 are 3-convenient and 1-convenient. Also, the highest admissible 1-convenient and 3-convenient prices are 10 and 9.97. Following Lemma 2.2, p^*, the profit-maximising price if $SC > 0$, belongs to $[\underline{p}^*, \overline{p}^*]$, with $\underline{p}^* = \min\{9.97; 9.99; 10\} = 9.97$ and $\overline{p}^* = \max\{9.97; \max\{9.97; 9.99; 10\}\} = 10$. Therefore, $[\underline{p}^*, \overline{p}^*] = [9.97, 10]$. We verify that $p_0 = 9.97$ belongs to the interval.

Let $P(p)$ be the probability that the seller sets a price p.

Proposition 2.3. *Let p_A and p_B be candidate prices, $(p_A, p_B) \in F(p_0)^2$. We have*

$$OC(p_A) > OC(p_B) \implies P(p_A) > P(p_B).$$

The higher the objective convenience of a price, the higher is the probability that the seller sets it.

Proof. The proof is in Appendix A. □

The seller is more likely to set a more objective convenient candidate price. For example, even if the buyer would accept paying 10.10, the probability that the seller sets a price of 10 is greater than the probability that she sets a price of 10.10, because $OC(10) = -1 > OC(10.10) = -2$.

Let $P(p, cash)$ be the probability that the buyer pays cash price p.

Proposition 2.4. *Let p_A and p_B be candidate prices, $(p_A, p_B) \in F(p_0)^2$. We have*

$$OC(p_A) > OC(p_B) \implies P(p_A, cash) > P(p_B, cash).$$

The higher the objective convenience of a price, the higher is the probability that the buyer pays cash.

Proof. The proof is in Appendix A. □

The buyer is more likely to pay cash a more objectively convenient candidate price. For example, the probability that the buyer pays cash 10 is greater than the probability that he pays cash 10.10, because $OC(10) = -1 > OC(10.10) = -2$.

An implication of Propositions 2.3 and 2.4 is that there is a subjective convenience threshold for the use of a payment instrument. Below this subjective convenience threshold, the price is paid by card; above the subjective convenience threshold, the price is paid with cash. Therefore, the domains of card and cash payments are compact with respect to subjective convenience and non-compact with respect to price, as opposed to Whitesell (1989).

2.4 Data

TABLE 2.1: Payment Characteristics

	Min	Max	Mean	SD
% of prices paid cash			47.4%	
% of prices paid with card			52.6%	
Price occurrences paid cash	0	7	0.9	1.4
Price occurrences paid with card	0	3	0.6	0.6
Price occ paid cash or with card	1	7	1.5	1.1
Direct greedy steps	1	12	5.2	2.3
Indirect greedy steps	2	10	4.8	1.8
Objective convenience	-8	-1	-3.9	1.5

Notes. Cash and card are dummies for transactions paid with cash and by card. The number of price occurrences is the number of transactions at a given price. Objective convenience is the opposite of the minimum steps of the direct and indirect greedy algorithms.

The original data set comes from a field inquiry. We chose a retail store, that faced imperfect competition, so that the seller may adjust the price more readily. We noted the prices and payment instruments (cash or card) used to purchase a single product, for which sellers better control the price. Table 2.1 lists the payment characteristics. Of the 411 prices, ranging from 0.57¢ to €480, 91.75% of them are inferior to €100. Just less than half of the transactions are paid cash (47.4%) and a little more than half are paid by card (52.6%). There are 113 repeated prices (86 paid cash, 27 paid by card). Recall that objective convenience is the opposite of the number of tokens. For some prices, only one token is required; maximum objective convenience is -1. Other prices demand a minimum of 8 tokens; in this case, the minimum objective convenience is -8.

2.5 Empirical Results

The empirical results are based on the measure of objective convenience, which increases with the convenience of a price (fewer tokens required). We use the variable price occurrences (or number of occurrences of each price, or number of repetitions for each price), which differs from the number of transactions (or number of price observations). For instance, for the following prices distribution $\{1;2;3;3\}$, there are four transactions at three different prices, one occurrence for $p = 1$, one occurrence for $p = 2$, and two occurrences for $p = 3$.

To support Proposition 2.3 and Proposition 2.4, we study two pairs of variables. The first pair is the objective convenience of the price and the number of price occurrences (or the number of transactions at a given price). The second pair is the objective convenience of the price and the number of prices occurrences paid cash. In the first pair, if objective convenience relates positively to the number of price occurrence, the seller is more likely to set a more convenient price. A positive relation supports Proposition 2.3. In the second pair, if objective convenience is positively associated with the number of price occurrences paid cash, the buyer is more likely to pay cash a more convenient price. A positive association gives evidence to Proposition 2.4.

For both pairs, we test for statistical independence using the tests of χ^2 and Kruskall-Wallis. The χ^2 test makes no assumption about the underlying distributions, whereas Kruskal-Wallis assumes that distributions of populations have broadly the same shape, which is verified in the data set. Moreover, we compute Pearson correlation coefficient and Kendall's tau to test for independence and also to determine the direction of any potential relations. The significance test of the Pearson correlation coefficient requires no assumption about the underlying distributions and Kendall's tau test assumes that each variable is ordered, as we verify in the data set. All the tests are non-parametric; they do not require normality assumptions.

The independence results of the two pairs in Table 2.2 are the subjects of our discussions in the next two subsections.

TABLE 2.2: Independence of Objective Convenience to the Price Occurrences and to the Price Occurrences Paid Cash

	χ^2	Kruskall-Wallis	Correlation	Kendall's tau
OC / price occ	243.1	74.0	0.42	22,907
OC / p occ cash	219.5	57.9	0.39	19,218

Notes. All p-values are under 0.001. χ^2 have 35 and 42 degrees of freedom for the first and second pairs. Kruskal-Wallis have 7 degrees of freedom for both pairs. OC is objective convenience; price occ is the price occurrences; p occ cash is the price occurrences paid cash. Correlation is the Pearson correlation coefficient.

2.5.1 Sellers set convenient prices more often

2.5.1.1 Independence tests

With regard to independence tests, the first line of Table 2.2 shows a positive relation between objective convenience and the number of price occurrences. The χ^2 and Kruskall-Wallis indicate a strong relation between the pair of variables. The Pearson correlation and Kendall's tau also confirm the relation and also show that the relation is positive. Each test is statistically significant (each p-value is under 0.001). The results in Table 2.2 therefore confirm Proposition 2.3: the more convenient a price, the more likely the seller is to set it.

2.5.1.2 Regression

The regression estimates check the robustness of the independence tests and enrich the results. We estimate an ordered probit and a binary probit. For the ordered probit, n is the number of price occurrences. The variable n is determined by a latent variable n^*. Let T_i be the threshold relative to n^* with the convention $\overline{T}_i = \underline{T}_{i+1},\ i \in [\![1,\ -\min_{p\in S} OC(p) - 1]\!] = [\![1,3]\!]$. There are four modalities and three thresholds for the price occurrences (in the data set, the same prices are observed between one and four times). We have

$$P(n = i) = P(\underline{T}_i \leq n^* \leq \overline{T}_{i+1}),$$

where

$$n^* = F(a_1 \text{ObjectiveConvenience(Price)} + a_2 \ln(\text{Price}) + \varepsilon).$$

We assume that F approximates a normal cumulative distribution and we estimate an ordered probit, followed by a binary probit. For the ordered probit, the dependent variable is the number of occurrences of each price. For the binary probit, the dependent variable equals 0 if there is exactly one price occurrence and 1 if there are two or more price occurrences. Proposition 2.3 implies that the seller is more likely to set a price with higher objective convenience; we expect $a_1 > 0$. Moreover, the probability that the seller sets the exact a price decreases with the transaction size (measured by the price logarithm), and $a_2 < 0$.

TABLE 2.3: Effects of Objective Convenience and Transaction Size on the Price Occurrences

Dep variable: price occurrences	(1)	(2)	(3)	(4)
Objective convenience	0.52^a	0.60^a	3.49^a	3.69^a
	(0.09)	(0.08)	(0.55)	(0.58)
Log of price	-0.27^a	-0.32^a	-3.57^a	-3.75^a
	(0.08)	(0.07)	(0.82)	(0.87)
LR χ^2 (2 df)	73.23^a	152.92^a		
	(0.00)	(0.00)		
Pseudo-R^2	0.21	0.32		
N	345	411		

Notes. ^{a} $p < 0.001$, ^{b} $p < 0.01$, ^{c} $p < 0.05$. Standard errors are below the coefficients in parentheses. The p-value is below the χ^2. The transaction size is measured with the logarithm of price. Taking the logarithm of price enhances the likelihood ratio (LR). Column (1) gives the ordered probit estimation, and Column (2) gives the binary probit estimation. For the ordered probit, the dependent variable is price occurrences. For the binary probit, the dependent variable equals 0 if the price is unique and 1 otherwise. Thus there are fewer observations for the ordered than for the binary probit. Columns (3) and (4) give the elasticities calculated from the binary probit at the mean and at the median. The constant is not reported.

Table 2.3 shows that higher objective convenience leads to more price occurences. The ordered probit in Column (1) gives a point estimate for objective convenience that is positive and highly statistically significant. The point estimate with the binary probit in Column (2) shows a larger and even more precise coefficient. The point estimates for the ordered and binary probits lack direct interpretation. For the ordered probit, we cannot calculate point elasticities, because there are four modalities of price occurrences and two independent variables. But for the binary probit, we compute these elasticities. An increase of 10% in objective convenience augments the price occurrences by about 35% at the mean (third column) and 37% at the median (fourth column). The elasticity is strong and significant. In contrast, the four columns indicate a strong negative and highly significant transaction size effect. An increase of 10% of the transaction size decreases the price occurrences by around 36% at the mean and the median. Therefore objective convenience increases price occurrences, and the point estimate is robust to the transaction size. The regression estimates confirm Proposition 2.3: The seller is more likely to set a more convenient price.

That is, the independence tests and regression estimates both support Proposition 2.3. The seller conducts a strategy of price convenience.

2.5.2 Buyers Pay Convenient Prices More Often Cash

2.5.2.1 Independence Tests

With respect to independence tests, the second line of Table 2.2 indicates a positive relation between objective convenience and the number of price occurrences paid cash. The χ^2 and Kruskall-Wallis tests indicate a relation among the variables. The Pearson correlation and Kendall's tau confirm the relation, and also show that the link is positive. Each test is statistically significant (each p-value is under 0.001). Thus, each result in Table 2.2 confirms Proposition 2.4: the more convenient a price, the more likely the buyer is to pay cash.

2.5.2.2 Regressions

The regression estimates complement the independence tests. We also consider several robustness checks of the independence tests. Whitesell (1989) assumes that the buyer chooses between paying cash and by card. In his setting, the cost of a card payment is fixed (linked to a subscription fee) and the cost of cash is proportional to the transaction size (foregone interests). Thus, transactions below a certain threshold are paid for with cash, and the others are paid by card. Empirical studies confirm that fewer cash payments take place as the transaction sizes increase (Mot and Cramer, 1992; Klee, 2008). Our data set is consistent with this assumption. In Table 2.4, we sort the transaction sizes into ten classes and list the proportion of cash payments for each class. The cash payment proportion decreases with a higher transaction size, such that cash payments are less likely with higher prices. This effect, however, may originate from a size effect or because convenient prices are less frequent at higher prices. Therefore, we control for the size effect.

TABLE 2.4: Transaction Size and Proportion of Cash Payments

Correlation Between Transaction Size and Proportion of Cash Payment (p-value): -0.22 (0.000)										
Decile of prices	1	2	3	4	5	6	7	8	9	10
Upper border price for class	4.0	7.9	10.9	16.1	21.0	29.4	40.0	57.0	86.8	480.0
Proportion of cash payment	87%	78%	54%	47%	44 %	29 %	18%	22%	22%	24%

Note. Each class represents a decile of prices. Classes are ordered in the sense that the highest price of class i is just inferior to the lowest price of class $i+1$. Of these prices, 92.23% are less than € 100, and the minimum price is 57 ¢. The logarithm of price measures the transaction size.

We estimate an ordered probit and a binary probit. For the ordered probit, n is the number of price occurrences if the price is paid cash. There are five modalities. The zero modality corresponds to a card payment, and there are up to four cash transactions at the same price (Table 2.1). The distribution of the latent variable n^* is

$$n^* = F(b_1 \text{ObjectiveConvenience(Price)} + b_2 \ln(\text{Price}) + \varepsilon).$$

We assume that F approximates a normal cumulative distribution. For the ordered probit, the dependent variable is the number of occurrences of each price paid cash. For the binary probit, the dependent variable equals 0 if the price is paid by card and 1 if the price is paid cash. According to Proposition 2.4, a more convenient price is more likely to be paid cash; it implies $b_1 > 0$. Table 2.4 suggests a size effect, because the price occurrences paid cash decrease with higher prices, such that $b_2 < 0$.

Table 2.5 reveals that high objective convenience augments the number of price occurrences paid cash. As expected, the ordered probit (Column 1) shows a positive and statistically significant correlation between objective convenience and the price occurrences paid cash. The binary probit (Column 2) indicates a stronger and highly significant relationship. Specifically, an increase of 10% in objective convenience raises the number of price occurrences paid cash by 4.8% at the mean (third column) and 7.7 % at the median (fourth column). The first and second columns confirm a strong transaction effect: the larger is the price, the fewer price occurrences paid cash. With respect to the elasticities, a 10% increase in the logarithm of the price lowers

TABLE 2.5: Effects of Objective Convenience and Transaction Size on the Price Occurrences Paid Cash

Dep variable: cash price occ	(1)	(2)	(3)	(4)
Objective convenience	0.14^b	0.51^a	0.48^a	0.67^a
	(0.05)	(0.08)	(0.67)	(0.72)
Log of price	-0.46 ^{a}	-0.47^a	-6.19^a	-6.50^a
	(0.06)	(0.08)	(1.18)	(1.26)
LR χ^2 (2 df)	93.40 ^{a}	137.27 ^{a}		
	(0.000)	(0.000)		
Pseudo-R^2	0.14	0.33		
N	373	411		

Notes. ^{a} $p < 0.001$, ^{b} $p < 0.01$, ^{c} $p < 0.05$. Standard errors are below the coefficients in parentheses. The p-value is below the χ^2. The transaction size is measured with the logarithm of price. Taking the logarithm of price enhances the likelihood ratio (LR). Column (1) gives the ordered probit estimation, and Column (2) gives the binary probit estimation. For the ordered probit, the dependent variable is the occurrences of price paid cash. For the binary probit, the dependent variable equals 0 if the price is paid by card and equals 1 if the price is paid cash. Therefore there are fewer observations for the ordered than for the binary probit. Columns (3) and (4) give the elasticities calculated from the binary probit at the mean and at the median. The constant is not reported.

the price occurrences paid cash by about 6.4% at the mean and at the median. The implication is that objective convenience has a positive impact on the proportion of cash payments, even after controlling for the transaction size; Proposition 2.4 thus is confirmed.

Here again, the independence tests and regression estimates both offer an empirical foundation for Proposition 2.4. The buyer is more likely to pay cash in response to a more convenient price. Therefore, the convenience price strategy of the seller is successful, because it promotes cash payments.

2.6 Conclusion

We examine if sellers set convenient prices to encourage buyers to pay cash and if this strategy is successful. We develop a theoretical model, based on game theory, that accounts for the seller's and buyer's perceived cost of payment instrument. We derive analytical results and formulate two testable propositions: More convenient prices are (1) more likely to be set by the seller and (2) more likely to be paid for with cash by the buyer. To test the propositions, we use an original data set, obtained through a field inquiry. The empirical evidence supports both theoretical propositions: Convenient prices are set more often set and paid for with cash more often. We thus conclude that sellers conduct a convenient price strategy and that this strategy is effective.

This study introduces the relative cost of using a payment instrument for a rational seller and a rational buyer. It thus establishes the first micro-foundation for price convenience. Price convenience is measured with objective convenience and its monetary equivalent, subjective convenience. Considering subjective convenience, there is no more threshold price below which the price gets paid with cash and above which it is paid by card, contrary to Whitesell (1989). Moreover, subjective convenience (a real measure) accounts for a wider variety of price distributions than other measures of convenience based on the number of tokens needed to pay a transaction (an integer measure). Our study also highlights the role of price convenience in price distributions. As such, it leads to a more comprehensive understanding of price stickiness and psychological prices.

Appendix A

We first show a sublemma:

Sublemma 1.

$$\forall i,\ \arg\max_{p \in Cl_i} \pi(p) = \max_{p \in Cl_i} p.$$

In each convenience class, the profit-maximising price is the highest admissible price.

Proof of Sublemma 1. Define p_m as the highest maximising price: $p_m = \max_{p \in Cl_i}$. Assume $p_m \neq p_n$, $OC(p_m) = OC(p_n)$, and $\pi(p_m) < \pi(p_n)$. Then,

$$p_m \overline{b} + sSC(p_m) < p_n \overline{b} + sSC(p_n).$$

The last inequality and Equation $(2.1b)$ together imply $p_m < p_n$, which is a contradiction. □

Proof of Lemma 2.1. The proof of Lemma 2.1 is immediate, using Sublemma 1 and considering that S is the reunion of convenience classes, $S = \bigcup_{i \in [\![\min\{OC(p), p \in S\}, -1]\!]} Cl_i$. □

Proof of Lemma 2.2. The proof is immediate, considering Sublemma 1 and $(F(\overline{p}) \cup \overline{p}) \subset J(p_0)$.

□

Proof of Proposition 2.3. Assume $(p_A, p_B) \in (F(p) \cup p_0)^2$ and $OC(p_A) > OC(p_B)$ (p_A is objectively more convenient than p_B). If $p_A > p_B$, then both convenience and direct effects on the profit lead the seller to set p_A. Recall that $\overline{b} - \underline{b} = 1$. If $p_B > p_A$, the following inequalities become equivalent:

$$\pi(p_A) - \pi(p_B) = (p_A - p_B)(\overline{b} - \underline{b}) + s(SC(p_A) - SC(p_B)) > 0,$$

$$(p_A - p_B) > s(SC(p_B) - SC(p_A)).$$

Equation (2.1a) yields $SC(p_A) > SC(p_B)$. Therefore,

$$\pi(p_A) > \pi(p_B) \Leftrightarrow s > \frac{p_B - p_A}{SC(p_A) - SC(p_B)}.$$

Profit is higher with the more convenient price p_A if the cost of card management s is higher than $\frac{p_B - p_A}{SC(p_A) - SC(p_B)}$, that is, the price gain in units of subjective convenience loss when p_A increases to p_B. Define $\lambda = \frac{p_B - p_A}{SC(p_A) - SC(p_B)}$. Because of (2.2), we have $\lambda \geqslant \underline{s}$. If $\lambda > \overline{s}$, the seller sets p_A to obtain higher profit.

Let $s(p)$ be the set of s for which the seller sets p and $P(p_{A>B})$ be the probability than the seller prefers p_A over p_B. We have

$$P(p_{A>B}) = \frac{\int_{s(p_A)} du}{\int_{\underline{s}}^{\overline{s}} du} = \frac{\int_{\lambda}^{\overline{s}} du}{1} = \overline{s} - \lambda,$$

$$P(p_{B>A}) = \frac{\int_{s(p_B)} du}{\int_{\underline{s}}^{\overline{s}} du} = \frac{\int_{\underline{s}}^{\lambda} du}{1} = \lambda - \underline{s}.$$

We have

$$P(p_{A>B}) - P(p_{B>A}) = \int_{s(p_A) \setminus s(p_B)} du = (\overline{s} + \underline{s}) - 2\lambda,$$

and with (2.2), we obtain

$$P(p_{A>B}) > P(p_{B>A}).$$

If p_A is objectively more convenient than p_B, then the probability that the seller prefers p_A over p_B is greater than the probability that she prefers p_B over p_A. In addition, the profit-maximising price, regardless of subjective convenience effect p_0, is set with a probability of zero ($p_0 \notin F(p_0) \implies P(p_0) = 0$). □

Proof of Proposition 2.4. The buyer minimises the payment cost of the transaction by choosing to pay with either cash or card, given the relative cost of the card b and the price p. The program of the buyer implies $P(p, cash) = P(b \geqslant -SC(p)) = \overline{b} + SC(p)$ and together with (2.1a), it leads to

$$OC(p_A) > OC(p_B) \implies P(p_A, cash) > P(p_B, cash).$$

If p_A is objectively more convenient than p_B, then the probability that the buyer pays p_A cash is greater that the probability that he pays p_B cash. □

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Appendices for Chapter 2

Appendix A: Proofs

We first prove a sublemma.

Sublemma 2.

$$\forall i,\ \arg\max_{p \in Cl_i} \pi(p) = \max_{p \in Cl_i} p.$$

In each convenience class, the profit maximising price is the highest admissible price.

Proof of Sublemma 2. Define p_m as the highest maximising price: $p_m = \max_{p \in Cl_i}$. Assume $p_m \neq p_n$, $OC(p_m) = OC(p_n)$, and $\pi(p_m) < \pi(p_n)$. Then,

$$p_m \overline{b} + sSC(p_m) < p_n \overline{b} + sSC(p_n).$$

The last inequality and (2.1b) implies $p_m < p_n$, which is a contradiction. □

Proof of Lemma 2.1. The proof of Lemma 2.1 is immediate using Sublemma 1 and considering that S is the reunion of convenience classes, $S = \bigcup_{i \in [\![\min\{OC(p), p \in S\}, -1]\!]} Cl_i$. □

Proof of Lemma 2.2. The proof is immediate considering Sublemma 1 and $(F(\overline{p}) \cup \overline{p}) \subset J(p_0)$. □

Proof of Proposition 2.3. Assume $(p_A, p_B) \in (F(p) \cup p_0)^2$, $OC(p_A) > OC(p_B)$ (p_A is objectively more convenient than p_B). If $p_A > p_B$ then both convenience and direct effects on the profit lead to setting p_A. Recall $\overline{b} - \underline{b} = 1$. If $p_B > p_A$, the following inequations are equivalent

$$\pi(p_A) - \pi(p_B) = (p_A - p_B)(\overline{b} - \underline{b}) + s(SC(p_A) - SC(p_B)) > 0,$$

$$(p_A - p_B) > s(SC(p_B) - SC(p_A)).$$

Equation (2.1a) yields $SC(p_A) > SC(p_B)$. Therefore

$$\pi(p_A) > \pi(p_B) \Leftrightarrow s > \frac{p_B - p_A}{SC(p_A) - SC(p_B)}.$$

The profit is higher with the more convenient price p_A if the cost of card management s is higher than $\frac{p_B-p_A}{SC(p_A)-SC(p_B)}$, the price gain in unit of subjective convenience loss when p_A increases to p_B. Define $\lambda = \frac{p_B-p_A}{SC(p_A)-SC(p_B)}$. Because of (2.2), we have $\lambda \geqslant \underline{s}$. If $\lambda > \overline{s}$, the seller sets p_A to obtain higher profit.

Let $s(p)$ be the set of s for which the seller sets p and $P(p_{A>B})$ the probability than the seller prefers p_A over p_B. We have

$$P(p_{A>B}) = \frac{\int_{s(p_A)} du}{\int_{\underline{s}}^{\overline{s}} du} = \frac{\int_{\lambda}^{\overline{s}} du}{1} = \overline{s} - \lambda,$$

$$P(p_{B>A}) = \frac{\int_{s(p_B)} du}{\int_{\underline{s}}^{\overline{s}} du} = \frac{\int_{\underline{s}}^{\lambda} du}{1} = \lambda - \underline{s}.$$

We have

$$P(p_{A>B}) - P(p_{B>A}) = \int_{s(p_A)\setminus s(p_B)} du = (\overline{s} + \underline{s}) - 2\lambda,$$

and with (2.2) we obtain

$$P(p_{A>B}) > P(p_{B>A}).$$

If p_A is objectively more convenient than p_B, then the probability that the seller prefers p_A over p_B is higher than the probability that she prefers p_B over p_A. In addition, the profit maximising price regardless of subjective convenience effect p_0 is set with probability zero ($p_0 \notin F(p_0) \implies P(p_0) = 0$). □

Proof of Proposition 2.4. The buyer minimises the payment cost of the transaction by choosing either to pay cash or to pay with card, given the relative cost of card b and the price p. The program of the buyer implies $P(p, cash) = P(b \geqslant -SC(p)) = \overline{b} + SC(p)$ and together with (2.1a), it leads to

$$OC(p_A) > OC(p_B) \implies P(p_A, cash) > P(p_B, cash).$$

If p_A is objectively more convenient than p_B, then the probability that the buyer pays p_A cash is higher that the probability that he pays p_B cash. □

Appendix B: Technical Appendix

In this appendix, we propose the following additional measures of objective convenience.

First, we consider the minimum number of tokens exchanged between the buyer and the seller whatever the combination. For example, with this measure of objective convenience, a price of 10.99 is paid in 3 tokens (the buyer hands a 10 euros note and a €1 coin, the seller returns a ¢1 coin). This measure assumes that there are neither constraints of token availability nor relevant computational limits. We call this measure of convenience "Optimal Objective Inconvenience" and we note the optimal convenience "OPT OIC". The "Optimal Objective Convenience" is the opposite and is noted "OPT OC".

Second, cash is typically drawn at ATMs, and ATMs supply only notes. Therefore, we consider the minimum number of tokens exchanged in any combination if the buyer hands only notes. We call this measure of objective inconvenience "n Note Objective Inconvenience" , and we note it OI_n, where n is the facial value of the minimum note (n is $5, 10$, or 20). For example, $OI_{20}(20) = 1$ and $OI_{20}(22) = 6$, the buyer hands two notes of e20 and the seller hands a e10 notes, a e5 note, a e2 coin, and a e1 coin. "Notes Objective Convenience" is the opposite and is noted OC_n

Third, we define the following measure of objective inconvenience. For a price corresponding exactly the facial value of an element of the denomination, the buyer hands the lowest token equal or superior to the price, then the seller returns change with the minimum number of tokens. We assume that the seller carries the lowest token superior to the price, and that all tokens are available in sufficient number for the seller to return the change with a minimum number of tokens. For all other prices, the buyer hands a single token, and the merchant returns change. We call this measure of objective inconvenience "Single Buyer Token Objective Inconvenience" and we note it "SBT IC". "Single Buyer Token Objective convenience" is the opposite, and is noted "SBT OC".

Let us give several example. First, a price of €10 requires that the buyer gives a €10 note. One token is involved: a note of €10. Second a price of €9.90 implies a return from the seller to minimise the number of exchanged tokens. The buyer gives a €10 note and the seller returns a ¢10 coin. Two tokens are involved: a note of €10 and a coin of ¢10.

We now give the algorithms used to compute the measures of objective convenience proposed.

TABLE 2.6: Direct Greedy Algorithm: The Buyer Pays the Full Sum Directly

input : p, The price to be paid.

output: $Gr(p)$, the number of steps of the greedy algorithm.

$Gr(p) = 0;$

$p_{temp} = p;$

while $p > 0$ **do**

```
; // EQ is the Euclidian Quotient, E[x] is the integer part of x.;
```

$EQ = E[\frac{\max_{u \in den} u \leq p_{temp}}{p_{temp}}];$

$p_{temp} = p_{temp} - EQ * (\max_{u \in den} u \leq p\ );$

$Gr(p) = Gr(p) + EQ\ ;$

end

return *Gr(p)*

TABLE 2.7: Indirect Greedy Algorithm $IGR(p)$

input : p, the price to be paid.

output: $IGr(p)$, the number of steps of the greedy algorithm.

$IGr(p) = 0;$

$p_{temp} = \max_{i \in den}\{i < p\};$

while $p > 0$ **do**

$p = p - \max\{u \in den, u \leq p\};$

end

return *IGR(p)=Gr(*p_{temp}*)+1*

The following algorithm yields the minimum number of steps. The set of denomination used in this algorithm is $Den \cup -Den$. Positive numbers represent tokens handed by the buyer and negative numbers represent tokens returned by the merchant. Note that this algorithm yields the "n Note Objective inconvenience" OI_n if the set of denomination Den' used in this algorithm is $\{i \in Den \mid i \geq n\} \cup -Den$. We assume that $comb(x, p)$ returns all the p-elements subsets (the subsets with cadinality p) of the vector x, with the coordinates possibly repeated. For instance, if $x = (1, 2, 3)$, $comb(x, p)$ returns $\{1, 1\}$, $\{2, 2\}$, $\{3, 3\}$, $\{1, 2\}$ $\{1, 3\}$, and $\{2, 3\}$. We also assume that $SUM(x)$ returns the sum of the coordinates of x.

TABLE 2.8: Optimal Inconvenience

input : p, the price to be paid.

output: Opt_IC, the minimum number of tokens exchanged.

for $i \leftarrow 1$ **to** $GR(p)$ **do**
  if $SUM(comb(Den', i) = p$ **then**
    return i
  end
end

TABLE 2.9: Single Buyer Token Objective Convenience

if *Gr(p)=1* **then**
  return $SBT\_OC = -1$
else
  return $SBT\_OC = -Igr(p)$
end

TABLE 2.10: Limited Rationality Objective Convenience

input : p, the price to be paid.

output: LR_OC, Limited Rationality Objective Convenience.

return $LR\_OC = min(Gr(p); Igr(p))$;

Some Properties of the Greedy Algorithm

The facial values of European denomination tokens are all multiples of 1,2, 5 and of ¢1, ¢10, €1, €10, and €100. If we note $S = \{1,2,5\}$ and $S' = \{0.01, 0.1, 1, 10, 100\}$, any element of *Den* is the product of a unique element of S and a unique element of S'. $\forall s \in Den, \exists! i \in S, \exists! j \in S', s = i * j$. We refer to an element of s as a "special numeral". We refer to an element of s as a "special numeral", and we call a "tenth" an element of S'. Consider the list of the elements of S' taken in increasing order. We call the i^{th} element of this list the i^{th} tenth. For instance, the first tenth is 0.01 and the fourth tenth is 10.

We need 1 special numeral to make 1 , 2 and 5. We need 2 special numerals to make $3(2+1)$, $4(2+2)$, $6(5+1)$, $7(5+2)$. We need 3 special numerals to make $8(5+2+1)$ and $9(5+2+2)$. Define $SPN : I = [\![0,9]\!] \mapsto I = [\![0,3]\!]$ is the function giving $SPN(0) = 0$, $SPN(1) = 1$, $SPN(2) =$

1, $SPN(3)=2$, $SPN(4)=2$, $SPN(5)=1$, $SPN(6)=2$, $SPN(7)=2$, $SPN(8)=3$, $SPN(9)=3$. If x is a postive integer lesser than 10, $SPN(x)$ gives the minimum number of special numerals needed to make x.

Define a representation of a price as a set of facial values of tokens summing to the price (For instance, a representation of 15.23 is $(10,2,2,1,0.20,0.02,0.01)$).

Proposition 2.5. *Let* $P=\overline{x_1x_2x_3.x_{-1}x_{-2}}<1000$ *be a price in euros, with* $(x_1,x_2,x_3,x_{-1},x_{-2})\in I=[\![0;9]\!]^5$*. Then,*

$$Gr(p)\ =\Sigma_{i=-2}^{3}SPN(x_i).$$

In other words, for the Euro denomination, the number of the steps of the greedy algorithm for a price lesser than 1000 *is the sum of the number of steps of the greedy algorithm for each of the numerals composing the price.*

Proof of Proposition 2.5. Assume that the Proposition is not true. Then, for a certain $k\in[\![0;3]\!]$, the greedy algorithm uses two special numerals of the $(k-1)^{th}$ tenth to make more than 10. But the special numeral 1 of the k^{th} tenth is available. This is a contradiction given the definition of the greedy algorithm. □

Proposition 2.5 states that a representation is greedy if and only if the sub-representation of each tenth is greedy. In the remainder of the technical appendix, we do not allow for a representation of a price involving change returned by the seller and consider only direct payments.

The greedy algorithm always yield the representation of a price $p<1000$ involving the minimum number of tokens with the Euro denomination. To prove this assertion, we first prove the following lemma.

Lemma 2.6. *Consider a representation of price p involving a minimum of tokens (this representation is said to be optimal). The sum of the special numeral of each tenth is strictly less than 10.*

Proof. Assume that the proposition is not true. Then, for a certain $l\in[\![-1;3]\!]$, the special numerals of the l^{th} tenth of an optimal representation, forming the $SN(l)$ set, sum up to L, with $L\geq 10$. Define L' the smallest sum of $SN(l)$, with $L'\geq 10$. We have $L'\in\{10,11,12,13,14\}$. It is then immediate to check that the representation is improved by replacing the elements of

$SN(l)$ by the special numeral 1 of the $(l+1)^{th}$ tenth and the greedy decomposition of $L'-10$ of the $l^{th}tenth$. ☐

Proposition 2.7. *The greedy representation of a price* $p < 1000$ *involves the minimum number of tokens.*

Proof. The proof is immediate considering Lemma 2.6, Proposition 2.5 and noting than *SPN* is the restriction of *Gr* to $[\![0;9]\!]$. ☐

Thus, we can compute the minimum number of tokens involved just by looking at the figures composing a price $p < 1000$. The minimum number of tokens is the sum of the numbers of special numerals needed to make each figure composing the price. For instance, a price of 10.99 involves no less than 7 tokens to be paid directly since $7 = 1+3+3$.

Appendix C: Code

This the program, written in Mata, used to generate the main variables [1]. Mata is a matrix computing C like language.

```
 /* The program assumes that the vector of prices is "price",
 the dummy for cash payments is "cash" and the dummy
 for card payment is "card" */

mata
mata drop greedy() igr() objinc() objincnotes()
/* "denom" is the vector of facial values of coins and notes */
/* Elements of vector are decreasing from first to last element */
/* Facial values of elements are in cents, prices are also in cents.
This is because 0.1 can not be written in binary */
denom=(50000\20000\10000\5000\2000\1000\500\200\100\50\20\10\5\2\1)
denomnotes5=(50000\20000\10000\5000\2000\1000\500)
denomnotes10=(50000\20000\10000\5000\2000\1000)
```

1. The implementations of the functions "objinc" and "objincnotes" calculates the minimum number of tokens exchanged for all prices in the database, it does not calculate the minimum number of tokens for all conceivable prices (you could construct a price class for which the output would be incorrect.

```
denomnotes20=(50000\20000\10000\5000\2000)
real scalar function greedy(real scalar pri,real colvector den){
real scalar greed
greed=0
real scalar currentpri
currentpri=pri
for (j=1;j<=rows(den);j++) {
if (currentpri>=den[j]) {
greed=greed+trunc(currentpri/den[j])
currentpri=currentpri-(trunc(currentpri/den[j])*den[j])
}
}
if (currentpri != 0) {
return(0)
}
return(greed)
}
real scalar function igr(pointer(function) gree,
 real scalar pri, real colvector den){
den2=den[(rows(den)::1),.]
for(k=1;k<=rows(den2);k++){
if (den2[k]>pri){
pr=den2[k]-pri
cra=(*gree)(pr,den)+1
break
}
}
return(cra)
}
real scalar function objinc(pointer(function) gree, pointer(function) igr,
real colvector den, real scalar pri) {
dirgr=(*gree)(pri,den)
if (dirgr==1) return (dirgr)
$n=0
```

```
conv=(*igr)(gree,pri,den)
pricet=pri
n=0
while (pricet>0) {
n=n+1
prevprice=pricet
for (z=1;z<=rows(den);z++){
if (pricet>den[z]) {
pricet=prevprice-den[z]
break
}
}
if (pricet==1) break
changeafter=(*igr)(gree,pricet,den)+n
if (conv>=changeafter) conv=changeafter
}
if (dirgr<conv)  conv=dirgr
return(conv)
}
if (pricet<=min(dennotes)) break
real scalar function objincnotes(pointer(function) gree, pointer(function) igr,
real colvector dennotes,real colvector den, real scalar pri) {
dirgr=(*gree)(pri,dennotes)
if (dirgr==1) return (dirgr)
conv=(*igr)(gree,pri,den)
pricet=pri
n=0
while (pricet>0) {
n=n+1
prevprice=pricet
for (z=1;z<=rows(dennotes);z++){
if (pricet>dennotes[z]) {
pricet=prevprice-dennotes[z]
break
```

```
}
}
changeafter=(*igr)(gree,pricet,den)+n
if (conv>=changeafter) conv=changeafter
}
if (dirgr<conv)  conv=dirgr
return(conv)
}
/* Get the prices from stata */
pri=st_data(.,"pricecent")
cash=st_data(.,"cash")
card=st_data(.,"card")
priclasse=st_data(.,"price1classe2")
prieff=st_data(.,"priceeffectif10")
/*declare GR IGR and IC as vectors, and give them
 an initial value by equaling them to the vector pri*/
GR=pri
IG=pri
COINS=pri
IC=pri
IC2=pri
ICNOTES5=pri
ICNOTES10=pri
ICNOTES20=pri
ntranscash=cash
j=0

/* Generate GR IGR and IC with the right values for each price */
for(i=1;i<=rows(pri);i++) {
GR[i]=greedy(pri[i],denom)
IG[i]=igr(&greedy(),pri[i],denom)
IC[i]=objinc(&greedy(),&igr(),denom,pri[i])
IC2[i]=min((GR[i]\IG[i]))
ICNOTES5[i]=objincnotes(&greedy(),&igr(),denomnotes5, denom,pri[i])
```

```
ICNOTES10[i]=objincnotes(&greedy(),&igr(),denomnotes10, denom,pri[i])
ICNOTES20[i]=objincnotes(&greedy(),&igr(),denomnotes20, denom,pri[i])
}
/* Generate ntranscash */
/* For robustness, sort cash and price matrix again in mata*/
_sort((pri,cash,card,GR,IG,IC,IC2,ICNOTES5,ICNOTES10,ICNOTES20
,priclasse,prieff), (1,2))
for(i=1;i<=rows(pri)-1;i++) {
if ((cash[i]==1)&(pri[i]==pri[i+1])){
j=j+1
}
if((j>0)&(pri[i]!=pri[i+1])) {
for(k=0;k<=j;k++)   {
ntranscash[i-k]=j+1
}
j=0
}
}


/*We pass variables to Stata*/
st_addvar(("float","float","float","float", "float",
 "float", "float", "float","float","float"),("greedy","igreedy","IC"
 ,"IC2","ICNOTES5", "ICNOTES10","ICNOTES20",
 "ntranscash","priclasse","prieff"))
st_store(.,("greedy","igreedy","IC","IC2","ICNOTES5"
,"ICNOTES10","ICNOTES20"  , "ntranscash","price1classe2","priceeffectif10"),
(GR,IG,IC,IC2,ICNOTES5,
ICNOTES10,ICNOTES20,ntranscash,priclasse,prieff))
end


/* Generate the number of cash and card
transactions, ntranscash and ntranscard */
```

```
capture drop ntrans  ntranscard nreptransbinaire
g ntrans=0
by  pricecent, sort:  replace ntrans=_N
g nreptransbinaire=0
replace nreptransbinaire=1 if ntrans>1
/* Generate log price */
capture g logpricecent=log(pricecent)
g ntranscard=ntrans-ntranscash
g nreptranscashbinaire=0
replace nreptranscashbinaire=1 if ntranscash>=2
g OptOC=-IC
g LROC=-IC2
g OptOcNotes5=-ICNOTES5
g OptOcNotes10=-ICNOTES10
g OptOcNotes20=-ICNOTES20
g SBTOC=-igr
replace SBTOC  =-1 if greedy==1
by pricecent, sort: g rankinpricegroup=_n
```

Appendix D: Supplementary Appendix

Table 2.11 and Table 2.12 show the results supporting proposition 2.3 and proposition 2.4. The regressions are the same as in the main body of the paper, but with different measures of objective convenience.

TABLE 2.11: Effects of Objective Convenience and Transaction Size on the Number of Price Occurrences: Different Measures of Objective Convenience.

	Binary Probit					Ordered Probit				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Price	-0.33[a]	-0.26[a]	-0.36[a]	-0.61[a]	-0.38[a]	-0.28[a]	-0.22[b]	-0.31[a]	-0.53[a]	-0.31[a]
	(0.07)	(0.07)	(0.07)	(0.08)	(0.07)	(0.08)	(0.08)	(0.09)	(0.10)	(0.08)
OptOC	0.66[a]					0.57[a]				
	(0.08)					(0.10)				
OC_5		0.26[a]					0.22[a]			
		(0.04)					(0.04)			
OC_{10}			0.35[a]					0.30[a]		
			(0.04)					(0.05)		
OC_{20}				0.39[a]					0.33[a]	
				(0.05)					(0.06)	
SBTOC					0.36[a]					0.32[a]
					(0.05)					(0.06)

Notes. Column (1) to (5) show the results of the binary probits. The dependent variable is a binary variable equaling 0 if the price unique and 1 if the price is repeated at least twice. Each model uses a different measure of objective convenience. Column (6) to (10) show the results of the ordered probits. The dependent variable is the number of times a price is repeated in the database. Each model uses a different measure of objective convenience. The price is taken in logarithms. The constant is not reported.

TABLE 2.12: Effects of Objective Convenience and Transaction Size on the Price Occurrences Paid Cash: Different Measures of Objective Convenience

	Binary Probit					Ordered Probit				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
[1em] Price	-0.48[a]	-0.43[a]	-0.59[a]	-0.93[a]	-0.52[a]	-0.47[a]	-0.41[a]	-0.44[a]	-0.49[a]	-0.47[a]
	(0.08)	(0.08)	(0.09)	(0.12)	(0.08)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
OptOC	0.60[a]					0.14[c]				
	(0.10)					(0.06)				
OC_5		0.25[a]					0.09[b]			
		(0.04)					(0.03)			
OC_{10}			0.36[a]					0.10[a]		
			(0.05)					(0.03)		
OC_{20}				0.45[a]					0.08[c]	
				(0.06)					(0.03)	
SBTOC					0.30[a]					0.11[b]
					(0.06)					(0.04)
N			411					345		

Notes. Column (1) to (5) show the results of the binary probits. The dependent variable is a binary variable equaling 0 if the price unique and 1 if the price is repeated at least twice. Each model uses a different measure of objective convenience. Column (6) to (10) show the results of the ordered probits. The dependent variable is the number of occurences a price is repeated in the database. Each model uses a different measure of objective convenience. The price is taken in logarithms. The constant is not reported.

Chapter 3

Does Crime Impact the Preference for Cash of Merchants?

Bruno Karoubi

Abstract

This paper is an attempt to determine whether crime as an environmental factor has a significant impact on the preference for cash of merchants. We exploit a unique database from a representative sample and show that crime has a twofold impact on the subjective preference for cash of merchants. We build an indicator composed of theft variables concerning primarily both consumers and merchants. We conclude that a merchant whose store is located in a department in which my indicator is high has *Ceteris Paribus* a lower than average preference for cash. We also find that a higher level of financial fraud increase the preference for cash of merchants. The first effect is interpreted to be the result of a precaution motive (cash payment and storage involve risk of loss and theft), while the second result from adverse selection (cash payments make tax evasion easier).

Keywords: Crime, Demand for money, Payment Instruments.

JEL Classification: E4.

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Introduction

Electronic payment instruments are cheaper to produce, easier to stock, and less liable to fraud than cash. To give an order of magnitude, Humphrey *et al* (2003) estimates that "an electronic payment costs one third to one half that of a paper based instrument", so that "a country may save 1% of its gross domestic product annually as it shifts from a fully paper-based to a fully electronic based payment system".

Therefore, understanding the determinants of the payment instrument choice is a high stake challenge for the social planner.

The impact of crime *as an environmental factor* on payment instrument however has not been investigated so far to the best of our knowledge, except from a theoretical standpoint in a paper by Chakravorti and Bolt (2009). In their model, the probability of street mugging decreases the probability of using cash.

The choice of payment instrument involves two asymmetric sides: the merchant decides whether she accepts alternative payment instruments; [1] the consumer decides which payment instrument she holds and which will effect the transaction conditional on merchant acceptance. Therefore, the bank payment card market is analyzed as two-sided, because the network's profit depends not only on the raw number of users, but also on the proportion of merchants and of card bearers (Tirole, 2003 gives a theoretical analysis of the impact of those cross side network externalities).

Both sides have a decisive impact on the payment instrument effecting the transaction. However, the merchant side is almost systematically neglected by empirical academic research. To the best of my knowledge, there are extremely few empirical studies investigating the question of crime impact on merchant payment behavior in general.

This paper is an attempt to fill this gap. We study the impact of crime on merchant preference for cash payments. Since merchants can not turn down cash, their declared appreciation for this payment instrument appears to be the natural candidate for studying the impact of crime on their relation to cash.

1. Merchants can not turn down cash because it has legal tender in most countries.

We find that the level of theft in the department decreases merchants' preference ratings for cash while a high level of financial fraud increases it.

The remainder of this paper is organised as follows. In section 2, we describe the dataset and discuss the econometric models. In section 3, we present and discuss the results. A conclusion is given in section 4.

Data

The data was collected from a field inquiry conducted from March to May 2008. The sample is designed to be representative of the French population of merchants in size, sector and location. Merchants answered questions by phone regarding their behavior and preferences towards payment instruments. They also provided controls for their position in the business, and for their the relevant socio-demographic characteristics of their customers. The dataset comprises variables related to payment patterns and individual characteristics. 4601 merchants were surveyed, of which 3983 answered all the questions coded into variables used in the econometric models. [2]

Table 3.1 provides descriptive statistics for the main variables, discussed in the next section. Table 3.2 describes all the variables used in the econometric models. Mean and standard errors of polytomous variables are provided. For ordered binary variables, the mean and the standard error of the corresponding ordered polytomous variable [3] are briefly discussed. Short comments about the proportion of merchants represented by grouping of modalities, or grouping of ordered binary variables are also presented. [4]

All crime variables were extracted from a document coming from the French "Ministère de l'Intérieur", the "Etat 4001" for the year 2008. The document provides the number of complaints filed in Police Stations and Gendarmeries for all French departments and for all charges defined by the French nomenclature of crime and offenses. We divided this raw count by the

2. Missing answers are randomly distributed, and therefore the estimation sample does not suffer from selection bias. Indeed, we performed a Kendall's tau test of independence between the participation and preference ratings, since the former variable is binary and the latter is ordered. The null of independence clearly can not be rejected, for Kendall's score is 17342, with a continuity corrected standard error of 31702 and a P-value of 0.58.

3. The i^{th} modality of this variable equals 1 when the i^{th} binary variable equals 1.

4. Note that modalities are not mutually exclusive. For instance, a merchant can declare having many customers in their twenties and many customers in their fifties; in that case, both relevant binary variables equal 1. The second and fifth modality of the corresponding ordered polytomous variable also equal 1.

departmental population [5] in order to neutralize the size effect, as the number of inhabitants can vary greatly between departments. Recall that a department is a geographical division like a state or prefecture, intermediate in size between a town and a region.

TABLE 3.1: Descriptive Statistics

	Mean	Standard error	Definition
Pref. rating for cash	3.55	1.67	Merchants' preference ratings for cash on a Likert scale, graduated from 1 to 5.
Fraud and breach of trust	4393	4742	Number of "Swindling and breach of trust", as defined by the French nomenclature of crime and offenses, declared to French Police stations ans Gendarmeries for each department for the year 2008.
Overall Theft	7755	6678	Sum of the number of complaints filed for "Theft committed in a vehicle" , "Theft against individuals" , "Armed robbery" as defined by the French nomenclature of crime and offenses, declared to French Police stations and Gendarmeries, for each department for the year 2008.
Fraud and breach of trust (for 1000 inhabitants)	4.01	2.52	Same as Fraud and breach of trust, but for 1000 inhabitants.
Overall Theft (for 1000 inhabitants)	7.21	3.58	Same as Overall theft, but for 1000 inhabitants.

Description of the Variables

As discussed earlier, there is an important asymmetry between merchant and consumers: the consumer decides which payment instrument she holds *as well as* the payment instrument effecting the transaction, while merchant decides which alternative payment instrument she accepts once and for all. This decision is sunk when an individual transaction occurs. Thus, an objective measure of merchant preference for cash is uneasy to collect.

Therefore, the independent variable we chose is a proxy for the merchants declared "cash appreciation". More precisely, we use the merchant rating of cash on a Likert scale (1 is the worst rating, 5 is the best).

We expect the merchant preference for cash (denoted Y) to vary according to the store type and equipment, once controlled for the consumer characteristics. We also intend to check whether crime variables impact this preference.

5. The departmental population was extracted from the INSEE website.

TABLE 3.2: Description of The Variables

Variable	Definition	Observations
Average Customer Wealth	Merchant estimation of their customer's average wealth. 5 classes are proposed, each class is included as a dummy variable, equaling 1 if the customers belongs to the relevant wealth class, and 0 otherwise.	3 merchants out of 4 (*i.e.* 74.38% of the sample) declare they have middle class customers. The weighted average is 3.03 - modality 3 is middle class- and representative enough of the whole distribution since the corresponding polytomous ordered variable's standard error is 0.68.
Average customer age	Merchant estimation of their customer's average age; 7 classes are proposed, each class is included as a dummy.	The average customer is on his late thirties and is representative enough (the weighted average is 3.82 (modality 3 is "a significant part of my customers are on their thirties" and modality 4 is "a significant part of my customers are on their forties") and the corresponding polytomous ordered variable's standard error is 1.01) . A little less than two thirds of the merchants in the sample- 62.33% - declare that a significant part of their customers are on their thirties.
Distance to the customer's living place	Distance from the store to the customer's living place; 5 classes are proposed, each class is included as a dummy.	The average consumer comes from the same town as the store but not from the immediate vicinity (the weighted average is 2.06 (modality 2 is "town") and representative enough of the whole sample since the standard error of the corresponding polytomous ordered variable is 0.64. A big half of merchants in the sample declare having customers from the vicinity, and more than 4 out of 5 declare having customers from the same town (respectively 53.44% and 83.54%.).
Distance to the closest ATM	Distance from the store to the closest Automated Teller Machine (ATM); This variable has 5 modalities, sorted from nearest to farthest.	The average distance from the store to the closest ATM ranges between 50 and 100 meters (this variable has a mean of 2.4 and a standard error of 1.44). This distance is less than 500 meters for roughly 3 merchants out of 4 (74.28%), and is more than 1 kilometer for 1.3% of merchants in the sample.
Frequency of cash refusal	Merchant estimation of cash refusal frequency; This variable has 5 modalities, sorted form less frequent to more frequent, in increasing order.	The average merchant refuses cash infrequently, which is expected since cash has legal tender in France. The mean is 4.3 (modality 4 is "I refuse cash infrequently") and the standard deviation is 1.48. A little less than 4 merchants out 5 of never refuse cash (78.75%).
Frequency of check refusal	Merchant estimation of check refusal frequency. This variable has 5 modalities, sorted from more to less frequent.	The average merchant refuses check rarely, which is expected since checks are often used in France. The mean is 4.2 (modality 4 is "I refuse check payments infrequently") and the standard deviation is 1.41. A little less than 2 merchants out of 3 never refuse check (65.77%).
Frequency of bank cards refusal	Merchant estimation of bank cards refusal frequency. This variable has 5 modalities, sorted form more to less frequent.	Merchant accepting bank cards almost never refuse bank cards payments, which is expected since merchants are theoretically forced to accept a bank card if they display the relevant logo. The mean is 4.7 (modality 5 is "I never refuse bank cards") and the standard deviation is 0.6 for card accepting merchants. A little less than 4 out of 5 card accepting merchants never refuse bank card.
Cash transport frequency	Merchant estimation of cash transportation to the bank; This variable has 7 modalities, ranging from more to less frequent.	The average merchant moves cash to the bank from times to times to often. The mean is 2.59 (modality 2 is "I move cash to the bank once a week" and modality 3 is "I move cash to the bank several times a week") and the standard error is 1.42. A little third of the sample moves cash to the bank once a week or more (32.62%.).
Fake Note detector	Dummy variable, equals 1 if the merchant owns a fake note detecting device, 0 otherwise.	Roughly one merchant out of five owns a fake note detector (this binary variable has a mean of 0.21).
Business creation	Dummy variable, equals 1 if the present owner created the firm, 0 if ownership results from a takeover.	A small half of merchants in the sample created their firm. The mean of this binary variable is 0.48 and the standard deviation is 0.51 .
Cash fraud frequency	Merchant estimation of the frequency of payments with fake notes and coins; This variable has five modalities, from more to less frequent.	The average merchant is presented with cash fraud very infrequently. The mean is 4.3 (modality 4 is "I am presented with fraud infrequently" and modality 5 is "I am never presented with fraud") and the standard deviation is 1.48. A little more than 1 merchant out of 5 is presented with cash fraud infrequently, and a little more than 3 out of 5 is never presented with cash fraud (respectively 22.69% and 61.88%).
Store area	Store area, in square meters.	This variable is very dispersed (its standard error of this variable is 566.65, more than twice its mean, 185.8). However, note that a little more than three merchants out of 5 - 61% to be precise- have a store area ranging from 20 to 100 square meters.

The independent variables used in the econometric models can be grouped in three disjoints subsets: the consumer controls, the controls on the store type and equipment, and eventually the environmental crime variables, which are department level.
In other words, we have:

$$Y = f(\text{Crime variables, Store type, Consumer Controls}).$$

We now briefly present the retained variables in each of the just cited subsets, starting with the crime indicators.

Crime Variables

First, note that bank card payments are very secure, compared to cash, the most used payment instrument for small value purchases (see for instance Federal Reserve Bulletin, 2005). Many insurance policies against fraud are proposed, depending on particular cards and issuing banks. Moreover, a cash desk can be considered more provocative of theft, whether committed by employees or by shopbreakers, than a card terminal. Note that, due to the two sided structure of bank card markets, a partial internalization of the risk run by consumers is expected.

Therefore, we expect a variable representative of the overall level of theft (denoted T) both consumer and merchant side to impact negatively the preference rating for cash, i.e. **f'(T)**< 0 **(assumption (i)**).

Second, note that cash payment are anonymous and immediate, and maintaining a high stock of cash makes off the books payments, and therefore off the books hiring easier. We expect a variable controlling for the propensity to financial fraud, denoted S, to impact positively the preference ratings for cash, i.e **f'(S)**> 0 **(assumption (ii)**).

We expect an effect of crime as an *environmental* factor. Therefore, the relevant data is aggregate. While the ideal level of aggregation would probably be zip code or commune, the count of filed complaints at this scale is not available. We chose department level crime indicators as we considered them second best. We merged those crime indicators with individual level variables according to the store department.

We built an indicator of "Overall theft" (referred to as such in the remainder of this paper) as equal to the sum of three crime variables: "Theft Committed in a Vehicle", "Theft Against Public or Private Establishments" and "Armed Robbery". The first is a form of theft which only concerns consumers, while the second and third represent nonviolent and violent theft directed against merchants.

This indicator controls both for the direct risk run by merchants and for their partial internalization of the consumers equivalent. Note that the direct risk includes both the potential damage to the physical integrity and the potential financial loss in the event of a theft.

We also retained an indicator of financial fraud (Fraud and breach of trust).

Note that the retained crime variables were as little redundant and correlated as possible. Indeed, crime is self-breeding, creating a more friendly environment, and macroeconomic conditions can provoke the combined appearance of various crime forms [6] so that most crime variables give, in a sense, the same information.

Other Variables

First, the consumer controls are essential, as the final decision of the payment instrument effecting the transaction rests exclusively with the consumer, given the merchant acceptance decision. Therefore, the following variables may impact merchants' appreciation for cash.

The **Distance to the Customer's Living Place** may impact the payment instrument choice. For instance, a tourist living in a different currency zone has to consider additional criteria to choose between payment instruments. Thus, comparisons of the exchange rate charged when performing a card payment to the exchange rate charged by the change desk becomes relevant. Moreover, a customer living very close to the store is more likely to perform daily shopping, and transaction size is more likely to be limited; a customer from another region is more likely to be in holidays, which can obviously impact the consumption profile.

Payment instrument choice is closely correlated to the **Average customer wealth**, because wealth impacts the average transaction size (cash holdings are directly proportional to income flow in Baumol-Tobin's inventory theoretic model of money demand; See For instance Federal Reserve Bulletin, 2005, for empirical evidence). Therefore, merchants were asked to rate the level of income of their customer on a six-point scale (denoted customer wealth on the regressions).

6. For instance, it is clear that poverty ridden areas are more exposed to all types of crime.

the **Average Customer Age** may affect payment behavior: for instance teenagers receive more often their pocket money in cash, and aged persons often distrust card payments.

Second, the store characteristics, its equipment and payment policy impact the convenience of paying by cash relative to other means of payment.

Possession of a Fake Notes Detector may be correlated with the merchant's wariness of cash payments, or level of protection against fraud. In the same line of thought, a higher **Cash Fraud Frequency** could be associated with a more negative opinion of cash.

When the ownership results from a takeover and not from a business **Creation**, the capital bought by the previous owners is often kept, and banking contracts are not always renegotiated. Therefore, the cost of accepting cards is lower if payment terminals were bought previously, and in the same line of thought cash storage is less risky if cash handling and storage equipment are at disposal.

Obviously, a negative opinion of cash payments can explain a high **Cash Refusal Frequency** - even though refusing cash is illegal in France; merchants disliking check or credit cards may appreciate anonymity, or independence from banking accounts of cash payments, characteristics opposite from those of the main alternatives.

A merchant confronted to a high **Cash Fraud Frequency**, is more aware of the dangers associated with cash payments, and may therefore dislike them more in average.

The **Distance to the Closest ATM** is closely related to the “shoe leather cost" (i.e. the cost of moving to the ATM) in the aforementioned inventory theoretic demand for money.

The **Store Area** impacts the payment instrument policy. Indeed, a big shopping area implies a minimum level of sales. Therefore, such a store is more likely to host an important frequency of transactions; fastness of payment becomes more important. Moreover, large area stores often belong to a chain. Their payment instruments policy is generally decided at a central level.

Econometric Strategy

It seems very plausible that potential missing regressors are independent and identically distributed, so that the Central Limit Theorem applies. Therefore, We estimate an ordered probit. [7]

Intra-departmental heterogeneity in crime indicators could bias the results. In order to address this question, we estimated all regressions on a sample of merchants located outside the Paris region, which is the most heterogeneous in France, as well as on the whole sample.

Eventually, it could be feared that the level discrepancy between aggregate crime variables and the remainder of the dataset, which is individual, would entail the capture of a department fixed effect rather than a crime-related effect. To deal with this problem, we included dummies for all departments except one. Moreover, because crime variables are at a higher level of aggregation, standard errors might be inaccurate because of intradepartmental correlations between residuals. Huber-White Sandwich estimator provides accurate variance since we have 90 clusters of balanced size (according to Kezdi (2004), 50 such clusters is close enough to infinity for accurate inference).

Testing assumption (i) and assumption (ii) is equivalent to testing the sign and significance of the crime variables.

Results

Table 3.3 provides global adjustment statistics in order to compare the fit of econometric models and table 3.4 sums up the results of ordered probit estimations. For the sake of conciseness, only significant variables, at least for one of the two estimations, are shown.

7. The probit model assumes that the residual follows a Gaussian distribution. By application of the Central Limit Theorem, an averaged sum of i. i. d. random variables follows asymptotically the very same distribution.

TABLE 3.3: Model Fit Comparisons: R^2, Chi-2 and Likelihood Ratio Tests.

	Test Statistic	Standard variance estimation	Robust variance estimation
	Likelihood ratio, 116 d.f.	426.03	Irrelevant
Model with dummies	Chi2 , 22 d.f.	292.85	320.63
		R^2=0.0327	
	Likelihood ratio, 24 d.f.	309.67	Irrelevant
Model without dummies	Chi2 , 22 d.f.	305.13	370.04
		R^2=0.0237	

Notes. P-Values are in parenthesis. All Chi-2 and Likelihood Ratio tests reject the null with P-Values less than 0.001
.

TABLE 3.4: Merchant Preference For Cash

Merchant preference for cash		
	All regions	Outside Paris
Overall Theft	-0.41 ^{a} (-19.87)	-0.58 ^{a} (-19.96)
Fraud and Breach of Trust	1.17 ^{a} (19.38)	1.95^a (20.23)
Customer Wealth: Wealthy	-0.07 ^{b} (-1.82)	-0.09 ^{b} (-2.02)
Customer Age: Twenties	0.04 ^{b} (2.42)	0.08 ^{c} (1.64)
Cash Fraud Frequency	-0.15^a (-4.37)	-0. 14^a (-3.80)
Store Area	-1.04e$^-$4 ^{a} (-3.55)	-9.71e$^-$5 ^{a} (-2.94)
Distance ATM	-0. 02 (-1. 19)	-0. 02 ^{c}(-1. 67)
Cash Refusal Frequency	0.32 ^{a} (9.12)	0.29 ^{a} (8.05)
Check Refusal Frequency	-0.06 ^{a} (-5.83)	-0.05 ^{a} (-4.72)
Transportation Frequency	-0.07 ^{a} (-4.25)	-0.07 ^{a} (-3.49)
Creation	-0.21 ^{a} (-6.37)	-0.21 ^{a} (-5.21)
Pseudo R^2	0.03	0.03
Chi-2	9828	57630
N	3983	3249

Notes. ^{a} $(p < 0.001)$, ^{b} $(p < 0.01)$, ^{c} $(p < 0.05)$, ^{d} $(p < 0.1)$. t statistics in parentheses. Both Chi-2 provided have 24 degrees of freedom, corresponding to the number of micro level and crime variables. P-Values are less than 0.0001 for both Chi-2. The constant is not reported.

Comparisons of Model Fit

There are 891 merchants in the Paris region, which amounts to 19.37% of the sample. On the one hand, eliminating them might not preserve the sample representativeness; On the other hand, heterogeneity in crime indicators might be excessive for the Paris region.

Estimations on the whole sample and on the merchants located outside the Paris region yield essentially the same results. The significance and sign of variables are the same, and in particular for crime indicators (cf. table 3.4. The "Distance to the closest Automated Teller Machine (ATM)" is significant at the 10% level in the restricted sample, but not significant on the whole sample. This is a threshold effect, since the difference between t statistics is small; moreover, it is the only such discrepancy).

Heterogeneity in crime indicators is therefore plausibly not excessive, even if representativeness is preserved in the restricted sample. Therefore, sacrificing the information given by merchants from the Paris region appears unnecessary. We now turn to commenting the fit of the econometric models estimated on the whole sample based on table 3.3.

Note that model fit, evaluated by the size of the chi-squared statistic, is always better when intradepartmental correlation is taken into account by performing Huber-White sandwich estimations of standard errors. The chi squared testing the simultaneous nullity of all coefficients relative to micro level and crime variables [8] increases notably when department fixed effects are taken into account by the inclusion of departmental dummies (the number of degrees of freedom is 22 for both statistics, corresponding to the number of variables tested). Moreover, the crime indicators become highly significant as we will see below, instead of the opposite, though the direction of their impact remain constant (maximum likelihood estimations of the coefficient of "Overall theft" and "Fraud and breach of trust" are respectively -0.78 and 0.3 with respectively a 44.5% and a 76% chance to be zero). [9]

All things considered, the most reliable model involves both department dummies in order to control for fixed effects, and robust variance estimation to take into account the potential intradepartmental correlation of cash preference ratings.

We now turn to discussing micro level variables and crime indicators.

Micro-Level Variables

The distance to the closest ATM is significant in the restricted sample, and has a negative impact on merchants preference for cash. This could be accounted for by merchants internalization of the consumers disutility associated with their “shoe leather cost".

8. Both chi-squared provided do not test the nullity of department level dummies so that they have the same number of degrees of freedom, for easier fit comparisons. Crime variables were also excluded because their contribution to the chi-squared vary drastically between models and estimation methods, as they are department level. Also note that the maximum number of constraints tested for cluster robust estimations is the number of clusters minus one, i.e. 94 here.

9. Since the model without departmental dummies is arguably less reliable, detailed results are not shown here.

Merchants refusing cash, merchants accepting check payments, and merchants who do not frequently move their cash to the bank appreciate it less than average. [10] The first result is straightforward. Merchants who wish to limit the share of cash effected transactions have incentives to accept alternative payment instruments, which explains the second result. Merchant who consider that storing large sum in cash is dangerous tend to move their cash to the bank often, and also to dislike this payment instrument, which explains the third point.

A more counter-intuitive result is that the more merchant think frauds are frequent, the more they appreciate cash. This can be explained by a selection effect: merchants having a positive opinion on cash effect more transactions with this payment instrument- which can be achieved by refusing alternative payment instrument for instance- and are therefore more frequently confronted by fraud.
Card refusal frequency has no impact on the merchant preference for cash. [11] This result can also be explained by a selection effect. Indeed, a merchant who prefers bank card over cash will probably effect more transaction with the former payment instrument (the inconvenience associated with paying with many coins and notes is relevant for the merchant as well as for the consumer most of the times). Therefore, merchants will automatically refuse card payment more often.

Crime Indicators

Crime indicators retained are all significant at the 1 % threshold.

First, Overall theft has a negative impact on merchant preference, which tends to show that a high level of theft risk triggers the desire to be paid with a more secure payment instrument so as to be protected against the risks of theft and loss and in order to keep track of transactions.

Second, the level of Fraud and Breach of Trust has a significant and positive coefficient. We interpret this as an adverse selection effect. Indeed, the more “average propensity to financial

10. Remember that frequency variables are coded so that lower values correspond to high frequencies.
11. This doesn’t imply that merchants refusing cards do not prefer to be paid in cash *for particular transactions*. Indeed, they can still consider such substitution is the best available option.

fraud" in the department, the more likely it is that employer in businesses (not necessarily merchants) will hire off the books workers, obviously paid in cash. This is both because these jobs are an important dimension of tax evasion, and because the pool of potential black market workers increases, making it easier to fill such positions. Therefore, cash payments will be more frequent and merchants will be more experienced and equipped for handling cash in average. They will like it more.

Another line explanation for the latter effect, though less environmental, is that merchants themselves hire off the books workers, and therefore need cash to pay them.

Conclusion

In this paper, we exploit a unique database, coming from a representative sample of merchants, in order to determine whether crime as an environmental factor impacts the preference for cash of merchants.

Our indicator of Overall theft, concerning both merchants and consumers, has a negative impact on cash preference, out of a precaution motive: merchants prefer to be paid in a more secure payment instrument lest they be burglared, or in order to be preserved from the risk of theft or loss. [12]

We also find that a high level of Fraud and breach of trust, as an indicator of the "average propensity to financial fraud", is associated with a better opinion of cash. This is because of the anonymity and difficult tracking of cash payments: tax evasion or off the books job hiring are of course easier to perform when payments are effected in cash (this confirms Ricciarelli, 2007, on the use of cash for illegal behavior) .

12. Even though insurance may guarantee reimbursement of stolen cash for merchants, such guarantee is costly, and theft by employees may also be difficult to prove. Moreover, possession of a cash desk may turn out to be an incentive to burglary, or at least be more provocative of a burglary than a bank payment card terminal.

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Chapter 4

La criminalité favorise-t-elle l'acception de la carte bancaire ?

Bruno Karoubi

Abstract

Comme corollaire à la question développée dans le chapitre précédent, le présent article se pose la question de l'impact de la criminalité comme facteur environnemental sur l'acceptation de la carte bancaire. La base de données est identique et notre méthodologie est similaire. Nous utilisons un document publié par le Ministère de l'Intérieur, l'Etat 4001, pour associer à chaque commerçant le niveau de criminalité de son département. Nous concluons qu'un niveau élevé de criminalité financière défavorise l'acceptation de la carte bancaire tandis qu'un niveau de criminalité violente la favorise. L'effet de la criminalité financière est interprété comme un effet de sélection adverse, et l'effet de la criminalité violente résulte d'internalisation partielle par les commerçants des risques encourus par les consommateurs.

Key Words: Crime, Payment instruments. *JEL Classification:* E4.

Article en révision pour la revue économique.

Introduction

En France, la carte bancaire est l'instrument de paiement le plus utilisé, en termes de valeur agrégée des transactions (cette dernière se monte à 462.3 milliards d'euros selon Banque de France, 2011). 43% des paiements de détail sont réglés par carte bancaire (Ibid, 2011). La carte bancaire constitue le fer de lance des instruments de paiement électroniques. Ces derniers sont moins coûteux à produire, moins encombrants et mieux protégés contre la fraude que les alternatives. Pour donner un ordre de grandeur, Humphrey *et Al* (2003) estime que « le coût d'un instrument de paiement électronique représente entre le tiers et la moitié de celui d'un instrument papier », de sorte "[qu'] un pays peut économiser 1% de son Produit Intérieur Brut par année en passant d'un système de paiement intégralement papier à un système de paiement intégralement électronique". Dans cette mesure, la compréhension des déterminants du choix de l'instrument de paiement est un enjeu majeur pour le planificateur social.

Bien que Chakravorti et Bolt (2009) développent un modèle théorique, dans lequel la probabilité d'agression diminue la probabilité d'utiliser les espèces, l'impact du crime comme facteur environnemental sur l'acceptation des cartes bancaires n'a pas été analysé pour le moment à notre connaissance. De plus, les décisions des commerçants sont presque systématiquement négligées par les études académiques empiriques sur les instruments de paiements, alors que les deux côtés du marché ont un impact décisif sur les caractéristiques de l'équilibre. Tandis que Karoubi (2012) s'intéressait à la préférence subjective des commerçants pour les espèces, le présent article étudie l'impact de forme de crime représentatives sur la décision d'acceptation de la carte bancaire par les commerçants.

Nous exploitons une base de données unique, constituée à partir d'un échantillon représentatif de commerçants français. Nous concluons que les commerçants dont les magasins sont situés dans des départements touchés par une forte criminalité violente acceptent plus couramment la carte bancaire. Nous concluons également qu'un niveau élevé de criminalité financière diminue sa probabilité d'acceptation.

La section 2 présente la base de données utilisée. Elle discute les variables retenues dans le modèle et la stratégie économétrique. La section 3 présente les résultats. Finalement, la section 4 conclut.

Base de données

La base de données a été recueillie dans le cadre d'une étude de terrain conduite entre mars et mai 2008. L'échantillon a été conçu de sorte à être représentatif de la population française de

TABLE 4.1: Statistiques descriptives et définition des variables de crime

	Moyenne	Ecart-type	Définition
Fraude et abus de confiance	4393/3574	4742/ 3691	Nombre de plaintes déposées pour « Fraude et Abus de Confiance » dans les commissariats et gendarmeries pour chaque département.
Vols Ensemble	18251 / 13657	18805/ 11722	Somme du nombre de plaintes déposées pour « Vol à la Roulotte », « Vol au Préjudice d'Individus » et « Vols à Main Armée », pour chaque département.
Fraude et abus de confiance (pour 1000 habitants)	4.0/3.2	2.5/1.8	Identique à « Fraude et abus de confiance », mais pour 1000 habitants.
Vols Ensemble (pour 1000 habitants)	15.8 /12.5	8.8/5.9	Identique à « Vols Ensemble », mais pour 1000 habitants.

Notes Les variables de crime sont données d'abord pour 2008 puis pour 2007 (2008/2007).

commerçants, en taille, en secteur d'activité et en localisation. Il a été constitué grâce à la méthode par strates (il s'agit de diviser la population en groupes homogènes mutuellement exclusifs, et de sélectionner dans chacun de ses groupes des échantillons indépendants). Les commerçants ont détaillé leurs comportements et préférences concernant les instruments de paiements en répondant à un questionnaire soumis dans le cadre d'entretiens téléphoniques. Les répondants ont aussi fourni des renseignements concernant leurs fonctions dans l'entreprise, et à propos des caractéristiques socio-démographiques de leurs clients. L'échantillon comprend 4601 entreprises.

Le tableau 4.1 fournit les statistiques descriptives pour les variables principales, discutées dans la prochaine section. Le tableau 4.2 décrit toutes les variables utilisées dans les modèles économétriques. Il donne la moyenne et l'écart-type des variables polytomiques. Pour les variables binaires ordonnées, la moyenne et l'écart-type de la variable polytomique correspondante sont brièvement discutés [1]. De courts commentaires sur la proportion de commerçants représentés par des regroupements de modalités, ou par des groupements de variables binaires ordonnées sont également présentés. Les modalités ne sont pas mutuellement exclusives. Par exemple, un commerçant peut déclarer avoir une proportion significative de clients entre vingt et trente ans, ainsi que beaucoup de clients entre cinquante et soixante ans : les variables binaires correspondantes valent 1. La deuxième et la cinquième modalité de la variable polytomique correspondante vaut alors 1.

Toutes les variables mesurant le crime ont été extraites d'un document publié par le Ministère de l'Intérieur, l'Etat 4001. Ce document fournit le compte des plaintes déclarées en commissariat de police et dans les gendarmeries pour tous les crimes et délits définis par le droit français, pour chaque département. Nous avons divisé ces données brutes par la population départementale pour neutraliser l'effet taille, puisque le nombre d'habitants peut varier nettement entre départements.

1. La i^{me} modalité de cette variable vaut 1 quand la i^{me} variable binaire ordonnée vaut 1.

TABLE 4.2: Description des variables

Variable	Définition	Observations
Acceptation carte bancaire	Variable binaire valant 1 si le commerçant accepte la carte bancaire, et 0 sinon. C'est la variable expliquée dans tous les modèles économétriques étudiés dans l'article.	Un peu plus de deux commerçants sur trois (68,31%) accepte la carte bancaire.
Niveau Financier Clientèle	Estimation par les commerçants du niveau financier moyen de leurs clients. 5 classes sont proposées, chaque classe est incluse comme variable binaire valant 1 si les clients appartiennent à la classe financière correspondante, et 0 sinon.	3 commerçants sur 4 (74,38% de l'échantillon) déclarent que leurs clients appartiennent à la classe moyenne. La moyenne pondérée vaut 3,03 — la modalité 3 est la classe moyenne — et relativement représentative de l'ensemble de la distribution puisque la variable polytomique correspondante a un écart type faible (0,68).
Age Clientèle	Estimation par les commerçants de l'âge moyen de leurs clients. 7 classes sont proposées, chaque classe est incluse comme variable binaire.	Le client moyen est âgé d'un peu moins de quarante ans, puisque la moyenne pondérée vaut 3,82 — la modalité 3 correspond à « Une part importante des clients est âgée d'entre trente et quarante ans » et la modalité 4 correspond à « Une part importante des clients est âgée de quarante à cinquante ans ». La variable polytomique ordonnée correspondante a pour écart-type 1,01). Un peu moins de deux tiers des commerçants (62,33%) déclare qu'une part significative des consommateurs est âgée de trente a quarante ans.
Distance Habitation Client	Distance moyenne entre le magasin et lieu d'habitation des clients ; 5 classes sont proposées, chaque classe est incluse comme variable binaire.	Le client moyen vient de la même ville que le magasin, mais pas du voisinage immédiat (la moyenne pondérée est 2,06 — la modalité 2 est « ville ». Le client moyen est relativement représentatif de l'ensemble de la distribution puisque l'écart-type de la variable polytomique correspondante est 0,64. Un peu plus de la moitié des commerçants (53,44%) déclare avoir des clients dans le voisinage, et plus de 4 commerçants sur 5 (83,54%) déclarent avoir des clients dans la même ville.
Distance DAB	Distance entre le magasin et la Distributeur Automatique de Billets (DAB) le plus proche ; cette variable a cinq modalités, ordonnées de la distance la plus faible à la plus élevée.	La distance moyenne entre le magasin et le DAB le plus proche se situe entre 50 et 100 mètres (cette variable a une moyenne de 2,4 et un écart-type de 1,44). Cette distance représente moins de 500 mètres pour environ 3 commerçants sur 4 (74,28%), et représente plus d'un kilomètre pour 1,3% des commerçants.
Fréquence refus CB	Estimation par les commerçants de la fréquence de refus de la carte bancaire. Cette variable n'a que 5 modalités, ordonnées du plus au moins fréquent.	Les commerçants acceptant la carte bancaire ne la refusent pratiquement jamais, ce qui est attendu puisque les commerçants ne peuvent théoriquement refuser les paiements par carte bancaire s'ils affichent le logo « CB » (Pour les commerçants acceptant la carte bancaire, la moyenne vaut 4,7 — la modalité 5 correspond à « je ne refuse jamais les paiements par carte bancaire » — et un écart-type de 0,6. Parmi ces derniers, un peu moins de 4 individus sur 5 accepte systématiquement la carte bancaire.
Fréquence Transport Espèces	Estimation par les commerçants de la fréquence de transport des espèces à la banque ; cette variable a sept modalités, ordonnés de la fréquence la plus élevée vers la fréquence la moins élevée.	Le commerçant moyen transporte des espèces à une fréquence intermédiaire entre « de temps et temps » et « souvent ». Cette variable a une moyenne de 2,59 — la modalité 2 correspond à une fréquence hebdomadaire et la modalité 3 correspond à une fréquence pluri-hebdomadaire — et un écart-type de 1,42. Un peu moins d'un commerçant sur trois transporte des espèces à la banque une fois par semaine ou plus (32,62%).
Détecteur Faux Billets	Variable binaire, valant 1 si le commerçant possède un détecteur de billets, 0 sinon.	1 commerçant sur 5 approximativement possède un détecteur (la moyenne vaut 0.21).
Création	Variable binaire, vaut 1 si le propriétaire actuel a créé l'entreprise, 0 dans le cas contraire.	Un peu moins d'un commerçant sur deux a créé la firme (Cette variable binaire a une moyenne de 0.48 et un écart-type de 0.51).
Fréquence Fraude Espèces	Estimation par les commerçants de la fréquence des paiements en fausse monnaie ; cette variable a cinq modalités, rangées des paiements en fausse monnaie fréquents vers les paiements en fausse monnaie peu fréquents.	Le commerçant moyen est confronté à la fraude très peu fréquemment (cette variable a une moyenne de 4,3 — la modalité 4 correspond à « Je suis confronté à la fraude peu fréquemment » et la modalité 5 correspond à « Je ne suis jamais confronté à la fraude » — et un écart-type de 1,48). Un peu plus plus d'un commerçant sur cinq (22.69%) est confronté à la fraude peu fréquemment, et un peu plus de 3 sur 5 n'est jamais confronté à la fraude (61.88%).
Surface Magasin	Surface du magasin, en mètres carrés	Cette variable est très dispersée (son écart-type est 566.65, plus de deux fois sa moyenne, 185.8). Cependant, 1 peu plus de 3 commerçants sur 5 (61%) dispose d'une superficie comprise entre 20 et 100 mètres carrés.
Vérification Chèque	Variable binaire, valant 1 si le commerçant possède un dispositif de vérification des chèques, 0 sinon.	Seulement 6.06% des commerçants possède un système de vérification de chèques.
Régime Fiscal	Variable contrôlant pour le régime fiscal. Cette variable a 9 modalités, les modalités les plus élevées tendent à représenter de plus grandes firmes.	Plus de 3 commerçants sur 4 sont au « régime réel simple » ou au « régime réel normal » (71.38%). Les entreprises sous ces régimes sont imposées sur la base de leurs profits réels.
Catégorie Juridique	Statut juridique de l'entreprise. Cette variable a 15 modalités. Ces modalités tendent à être ordonnée de la propriété la plus concentrée vers la propriété la plus diluée.	Plus de 7 entreprises sur 10 (70.84%) sont individuelles ou à responsabilité limitée. 38.54% des entreprises sont individuelles, et 32.30% des entreprises sont à responsabilité limitée.

Description des variables

Nous nous attendons à ce que l'acceptation de la carte bancaire (notée Y) varie en fonction du type de magasin et de son équipement, ainsi que de la nature, de la fréquence et du montant des frais bancaires, une fois contrôlé pour les caractéristiques des consommateurs. Par suite, les variables indépendantes retenues dans les modèles économétrique peuvent être groupés en quatre ensembles disjoints : les variables de crime, les contrôles des caractéristiques des consommateurs, les contrôles sur le type et l'équipement du magasin et enfin des contrôles concernant les frais bancaires. En somme, nous avons

$$Y = f(\text{Variables de Crime, Contrôle consommateurs, Type de magasin, Frais bancaires}).$$

Nous présentons et discutons maintenant les variables retenues dans les modèles économétriques appartenant à chacun de ces ensembles, en commençant par les variables de criminalité.

Variables de crime

D'abord, les paiements par carte bancaire sont très sécurisés comparativement aux paiements en espèces, ces derniers étant les plus courants pour les transactions de faible montant (cf. par exemple Federal Reserve Bulletin, 2005). Il existe de nombreuses politiques d'assurance contre la fraude, selon le types de carte et les banques émettrices. De plus, une caisse est exposée aux vols — commis par des employés ou bien par des personnes extérieures — alors que les paiements par carte dispensent de stockage.

Dans la mesure où ils n'ont intérêt à disposer d'un terminal que si les porteurs de carte sont suffisamment nombreux, les commerçants internalisent partiellement les risques encourus par les consommateurs. En effet, si les consommateurs craignaient de s'exposer à des risques d'agression par la détention d'espèces, la proportion de porteurs de carte augmenterait, et l'incitation des commerçants à accepter la carte bancaire se renforcerait. Nous nous attendons par conséquent à ce qu'une variable représentant à la fois l'exposition au vol des commerçants et des consommateurs (notée T) renforce la probabilité d'acceptation de la carte bancaire *i.e.* **f'(T)**> 0 (hypothèse (i)).

Les paiement par carte bancaire génèrent un fichier stocké sur un serveur distant, comprenant les coordonnées des comptes débités et crédités, ainsi que la date, l'heure et le montant de la transaction. Par conséquent, l'évasion fiscale est difficile, voire impossible. Dans le même esprit, les paiements par carte bancaire diminuent le stock d'espèces à disposition immédiate, et rendent

par conséquent le travail dissimulé (travail « au noir ») plus difficile. Nous nous attendons à ce qu'une variable contrôlant pour la « propension à la fraude financière », notée S, influence négativement la probabilité d'acceptation de la carte bancaire, *i.e* **f'(S)**< 0 (hypothèse (ii)).
Cet article vise à mesurer l'impact du crime comme facteur **environnemental**. Par conséquent, les variables pertinentes doivent être agrégées. Le niveau d'agrégation optimal serait sans doute celui de l'arrondissement ou de la ville, mais les données ne sont disponibles qu'au niveau du département. Nous avons donc fusionné les indicateurs de crime avec les variables de niveau individuel selon le département du magasin.

Nous avons construit un indicateur de « Vol d'ensemble »— désigné ainsi dans la suite du texte — comme étant égal à la somme de trois variables de crime : « Vol à la Roulotte », « Vol à Main Armée » et « Vol au Préjudice d'Etablissements Publics ou Privés ». La première variable correspond à une forme de vol concernant exclusivement le consommateur, alors que la seconde et la troisième représentent respectivement le vol violent et non-violent dirigés contre les commerçants. Cet indicateur contrôle à la fois pour le risque direct encouru par les commerçants et pour leur internalisation partielle du risque encouru par les consommateurs. Le risque direct inclut à la fois le dommage potentiel à l'intégrité physique et la perte financière potentielle en cas de vol.

Nous avons retenu également un indicateur de fraude financière (Fraude et Abus de Confiance).

Nous avons pour objectif de vérifier que cet indicateur issu de l'Etat 4001 agrégé au niveau départemental, est bien compatible avec les données issues de l'enquête, de niveau individuel, en particulier avec la fréquence estimée de paiement en fausse monnaie. Nous avons calculé la fréquence estimée moyenne de paiement en fausse monnaie pour chaque département, puis nous avons calculé la corrélation entre cette variable et l'indicateur de criminalité financière issu de l'Etat 4001 (Fraude et Abus de confiance). Nous avons également examiné l'indépendance de ces deux variables au moyen d'un test du Chi-2.

La probabilité d'indépendance estimée est inférieure à un pour dix mille, et comme on pouvait s'y attendre, plus la criminalité financière est importante dans le département, plus la fréquence moyenne estimée de paiement en fausse monnaie est importante. [2]

Les zones gravement touchées par la pauvreté sont plus exposées à toutes les formes de crime (voir par exemple Devine *et al*, 1988, LaFree et Drass, 1996, Lafree, 1999 pour des discussions théoriques et pour des illustrations empiriques). Les théories sociologiques expliquant ce point ont en commun de considérer que la pauvreté tend à détruire la légitimité de l'ordre social et à affaiblir les liens sociaux. En effet, le crime s'auto-entretient, en créant un environnement

2. La corrélation entre ces deux variables est hautement significative — la probabilité de non-significativité est inférieure à 1 pour 10000 — et vaut -0,36 : plus la criminalité financière est importante, plus les paiements en fausse monnaie sont fréquents (et plus la variable polytomique prend une valeur faible, voir tableau 4.2). Le Chi2 testant l'indépendance vaut 678, et la probabilité d'indépendance correspondante est inférieure à 1 pour 10000.

plus propice. La littérature économique considère que ce sont plus directement les conditions macroéconomiques qui provoquent l'apparition combinée de nombreuses formes de crime (cf par exemple Becker, 1968 et Brenner, 1976).

La plupart des variables de crimes donne la même information d'un certain point de vue. C'est pourquoi nous avons veillé à retenir des variables de crime environnementales aussi peu corrélées que possible.

Autres variables

Nous discutons d'abord les contrôles des caractéristiques des consommateurs.

Premièrement, le **Niveau financier moyen** de la clientèle peut affecter le choix de l'instrument de paiement, soit directement soit par l'intermédiaire de variables corrélées, par exemple, le montant de la transaction. Les cartes bancaires ou les chèques peuvent être utilisés pour retarder les paiements effectifs (ils peuvent être utilisés comme outils de gestion de trésorerie). Par conséquent, les commerçants ont noté la richesse des consommateurs sur une échelle à six barreaux (échelle de Likert).

Deuxièmement, la **Distance au Distributeur Automatique de Billets** (DAB) le plus proche, bien que ceci puisse être vu comme une caractéristique du magasin, est fortement liée « au coût d'usure du cuir des chaussures » (*"shoe leather cost*"), c'est-à-dire le coût à retirer des espèces, essentiellement le coût de déplacement au DAB le plus proche dans le modèle de demande de monnaie développé par Baumol (1952) et Tobin (1956).

Troisièmement, l'**Age moyen** de la clientèle peut affecter les comportements de paiements : par exemple, les adolescents reçoivent leur argent de poche en espèces, et les personnes âgées nourrissent souvent une certaine méfiance vis-à-vis des instruments de paiement électroniques.
Le deuxième ensemble de variables concerne les contrôles sur le type de magasin et son équipement.

En premier lieu, la possession d'un **Système de vérification des chèques** est liée à la méfiance du commerçant pour les paiements par chèque, ou à son niveau de protection contre la fraude. Elle peut entraîner une plus grande acceptation de la carte bancaire par un mécanisme de substitution.

En deuxième et troisième lieu, le **Régime fiscal** et la **Catégorie juridique** contrôlent pour le statut légal du magasin. En effet, ces éléments déterminent le niveau d'incitation à l'évasion fiscale. Plus précisément, la variable « Catégorie juridique » prend dix modalités, les valeurs les plus élevées correspondant à une responsabilité individuelle plus diluée (et en tant que telle, le plus souvent à une entreprise de plus grande taille). La variable « Régime Fiscal » a quatre modalités, le valeurs élevées correspondant à une cycle fiscal long : les paiements d'impôts et taxes sont plus espacés dans le temps.
Le troisième ensemble de variables contrôle pour les frais bancaires. Premièrement, la possession d'un **Compte bancaire rémunéré** augmente le coût monétaire direct d'utilisation d'un

instrument de paiement lié au compte comme la carte bancaire. Deuxièmement, le perception du coût associé à la gestion des comptes peut être influencée par la **Fréquence des frais bancaires**.

Stratégie économétrique

Nous avons retenu un modèle probit[3]. pour étudier l'acceptation de la carte bancaire. Notre modèle, construit selon une approche descriptive, comprend un nombre important de variables pertinentes. Il est donc plausible que les erreurs statistiques soient modélisables comme une somme de variables aléatoires indépendantes et identiquement distribuées. D'après le théorème central limite, le résidu suit alors asymptotiquement une loi gaussienne, ce qui correspond à la distribution du résidu supposée par le modèle probit.

L'hétérogénéité intra-départementale dans les variables de crime pourrait introduire un biais dans les résultats. Pour tenir compte de cette possibilité, nous avons estimé les régressions sur un échantillon de commerçants situés en dehors d'Île-de-France, puisque c'est la région la plus hétérogène en ce qui concerne la criminalité. Neuilly-sur-Seine est par exemple la ville la plus riche de France, tandis que l'économie souterraine tient une place importante dans certaines villes de Seine-Saint-Denis, gangrenées entre autres par la violence et le trafic de drogue. La circonscription de Police de Seine-Saint-Denis est ainsi caractérisée par le taux de violence pour 1000 habitants le plus élevé des circonscriptions de Police françaises (soit 31,27 faits de violence pour 1000 habitants, quand la moyenne nationale est de 6).

La variance entre les richesses des villes de la région parisienne est la plus élevée parmi les régions françaises. En outre, l'Île-de-France très centralisée, en ce sens que l'essentiel de l'activité économique et culturelle se concentre dans la capitale (on observe une asymétrie forte entre Paris et les villes de la grande couronne).

Finalement, on pourrait craindre que la différence de niveau d'agrégation entre les variables de crime départementales et le reste des données, de niveau individuel, entraîne la capture d'un effet fixe départemental en lieu et place de l'impact des divers types de criminalité. Pour traiter cette question, nous incluons des variables binaires contrôlant pour l'appartenance du magasin à chacun des départements. De plus, puisque les variables de crime sont plus agrégées, les écart-types estimés pourraient être biaisés en raison de corrélations intra-départementale entre résidus. L' estimateur Sandwich de Huber-White fournit dans ce cas une estimation correcte de la variance, puisque nous disposons de 94 sous-ensembles de taille équilibrée (soit autant que le nombre de départements minoré de un). D'après Kezdi, 2004, une cinquantaine de clusters de taille équilibrée est suffisamment proche de l'infini pour l'inférence exacte.

3. Le modèle probit est un ensemble d'hypothèses statistiques qui garantit la convergence des estimateurs du maximum de vraisemblance. Son utilisation est standard lorsque le modèle économétrique comprend une variable dépendante binaire non censurée, et que le résidu peut raisonnablement être considéré comme aléatoire.

Tester l'hypothèse (i) — c'est-à-dire un impact négatif du taux de fraude financière sur la probabilité d'acceptation de la carte bancaire — et l'hypothèse (ii) — c'est-à-dire un impact positif du taux de vol sur la probabilité d'acceptation de la carte bancaire — est équivalent à tester le signe et la significativité des variables de crime.

Résultats

Avant de présenter les résultats de l'estimation du modèle probit, nous comparons les ajustements globaux des différents modèles estimés.

Comparaisons des ajustements globaux des modèles

Nous comparons maintenant les ajustements globaux des différents modèles économétriques estimés. La table 4.3 présente les statistiques pertinentes.

TABLE 4.3: Comparaison des qualités d'ajustement des modèles estimés

	(1)	(2)	(3)	(4)
Coefficient Abus de confiance	-5.88/0.10		-5.74/-0.03	
t de Student Abus de confiance	-840/18.86	-78.14/2.20	-816.21/ -2.74	-75.99/0.18
Coefficient Vols Pers	2.02/-0.03		1.98/0.01	
t de Student Vols Pers	796 /-15.55	72.19/-1.86	750/3.35	70.18/0.27
Chi-2	630.17/631.63	385.27/385.58	594.29/605.79	339.77/340.29
Pseudo R^2	0.09/0.09		0.10/0.10	

Notes. Les colonnes (1) et (2) présentent les statistiques du T de Student et les Chi-2 pour les modèles estimés sur l'échantillon complet ; les colonnes (3) et (4) retiennent seulement les commerçants situés hors de la région parisienne. Les colonnes (1) et (3) présentent les Chi-2 calculés grâce aux estimations robustes des écart-types, tandis que les T de Student présentés dans les colonnes (2) et (4) sont calculées par la méthode standard. Tous les tests du Chi-2 rejettent l'hypothèse nulle avec une P-Value inférieure à 0.001. Les résultats sont donnés d'abord pour l'année 2008 puis pour l'année 2007 (2008/2007).

L'échantillon comprend 891 commerçants situés dans la région Île de France, ce qui représente 19.37% de l'effectif total. L'élimination des observations correspondantes pourrait menacer la représentativité de l'échantillon mais l'hétérogénéité intra-départementale dans les variables de crime pourrait être excessive dans la région parisienne. Nous présentons à la fois les résultats obtenus sur l'échantillon complet et sur l'échantillon restreint.
Les ajustements globaux des modèles, évalués par la taille de la statistique du Chi2 de Wald, sont systématiquement plus satisfaisants quand la corrélation intra-départementale est prise en compte par l'estimation Sandwich Huber-White des écart-types. Dans le modèle estimé sur l'échantillon restreint, la statistique du Chi-2 relative à la nullité simultanée de tous les coefficients associés aux variables individuelles augmente de 255 points, passant de 339 à 594 lorsqu'on passe de l'estimation standard à l'estimation robuste (cf tableau 4.3 ; on ne tient pas compte des variables de crime puisque leur niveau d'agrégation est différent).

Le signe et la significativité des variables de crime reste inchangée dans tous les modèle estimés (avec ou sans contrôles départementaux, avec estimation robuste ou standard des variances, pour l'échantillon complet ou privé des commerçants de la région parisienne).

Dans le but d'examiner la possibilité que les commerçants fondent leur décision d'achat d'un terminal carte bancaire sur l'observation du niveau de criminalité de l'année passée, nous avons remplacés les variables de crime prises pour l'année de l'étude (2008) par leurs équivalents pris pour l'année précédente (2007). Les variables de crime perdent en significativité de manière drastique (voir la table 4.3). Le signe des coefficients n'est pas stable selon qu'ils sont estimés sur l'ensemble de l'échantillon ou sur l'échantillon privé de la région parisienne. Elles ne sont plus significatives sur l'échantillon restreint. L'interprétation du modèle est malaisée ; contrairement à l'hypothèse qu'on pourrait formuler *a priori*, la décision de s'équiper en terminal de paiement semble intervenir dans un délai court après l'observation du niveau de criminalité : ces décisions sont simultanées, ou bien dans une séquentialité rapprochée.

Nous présentons et commentons l'estimation robuste (sur l'échantillon complet ainsi que sur l'échantillon restreint) du modèle incluant les variables de crime prises pour l'année 2008, ainsi que les contrôles départementaux. Ce modèle est en effet le plus crédible et le mieux prémuni contre les différents biais possibles. En outre, les statistiques d'ajustement global sont satisfaisantes. Le Pseudo R^2 vaut 0,10 sur l'échantillon restreint (0,09 sur l'échantillon complet) et le Chi-2 testant la nullité simultanée des coefficients est très élevé (la probabilité de nullité simultanée est inférieure à 1 pour 10000). Ceci suggère que le modèle décrit correctement les données. Nous présentons les estimations.

Présentation des estimations

la Table 4.4 fournit les résultats de l'estimation du modèle probit.

TABLE 4.4: Acceptation CB

	Acceptation CB	
	(1)	(2)
Distance Habitation : Etranger	0.24	0.25
	(0.07) [a]	(0.07) [a]
Niveau Financier Clientèle : Très Modeste	-0.36	-0.39
	(0.07) [a]	(0.09) [a]
Niveau Financier Clientèle : Modeste	-0.23	-0.23
	(0.05) [a]	(0.06) [a]
Niveau Financier Clientèle : Classe Moyenne	-0.08	-0.11
	(0.05)[c]	(0.06) [a]
Niveau Financier Clientèle : Aisée	0.15	0.2
	(0.06) [a]	(0.05) [a]
Niveau Financier Clientèle : Ne Sait Pas	-0.45	-0.58
	(0.17) [a]	(0.19) [a]
Age clientèle : 30 à 40 ans	0.23	0.22
	(0.05) [a]	(0.06) [a]
Age clientèle : 40 à 50 ans	0.27	0.26
	(0.05) [a]	(0.05)[a]
Age clientèle : 50 à 60 ans	0.10	0.09
	(0.07) [d]	(0.08) [d]
Age clientèle : Plus de 60 ans	-0.10	-0.11
	(0.07) [b]	(0.06) [b]
Distance Banque	-0.03	-0.02
	(-0.08) [c]	(0.02) [d]
Fréquence des frais de gestion du compte	0.11	0.11
	(0.01) [a]	(0.02) [a]
Rémunération compte	0.25	0.28
	(0.04) [a]	(0.04) [a]
Système de vérification chèque	-0.49	-0.48
	(0.07) [a]	(0.08) [a]
Régime fiscal	-0.03	-0.04
	(0.01) [a]	(0.01) [a]
Vols Ensemble	2.02	1.98
	(0.002) [a]	(0.002) [a]
Fraude et Abus de confiance	-5.88	-5.75
	(0.007) [a]	(0.007) [a]
Pseudo R^2	0.09	0.10
N	4601	3710

Notes. [a] (p<0.001), [b] (p<0.01) , [c] (p<0.05), [d] ($p \geq 0.05$). Seules les variables significatives sont présentées, pour des raisons de concision. Les variables de crime sont définies dans la Table 4.2. Les écarts-types sont donnés entre parenthèses sous les coefficients. La colonnes (1) présente l'estimation conduite sur l'échantillon total, la colonne (2) présente l'estimation conduites sur l'échantillon privé des commerçants de la région parisienne. Tous les modèles présentées comprennent des contrôles départementaux et sont estimés par la méthode Sandwich d'Huber et de White.

Nous discutons maintenant les variables individuelles avant d'aborder les variables environnementales de crime.

Variables de niveau individuel

Les commerçants refusant les chèques acceptent plus fréquemment les cartes bancaires, probablement pour garantir la possibilité de payer avec un instrument de paiement alternatif. Les commerçants bénéficiant d'un compte courant rémunéré sont plus nombreux à accepter la carte bancaire. En effet, ces derniers sont plus intéressés à maintenir le solde de leur compte aussi élevé que possible, et par suite plus prompts à accepter un paiement directement lié au compte bancaire. Les entreprises dont le chiffre d'affaires est plus élevé acceptent moins volontiers la carte bancaire, puisqu'elles vendent moins souvent au détail (la proportion de paiements d'entreprise à entreprise est plus élevée pour les firmes de grande taille, puisqu'en moyenne les étapes de production sous-traitées sont plus nombreuses ; voir par exemple Masten, 1984).

Variables de crime

Premièrement, le contrôle lié à la criminalité violente (« Vol d'ensemble ») a un impact positif sur la probabilité d'acceptation de la carte bancaire. Un niveau élevé de criminalité violente renforce la volonté d'être payé en carte bancaire pour être protégé contre les risques de vol et de perte. Deuxièmement, le niveau de criminalité financière (contrôlé par la variable « Fraude et abus de confiance ») a une influence significativement négative sur la probabilité d'acceptation de la carte bancaire. C'est la conséquence d'un processus de sélection adverse. En effet, les paiements en espèces, difficiles à tracer et facilitant l'évasion fiscale, sont plus fréquents dans les départements où sévit une propension moyenne à la fraude financière plus élevée. L'incitation à accepter la carte bancaire est alors plus faible. Dans une perspective moins environnementale, les commerçants eux-mêmes pourraient employer des travailleurs non-déclarés, et auraient donc besoin d'espèces pour les payer ; bien entendu, la probabilité d'acceptation de la carte bancaire sera plus élevée dans les départements où cette pratique est moins commune.

Les hypothèses (i) et (ii) (impact négatif de la fraude financière et impact positif du niveau de vol sur la probabilité d'acceptation de la carte bancaire) reçoivent une confirmation empirique.

Discussion

Il est essentiel que les variables incluses soient exogènes, c'est-à-dire orthogonales au résidu. En effet, l'estimation des coefficients associés aux variables endogènes — c'est-à-dire corrélées avec le résidu — est biaisée quelle que soit la taille de l'échantillon (en d'autres termes, le coefficient estimé n'est pas asymptotiquement convergent).

Dans le cadre du modèle étudié, l'endogénéité des variables de crime semble peu plausible, puisque les trois sources classiques de corrélation entre le résidus et les régresseurs sont ici peu vraisemblables. En effet, la probabilité d'**erreur de mesure systématique** potentielle parait contenue, puisque les données proviennent directement des déclarations aux commissariat et gendarmeries. De plus, le modèle comprend 25 régresseurs hors contrôles départementaux : la présence dans le processus générateur de données d'une **variable non incluse** significativement corrélée avec un des régresseurs et avec la variable dépendante parait douteuse. Enfin, on ne voit pas quel modèle économique impliquerait l'existence d'une **variable causale** à la fois pour une des variables de crime et pour l'acceptation de la carte bancaire.

Néanmoins, par souci de rigueur, nous proposons par la suite d'utiliser le test de Smith-Blundell d'endogénéité des variables pour les variables de crime. C'est en effet sur l'estimation des coefficients associés à ces dernières que repose l'essentiel de la discussion. Le test d'endogénéité proposé dans Smith et Blundell (1986) suppose l'existence d'un instrument, c'est-à-dire d'une variable exogène significativement corrélée avec la variable suspecte d'endogénéité. Dans la mesure où la variable de « Vol d'Ensemble » est une variable composite de niveau départemental, il n'est pas aisé de proposer un instrument valide. En revanche, nous proposons d'instrumenter le contrôle de criminalité financière par la fréquence moyenne de fraude associée au paiement en espèces sur l'ensemble du département. Ces deux variables sont en effet corrélées comme vu plus haut, et l'exogénéité de l'instrument est assurée puisque le coefficient associé à la fréquence individuelle de fraude n'est pas significatif. [4]

La première étape du test de Smith-Blundell consiste à régresser la variable suspectée d'endogénéité sur l'instrument. Le résidu de cette première régression est introduit dans une deuxième étape dans la régression initiale. Si la variable suspecte est exogène, le coefficient associé au résidu n'est pas significatif.

Dans la mesure où l'instrument comme la variable instrumentée sont identiques pour deux commerçants du même département, la variance du résidu associé à la régression préliminaire pourrait être insuffisante et le test impossible à mener. C'est malheureusement le cas lorsque l'on instrumente le contrôle de criminalité financière normalisé par la population départementale pris pour l'année 2008 dans le cadre du modèle comprenant le contrôle de criminalité violente également normalisé par la population départementale pour l'année 2008.

Il reste toutefois possible de tester indirectement l'exogénéité des variables de crime en remplaçant ces dernières ou les instruments par des variables corrélées. En revanche, il est incontournable d'utiliser de telles variables « proxy » [5] à la fois pour la variable de crime instrumentée et pour la variable de crime incluse dans le modèle. Nous avons donc instrumenté le contrôle de criminalité financière brut (c'est-à-dire non normalisé par la population du département) pour

4. La validité de l'instrument suppose l'absence de corrélation statistique entre l'instrument et le résidu économétrique, c'est-à-dire de la corrélation statistique entre l'acceptation de la carte bancaire **conditionnellement aux régresseurs** et le résidu.

5. On appelle variable « proxy » corrélée une variable d'intérêt, éventuellement non disponible ou non susceptible d'être incluse dans un modèle économétrique pour des raisons statistiques.

l'année de l'enquête. Nous avons inclus dans le modèle testé le contrôle de criminalité violente pris pour l'année 2007 normalisé par la population départementale.

La probabilité d'absence de rejet de l'hypothèse nulle d'exogénéité vaut ici 60,72%. Nos conclusions sont donc compatibles avec les données.

Notons pour conclure cette partie que les t de student des variables de crime sont élevés. Ceci s'explique par le niveau d'agrégation départemental de ces données et la technique d'estimation que nous avons retenue. En effet, nous avons choisi l'estimation par clusters et les variables de crime environnementales sont constantes pour tous les individus du département.

Conclusion

Comme suite à l'analyse de Karoubi (2012), nous exploitons une base de données unique constituée à partir d'un échantillon représentatif de commerçants français pour étudier l'influence du crime sur l'acceptation de la carte bancaire.

Notre indicateur de criminalité violente, subie à la fois par les consommateurs et les commerçants, augmente la probabilité d'acceptation de la carte bancaire. Ceci s'expliquer par un motif de précaution. En effet, les paiements par carte bancaire sont moins sujets à la fraude que les alternatives, et découragent donc le vol.

Nous montrons également qu'un niveau élevé de criminalité financière dans le département diminue la probabilité d'acceptation de la carte bancaire. C'est un effet de sélection adverse. En effet, les transactions réglées par carte sont aisément traçables relativement aux transactions en espèces. Ainsi, les espèces circuleront moins dans un environnement caractérisé par une faible propension à la fraude financière, et les incitations à l'acceptation de la carte bancaire seront plus fortes. De plus, maintenir un stock d'espèces élevé facilite le travail dissimulé.

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Chapter 5

Does Crime Influence the Payment Decisions of Consumers?

Bruno Karoubi

Abstract

We analyze the impact of crime *as an environmental factor* on the use of cash and of bank cards. We exploit a unique database of a representative sample of French consumers. The database comprises controls for payment behaviour and socio-demographic characteristics. We associate to each consumer an indicator of violent and financial crime in his department (a department is a geographical division, similar to a county). All other things being equal, we show that a higher level of violent crime augments the average weekly amount of cash withdrawn, and reduces the probability that a consumer owns a payment card. We also conclude that a high level financial criminality has opposite effects. The probability of aggression is higher when withdrawing cash, and ATMs deliver only notes (typically the minimum withdrawal is 10 or 20 euros). We therefore interpret the increase in the amount of cash withdrawn as a consequence of the reduction of the number of cash withdrawals together with the non linearity of amounts withdrawn at ATMs. We interpret the increase in the proportion of payment card owner when financial crime is high as adverse selection: financial fraudsters are more aware of the insurances provided with payment cards, and therefore value more the ownership of a payment card.

Keywords: Crime, Payment Instruments.

JEL Classification: E4.

Introduction

There has been only scant investigation on the impact of crime *as an environmental factor* on general economic activity. Moral hazard and adverse selection problems have been examined, but they are relevant only on explicit contracts, involving two asymmetrically informed sides.

The final decision of the payment instrument used is taken exclusively by the buyer, conditional on the payments instruments that the seller accepts. The choice depends on the transaction size (cf for instance Whitesell, 1989), and on the preference for close substitutes, like card (cf for instance Santomero and Seater, 1996).

The impact of Crime *as an environmental factor* on the choice of payment instrument, however, has not been studied to the best of our knowledge except from a theoretical standpoint in a paper by Chakravorti and Bolt (2009). In their model, the probability of street mugging decreases the probability of using cash. Shy and Tarrka (2004) introduce a fraud probability, but this ad hoc parameter is neither discussed, nor endogeneized. It is introduced to obtain an equilibrium in which all payment instruments are represented. Karoubi (2012) studies the impact of Crime on the preference for cash of merchants, and on the acceptance of bank card. but the study does not consider the consumer side.

The present paper is an attempt to fill this gap.

More precisely, we use a unique database of 1392 representative consumers. The database comprises the preference for payment instruments, and socio-cultural characteristics. We merged department level Crime indicators - a department is a geographical regional division like a county - with the individual dataset, according to the department of the consumer. The Crime indicators available corresponds to each crime defined in the French nomenclature of crime and offenses. The Crime indicators control control for violent and financial crimes, and are among the least correlated.

We find that the more violent crime in a department (more precisely the higher the level of street crime), the higher the weekly amount withdrawn in cash, and the less likely the ownership of a payment card. We also find that the more financial fraud in a department, the lower amount of weekly cash withdrawals and the more likely the ownership of a payment card. Our results confirm that crime as an environmental factor directly influence the choice of payment instrument.

Data

The main data set was collected from a field inquiry conducted from March to May 2005. The sample is representative of the French population in profession, income and geographical origin.

We use the stratum method to build the sample (we divide the population in multiple homogeneous disjoint groups, and we select independent subsamples inside each group). Consumers described their behavior and preferences towards payment instruments, by answering to a questionnaire submitted by phone. Consumers also detailed their socio-cultural characteristics.

Table 5.1 gives the descriptive statistics for the main variables, discussed in the next section. Table 5.2 describes all the variables used in the econometric models.

All crime variables were extracted from the Etat 4001, a document published by the french Home Office ("Minisétre de l'intérieur") counting all complaints in french Police stations and Gendarmeries for each department (a departement is a regional subdivision like a county). Since we aim at providing evidence of an environmental effect, The relevant crime data is aggregate. The ideal level of aggregation would be zip code or commune, but unfortunately the count of crimes are not available at a smaller level than the department.

We appended crime variables of 2005 (year of the individual variables) and crime variables of 2004 to the main dataset. We merged the databases according to the department of the individual (for instance, the observation corresponding to a consumer living in Paris has crime variables of the department 75). We divided the two crime variables by the department population, extracted from the INSEE website in order to neutralize the size effect (a department can be more populated than another).

We now describe the dependent variables retained to characterize the payment behaviour of consumers, and more specifically their relation to cash and card payments.

TABLE 5.1: Descriptive Statistics

Variable	**Min**	**Max**	**Std Dev.**	**Mean**	**Median**
ATM Amount	10	1200	98.51	86.06	60
EFTPOS Card	0	1	0.39	0.81	1
ATM Per Capita	0.50	1.07	0.11	0.72	0.71
ATM Per Square Meter	1.62	2198.10	351.25	89.62	10.77
EFTPOS Per Capita	8.31	25.12	3.09	12.45	12.22
Surcharge	0	1	0.47	0.33	0
Withdrawal Place	1	4	0.51	1.90	2
Income	1	8	2.15	3.54	3
Gender	0	1	0.50	0.43	0
Age	18	93	16.44	44.86	42
Married	0	1	0.49	0.62	1
Degree	1	7	1.89	3.83	3
No Cash Risk	0	1	0.48	0.65	1
Number of Purchases	0	40	6.23	11.98	11
Average Purchase Amount	0.64	471.60	26.49	29.79	24.38

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Variable	**Min**	**Max**	**Std Dev.**	**Mean**	**Median**
Number of Banks	1	3	0.44	1.21	1
Number of Banking accounts	1	4	0.56	1.32	1
Account Checkout Frequency	1	5	1.12	2.86	3
Financial Frauds, 2004	0.30	12.49	1.80	5.25	4.90
Financial Frauds, 2005	0.34	12.01	1.69	5.0	4.57
Street Crime, 2004	1.49	55.88	11.70	30.86	31.41
Street Crime, 2005	1.44	56.58	11.29	29.17	29.70
Violent Theft, 2004	0.03	7.86	1.71	1.74	1.35
Violent Theft, 2005	0.04	7.86	1.77	1.80	1.27

TABLE 5.2: Description of the Variables Used in the Econometric Models

Variable	**Notes**
ATM Amount	Continuous variable. Amount typically withdrawn at ATMs per week. 94.85% of weekly withdrawals are inferior to 200 euros.
EFTPOS Card	Binary variable. The variable is 1 if the consumer owns an EFTPOS card.
ATM Per Capita	Continuous variable. Number of ATMs per inhabitant in the department. 53.88% of the consumers live in a department with less than 0.71 ATM per capita.
ATM Per Square Meter	Continuous variable. Number of ATMs per square meter in the department.
EFTPOS Per Capita	Continuous variable. Number of EFTPOS points per inhabitant in the department
Surcharge	Binary variable. The variable is 1 if the bank charges cash withdrawals.
Withdrawal Place	Polytomic variable. The variable is 1 if the consumers mainly withdraws the money at the counter of the bank, 2 if he withdraws mainly at ATMs, 3 if another person mainly withdraws for the consumer, and 4 if the consumer never withdraws.
Gender	Binary variable. The variable is 1 if the consumer is woman, and is 0 if the consumer is a man.
Age	Continuous variable. Age of the consumer.
Married	Binary variable. The variable is 1 if the consumer is married, else it is 0.
Degree	Ordered polytomic variable. The variable has 7 modalities, and a higher modality corresponds to a higher degree. Modalities range from "No Degree" to "Master's Degree and Higher".
Income	Ordered polytomic variable. The variable has 8 modalities. A higher modalities correspond to a higher income.
No Cash Risk	Binary variable. The variable is 1 if the consumer considers that holding notes and coins involves a significant risk. The first modality corresponds to a null perceived risk.
Number of Purchases	Continuous variable. Average number of purchases performed in a week.
Average Purchases Amount	Continuous variable. Average amount of purchases the performed in a week.
Number of Banks	Ordered Polytomic variable. Number of banks holding accounts for the consumer. A little more than 4 consumer out of 5 have a single bank.
Number of Banking Accounts	Ordered Polytomic variable. Number of accounts of the consumer. 72.54% of consumers have a single banking account.
Account Checkout Frequency	Ordered Polytomic variable. The variable has 5 modalities, ranging from "every day" to "less than once a month". A little more than two thirds of the sample (67.10%) checks the account less than once every 15 days.

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Variable	**Notes**
Financial Frauds, 2004	Continuous variable. Count of complaints filed for Financial Frauds in the department for a thousand inhabitants, year 2004. The departement "Nord" has the lowest rate. The department "Ile de France" (Paris department) has the highest rate, followed by the department "Val de Marne", the department "Hauts-De-Seine" and the department "Seine Saint Denis" (the departments are all in the Paris region).
Financial Frauds, 2005	Continuous variable. Count of complaints filed for Financial Frauds in the department of the consumer for a thousand inhabitants, year 2005. The department "Ile de France" (Paris department) has the highest rate, followed by the department "Ille et Villaine", the department "Bouches du Rhône" and the department "Hauts-De-Seine".
Street Crime,2004	Continuous variable. Count of complaints filed for Street Crimes in the department for a thousand inhabitants, year 2004. The departement "Nord" has the lowest rate. The department "Bouches du Rhône" has the highest rate, followed by the department "Île de France" (the Paris department) and the department "Seine Saint Denis".
Street Crime, 2005	Continuous variable. Count of complaints filed for Street Crimes in the department for a thousand inhabitants, year 2005. The departement "Nord" has the lowest rate. The department "Bouches du Rhône" has the highest rate, followed by the department "Seine Saint Denis" and the department "D̂e France" (the Paris department).
Violent Theft, 2004	Continuous variable. Number of complaints filed for Violent Theft in the department for a thousand inhabitants, year 2004. The departement "Nord" has the lowest rate. The department "D̂e France" (the Paris department) has the highest rate, followed by the department "Seine Saint Denis".
Violent Theft, 2005	Continuous variable. Number of complaint filed for Violent Theft in the department of the consumer for a thousand inhabitant, year 2005. The departement "Nord" has the lowest rate. The department "Seine Saint Denis" has the highest rate, followed by the department "D̂e France" (the Paris department).

Dependent Variables

Since we want to characterize an impact on the use of cash, the dependent variable must be a proxy of the level of cash use. Cash spent per a fixed time period appears as the natural candidate. It is difficult however for a representative sample to keep track of cash spent with sufficient reliability, since the process would involve high cognitive costs or a significant organization. Therefore, we retained the best proxy easily available, the amount of cash withdrawn at an ATM per week. Consumers can withdraw cash at the counter of a bank but the amounts are comparatively negligible (they amount to less than one hundredth of the average amount withdrawn at an ATM in our database). Not all consumers of our sample withdraw cash however (only 1092 out of 1392 individuals). Therefore, individuals using an ATM may have systematic common characteristics explaining their withdrawal choice and biasing the results. In order to correct for this potential selection bias, we estimated a Heckman selection model. The selection equation explains the choice of using ATM to withdraw.

We also want to characterize an impact of crime on the use of bank card, our dependent variable must be a proxy of the level of card use. The amount of card transactions performed in a fixed period appears as a natural candidate; it is not available however, and the evaluation of this amount by the consumer would not be reliable. The ownership of a bank card could be an interesting proxy, but most French bank cards allow both cash withdrawals and payments. Some cards exclusively allow cash withdrawals though (111 consumers own a withdrawal only card, out of 1131 card owners).

Independent Variables

Since it is plausible that the reasons for withdrawing more or less cash also impact the usage of ATM and have an influence on the decision of owning a bank payment card (Electronic Fund Transfer at Point of Sale card, EFTPOS card), we considered the same independent variables to model the weekly cash withdrawal, the usage of an ATM (for the selection equation) and the decision of owning a bank payment card. We now examine the variables.

We separate the variables into three disjoint sets : the variables related to the cost of cash withdrawals and to the cost of card payments, the consumer controls, and the variables controlling for the relation of the customers to the banks.

The first subset of variables is linked to the cost of withdrawing cash, and the cost of paying by card. For instance the variables identified in Baumol (1952) and Tobin (1956) have a crucial role in the decision of withdrawing cash. The variables impact the decision of owning a payment card because payment instruments are imperfect substitutes.

The ATM population density and the **ATM spatial density** impact the "shoe leather cost" (i.e. the hardness of moving to an ATM). Recall that the inventory theoretic model of cash demand considers a consumer earning a fixed income per period, and facing a continuous need for cash holding to carry out transactions. The optimal number of cash withdrawals is proportional to the square root of the costs of cash withdrawals and the inverse of the interest rates.

The number **EFTPOS points per capita** is the main control for the level of acceptance of payment cards by merchants.

The **Withdrawal place** traduces the usual effort associated with cash withdrawals. A higher value corresponds to a lower average effort for cash withdrawing. Indeed, the first modality corresponds to a withdrawal at the bank counter, the second to a withdrawal at an ATM, the third to a withdrawal effected by a third person, and the fourth to a never withdrawing consumer. [1].

The second subset of variables refers to the characteristics of the consumer.

Gender influence significantly payment patterns; Burg et Toussaint (2011) find that check is more used by women, because they can put their checkbook in their purse.

Age impacts the psychological relation to money, and therefore payment patterns; for instance, aged people tend to distrust electronic payment instrument, children and teenagers usually receive and spend their pocket money in cash.

1. We estimated regressions in which we introduced dummies for each of the four modalities of this variable, and the results on crime proxies (sign and significance of the associated coefficients) were stable.

We introduced a binary variable controlling for whether the consumer is **Married**, since husband and wife have a specific payment instrument usage pattern (for instance, husband and wife may debit a join banking account by using a specific card).

Educated people tend to be more willing to use credit card payments, and a higher **Degree** is associated with a more intellectual — less manual — profession, which impacts the profile of consumption and therefore the payments instruments used.

Low **Income** individuals choose their payment instruments at least partly for their funds management (they use credit card or other payment instruments with deferred debit like checks), high income individual buy higher priced goods, and are less likely to use cash *Ceteris Paribus*.

The perceived **Subjective risk** of cash payments imply more reluctance to carry and use cash. Therefore, we introduced a binary variable to control for whether the consumers thinks cash is a significantly risky payment instrument.

Some cognitive cost (computation of the total payment value or division of the total prices in coins and notes) increase with the **Number of purchases**, and the costs are particularly significant when the consumer pays cash. Prices are usually set immediately lower than a psychological barrier (*e. g.* 10, 100, 1000 and so on currency units). Karoubi (2012) shows that merchants set the convenience of their price in order to influence the choice of the payment instrument.

Obviously, the transaction size plays an important role on the choice of the payment instrument (cf for instance Federal Reserve Bank, 2005). Therefore the **Average value of total purchases** impacts cash use.The **Type of profession** controls for the work status of the consumer which impacts the consumption profile because it is a proxy of the socio-cultural environment and of the lifestyle.

The last set of variables account for the relation of the consumers to the banks.

We introduced a binary variable controlling for the **Number of banking accounts** that the consumers owns. Indeed, an individual with multiple banking accounts may find it more convenient to pay by credit card because of the possibility of switching between bank fees associated with each account, or because multiple accounts make it easier to manage different types of expenses.

We also introduced a dummy variable indicating whether the bank of the consumer charge withdrawals at ATMs outside the network, denoted **Surcharge**. The inquiry was carried out before this practice became generalized in July 2002 and roughly one third of the sample is subject to surcharges. [2]

An individual with multiple accounts held by different banks has an additional degree of freedom relative to the situation in which he is affiliated with a single bank (even if the latter holds multiple accounts). For instance, if an account happens to be in deficit, it is impossible for the

2. In July 2002, the Euro regulation was implemented, and banks had to unify the pricing across Europe. Most French banks reacted by implementing surcharges. Usually, the three or four first withdrawals at an ATM not belonging to the bank are free, while the following are priced 1 euro. See for instance Karoubi (2013).

holding bank to block the other accounts. Therefore, we introduced a dummy for the number of **Account holding banks**.

The perceived cost of using the payment card may vary with the **Account checkout frequency**. Moreover, an individual checking his account is often more cautious in sparing money. She is often more aware of bank card fees, and is thus more able to make an informed decision about the ownership of a payment card.

Econometric Strategy

For the ownership of a payment card, it seems reasonable to assume that all missing regressors are NID, so that the central limit theorem applies, and that the residual is approximately gaussian. Therefore, we estimate a classic probit.

On the technical ground, we assume that a latent variable can be defined, noted hereafter Ỹ, whose values determine those of the actual dependent variable. The latent variable is the consumer's benefit to pay by card. The individual decides to own a payment card if and only if those benefits overcome the hardness associated with owning a payment card (the hardness correspond to the statistical threshold defined below). We assume that

$$\begin{cases} \Pr(Y=1) = \Pr(\tilde{Y} \geq T), \\ \text{where T is a threshold, and where the probability density function of } \tilde{Y} \text{ is:} \\ \tilde{Y} = \alpha X + \varepsilon, \\ \varepsilon \text{ is a normal white noise, } E(\varepsilon) = 0,\ V(\varepsilon) = 1. \end{cases}$$

For the weekly amount of cash withdrawn, we estimate a Heckman selection model. Indeed, consumers who withdraw cash at ATMs may have systematic common characteristic which would influence the amount withdrawn.

Results

Table 5.3 presents the results.

We discuss first the regression explaining the amount of cash withdrawn in a week. Current year crime indicators are not significant, as opposed to previous year crime indicators. Consumers observe the level of Crime before reacting.

Both our indicators of violent crime (Violent theft and Street Crime) have a positive impact on the amount withdrawn at ATMs each week. The result is counter-intuitive, since we would expect a consumer to reduce the sum she carries to reduce her liability to violent theft. We can however explain this result by considering that withdrawing cash is the real danger since it is visible and has to be performed at an ATM, i.e. at specific places known of a potential aggressor. A rational consumer would increase the average sum withdrawn to reduce the number of withdrawals. Since most ATMs deliver exclusively notes of 10 or 20 euros, fine tuning the sum withdrawn is impossible, and therefore an increase in the average sum withdrawn may imply a higher amount withdrawn. It is unfortunately impossible to perform a reliable test that the number of withdrawals decreases when violent crime increases, since we do not observe the number of withdrawals in a fixed period of time.

Our indicator of financial frauds has a negative impact on the weekly amount of cash withdrawn. In a department where financial frauds are common, cash is less frequent. financial frauds typically concerns high amounts, and often involve accounting manipulations. Cash payments are more rare when prices are high (Whitesell, 1992), and are excluded when performing accounting manipulations.

For the regression explaining the ownership of a payment card, both current year and previous year crime indicators are significant. Consumers both react to previously observed and to current crime. Our indicator of violent crime (Violent Theft) has a negative impact on the ownership of a payment card. In other words, the more violent crimes in the department, the less the consumer owns a payment card. This result is consistent with our conclusions on the amount of cash withdrawn. If a consumer withdraws higher amounts, he has less incentives to own a payment card, since he pays cash more easily. Our indicator of financial frauds has a positive impact on the probability of ownership of a payment card. The higher financial fraud in the department, the more common the ownership of a payment card. This is consistent with our conclusions regarding the weekly amount of cash withdrawn. Indeed, Fraudsters are typically expert in financial questions, and are typically aware of the risks associated with cash payments, as well as the insurance provided with card payments. They are more prone to insure their legitimate payments by using payment cards.

For both regressions, the inclusion of department level dummies was not possible. Indeed, for the regression with the weekly amount of cash withdrawn as dependent variable, the likelihood is not concave, and the Limited Information Maximum Likelihood estimator (LIML) obtained by performing a two step estimation *à la* Heckman is not reliable, since various variables are dropped due to multicollinearity and since some observations are completely determined as linear combination of the regressors; the estimated standard errors are therefore questionable. The estimation of the probit with the ownership of a payment card as a binary dependent variables suffers of the same problems. Our Database, while containing a sizable amount of observations (1407 consumers) is not big enough to fit a model with more than 120 variables satisfyingly.

We estimated the regressions using cluster robust estimation (each department is considered a cluster), to ensure that we captured a crime related effect and not merely a department fixed effect. The results were qualitatively the same, though the significance of crime variables is slightly degraded.

TABLE 5.3: Estimation Results

	(1)	(2)	(3)	(4)
ATM Population Density	-25.1	-52.7	1.25^{d}	1.00
	(51.1)	(49)	(0.74)	(0.75)
Density of EFTPOS Points	2.96^{d}	2.48	-3.96e-03	-8.62e-05
	(1.74)	(1.72)	(2.57e-02)	(2.57e-02)
Surcharge	6.99	6.28	0.57^{a}	$0.58e^{a}$
	(6.22)	(6.26)	(0.1)	(0.1)
Withdrawal Place	13.4	13.3	0.44^{a}	0.45^{a}
	(14.5)	(14.5)	(0.08)	(0.08)
Gender	9.87	9.40	$0.\ 16^{d}$	$0.\ 16^{d}$
	(6.13)	(6.13)	(0.09)	(0.09)
Age	0.63^{b}	0.58^{b}	-5.47e-04	-5.97e-04
	(0.22)	(0.22)	(2.74e-03)	(2.74e-03)
Married	-0.02	0.46	0.19^{c}	0.19^{c}
	(6.51)	(6.52)	(0.09)	(0.09)
Degree	-6.67^{a}	-6.64^{a}	0.12^{a}	0.12^{a}
	(1.69)	(1.69)	(0.02)	(0.02)
Subjective Risk	11.6^{d}	10.3	-0.41^{a}	-0.41^{a}
	(6.32)	(6.29)	(0.10)	(0.10)
Number of purchases	1.50^{b}	1.51^{b}	2.83e-03	3.31e-03
	(0.51)	(0.51)	(0.01)	(0.01)
Average Purchase Amount	0.09	0.10	4.14e-03^{c}	4.38e-03^{c}
	(0.14)	(0.14)	(2.05e-03)	(2.07e-03)
Account Checkout Frequency	-4.89^{d}	-4.83^{d}	-0.05	-0.06
	(2.74)	(2.74)	(0.04)	(0.04)
Street Crime, 2004		1.03^{c}		
		(0.47)		
Violent Theft, 2004	9.57^{c}		-0.1^{d}	
	(3.73)		(0.05)	
Financial frauds, 2004	-5.03^{d}	-6.96^{d}	0.10^{c}	
	(3.04)	(3.82)	(0.04)	
Violent theft,2005				-0.11^{c}
				(0.05)
Financial and economic frauds, 2005				0.11^{c}
				(0.05)
N	1383	1383	1383	1383

Notes. Standard errors in parentheses. ^{d} $p < 0.1$, ^{c} $p < 0.05$, ^{b} $p < 0.01$, ^{a} $p < 0.001$. Column (1) and (2) present the estimation of the main equation of the Heckman selection model, with different crime indicators. The dependent variable is the weekly amount withdrawn at ATMs. The selection equation is not reported here for the sake of conciseness. Column (3) and (4) present the estimation of the probit model with different crime indicators. The dependent variable is a binary variable equaling 1 if the consumers owns a payment card. The constant is not reported for all models presented.

Conclusion

We focus on the impact of Crime on the use of payment instruments. We use a unique database of a representative sample of consumers. We complete the database with department level crime indicators, extracted from the"Etat 4001", a document published by the French Home Office ("Ministére de l'intérieur") counting all complaints filed in French Gendarmeries and Police stations. We retain indicators of violent Crime (Street Crime and Violent theft) and an indicators of financial frauds ("Financial Frauds").

We show that the more violent Crime in a department (more precisely the higher the level of Street Crime), the higher the weekly amount withdrawn in cash, and the less likely the ownership of a payment card. This is interpreted as a consequence of a reduction of the number of withdrawals while maintaining total amount withdrawn, since ATMs typically deliver only notes (most often notes of at least 20 euros).

We also show that the more financial fraud in a department, the lower amount of weekly cash withdrawals and the more likely the ownership of a payment card. This result is interpreted as a consequence of the expertise of financial fraudsters: they are more sensitive to the risks associated with cash payments, and value more the insurance bundled with card payments. They use more payment cards and are therefore more likely to own them.

Our results should be considered in light of Karoubi (2012). Even if the databases are not contemporaneous, we can put together the conclusions of both papers. The impact of violent crimes on the use of cash is twofold: a higher level of violent crime decreases the appreciation of cash for merchants, and increases the weekly amount withdrawn in cash for consumers. The impact of financial crimes on the use of card is also twofold: violent crime increase the acceptance of payment card, and financial fraud decreases the likelihood of card acceptance, while increasing the likelihood of card ownership.

Our results and the results of Karoubi (2012) strongly support and complement each other.

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Chapter 6

The Role of Perceived Risk in Holding and Using Payment Instruments

Bruno Karoubi [1]**, Régis Chenavaz** [2]**, and Corina Paraschiv** [3]

Abstract

This empirical study measures the impact of perceived risk on the decision to hold and on the decision to use the main retail payment instruments (cash, card, and check). We show that, because the decision to hold a payment instrument is made before the decision to use it, both decisions are related and must be studied jointly. In addition to global risk, we identify ten risk factors that may affect consumers choices related to payment instruments. The study provides evidence that the global perceived risk of holding and the global perceived risk of using a payment instrument decrease the frequency of holding and using this payment instrument. We also observe cross effects between payment instruments, and confirm that card is the main substitute for cash. The analysis based on risk factors shows that availability risk (risk of not holding the payment instrument when needed) as well as time risk (risk of losing time when performing a transaction) have the most transverse influence on the hold and use of payment instruments. Our results confirm the interest for a quickly to use and constantly available payment instrument, contactless payment via mobile phone satisfying these requirements.

Key Words: Payment instrument, Perceived risk.

JEL Classification: E4.

1. ERUDITE, University Paris-Est Créteil
2. KEDGE Business School
3. University Paris Descartes and GREG-HEC

Introduction

Literature usually represents the choice between the main retail payment instruments (cash, card, and check) without accounting for psychological aspects of decision making, since the choice is the result of a maximization program (Whitesell, 1989; Mello and Zylberman, 2007). The psychology of choice is excluded from the analysis, and its effects are assumed fixed *ex-ante*.

This paper adopts the opposite viewpoint. Building on the model of perceived risk developed by Roselius (1971) and Jacoby and Kaplan (1972), we investigate the impact of the perceived risk and of the main risk factors on the frequency of use of different payment instruments.

The decision to use a payment instrument for a given transaction implies a previous decision to hold this particular payment instrument available at the moment of purchase. Throughout this paper we will study these two decisions that will be referred to as use decision and hold decision. Both hold and use decisions are observable consequences of consumers' preferences regarding payment instruments. Perceived risk is an important non-observable determinant of those observable preferences. The aim of our study is to identify the role of the global perceived risk and of different risk factors in determining the frequency of holding and the frequency of using the main retail payment instruments (cash, card, and check).

The global perceived risk is modeled in the literature as the combination of several additively separable dimensions. The most important risk dimensions of perceived risk identified are physical risk, financial risk, performance risk, psycho-social risk (Jacoby and Kaplan, 1972) and time risk (Roselius, 1972). Following the literature, we model global perceived risk as an additive construct of several risk factors.

To understand the role of global perceived risk and its factors on the hold and use decisions for different payment instruments, we undertake an empirical analysis, using an original database from French residents.

The main results of our study are as follows. First, we show that the equations of holding and of using a payment instrument are linked, and may not be estimated separately. This underlines the importance of a joint study of hold and use decisions to understand payment behavior. Second, we provide evidence about the substitution patterns between payment instruments. Our results show that significant cross effects primarily concern bank card and cash. Third, we show that unavailability risk and time risk have the most cross-cutting influence on hold and use decisions for payment instruments. This highlights that consumers look for a constantly available and quick to use payment instrument.

The rest of the paper is organized as follows. Section 2 gives a short overview of the main research results on perceived risk and identifies risk factors related to the different payment instruments. Section 3 describes the econometric model. In Section 4, we present our data collection method and describe sample characteristics. We present the results in Section 5 and conclude in Section 6.

Literature

The concept of perceived risk is central when modeling the psychological aspects of consumer's decision to use a particular payment instrument for a purchase. In this section, we present a short summary of the main thrusts of the academic literature on perceived risk in a general perspective, as well as specific results related to payment instruments.

The first introduction of the concept of perceived risk goes back to Bauer (1960) that applies this concept to consumption habits (Bauer, 1964). Bauer's studies renewed the framework of consumption behaviour by analysing them as a reaction to risk, defined as the set of unpleasant consequences of a purchase decision for a consumer. The literature on perceived risk grew significantly thereafter (Peter and Ryan, 1976; Taylor, 1974).

During the last years, global perceived risk related to payment instruments received a growing attention in the literature, especially with the development of the Internet and the increasing use of credit cards for online purchases. For example, Ho and Ng (1994) study the perceived risk associated to debit cards and identify factors allowing to increase the use of electronic payment instruments, Garbarino and Strahilevitz (2004) study gender differences in global perceived risk for online shoping and Wang (2008) focuses on the factors such as perceived risk that may influence the use of contactless credit cards. However, comparisons between payment instruments in terms of perceived risk are less frequent. Cheng *et al.* (2011) show that risk perception impacts significantly the choice between payment instruments and, in particular, the choice between cash and card. Jonker (2007) explores, using data collected at household level, the determinants of the choice of the payment instrument. In the perspective of the social planner, the paper proposes measures to increase the use of payment cards, oriented toward the reduction of the cost of use. Ricciarelli (2007) provides evidence that cash is favored as a payment instrument for criminal activities or when fraud is planned. De Mello and Zylberman (2007) show that, at

Rio, crime acts involving physical violence have no impact on saving ratio, contrary to property crime. Karoubi (2010a) and Karoubi (2010b) analyze the impact of crime on the use of cash and on the use of bank cards. These two studies show the existence of a double effect associated with the use of cash to provide anonymity: cash non-traceability favors its use in criminal contexts, whereas the impossibility to insure the risk of theft and the risk of loss decreases the use of cash. Rysman (2007) shows that there is a positive feedback loop between global risk and card acceptance by merchants. Jonker (2007) suggests that the possibility to gain time in particular is an important determinant of the choice of payment instruments. Contrary to these papers, we distinguish in our study between the global risk of holding and the global risk of using a payment instrument. The first is defined as the risk of having a particular payment instrument with oneself and the second is defined as the risk of using a particular payment instrument for making a purchase.

The models of perceived risk fall upon two main categories. The first category assumes a multiplicative structure. In this framework, initiated by Cunningham (1967), the perceived risk has two components: an uncertainty component that models the level of uncertainty about the occurrence of negative consequences and a loss component that models the importance of such negative consequences for the consumer. With a multiplicative structure, it is difficult to study risk components separately because the variation of a component entails the variation of the other. Several authors point to the difficulties associated to the use of this category of perceived risk models to study consumption behavior (Bettman, 1975; Stone and Grønhaug, 1993).

The second category of perceived risk models assumes that the global perceived risk is additively separable in its dimensions. This category is based upon the work of Roselius (1971) and Jacoby and Kaplan (1972). These authors identify global perceived risk as an additive structure based on five main risks dimensions: financial risk (potential monetary losses), time risk (potential time losses related to product use and detention), performance risk (potential product dysfunctions), psycho-social risk (potential negative impact on self-image and others' image of oneself) and physical risk (potential negative impact on health related to product dysfunction). In our study, we adopt this second point of view and define global perceived risks of using and of holding payment instruments as additive constructs. Our work is in line with Ho and Ng (1994) that use an additive model of perceived risk to study electronic payment instruments.

Building on the risk dimensional approach proposed by Roselius (1971) and Jacoby and Kaplan (1972), we use the five risk dimensions identified in the literature (financial risk, psycho social risk, performance risk, time risk and psycho-social risk) to establish a list of ten risk factors that may affect the decision to hold and to use different payment instruments.

Physical risk refers to the risk that the usage of a payment medium may lead to physical discomfort or to a loss of physical integrity. For example, a man that does not carry a bag may find it problematic to hold a check or a person that uses a credit card to withdraw money in an insecure area could be subjected to a physical aggression. The two main factors of physical risk are the risk of discomfort and the risk of theft.

Financial risk relates to the direct and indirect monetary losses due to the use of a payment instrument rather than another. This effect can transit through the difficulty to get a refund (reimbursement risk), the possibility of fraud (fraud risk), the possibility of loosing the payment instrument (loss risk) or the importance of bank fees (cost risk) associated to particular payment instruments. In some cases, a consumer may use the choice of a payment instrument (check versus card) as a solvability management tool or in order to avoid bank fees.

Performance risk corresponds to the difficulty to conclude a transaction in the absence of a particular payment instrument (unavailability risk). For example, a retailer can refuse a payment by credit card or check for small amounts of money and if cash is not available, the transaction can not be concluded. Performance risk also represents the impossibility to perform the transaction with the preferred payment instrument either because this payment instrument is not accepted by the seller or because the payment is not successful for technical reasons (acceptance risk).

Time risk is the risk that the choice of a specific payment instrument may lead to losses in terms of waiting time, transaction time or processing time. For example, a credit card may increase transaction speed compared to a check, because for the later type of payment the consumer has to provide identity documents. Moreover, the use of check versus card represents sometimes a financial management tool allowing to delay the effective fund transfer.

Psycho-social risk is defined as the risk that the use of a payment instrument will lead to a degradation in self-esteem and self-perception or to a degradation of the image that others (friends, colleagues or society as a whole) have of an individual. For instance, the use of a credit card or a check may lead to a loss of privacy contrary to cash payment that allows to preserve the anonymity of the buyer (anonymity risk). In a lesser extent, paying small sums with a check instead of a credit card or cash may be a signal of financial difficulties.

By considering all the above-mentioned elements, we developed a list of ten risk factors that were retained in our analysis. The risk factors are summarized in Table 1. Some of the risk factors, such as the probability of fraud (Ricciarelli, 2007), financial cost (Jonker, 2007), the risk of identity theft (Mello and Zylberman, 2007) or the risk of losing anonymity (Karoubi, 2010b) have already been used in the literature to compare different payment instruments. But in general, the focus of literature on risk associated to payment instruments is on risk factors related to financial risk and physical risk. This is particularly true for studies that investigates crime impact on the economy. However, to our knowledge, no available study on perceived risk analyzes the risk factors that we identified in the literature jointly in relation to one another. By adopting a limited point of view about risk, available studies fail to provide a complete analysis of the relation between perceived risk and the decision to hold and to use preferentially one payment instrument over another. As opposed to such studies that focus on isolated risk dimension, the main purpose of our study is to investigate the risk factors in interaction.

Econometric Strategy

We study the role of perceived risk on the frequency of holding and the frequency of using the three main retail payment instruments, cash, bank card, and check. Cash is the default payment instrument. For the alternative payment instruments, namely bank card and check, the ownership decision (the decision to subscribe to this payment instrument) is a preliminary requirement for holding and using this instrument at the moment of purchase.

Our study is based on data about French consumers. In France, the ownership decision of a check is acquired for most of the population, and the ownership decision of a bank card is acquired for a clear majority (95 % of the French own a check, and roughly 2 French out of 3 own a bank card according to Ifop, 2012). In light of these characteristics of the French population, we decided to focus on the role of perceived risk on the hold and use decisions, rather than on the sole ownership decision for alternative payment instruments. Therefore, for each alternative payment instrument, the analysis of the relation between risk perception and the frequency of holding and on of using that instrument is restricted to people owning it; in other words, the ownership decision is acquired *ex-ante*.

Because we study both the hold and use decisions, we distinguish between two global perceived risks: the global perceived risk of using a payment instrument and the global perceived risk of holding a payment instrument. We control the dimensions of global risks by including the ten risk factors identified in Section 2 and summarized in Table 1. We assume an additive structure of global perceived risks which implies that global risks are additively separable in their dimensions.

We consider the use of payment instruments as a sequential choice, since the use of a payment instrument requires holding it. First, the consumer decides whether he holds a payment instrument. Second, if he holds that payment instrument, he decides whether he uses it to pay a transaction. The factors influencing the hold decision therefore also influence the usage decision.

Because we restrict the analysis to the subsample of consumers owning the alternative payment instrument, the frequency of holding influence the frequency of usage of a payment instrument. In statistical terms, the residual of the econometric equation explaining the frequency of holding a payment instrument and the residual of the econometric equation explaining the frequency of usage are correlated. An estimation ignoring this correlation would be biased. More specifically, we assume that, for each payment instrument considered, the frequency of holding and the frequency of usage may be modeled by a bivariate probit. Formally, let $Hold$ be the modal variable representing the hold frequency. Let $Usage$ be the ordered polytomous variable representing the frequency of usage. We have:

$$Hold = \alpha X + \varepsilon,$$

$$Usage = \alpha' X' + \varepsilon',$$

where X and X' are the matrices of regressors; α and α' are the maximum likelihood coefficients; ε and ε' are the matrices of residuals with $\begin{pmatrix} \varepsilon \\ \varepsilon' \end{pmatrix} \sim \mathcal{N}\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \rho \\ \rho & 1 \end{pmatrix}\right)$ and $\mathcal{N}$ is a bivariate normal distribution.

Data

The data was collected using an online self-administered survey. Table 6.1 summarizes the variables used in the model and presents the coding choices [4] for the questionnaire. The variables include the frequency of use and of hold, the global risks of use and of hold, the 10 risk factors as well as several control variables. We retained 393 questionnaire filled in integrality. We checked the consistency of answers and we filtered questionnaires with patent errors.

4. With the exception of acceptance, time and reimbursement risks that were operationalized in terms of gains, the other risk factors were operationalized in terms of losses. The interpretation of the results in Section 6 takes into account these definitions.

TABLE 6.1: Definition and Coding of the Variables

Definition	Coding
Frequency of Holding and Use	
Frequency of Small Cash Holding	Ordered Polytomous (Scale from 1 to 5)
Frequency of Large Cash Holding	Ordered Polytomous (Scale from 1 to 5)
Frequency of Check Holding	Ordered Polytomous (Scale from 1 to 5)
Frequency of Card Holding	Ordered Polytomous (Scale from 1 to 5)
Frequency of Cash Use	Ordered Polytomous (Scale from 1 to 5)
Frequency of Check Use	Ordered Polytomous (Scale from 1 to 5)
Frequency of Card Use	Ordered Polytomous (Scale from 1 to 5)
Frequency of Online Card Use	Ordered Polytomous (Scale from 1 to 5)
Global Risk	
Global Risk of Use	Ordered Polytomous (Scale from 1 to 7)
Global Risk of Holding	Ordered Polytomous (Scale from 1 to 7)
Factors of Risk	
Theft Risk	Ordered Polytomous (Scale from 1 to 7)
Discomfort Risk	Ordered Polytomous (Scale from 1 to 7)
Anonymity Risk	Ordered Polytomous (Scale from 1 to 7)
Loss Risk	Ordered Polytomous (Scale from 1 to 7)
Cost Risk	Ordered Polytomous (Scale from 1 to 7)
Time Risk	Ordered Polytomous (Scale from 1 to 7)
Reimbursement Risk	Ordered Polytomous (Scale from 1 to 7)
Unavailability Risk	Ordered Polytomous (Scale from 1 to 7)
Acceptance Risk	Ordered Polytomous (Scale from 1 to 7)
Fraud Risk	Ordered Polytomous (Scale from 1 to 7)
Control Variables	
Gender	Binary (0 if woman, 1 if man)
Age	Ordered Polytomous (Scale from 1 to 7)
Age at Study Completion	Ordered Polytomous (Scale from 1 to 6)
Income	Ordered Polytomous (Scale from 1 to 7)
Type of Agglomeration	Categorical (4 values)
Professional Status	Categorical (6 values)
Family Situation	Categorical (6 values)

The sample is relatively young (the age of the average individual is around 30, and 1 individual out of 2 is less than 25), and educated (178 individuals, amounting to more than half of the sample complete their studies between 22 and 23; 106 individuals among them complete their studies between 24 and 26). Only a weak proportion of the sample stopped studies before 20 (27 individuals). The gender composition is balanced with 196 women and 195 men. The sample is urban (more than half of the sample lives in large agglomerations). Therefore, many automated teller machines are available and search costs for an them is low. This aspect allows us to exclude, without loss of generality, the hardness of cash supply from the analysis and to focus on perceived risk *stricto sensu*. The familial and professional situations of the individuals, as well as their income profile, reflect the relative youth of the respondents; 179 are students. The proportion of workers or employees is about 8.9%, and roughly 1 individual out of 5 is an executive (80 individuals). About the same proportion of the sample exert liberal professions (76 individuals). 253 individuals are single (amounting to 60 % of the sample) and, from the ones that are not single, roughly 1 individual out of 2 enjoys a specific tax status for their couple life (they are married or have signed a civil union contract).

Results

Descriptive Results

Risk Perception

Table 6.2 summarizes the results of the study concerning the level of perceived risk associated to the different retail payment instruments. We can easily see that the findings are highly consistent with the literature on retail payment instruments. Indeed, at global level, the most important risk perceptions are related to the use of credit cards on the Internet and to the holding of large sums in cash. Concerning the importance of risk factors, we observe that discomfort risk is high for check and rather low for cash and card, that theft risk is higher for cash than for credit card and check and that anonymity risk is high for check and card and low for cash. Moreover, the choice of check as a payment instrument increases time risk, unavailability risk is high for cash and card and lower for check and acceptance risk is higher for check than for card and for cash.

TABLE 6.2: Mean and Standard Deviation of Risk Factors

	Cash		Card		Check
	€10	€100	Card	Card Online	
Global Risk of Use	2.18 (1.40)		2.63 (1.48)	4.08 (1.72)	2.71 (1.55)
Global Risk of Holding	1.31 (0.73)	4.04 (1.93)	2.22 (1.38)		2.86 (1.77)
Theft Risk	4.68 (1.81)		3.74 (1.79)		3.63 (1.69)
Discomfort Risk	2.88 (1.87)		1.68 (1.04)		5.07 (1.97)
Anonymity Risk	1.63 (1.33)		5.52 (1.64)	5.64 (1.59)	5.85 (1.55)
Loss Risk	4.07 (1.93)		3.39 (1.73)		3.43 (1.75)
Cost Risk	1.64 (1.12)	2.63 (1.81)	3.19 (1.90)		2.41 (1.7)
Time Risk	1.78 (1.28)		4.06 (2.02)	3.65 (1.95)	5.03 (1.85)
Reimbursement Risk	3.21 (1.94)		4.86 (1.57)	4.13 (1.75))	2.71 (1.65))
Unavailability Risk	5.52 (1.40)		5.62 (1.39)		3.03 (1.70)
Acceptance Risk	6.17 (1.25)		4.4 (1.74)		3.11 (1.74)
Fraud Risk	3.08 (1.55)		3.58 (1.62)	4.68 (1.74)	3.57 (1.63)

Notes. Standard deviations are in parenthesis. When the risk factor concerns cash independently of the sums, the columns for €10 and €100 are merged. The same remark applies to the use card offline and online.

Socio-Demographic Analysis of Use and Hold Decisions

As a preliminary step, we used the socio-demographic variables collected in the study (gender, age, income level, family situation, current situation and age at study completion) to build socio-demographic groups. The groups were obtained through binary modal variables defined by imposing cut-off values to the initial variables. The cut-off values were choosen in order to have complementary groups of about comparable size (see Table 6.7 in Appendix for details on group size). For each sociodemographic group, we calculated the average holding frequency and the average usage frequency. Table 6.3 presents all group which have a mean significantly different than the mean of the complementary group. In other words, when a group apears in Table 6.3 this means that the group uses more often the payment instrument than its complementary group. We also performed group comparisons for the global perceived risk of using and of holding the different payment instruments. Table 6.4 presents groups that evaluate perceived risk significantly higher than their complementary group.

TABLE 6.3: Groups Holding or Using More Often Each Payment Instrument

	Holding				Use			
	Cash €10	Cash €100	Card	Check	Cash	Card	Card Online	Check
Gender	-	Man (-3.68)[a]	Woman (2.75)[c]	Woman (8.76)[a]	Woman (2.25)[c]	-	Woman (4.05)[a]	Man (-3.42)[a]
Age ≥ 25	-	≥ 25 (-2.94)[b]	-	≥ 25 (-4.76)[a]	-	-	-	≤ 25 (3.26)[a]
Studies	-	Short Studies (-3.35)[a]	-	-	Long Studies (1.98)[c]	-	-	-
Income $\geq$ €3000	$>$ €3000 (-3.49)[a]	$>$ €3000 (-5.19)[a]	-	-	$\leq$ €3000 (1.98)[c]	$\leq$ €3000 (2.06)[c]	$\leq$ €3000 (4.52)[a]	-
Agglomeration	-	Large Agglomeration (-2.56)[c]	-	Small Agglomeration (2.71)[c]	Small Agglomeration (2.26)[c]	Small Agglomeration (3.38)[a]	Small Agglomeration (5.09)[a]	-
Single	-	-	-	Couple (4.87)[a]	-	-	-	Single (-2.57)[c]
Student	-	-	-	-	-	-	-	-
Activity	-	Active (-2.67)[b]	-	Active (-2.66)[b]	-	-	Inactive (3.27)[b]	-

Notes. [a] $p < 0.001$, [b] $p < 0.01$, [c] $p < 0.5$. Student's t are in parenthesis.

TABLE 6.4: Groups Evaluating Higher Global Risk of Holding and Use for Each Payment Instrument

	Global Risk of Holding			Global Risk of Use		
	Cash	Card	Check	Cash	Card Online	Check
Gender	Woman (3.91)^{a}	Woman (2.09)^{b}	-	-	Woman (3.24)^{b}	-
Age $\geq$ 25	$\leq$ 25 (3.84)^{a}	$\leq$ 25 (3.68)^{a}	$\leq$ 25 (3.85)^{a}		$\leq$ 25 (2.36)^{c}	$\leq$ 25 (2.84)^{b}
Studies	Long Studies (2.36)^{c}	-	Long Studies (-2.04)^{b}	-	-	-
Income $\geq$ €3000	$\leq$ €3000 (4.33)^{a}	$\leq$ €3000 (2.80)	$\leq$ €3000 (4.09)^{a}		$\leq$ €3000 (2.35)^{c}	$\leq$ €3000 (3.37)^{a}
Agglomeration	Small Agglomeration (3.37)^{a}	Small Agglomeration (2.57)^{c}	-	-	-	-
Single	Single (-2.54)^{b}	Single (-2.20)^{c}	Single (-4.23)	-	-	-
Student	-	-	-	-	-	-
Activity	Inactive (2.77)^{b}	Inactive (3.52)^{a}	Inactive (3.48)^{a}	-	Inactive (2.76)^{b}	Inactive (3.89)^{a}

Notes. ^{a} $p < 0.001$, ^{b} $p < 0.01$, ^{c} $p < 0.05$. Student's t are in parenthesis.

Table 6.3 shows that, compared to men, women hold bank cards and checkbooks more often, and use cash and credit cards for online purchases more. High income individuals hold cash more often and use cash and card less often. While the first finding is straightforward as higher income individuals typically have more withdrawal capacities, the second finding is probably related to the fact that the average transaction values for high income individuals are higher, reducing the frequency of use of payment instruments. While individuals above 25 hold large amounts in cash and checkbooks more often, younger people use checks more often.

Table 6.4 shows that some groups perceive a risk of use and a risk of hold systematically higher than the complementary groups. This is the case for younger individuals, individuals whose monthly income is less than €3000 a month, as well as individuals that do not work. Such groups are more liable to risk probably because they have less resources available to cover the risk. In the rest of the paper, we will refer to this set of groups as the *exposed groups*. Table 6.4 shows that exposed groups perceive a higher risk of holding for all payment instruments considered in the study (cash, card, and check). They also perceive higher risk for using credit card for online purchases.

Taken together, Table 6.3 and Table 6.4 allows to identify the profile of individuals holding and using each payment instrument and see the role of risk as a moderating variable.

For cash, the exposed groups evaluate hold risk higher. It should be noted that cash is the only payment instrument with homogeneous usage risks accross groups, despite the fact that individuals with a monthly income lesser than €3000 and individuals living in a small agglomerations use cash more often. The interpretation is straightforward. Perceived hold payment risks are in line with objective exposure, and high hold risks for exposed groups account for less frequent cash holding. Exposed groups have a tighter budget constraint however, and therefore some exposed groups use cash more often, all the more since use risks are homogenous between groups.

For cards, exposed groups evaluate a hold risk and an online use risk higher. Exposed groups are also the groups that use card for online payments more often. Tighter budget constraints and less serene relations to money may account for this result: because their available income is lower, exposed groups are more sensitive to cheaper online prices. The objective constraints more than offset the impact of perceived risk for card use online. This is in line with the results of the study on public perceptions of the European Commission (2003) that concludes that "many (Electronic payment users) are aware that there are risks, but consider that the advantages of online payments outweigh the negative factors."

For check, exposed groups and individuals that undertook long studies evaluate higher hold and usage risks. Women, individuals living in a small agglomeration, individuals above 25, individuals that are not single and working individuals hold checks more frequently. A possible explanation for this result could be that such groups are typically more aware of the value of checkbook holding either to manage a joint account or, in some cases, to postpone the effective transfer of funds. Note that holding a checkbook does not necessarily imply using it more often. In fact, the frequency of use of a check is higher for men, younger individuals and single individuals.

Regression Results

We now comment the results of the bivariate probit estimations. First, we verify the accuracy of our modeling choices. Table 6.6 presents global adjustment statistics and tests of independence for the equations of holding and the equations of use. This table confirms that the equation of holding and the equation of using can not be estimated separately. The correlations between residuals of the holding and using equations are significant for all retail payment instruments considered in the study. These findings confirm that hold and use decisions need to be investigated jointly. We can now discuss the results of the bivariate probit estimation that are repported in Table 6.5. These results highlight both direct effects and cross effects. In what follows, we discuss only the risk factors that have at least one significant effect.

TABLE 6.5: Bivariate Probit Estimations For the Frequency of Holding and the Frequency of Use of Each Payment Instrument

	Holding			Use		
	Cash	Card	Check	Cash	Card	Check
Global Risk of Use	-0.02	-0.10	-0.04	-0.07	0.01	0.004
	(0.04)	(0.07)	(0.04)	(0.05)	(0.04)	(0.04)
Global Risk of Holding	-0.35[a]	-0.1	-0.1[a]	0.1[c]	0.1[a]	0.10[c]
	(0.04)	(0.07)	(0.04)	(0.04)	(0.05)	(0.04)
Theft Risk	-0.02	0.006	0.07	0.02	0.010	-0.02
	(0.04)	(0.07)	(0.04)	(0.05)	(0.04)	(0.04)
Discomfort Risk	0.02	-0.2[b]	-0.2[a]	0.06	-0.08	0.1[b]
	(0.03)	(0.08)	(0.03)	(0.04)	(0.07)	(0.03)
Anonimity Risk	-0.05	-0.1	-0.009	-0.007	0.02	0.01
	(0.05)	(0.07)	(0.04)	(0.05)	(0.04)	(0.04)
Loss Risk	0.03	0.02	0.005	-0.03	0.05	-0.03
	(0.04)	(0.07)	(0.04)	(0.04)	(0.04)	(0.04)
Cost Risk	-0.23	-0.02	-0.04	0.01	-0.02	-0.04

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	(0.04)	(0.05)	(0.04)	(0.04)	(0.03)	(0.04)
Time Risk	0.1^b	0.1	0.08^c	-0.1^a	-0.04	-0.06
	(0.04)	(0.06)	(0.03)	(0.04)	(0.04)	(0.04)
Reimbursement Risk	-0.02	0.1^c	-0.04	0.07^c	-0.05	0.08^c
	(0.03)	(0.06)	(0.04)	(0.03)	(0.04)	(0.04)
Unavailability Risk	0.06	0.2^b	0.2^a	-0.1^c	-0.2^a	-0.1^b
	(0.04)	(0.07)	(0.04)	(0.04)	(0.05)	(0.04)
Acceptance Risk	-0.04	-0.002	-0.05	-0.002	0.05	-0.01
	(0.05)	(0.06)	(0.03)	(0.05)	(0.04)	(0.04)
Fraud Risk	0.07	-0.005	-0.03	-0.003	0.06	0.04
	(0.04)	(0.07)	(0.04)	(0.04)	(0.05)	(0.04)
Man	0.15	-0.64	-0.67	-0.003	0.10	-0.34
	(0.13)	(0.20)	(0.13)	(0.14)	(0.13)	(0.13)
Age $\geq$ 25	-0.06	-0.3	0.3	-0.07	0.09	-0.2
	(0.2)	(0.3)	(0.2)	(0.2)	(0.2)	(0.18)
Long Studies	0.2	0.06	0.004	-0.1	-0.04	-0.1
	(0.1)	(0.2)	(0.1)	(0.1)	(0.1)	(0.1)
Income $\geq$ €3000	0.6^a	-0.03	-0.10	-0.2	-0.07	0.2
	(0.2)	(0.3)	(0.2)	(0.2)	(0.2)	(0.2)
Large Agglomeration	0.03	0.1	-0.1	-0.2	-0.3^c	-0.3^c
	(0.1)	(0.2)	(0.1)	(-0.1)	(0.1)	-0.3^c
Single	0.10	0.3	-0.3^c	-0.1	-0.1	0.2
	(0.1)	(0.2)	(0.1)	(0.2)	(0.2)	(0.1)
Active	-0.13	0.24	0.02	-0.02	-0.05	0.03
	(0.14)	(0.24)	(0.14)	(0.15)	(0.15)	(0.15)
N	391	391	358	391	391	358

Notes. ^{a} $p < 0.001$, ^{b} $p < 0.01$, ^{c} $p < 0.05$. Standard deviations are in parenthesis. The constant is not reported.

TABLE 6.6: Global Adjustment Statistics for the Biprobits, Independence Tests Between the Equations of Holding and the Equations of Use for Cash, Card, and Check

	Cash	Card	Check
ρ	-0.22^b	-0.47^a	-0.63^a
	(0.07)	(0.09)	(0.04)
χ^2 (18 df)	150.09	54.26	175.62
	(0.000)	(0.000)	(0.000)
LR	10.07	21.26	119.22
	(0.001)	(0.000)	(0.000)

Notes. ^{a} $p < 0.001$, ^{b} $p < 0.01$, ^{c} $p < 0.05$. Parameter ρ is the correlation coefficient between the residuals of the equation of holding and the equation of use for each payment instrument. The χ^2 with 18 degrees of freedom corresponds to the Wald statistic of global adjustment for the biordered probits. The likelihood ratio (LR) tests independence of the equation of holding and the equation of use for each payment instrument. For the first line, the standard deviations are in parenthesis. For the second and third lines, the p-value are in parenthesis.

Direct Effects

We now discuss the direct effects for the three payment instruments considered. We verify that the global risk of holding each payment instrument reduce the holding and usage of the considered payment instrument.

For cash, a perception of time gains related to the use of cash influences both hold and use frequencies. A quick transaction encourages holding, but, rather surprisingly, reduces the use. Adverse selection could account for this result: the perceived speed of cash payments could decrease when cash is used often. The results also show that richer hold cash more often than poorer people. They also show that the higher is the use of cash, the higher the reimbursement risk and the lower the unavailability risk.

For card, the risk of unavailability encourages holding, and people that use card more often perceive a higher unavailability risk. The perceived time gains by paying with card online encourages both holding and usage. Moreover, the discomfort risk reduces the holding of a card.

For check, the risk of unavailability fosters holding, and the more people use check, the higher the percption of unavailability risk. The individuals considering that holding a check is risky and that the cost of holding is important hold a check less often. Conversely, women and individuals above 25 and those leaving in a small agglomeration hold a check more often.

Eventually, the controls for the socio-demographic characteristics do not appear to have a significant impact on the use of payment instruments. The only exception confirms the descriptive results: a woman holds more often both alternative payment instruments (card and check).

Cross Effects

We identify cross effects between the payment instruments. Cross effects primarily concern cash and bank cards. Indeed, we observe that individuals who consider that cash use involves a significant risk of fraud, hold and use more often bank cards, while individuals that perceive an important risk of fraud for online payments with bank cards use cash more often. These observations confirm that the two payment instruments are close substitutes, in line with the literature (Snellman *et al.*, 2001; Cheng *et al.*, 2011). Other cross effects concern almost exclusively cash and check. A high perceived risk for holding checks is associated to a higher frequency of cash holding, but not to a higher frequency of cash usage. Moreover, individuals who consider that the anonymity risk associated to check payments is important, hold cash more often.

Conclusion

The present paper aims at analyzing the relations between perceived risk and consumers' decision to hold and to use cash, card, and check. We estimate bivariate probits for the frequency of holding and for the frequency of usage of each payment instrument. First, we show that our bivariate modeling is justified: the residuals of the equations of holding and of use are significantly correlated. An independent estimation of the equations of holding and of usage would be biased. Second, we show that cross effects of payment risk primarily concern cash and card. We confirm that the two payment instruments are the closest substitutes between the main retail payment instruments (Snellman *et al.*, 2001). The perceived time gain associated to cash payments relatively to the other payment options is an important determinant of their holding and an important determinant of their usage. Unavailability risk is an important determinant of holding and usage of bank cards. The perceived time gain associated with using card for online payments makes both holding and usage of cards more frequent. Unavailability risk is an important determinant of the frequency of check holding. Unavailability risk influences both the holding and the usage of both alternative payment instruments. It has the most transverse influence on the frequency of holding and on the frequency of usage of the main retail payment instruments. The possibility to gain time has the second most transverse influence. Taken together, our results confirm the interest for a constantly available and quick to use new payment instrument, contactless payments by radio-frequency identification using mobile phone being a good candidate. Our results suggest that a contactless technology for payments via mobile phone should fit the expectations of consumers better than other possible processes (like a text message sent to a centralized operator).

Appendix

TABLE 6.7: Percentage of Grouping Variables

Variable	Groupe Size
Man	49.6%
Age $\geq$ 25 ans	41.7%
Long Studies	38.4%
Income $\geq$ €3000	38.4%
Large Agglomeration	50.4%
Single	64.4%
Student	08.1%
Active	49.9%
N	393

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Conclusion générale

Notre thèse s'est donnée pour but d'analyser la formation de la demande pour les instruments de paiement. Nous tentons de cerner les déterminants du choix entre les espèces, la carte bancaire et dans une moindre mesure le chèque. Dans cette conclusion, nous synthétisons les principaux résultats des essais qui la composent, puis nous traçons des pistes de recherche future.

Synthèse

Le premier chapitre examine le lien entre la demande pour les espèces et les coûts de retraits dans des distributeurs automatiques de billets extérieurs au réseau de la banque. En effet, depuis juillet 2002, la quasi-totalité des banques françaises impose la tarification des retraits déplacés en réaction à la mise en place de la réglementation européenne le premier juillet 2002. Cette réglementation impose l'harmonisation des tarifications de retraits à l'intérieur de la zone Euro.

Nous proposons un cadre théorique adapté à l'analyse, c'est à dire tenant compte à la fois de l'hétérogénéité des consommateurs, et de l'ensemble des options disponibles. Nous considérons un continuum de consommateurs à deux dimensions. La première dimension correspond à la pénibilité à se déplacer jusqu'à un distributeur membre du réseau de sa banque (de manière à échapper à la tarification des retraits déplacés). La deuxième dimension correspond au bénéfice algébrique à payer en espèces plutôt qu'en carte bancaire. Selon sa position sur le rectangle, un consommateur préférera retirer des espèces à un distributeur à l'extérieur de son réseau bancaire (il devra payer à sa banque le prix d'un retrait déplacé que l'on appelle *la surcharge*), retirer des espèces à un distributeur appartenant au réseau de sa banque, ou payer avec un instrument alternatif (identifié à la carte bancaire). Nous montrons que la demande d'espèces globale décroit avec le niveau des surcharges. Le nombre agrégé de retraits déplacés décroit également, alors que le montant agrégé des transactions réglées par carte bancaire augmente, à condition que les surcharges ne soient pas trop élevées relativement aux valeurs extrêmes de pénibilité et de bénéfices d'utilisation des instruments de paiement.

Nous exploitons une base de données unique, issue de la chambre de compensation française pour tester nos propositions théoriques. Cette base de données comprend le nombre de retraits déplacés, ainsi que les sommes retirées correspondantes en France mensuellement entre juillet

2001 et décembre 2006. Nous disposons également des transactions compensées réglées par carte bancaire.

Nous exploitons le caractère d'expérience naturelle de la mise en place de la tarification des retraits déplacés : cette dernière a été décidée par la quasi-totalité des banques françaises, et s'est mise en place en moins d'un mois. Nous estimons un modèle de séries temporelles interrompues (*Interrupted Time Series Design*) et nous confirmons l'ensemble des prédictions du modèle théorique. En particulier, la tarification des retraits déplacés entraîne une diminution du nombre de ces retraits, et une substitution des paiements en espèces vers les paiements en carte.

Le deuxième chapitre analyse une stratégie pouvant être appliquée par les marchands pour inciter les consommateurs à payer en espèce plutôt qu'en carte bancaire. Les paiements en espèces occasionnent des coûts de stockage, et exposent au risque de perte ou de vol. En revanche, ils n'occasionnent pas de coût monétaire direct et sont donc perçus comme moins coûteux (Bearing Point, 2009). La stratégie consistant à refuser les instruments de paiement alternatifs est coûteuse, parce qu'elle aboutit à dévier une partie de la demande potentielle.

Nous examinons la possibilité pour les marchands en compétition imparfaite d'ajuster leurs prix afin de faciliter les paiements en espèces. En effet, il est nécessaire de représenter un prix comme combinaison linéaire des valeurs faciales des pièces et billets disponibles pour payer directement, ou bien de porter les pièces et billets rendus en monnaie. En d'autres termes, il existe un coût cognitif à la division du prix en pièces et billets, ainsi qu'un coût lié à l'encombrement des rendus de monnaie. Ces coûts sont croissants avec le nombre minimum de pièces et billets nécessaires pour payer. Ils peuvent être ajustés par les marchands, en faisant varier les prix de manière négligeable en valeur absolue. Par exemple, un prix de 99.67 euros est beaucoup moins pratique à payer qu'un prix de 100 euros, alors que la variation de prix ne représente que 23 centimes, soit 0.23% du prix final. Nous proposons un modèle théorique s'appuyant sur ces idées. Nous montrons en particulier deux propositions : *toutes choses égales par ailleurs*, 1) un prix est d'autant plus fréquemment choisi par un marchand qu'il mobilise moins de pièces et billets, et 2) Un prix est d'autant plus fréquemment payé en espèces qu'il mobilise moins de pièces et billets. Nous avons collecté une base de données par une étude de terrain dans plusieurs magasins en concurrence imparfaite. Nous avons noté le prix payé et l'instrument de paiement utilisé (espèces ou chèque) pour 411 transactions. Nous avons veillé à ce que les prix ne soient pas trop élevés de manière à ce que l'arbitrage entre les espèces et la carte soit pertinent. Nous avons également veillé à ce que les achats soient constitués d'un nombre limité d'articles, ou bien d'un article unique, de manière à ce que les marchands conservent un contrôle sur le prix payé. En accord avec nos prédictions théoriques, nous constatons que plus un prix est pratique à payer en espèces, plus il est fréquemment choisi par les vendeurs et plus il est fréquemment payé en espèces par les acheteurs. Nous proposons diverses mesures du caractère pratique du paiement en espèces, et nos résultats sont stables quelle que soit la mesure envisagée.

Le troisième chapitre étudie l'impact du crime comme facteur environnemental sur les marchands. Ces derniers ne décident pas l'instrument de paiement utilisé pour chaque transaction, et la littérature académique les néglige souvent pour cette raison. Ils décident pourtant s'ils acceptent les instruments de paiement alternatifs, et fixent les prix. Ce chapitre prend le parti inverse. Nous utilisons une base de données unique, constituée d'un échantillon de 4601 marchands représentatifs de la France en taille, secteur et implantation géographique. Nous associons à chaque marchand le niveau des indicateurs de criminalité de son département. Nous nous basons sur l'État 4001, un document publié annuellement par le Ministère de l'Intérieur fournissant le nombre de plaintes déposées dans les commissariats et gendarmeries pour chacun des crimes et délits définis par le droit français.

Nous avons retenu un indicateur de criminalité financière, et nous avons construit un indicateur composite de criminalité violente, composé de variables de criminalité. L'indicateur de criminalité est construit comme somme de variables intéressant prioritairement les consommateurs.

Nous montrons que plus la criminalité financière est importante au niveau du département, plus les espèces sont appréciées par les marchands. Nous montrons également que plus la criminalité violente est importante, plus les marchands acceptent la carte bancaire. L'impact de la criminalité financière est un effet de sélection adverse. Les espèces permettent en effet de payer des salariés non déclarés, ou de mener des transactions sans traces écrites. C'est l'instrument de paiement privilégié pour la fraude fiscale.

Nous interprétons l'impact de la criminalité violente comme une internalisation partielle du risque subi par les consommateurs. En effet, nous avons construit l'indicateur de criminalité violente comme la somme de variables de criminalité concernant les consommateurs (comme le vol à la roulotte) et des variables concernant les marchands (comme le vol à main armée).

Le cinquième chapitre étudie l'impact du crime comme facteur environnemental sur les consommateurs. Nous utilisons une base de données originale constituée d'un échantillon de 1392 consommateurs représentatifs de la société française en origine géographique et catégorie socio-professionnelle. Nous associons à chaque consommateur le niveau de criminalité de son département, de la même manière qu'au chapitre 3. Nous concluons qu'un niveau élevé de délinquance sur la voie publique entraine une augmentation des sommes en espèces retirées hebdomadairement ainsi qu'une diminution de la fréquence de possession d'une carte de paiement. Nous concluons également que plus la criminalité financière est importante, moins le montant hebdomadaire retiré en espèces est important et plus la fréquence de possession des cartes est importante.

Ces deux effets sont contre-intuitifs. On s'attendrait *a priori* à ce que la criminalité violente dissuade de l'utilisation d'espèces et que la criminalité financière fragilise les incitations à posséder une carte bancaire. Ce serait une extrapolation plausible à partir de nos conclusions que nous avions tirées au troisième chapitre, concernant les marchands. Nous proposons les interprétations suivantes. Nous interprétons l'impact de la criminalité violente comme une conséquence de la non-linéarité des retraits aux distributeurs automatiques de billets. Ces derniers proposent typiquement des retraits multiples de 10 ou 20 euros, parce qu'ils sont alimentés exclusivement en billets. Le moment du retrait étant particulièrement risqué dans la mesure où les retraits sont visibles et qu'ils ont lieu en des points précis connus des agresseurs potentiels, le consommateur souhaitant minimiser les risques d'agression va diminuer le nombre de retraits, quitte à augmenter la somme moyenne retirée. Il n'est pas possible de choisir la somme retirée à l'euro près, et une diminution du nombre de retraits peut conduire à une augmentation de la somme totale retirée, même si l'objectif du consommateur est simplement de maintenir au moins les sommes retirées.

Nous interprétons l'impact de la criminalité financières comme un effet de sélection adverse. En effet, le niveau d'expertise moyen concernant les risques associés aux instruments de paiements est plus élevé chez les personnes pratiquant la fraude financière que dans le reste de la population. Le risque de perte ou de vol associé à la détention d'espèces en est plus sensible, comme la protection apportée par les assurances associées au paiement par carte bancaire. Les incitations à détenir la carte bancaire sont renforcées [5].

Le sixième chapitre aborde les déterminants psychologiques du choix d'un instrument de paiement. Nous exploitons les modèles de risque perçu proposés par Jacoby et Kaplan (1972) et Roselius (1971) en les appliquant aux différents instruments de paiement. Nous exploitons une base de données recueillie à l'aide d'un questionnaire en ligne auto-administré. Nous avons recueilli 393 questionnaires correctement remplis.

Nous étudions la fréquence de détention et d'utilisation des instruments de paiement principaux (espèces, carte bancaire et chèque). Dans la mesure où l'utilisation d'un instrument de paiement nécessite de l'avoir sur soi, nous avons considéré que les déterminants de l'utilisation devaient être modélisés conjointement. Nous avons estimé des probits ordonnées bivariés pour chacun des instruments de paiements. Pour la carte bancaire et le chèque, nous avons retenu uniquement les individus possédant un chéquier (la totalité de l'échantillon original possède la carte bancaire, et nous nous sommes restreints aux 358 individus possédant un chéquier sur les 391 individus de la base de données pour les estimations relatives au chèque).

Conformément à notre intuition, nous montrons que les équations de détention et d'utilisation sont liées, au sens où les résidus estimés pour ces deux équations sont corrélés. Nous confirmons que la carte bancaire et les espèces sont des substituts proches, puisque les principaux effets croisés des risques perçus concernent ces deux instruments de paiement. Nous montrons enfin que le risque de manque à l'influence la plus transversale, suivi du risque associé à la perte de temps.

5. Nous rappelons que les écarts de revenus sont contrôlés dans le modèle économétrique.

Perspectives

Nos résultats contribuent à faire progresser la connaissance des déterminants du choix d'un instrument de paiement. Néanmoins, Ce travail laisse de nombre de questions ouvertes. La mutation du paysage des paiements devrait entraîner la disparition du chèque à plus ou moins long terme, puisque ce dernier n'est pas défini dans l'Espace Européen des Paiements (en anglais, *SEPA*, "Single European Payments Area"). La fin programmée du chèque s'explique par son coût d'utilisation élevé ; ce coût est supporté par les banques, puisque la mise à disposition d'un chéquier est en général gratuite. De nouveaux instruments de paiements vont être mis en place, ainsi, les virements SEPA vont remplacer les virements nationaux le premier février 2014, et la standardisation des paiements par carte va intervenir afin de garantir l'interopérabilité à l'intérieur de la zone SEPA.[6] Cette interopérabilité pourrait avoir pour effet d'entraîner à plus ou moins long terme la disparition des systèmes de paiements par carte nationaux, d'autant que le système de carte SEPA devrait garantir la généralisation des normes technique supérieures pour les carte bancaires (notamment la norme EMV[7] 3, mise en place par Carte Bleue en France dès 2001).

En outre, les téléphones portables dotés de fonctionnalité multimédias (smartphones) sont des systèmes individuels disposant de capacité de calcul, et peuvent donc techniquement être exploités comme instruments de paiement en particulier grâce aux technologies de paiement sans contact (Near Field Communication, NFC). Ces technologies pourraient être implémentées grâce à l'inclusion d'une puce à radiofréquence identifiante (puce RFID). Typiquement, il suffit de rapprocher le portable d'un terminal marchand pour déclencher un paiement de faible montant (le seuil maximal est souvent fixé à 20 euros). Pour les transactions de montant plus élevé, un code personnel doit être tapé sur le clavier du téléphone. Cette facilité d'utilisation, couplée au taux de pénétration élevé du téléphone portable pourrait garantir une part de marché au paiement par téléphonie mobile (« m-paiement »). Il est déjà possible de payer ses frais d'inscription à l'université de Séoul ainsi que ses courses dans certains supermarchés de Corée du Sud à l'aide de son téléphone. La question mérite d'être analysée dans le cadre de la compétition avec les autres instruments de paiements, et en particulier dans le cadre de la compétition avec la carte bancaire.

On s'interroge également sur le modèle économique à grande échelle du m-paiement. On distingue trois types relativement plausibles de modèles économiques pour le paiement par téléphonie mobile :

6. Le projet SEPA a été conçu par le Conseil Européen des Paiements (European Payments Council) comme une étape supplémentaire de l'intégration financière des pays de la Communauté européenne (la zone SEPA regroupe les pays de l'Espace Economique Européen ainsi que la Suisse et Monaco). Les travaux sur le sujet ont commencé en juin 2002, et ont abouti en septembre 2005 à l'adoption du *"SEPA Card Framework"*, visant à garantir l'interopérabilité des systèmes de paiement par carte et à préparer la mise en place d'instrument de virement et de transfert - "*SEPA Credit Transfer*" et "*SEPA Direct Debit*"- à l'intérieur de le zone SEPA.

7. Pour Eurocard, Mastercard, Visa.

– Le premier modèle, obsolète techniquement et relativement peu pratique bien qu'aisé à mettre en place, consiste en l'introduction d'une entité qui se charge de réaliser les virements au marchand contre l'envoi d'un SMS et le paiement d'un prix fixe par le consommateur. L'entité capte la quasi-totalité des profits : l'opérateur de téléphonie mobile ne fait quasiment pas de profit supplémentaire – hormis ceux liés à l'accroissement du trafic des textos - et les banques n'en font pas plus. C'est le modèle adopté par la société Banksys en Belgique par exemple. Sa généralisation à grande échelle ne serait probablement acceptée ni par les banques ni par les opérateurs, même après négociation d'une compensation variable avec le volume des transactions. Les banques et les opérateurs ne renonceraient pas à des profits potentiels d'échelle beaucoup plus élevée. En outre, ce modèle pose peu de problèmes d'analyse économique stricto sensu : il s'agit simplement de « brancher » un intermédiaire sur un circuit.
– Le deuxième modèle implique que le marchand souscrive un compte dans une banque associée à l'opérateur de téléphonie mobile (soit par le biais de contrats, soit par participation directe de l'opérateur par exemple dans le cadre de joint-venture, soit directement par l'opérateur comme activité issue de la diversification de son cœur de métier) pour recevoir des paiements par téléphonie mobile (1) .
– Le troisième modèle implique la possibilité de transfert à partir de l'ensemble des banques de consommateurs vers l'ensemble des banques de marchands (2).

(1) permettrait aux opérateurs de contourner le consentement des banques, au prix d'une pénétration sur le marché plus difficile, alors que (2) implique la participation active de ces dernières. Or, il n'est pas certain que ce consentement soit acquis d'avance, parce que le m-paiement est un concurrent potentiel à la carte de crédit : ce dernier pourrait lui disputer une part de marché. Ces modèles économiques soulèvent de nombreuses questions de recherche. Nous en développons quelques-unes.

D'abord, on peut se demander sous quelles hypothèses (2) est préférable à (1) en ce qui concerne le surplus total et sous quelles conditions l'agrandissement du marché surcompense le manque à gagner dû à la captation d'une part de marché par les opérateurs de téléphonie mobile. Si le modèle préférable n'émerge pas comme conséquence naturelle du jeu des forces du marché, l'État est justifié à intervenir pour l'imposer (le coût ne serait pas *a priori* rédhibitoire puisque les modèles ne sont pas encore unifiés et répandus).

Ensuite, il serait intéressant d'étudier la problématique de la tarification optimale pour l'opérateur de téléphonie mobile et pour l'association de carte de crédit en situation de concurrence. En quoi la concurrence d'un instrument de paiement que tous les consommateurs possèderaient sans payer de coût fixe mais nécessitant un investissement des marchands [8] modifie les stratégies des associations de carte bancaire ? Du point de vue de l'opérateur de téléphonie (*"Mobile Network Operator"* en anglais, ou "MNO"), quelle est la meilleure stratégie pour imposer ce nouvel instrument de paiement ?

8. Bedre et Calvano(2009) montrent que le paiement d'un coût fixe n'a d'effet que si la partie le supportant a également le choix de l'instrument de paiement utilisé pour chaque transaction. La spécification d'un coût fixe payé par les marchands pour l'acquisition d'un terminal spécifique au m-paiement n'aurait pas d'intérêt

Enfin, et quitte à introduire une modélisation au moins sommaire du marché de la vente de forfaits téléphoniques classiques, il serait également intéressant d'étudier la possibilité pour le *"MNO"* de proposer des forfaits permettant à la fois l'accès au m-paiement et aux communications classiques à des tarifs plus avantageux que les forfaits séparés (*"bundling"*), ou bien d'imposer l'achat de l'un avec l'achat de l'autre (*"tying"*). Ceci pourrait créer des consommateurs captifs de leur opérateur m-paiement, puisque les couts de changement d'opérateur (*"switching costs"*) pourraient devenir prohibitifs, comme c'est souvent le cas sur le marché de la téléphonie mobile classique aujourd'hui.

Dans une autre perspective, les systèmes de paiement de masse prolongent la problématique des instruments de paiements individuels. En effet, les transferts monétaires de grandes ampleur - par exemple dans le cadre d'extinction de dettes interbancaires - transitent par des systèmes de paiements spécifiques. Ces derniers peuvent être regroupés en deux grandes familles : les systèmes de paiement en temps réel (RTGS pour *"Real Time Gross Settlement"*) et les systèmes de paiement à règlement net différé (DNS pour *"Deffered Net Settlement"*.

Dans le cadre des systèmes RTGS, les transferts ne sont effectués que si les banques possèdent effectivement des liquidités au moins équivalentes à la somme transférée. Dans le cas contraire, le transfert est annulé. Dans le cadre des systèmes DNS, les dettes interbancaires sont agrégées et calculées à intervalles réguliers (en général toutes les 24 heures), puis ces dernières sont soldées. Le système DNS présente l'avantage d'être moins exigeant en terme de liquidités, mais présente *a priori* l'inconvénient majeur d'introduire la possibilité d'un risque systémique en cas de défaut d'une banque. En effet, une banque investit souvent des montants supérieurs à ces capitaux propres en anticipant notamment sur le remboursement des créances qu'elle possède. La banque transmet le risque de défaut à l'ensemble de ses banques créancières dans le cadre d'un système DNS. Un scénario de « banqueroute en chaînes » et donc d'effondrement de l'ensemble du système financier est envisageable en cas de défaut sur un part importante des créances d'une banque de taille suffisante (on parle de banque systémique).

Le système RTGS présente l'inconvénient d'une exigence maximale en termes de liquidités. Cet inconvénient est d'autant plus sensible que le ratio de solvabilité bancaire minimum (défini en première approche comme le rapport des fonds propres sur le niveau d'endettement) a été relevé dans les normes bancaires issues de la réflexion sur la crise de 2008 (règles de Bâle III, avalisées par le G20 le 11 et 12 novembre 2010. En toute rigueur, le ratio de solvabilité retenu par Bâle III est défini comme le rapport des fonds propres réglementaires et de la somme du risque opérationnel, du risque de crédit et du risque de marché) [9].

La plupart des pays développés a remplacé le système DNS par crainte du risque systémique. Par exemple, Fedwire est un système RTGS maintenu par la Fed et ouvert à la quasi-totalité des institutions bancaires aux États-Unis. Le système à règlement différé CHIPS détenu par des

9. Notons que l'efficacité des règles macro-prudentielles imposées par Bâle III est sujette à controverse. Notons également que les Etats-Unis n'appliqueront ces normes qu'à partir de janvier 2014 pour les huit plus grandes banques américaines, et qu'à partir de janvier 2015 pour les banques de petite taille et de taille moyenne.

capitaux privés vient lui faire concurrence, mais son échelle de déploiement n'est pas comparable puisque seules 52 institutions bancaires de taille importantes l'utilisent au premier janvier 2013 (cf "CHIPS annual Statistic Document"). Un article très influent d'Humphrey datant de 1986 évalue à l'aide de simulations les conséquences potentielles pour l'ensemble du système du défaut d'une banque engagée dans des prêts bilatéraux avec un réseau d'autres banques. Ses résultats alarmants ont contribué significativement à ces choix. Néanmoins, un argument de Selgin (1994) consiste en l'hypothèse que les banques prennent des risques inconsidérés dans la mesure où elles savent que la banque centrale est prêteuse en dernier ressort (*"lender of last resort"*) : elles transfèrent donc le risque de défaut sur cette dernière et n'internalisent pas les pertes collectives. Cette situation d'aléa moral disparait si la banque centrale est crédible dans une position de non-intervention sur les marchés (c'est d'ailleurs dans cette perspective que le gouvernement américain s'est abstenu d'intervenir lors de la chute de la banque d'affaires Lehman Brothers, qui fait faillite officiellement le 15 septembre 2008). En effet, les régulateurs auraient confondu les systèmes DNS en général et le système Fedwire, qui n'en est qu'une implémentation particulière, mis en place par la Fed. Le système DNS ne serait pas plus exposé au risque systémique que le système RTGS et engendrerait un risque de liquidité bien moindre.

Un prochain article tentera de formuler et d'analyser l'argument de Selgin dans un cadre formalisé.

Références de la conclusion

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