

Essays in international trade : international fragmentation of production and trade costs

Elsa Leromain

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UNIVERSITÉ PARIS 1
PANTHÉON SORBONNE

Essays in International Trade:

International Fragmentation of Production and Trade Costs

Elsa Leromain

Thèse pour l'obtention du grade de
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en Sciences Economiques

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Résumé

Durant les dernières décennies, le point de vue adopté par l'analyse du commerce international est passé d'une perspective pays/industrie à une perspective centrée sur l'entreprise. L'entreprise est alors devenue l'élément central des recherches dans la discipline. Cette transformation a été nourrie par des progrès théoriques (Melitz 2003), de nouvelles bases pour l'équation de gravité (Chaney 2008) et l'accès à des données confidentielles au niveau de l'entreprise (Eaton et al., 2004, Bernard et al., 2007), initiant alors un dialogue fécond entre la théorie et l'empirisme. Mayer et Ottaviano (2008) ont confirmé des faits stylisés antérieurs sur l'internationalisation des entreprises en Europe, soulignant que les activités internationales sont réalisées par quelques très grandes entreprises, « the happy few ». Parallèlement aux bases de données sur les entreprises et leurs transactions, de nouvelles sources de données sont apparues, ouvrant une voie prometteuse pour le développement de la recherche en commerce international.

De plus en plus d'entreprises sont désormais impliquées dans les chaînes de production internationales : elles achètent des composants ou des services aux pays étrangers, et leur fournissent des inputs, complexifiant ainsi les échanges. Tandis que des modèles théoriques ont été développés pour mieux comprendre les contrats qui régissent chaque maillon de la chaîne et leurs implications pour la stratégie internationale des entreprises, les tableaux entrées-sorties mondiaux ont permis l'introduction de nouvelles mesures pour quantifier l'étendue de la fragmentation de la production à travers les frontières et l'internationalisation des chaînes de production.

Les progrès des sciences de l'informatique ont révolutionné les méthodes de collecte de données et ont permis d'accéder à des sources qui étaient auparavant inaccessibles (web scraping, big data des réseaux sociaux, moniteurs, capteurs, etc.).

La présente thèse contribue à ce pan de la littérature en utilisant des tableaux entrées-sorties mondiaux pour revisiter d'anciennes questions sur le commerce international (chapitre 1 et 2) et proposer des mesures empiriques originales pour les coûts au commerce non-traditionnels, qui sont fondées sur de nouvelles sources (chapitre 2 et 3). Avant de présenter le contenu de cette thèse, il faut d'abord comprendre non seulement pourquoi toutes ces nouvelles sources sont une avancée majeure par rapport aux bases de données existantes, mais aussi comment elles ont amélioré notre compréhension du commerce mondial.

Quantifier la fragmentation internationale de la production

La désagrégation progressive des processus de production à travers les frontières gagne en importance depuis quelques années. De plus en plus d'entreprises organisent actuellement leur production à l'échelle mondiale et choisissent de délocaliser la fabrication de pièces, composants ou même services vers des pays étrangers et souvent éloignés. Cependant, la fragmentation de la production n'est pas un phénomène nouveau. Dans *La Richesse des nations*, Adam Smith décrivait déjà les différentes étapes de la production d'épingles dans l'Angleterre de la fin du XVIIIe siècle :

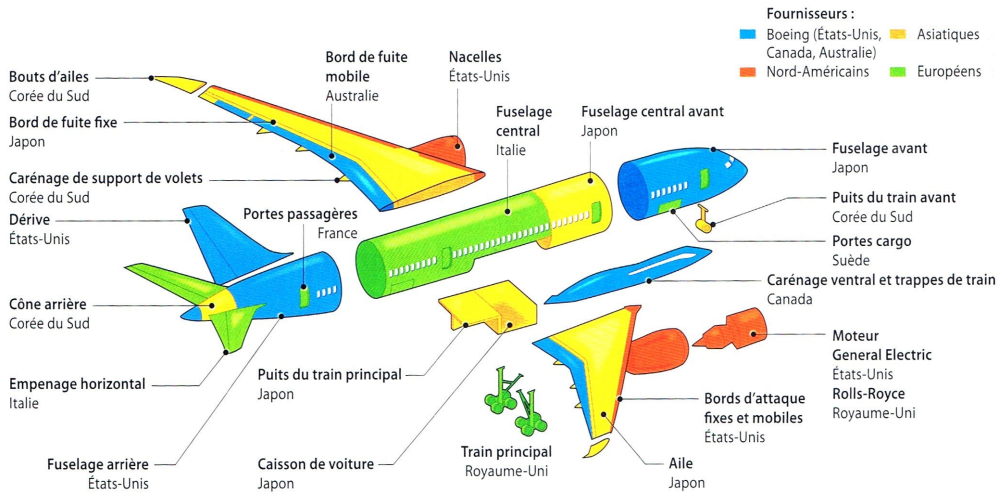
« *Prenons un exemple dans une manufacture de la plus petite importance, mais où la division du travail s'est fait souvent remarquer : une manufacture d'épingles. [...] Mais de la manière dont cette industrie est maintenant conduite, non seulement l'ouvrage entier forme un métier particulier, mais même cet ouvrage est divisé en un grand nombre de branches, dont la plupart*

constituent autant de métiers particuliers. Un ouvrier tire le fil à la bobille, un autre le dresse, un troisième coupe la dressée, un quatrième empointe, un cinquième est employé à émoudre le bout qui doit recevoir la tête. Cette tête est elle-même l'objet de deux ou trois opérations séparées : la frapper est une besogne particulière; blanchir les épingles en est une autre; c'est même un métier distinct et séparé que de piquer les papiers et d'y bouter les épingles; enfin, l'important travail de faire une épingle est divisé en dix-huit opérations distinctes ou environ, lesquelles, dans certaines fabriques, sont remplies par autant de mains différentes, quoique dans d'autres le même ouvrier en remplisse deux ou trois. » [1]

La spécialisation verticale internationale a été constatée par les chercheurs en commerce international il y a plusieurs décennies (Findlay 1978, Helleiner 1973...) et, dans une certaine mesure, ce phénomène existe depuis la « Grande Spécialisation » anglaise de la fin du XIXe siècle. Ce qui est récent, c'est l'étendue de la subdivision des processus de fabrication en étapes, chaque étape étant située dans un pays différent, avec des composants traversant plusieurs fois les frontières. Baldwin a nommé cette phase du commerce international le deuxième « unbundling » (décomposition). L'un des exemples les plus marquants d'une telle chaîne de production internationale est celui d'un avion. Le graphique 1 montre le fournisseur respectif des pièces principales du Boeing 787 et du pays dans lequel chacune est fabriquée. Le fuselage de l'avion est en partie produit par Spirit aux États-Unis, Kawasaki au Japon, Alenia en Italie et Vought aux États-Unis. La porte d'entrée des passagers est fabriquée par Latecoere en France, les portes d'accès à la soute par Saab en Suède et le train d'atterrissage par Messier-Dowty au Royaume-Uni. Pour les ailes, les entreprises Mitsubishi Heavy Industries et Kawasaki, situées à Nagoya (Japon), produisent respectivement le noyau et le fuselage avant. Les bouts des ailes sont fabriqués par KAL-ASD en Corée et le bord de fuite mobile par Boeing en Australie. La production des principaux composants d'un Boeing implique au moins 17 entreprises dans 9 pays

[1] Adam Smith, *Recherches sur la nature et les causes de la richesse des nations*, 1776, Traduction Édition Folio Essais, 1976, p. 38-39.

différents. Le Boeing 787 est ensuite assemblé dans l'usine de Boeing à Everett (État de Washington, États-Unis). Alors que nous savons que l'industrie aéronautique est l'un des nombreux exemples de chaînes de production internationales très fragmentées, cela reste un phénomène très difficile à quantifier de manière systématique avec les statistiques commerciales dont nous disposons. Comme le souligne le commissaire européen au commerce, Karel De Gucht «*[...] bien que nous soyons conscients de l'importance croissante des chaînes de valeur internationales, nous n'avons jusqu'à présent pas été en mesure de calculer correctement leur taille, leur nature et leur effet. C'est parce que notre appareil statistique actuel ne capture pas l'activité domestique contenue dans un bien ou service négocié* ».[2]



Source: OMC, 2011

Figure 1: Le puzzle d'assemblage du Boeing 787

Avec le développement des tableaux entrées-sorties (input/output) mondiaux, les économistes en commerce international ont un nouvel outil puissant pour étudier les chaînes de production internationales et quantifier l'ampleur de la fragmentation internationale dans le monde entier. Le concept de tableau entrées-sorties mondial a émergé du renouveau d'une an-

[2]Accessible à l'adresse: `http://trade.ec.europa.eu/doclib/docs/2012/april/tradoc_149337.pdf`

cienne littérature, portant sur les tableaux entrées-sorties multi-régionaux (Isard 1951, Miller 1966) et le commerce des bien intermédiaires (Sanyal et Jones 1982). Un tableau entrées-sorties mondial décrit non seulement l'utilisation des inputs au sein des industries dans une économie — comme pourrait le faire un tableau entrées-sorties national — mais fait aussi la distinction entre les différents pays d'approvisionnement. Ainsi, on sait combien l'industrie automobile française utilise d'inputs de l'industrie française du ≪caoutchouc et du plastique≫ mais aussi de la même industrie en Allemagne, au Royaume-Uni, aux États-Unis ou ailleurs. Cela nous permet de quantifier les liens d'entrée-sortie entre pays et de retrouver la valeur ajoutée incorporée dans les produits finaux à sa source.

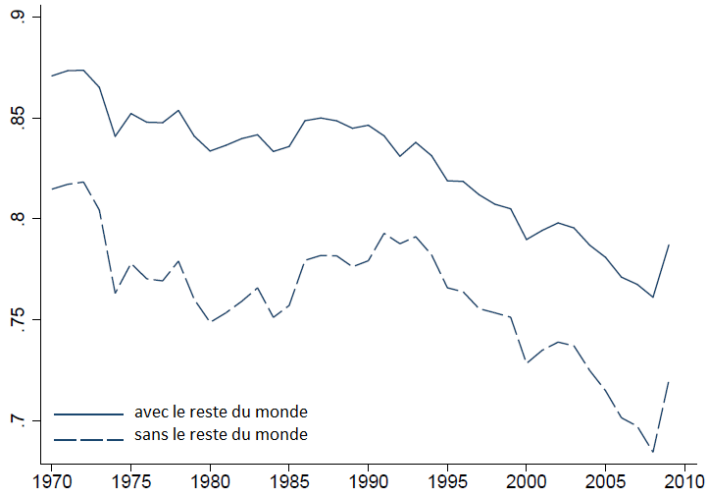
Plusieurs initiatives pour le développement des tableaux entrées-sorties mondiaux ont émergé simultanément. À l'aide des tableaux entrées-sorties GTAP, Johnson et Noguera (2012) ont construit un tableau entrées-sorties mondial pour plus de 100 pays avec différentes années de référence. Ces tableaux ont ensuite été utilisés par Trefler et Zhu (2010), Daudin et al. (2011), et Koopman et al. (2014). IDE-JETRO a construit un tableau entrées-sorties couvrant 8 pays d'Asie de l'Est à des intervalles de cinq ans entre 1985 et 2000. Parallèlement, l'OCDE a rassemblé des tableaux entrées-sorties pour les pays de l'OCDE et les principaux marchés émergents, disponibles pour différentes années de 1970 à 2005. À la suite d'un projet de trois ans avec 11 partenaires internationaux impliqués, l'équipe de la WIOD a développé des tableaux entrées-sorties internationaux couvrant 40 pays de 1995 à 2011. Cette dernière source présente des avantages cruciaux par rapport aux autres : la large couverture géographique permet d'avoir des tableaux réellement mondiaux; ceux-ci peuvent également être utilisés de manière cohérente pour étudier les changements au fil du temps. En outre, la base de données comprend des indicateurs socio-économiques et environnementaux qui peuvent fournir des informations intéressantes, tout en étant combinés avec les tableaux entrées-sorties.

Alors que les tableaux entrées-sorties globaux donnent une image claire du

réseau de production mondial au niveau de l'industrie, ils n'indiquent pas la structure complète du réseau de production au niveau de l'entreprise. Cette structure est très difficile à définir, même avec des données au niveau micro. Ces dernières ont traditionnellement révélé les exportations de sociétés individuelles, additionnées entre tous les acheteurs ; ou à l'inverse, les importations de sociétés individuelles, additionnées entre tous les vendeurs par lieu d'importation et généralement ne font pas de distinction entre les inputs et les produits finaux. les rares sources qui permettent cette distinction [3] sont disponibles pour un pays spécifique et ne différencient généralement pas les pays d'approvisionnement. L'accès récent aux nouvelles données acheteur/vendeur est très prometteur à cet égard. Dans un travail récent, Bernard et al. (2017) utilisent un ensemble de données d'entreprises norvégiennes où l'identité de l'exportateur et de l'importateur sont connues et où les transactions annuelles d'exportation d'une entreprise peuvent être liées à des acheteurs spécifiques dans chaque pays de destination et les transactions d'importation annuelles de chaque entreprise peuvent être liées à des fournisseurs spécifiques dans chaque pays source.

En se fondant sur des tableaux entrées-sorties mondiaux, les chercheurs en commerce international ont introduit de nouvelles mesures pour quantifier l'ampleur de la fragmentation internationale; ceci a considérablement amélioré les mesures antérieures qui s'appuyaient sur les statistiques de commerce agrégées et les tableaux entrées-sorties nationaux (Feenstra et Hanson 1996, Hummels et al., 2001). Plus précisément, Johnson et Noguera (2016) ont introduit le rapport des exportations en valeur ajoutée [Value-Added to Export (VAX)]. Le ratio VAX mesure la part des flux d'exportation due à la production nationale. Dans un monde sans échange d'inputs, toute la production se déroule dans un pays, le ratio est donc égal à 1. Le ratio de la valeur ajoutée mondiale à l'exportation de l'année t est défini comme $VAX_t = \frac{\sum_{i \neq j} \sum_s va_{ijt}(s)}{\sum_{i \neq j} \sum_s x_{ijt}(s)}$ avec $va_{ijt}(s)$ la valeur ajoutée et $x_{ijt}(s)$ les exportations de i vers j dans le secteur s. Selon Fally (2012),

[3] Par exemple, les bases de données sur les entreprises chinoises ou indiennes et leurs transactions, permettent cette distinction entre les inputs et les produits finaux.



Note: Le ratio VAX mesure la part des flux d'exportation due à la production nationale. Un ratio de 1 correspond à des exportations entièrement produites sur le sol domestique.

Figure 2: Evolution du ratio VAX mondial, Johnson and Noguera (2016)

l'inverse du ratio VAX au niveau mondial peut être interprété comme une moyenne pondérée du nombre de passages aux frontières associés à la production d'un dollar de produits finis. Le graphique 2, de Johnson et Noguera (2016), représente l'évolution du ratio VAX mondial de 1970 à 2010. Au cours de la période, le ratio VAX a diminué régulièrement, reflétant une augmentation significative du nombre moyen de passages aux frontières, donc une plus grande fragmentation internationale.

Ces tableaux nous permettent de répondre à une série de questions empiriques importantes : les barrières à l'échange traditionnelles influencent-elles le commerce en valeur ajoutée de la même manière que le commerce brut ? Les anciennes théories du commerce sont-elles pertinentes pour expliquer les nouvelles caractéristiques du commerce des inputs ? Le commerce en valeur ajoutée a-t-il une incidence sur les modèles de spécialisation des pays ? Est-ce que la mesure du contenu factoriel du commerce change lorsqu'on comptabilise l'utilisation des inputs étrangers ? Une modification de l'utilisation des inputs étrangers influe-t-elle sur l'ampleur du contenu factoriel du commerce ?

De nombreux travaux se sont développés en suivant ces axes de réflexion.

Noguera (2012) dérive une équation de gravité pour le commerce en valeur ajoutée à partir d'un modèle théorique, son équation montre d'importantes différences par rapport à une équation de gravité standard. Les termes phares d'une équation de gravité (les poids économiques des pays, les coûts au commerce bilatéraux, et les termes de résistance multilatérale) sont pondérés par des termes qui dépendent de la structure input-output mondiale. Les relations avec les autres partenaires sont aussi déterminantes. Ito et al. (2016) confirment la pertinence de l'utilisation d'anciennes théories du commerce pour expliquer les nouveaux développements du commerce des inputs. En utilisant la WIOD pour construire une définition du commerce en valeur ajoutée, ils montrent de manière empirique, en estimant une équation de gravité, que la théorie de Hecksher-Ohlin prédit mieux le commerce en valeur ajoutée que le commerce brut pour le secteur manufacturier. Koopman et al. (2014) calculent un indice d'avantage comparatif révélé au niveau du pays en utilisant des exportations en valeur ajoutée plutôt que des exportations brutes, ce qui conduit à des résultats significativement différents. Par exemple, la Chine et l'Inde montrent un fort avantage comparatif révélé (ACR) dans le secteur des produits finis en métal en 2004 (valeurs absolues de ACR respectives : 1,94 et 1,29). Cependant, en regardant la valeur ajoutée domestique dans les exportations de ce secteur, les deux pays classés en ACR tombent respectivement aux septième et quinzième places. En réalité, pour l'Inde, le secteur est passé d'un secteur d'avantage comparatif à un secteur de désavantage comparatif. Sans surprise, le classement de certains autres pays augmente. En ce qui concerne le contenu factoriel du commerce, l'hypothèse traditionnelle de l'absence de commerce d'inputs est devenue difficile à défendre avec l'intensification de l'utilisation des inputs étrangers. Les chercheurs en commerce international ont introduit une nouvelle mesure du contenu factoriel du commerce qui relâche cette hypothèse. Reimer (2006) et Johnson (2011) soulignent des différences importantes entre cette nouvelle mesure et la mesure traditionnelle. Ils montrent que le fait de ne pas tenir compte des liens entre l'industrie internationale surestime la quantité nette de facteurs échangés. L'intuition

est que le commerce des inputs rend les techniques de production effectives d'un pays dépendantes des techniques de ses fournisseurs. Au niveau mondial, les techniques de production entre différents pays sont plus similaires, étant interdépendantes. Et cela devrait être d'autant plus vrai que les pays sont impliqués dans les chaînes de production. Pourtant, Reimer (2006), Trefler et Zhu (2010) et Johnson (2011) ont constaté que la nouvelle mesure n'améliore pas significativement les tests empiriques de la prédiction de Vanek. En raison de l'absence de tableaux entrées-sorties mondiaux chronologiquement cohérents, ces contributions ne peuvent pas analyser l'impact des changements récents de l'utilisation des inputs étrangers sur l'ampleur du contenu des facteurs du commerce.

Des mesures empiriques pour les coûts au commerce non-traditionnels

Les progrès en informatique et dans les techniques de collecte de données (online scrapping, OCR des archives non numérisées ...), ainsi que l'accès aux sources de données inaccessibles auparavant semblent très prometteurs pour la mise en place de mesures empiriques pour les coûts commerciaux. Hinz (2016) utilise des images satellites nocturnes annuelles (1992 à aujourd'hui) pour calculer une mesure cohérente de la distance entre tous les pays du monde; ces nouvelles sources de données seraient d'autant plus pertinentes pour les coûts commerciaux non traditionnels et plus spécifiquement pour ce que Head et Mayer (2014) ont appelé *dark trade costs*, c'est-à-dire ces obstacles non traditionnels au commerce qui sont observables mais difficiles à définir.

Le fait de partager une langue est l'un de ces coûts commerciaux non-traditionnels. L'effet quantitatif global des langues communes sur le commerce est largement reconnu. Les méta-analyses indiquent un effet moyen de la langue commune sur le commerce de $0,5$ dans une équation de gravité. Egger et Lassmann (2012) recueillent des données provenant

de 701 estimations portant sur les effets linguistiques de 81 publications universitaires publiées entre 1970 et 2011. Les élasticités varient de $-0,57$ à $1,85$. La moyenne de l'échantillon est de $0,49$ et l'écart-type de $0,34$. Les résultats de Head et Mayer (2014) dans le chapitre de leur manuel sont très similaires. Ils se concentrent sur 608 estimations de l'effet linguistique à partir d'un échantillon restrictif de 159 documents. La médiane dans l'échantillon est de $0,49$, la moyenne est de $0,54$ tandis que l'écart-type est de $0,44$.

La plupart des travaux empiriques utilisent les mesures introduites par Melitz et Toubal (2014) pour étudier l'impact d'une langue commune sur le commerce.[4] Pour construire leur mesure de partage de langue officielle, ils ont utilisé le CIA World Factbook. Ils prennent en compte 19 langues officielles. Cette mesure est une variable dichotomique qui est égale à 1 si les deux pays ont la même langue officielle et 0 dans le cas contraire. Ils fournissent également des mesures concernant le partage de langues maternelles et le partage de langues parlées. Pour deux pays donnés, elles sont toutes deux définies comme la probabilité de choisir au hasard deux personnes qui partagent la même langue (maternelle ou parlée). Pour chaque langue, ils calculent la probabilité que deux personnes parlent une langue commune dans ces deux pays (soit le produit de la proportion de personnes qui la parlent dans ces deux pays), puis font la somme de ces probabilités pour toutes les langues. Pour évaluer la proportion de personnes parlant une langue donnée (maternelle ou parlée) dans chaque pays, ils utilisent plusieurs sources de données distinctes. Leur source principale est l'enquête *Eurobaromètre* menée auprès de 28 694 citoyens entre novembre et décembre 2005 dans 28 pays européens et en Turquie. Pour les autres pays, les auteurs recueillent des informations sur le site Wikipedia et Ethnologue. Compte tenu de sa large couverture par pays, la base de données de Melitz et Toubal (2012) constitue un énorme progrès par rapport aux bases de données précédentes pour l'estimation de l'équation de gravité. Toutefois, leur mesure pourrait être améliorée.

[4]Leur base de données couvre 195 pays et est disponible sur le site du CEPII.

Une des faiblesses principales de leur mesure est le fait qu'ils utilisent des sources hétérogènes pour quantifier la proportion de locuteurs d'une langue donnée. Différentes sources signifient différentes années de collecte de données, différents échantillons, mais surtout des définitions différentes pour la langue parlée. Comme leur mesure de langue commune est le produit de deux proportions, il est d'autant plus crucial que celles-ci soient définies de manière homogène entre les pays. Ceci nécessite une méthode cohérente d'évaluation de la capacité des gens à parler une langue dans différents pays. À cet égard, l'enquête Eurobaromètre est idéale car elle pose deux questions spécifiques chaque individu interrogé sur leur utilisation de la langue : « quelle est votre langue maternelle ? » et « quelle langue parlez-vous assez bien pour pouvoir avoir une conversation, à l'exclusion de votre langue maternelle ? ». Avec ces questions, une distinction est faite entre les langues maternelles et les langues parlées. On s'assure aussi qu'il existe un critère commun pour l'auto-évaluation de la maîtrise de la langue. Un individu est un locuteur allemand si et seulement s'il peut avoir une conversation en allemand. Certaines des autres sources qu'ils utilisent, cependant, n'ont pas une définition aussi claire et cohérente des langues étrangères acquises. Cela peut se révéler problématique car la proportion de personnes qui parlent une langue donnée pourrait être significativement différente selon que la langue parlée est évaluée par la langue étudiée à l'école, par une auto-évaluation, par un certificat de compétence linguistique ou bien par tout autre moyen. Dans la base de données de Melitz et Toubal (2014), il se trouve que les pays pour lesquels ils ont utilisé les données Eurobaromètre ont beaucoup plus de langues étrangères que n'importe quel autre pays. Par exemple, 97% de la population australienne parle anglais uniquement, 97% de la population aux États-Unis parle anglais et 16% parle espagnol ; alors qu'au Royaume-Uni, 99% de la population parle anglais, 23% de la population parle français, 9% parle allemand, 8% de la population parle l'espagnol. Bien que cela puisse être dû à la diversité linguistique intrinsèque des pays européens, il est fort probable que ces différences proviennent des définitions et des méthodes sous-jacentes.

La mesure de Melitz et Toubal (2014) est calculée au niveau des pays, comme la plupart des autres mesures de langues parlées utilisées dans la littérature. Seules quelques études ont utilisé une échelle plus précise (comme les régions, provinces, etc.) mais le plus souvent au sein d'un seul pays. Egger et Lassmann (2015) utilisent les données du recensement de 1990 de l'Office fédéral de la statistique pour mesurer la langue maternelle en Suisse. Lameli et al. (2015) utilisent des données historiques sur l'utilisation des dialecte allemands dans 101 unités régionales allemandes à la fin du XIXe siècle. Sauter (2012) a construit une mesure du partage linguistique entre les provinces canadiennes ; elle est définie comme la probabilité pour deux personnes de différentes provinces choisies au hasard de pouvoir communiquer entre elles. Il ne prend en compte que l'anglais, le français et le chinois. Pour les deux langues officielles du Canada (français et anglais), il utilise des informations sur la langue maternelle, la connaissance de la langue officielle et l'utilisation de la langue au travail à partir de données de recensement. Pour le chinois, il le mesure comme la part de la population d'origine chinoise dans une province. Ces études, centrées sur un pays spécifique, ont mis en évidence une hétérogénéité linguistique importante au sein d'un même pays. Celle-ci ne peut certainement pas être révélée par des mesures agrégées au niveau des pays. Pour étudier l'impact d'une langue parlée, il est alors essentiel d'utiliser des données à un niveau plus précis. À cet égard, les données provenant des réseaux sociaux ont le potentiel d'amener à de nouvelles mesures empiriques.

Les nouvelles sources de données, inaccessibles auparavant, nous permettent également d'améliorer les mesures empiriques concernant l'état des relations politiques entre les pays, qui est un autre déterminant non-traditionnel du commerce important assez difficile à définir. Un des pans de la littérature s'est concentré sur les questions liées à la sécurité, en particulier les conflits inter et intra-étatiques (Martin et al. 2008a, Martin et al. 2008b, Martin et al. 2012), le détournement de cargaisons (Anderson et Marcouiller 2002, Marcouiller 2000), le terrorisme (Mirza

et Verdier 2008, Sousa et al. 2009, Sousa et al. 2010) et la piraterie internationale (Bensassi et Martinez-Zarzoso 2012) comme proxy pour de mauvaises relations politiques. Cependant, un certain nombre de travaux s'intéressent plutôt aux caractéristiques politiques et sociétales des partenaires commerciaux, qui ne sont pas liées à la sécurité. Dans la littérature récente, une façon courante de mesurer l'état des relations politiques bilatérales est de constater la similitude des votes à l'Assemblée générale des Nations Unies (Voeten et Merdzanovic 2009). Cela suppose qu'une politique étrangère alignée est le reflet de bonnes relations diplomatiques. Rose (2007), quant à lui, assimile la qualité des relations diplomatiques entre deux pays à la taille de leur ambassade respective dans l'autre pays. Nitsch (2007) considère que le nombre de visites officielles de chefs d'États et des membres des parlements dans un pays étranger est proportionnel à la qualité des relations diplomatiques. Umana Dajud (2013) mesure la proximité politique entre deux pays selon deux axes : gauche/droite et autoritarisme/libéralisme politique. Il utilise les données du *Manifesto Project* (Volkens et al., 2013) et celles du *Policy IV Project* (Marshall et Jaggers, 2002).

À ma connaissance, seuls deux articles mettent à profit les progrès de l'informatique et des méthodes de collecte de données. Fuchs et Klann (2013) recueillent des informations précises sur les visites officielles de Sa Sainteté le 14ème Dalaï-Lama sur son site internet. Ils construisent une variable dichotomique qui prend une valeur de 1 si, au cours d'une année donnée, le Dalaï-Lama a rencontré un membre officiel du gouvernement dans un pays partenaire de la Chine. Ils l'utilisent pour estimer, après les visites du Dalaï-Lama, l'effet de celles-ci sur le commerce de ces pays et la Chine.

Inspiré par Pollins (1989) et Desbordes et Vicard (2009), Hinz (2017) utilise la base de données GDELT répertoriant les événements mondiaux (Leetaru et Schrodt, 2013, GDELT). Ce vaste ensemble de données (plus de 300 millions d'événements depuis 1979) offre un spectre extrêmement riche des événements politiques dans le monde. Contrairement aux autres

mesures, sa mesure des relations diplomatiques est directionnelle, c'est-à-dire qu'elle prend en compte le point de vue respectif de chaque pays. Ces données sont publiques et accessibles gratuitement. Toutefois, elles ne peuvent être traitées qu'à l'aide des nouvelles techniques d'analyse puisqu'elles proviennent d'articles codés issus de nombreuses agences de presse internationales.

Par cette thèse, je contribue au renouvellement empirique de la littérature en commerce international en approfondissant notre compréhension du commerce mondial selon plusieurs axes de réflexion. Dans le chapitre 1, je mets à profit la cohérence chronologique des nouveaux tableaux entrées-sorties mondiaux. Cela me permet de quantifier les conséquences de l'évolution de l'utilisation d'inputs étrangers sur le contenu factoriel du commerce. Reconnaissant l'importance des interdépendances croissantes entre les pays, je présente dans le chapitre 2 une nouvelle façon de mesurer la détérioration des relations politiques entre les pays et étudie son impact sur le commerce des différents biens échangés. Dans le chapitre 3, à l'aide des données provenant de Twitter, j'introduis une nouvelle mesure empirique des langues parlées, ce qui me permet d'évaluer l'incidence de la diversité des langues sur le commerce et le revenu réel.

Présentation de la thèse

Quantification des conséquences de la récente évolution de l'utilisation d'inputs étrangers sur le contenu factoriel du commerce : Chapitre 1

Le contenu factoriel du commerce est un concept important en commerce international, en ce qu'il nous permet de considérer le commerce non pas comme un échange de marchandises mais comme un échange de services de facteurs. Ce concept a été introduit par Vanek dans un premier temps pour tester empiriquement le modèle Hecksher-Ohlin. Trefler et

Zhu (2010) ont montré que la prédiction de Vanek n'est pas seulement valable pour Hecksher-Ohlin, mais aussi pour une catégorie de modèles plus large.[5] En outre, le contenu factoriel du commerce est un concept-clé pour comprendre les conséquences des changements récents dans l'internationalisation des chaînes de production sur l'emploi et les salaires - un sujet qui a été central dans les débats des dernières décennies. Burstein et Vogel (2011) montrent que, sous certaines conditions, les changements dans le contenu factoriel du commerce déterminent l'impact du commerce sur les prix relatifs des facteurs. Comme nous l'avons déjà mentionné, l'évolution récente des tableaux entrées-sorties internationaux a permis de préciser la définition du contenu factoriel du commerce, en relâchant l'hypothèse, difficile à défendre, de la non-utilisation d'inputs étrangers. De précédents travaux ont révélé que la prise en compte de l'utilisation des inputs étrangers modifiait de manière significative l'ampleur du contenu factoriel du commerce, tout en n'altérant pas radicalement les tests empiriques de la prédiction de Vanek.

En exploitant la nouvelle dimension chronologique des tableaux entrées-sorties mondiaux, ce chapitre apporte deux contributions importantes à la littérature précédente en étudiant les conséquences de l'utilisation des inputs étrangers sur le contenu factoriel du commerce. Tout d'abord, il permet de reconsidérer le résultat surprenant de cette littérature. Reimer (2006), Trefler et Zhu (2010) et Johnson (2011) ont constaté qu'une mesure appropriée du contenu factoriel du commerce intégrant l'utilisation d'inputs étrangers n'améliore pas de manière significative la précision de la prédiction de Vanek. Le problème du commerce manquant demeure. Les résultats mitigés de ces articles pourraient être dues à la relativement faible fragmentation internationale dans leur données. Trefler et Zhu (2010) utilisent les tableaux entrées-sorties GTAP de 1997 et ceux utlisés par

[5] La prédiction de Vanek s'applique aux modèles qui ont les propriétés suivantes : (i) chaque pays est doté de f, offre d'au moins deux facteurs; (ii) les facteurs sont mobiles dans les entreprises et les industries d'un même pays mais immobiles entre différents pays; (iii) les marchés des facteurs sont en concurrence parfaite (iv); l'offre de facteurs est égale à la demande de facteurs; (v) il existe des différences internationales de techniques de production. L'hypothèse de la similarité de la consommation est une condition nécessaire et suffisante pour la proposition de Vanek.

Johnson (2011) datent de 2001. M'appuyant sur le long panel de la WIOD, je mesure le contenu factoriel du commerce en 1995 et en 2007 à l'aide des deux mesures introduites par la littérature. Ces deux années diffèrent significativement en termes d'utilisation des inputs étrangers. J'utilise ces mesures non seulement pour comparer les conséquences de l'introduction de l'utilisation des inputs étrangers dans le contenu factoriel du commerce, mais aussi pour réévaluer son impact sur la prédiction de Vanek au cours de ces deux années. Je constate que l'impact de l'introduction des inputs étrangers dans la mesure du contenu factoriel est plus important en 2007, mais ceci n'affecte cependant pas la prédiction de Vanek.

Ensuite, en utilisant la définition correcte du contenu factoriel du commerce, j'analyse les changements du contenu factoriel du commerce entre 1995 et 2007. Si l'on isole la contribution distincte de chaque élément entrant dans la définition du contenu factoriel du commerce (la matrice de la technologie de production, le vecteur du commerce et la matrice entrée-sortie), on peut étudier de manière très claire le rôle des changements dans l'utilisation des inputs étrangers sur le contenu factoriel du commerce - ce qui n'était pas possible avec les tableaux entrées-sorties mondiaux antérieurs. Je montre que, au cours de la période, avec l'accroissement des flux commerciaux bilatéraux, le contenu factoriel du commerce a considérablement augmenté. L'atténuation des différences dans les techniques de production a entraîné une réduction du contenu factoriel du commerce. À première vue, la contribution de la matrice entrée-sortie sur les changements du contenu factoriel du commerce au cours de la période est moins évidente. Séparant les pays par groupes, j'ai constaté que les changements dans l'utilisation des inputs étrangers ont conduit à une augmentation significative du contenu factoriel en capital et en travail hautement qualifié dans les pays riches. Ceci suggère une augmentation de la spécialisation dans leur avantage comparatif. Cela fournit des preuves supplémentaires de la pertinence des anciennes théories du commerce pour expliquer les développements récents dans le commerce international et le choix des entreprises du lieu de production, qui sont très probablement entraînés par la minimisation des coûts et les prix des

facteurs. Une compréhension claire des chaînes de production est cruciale pour bien comprendre leurs conséquences sur la redistribution du revenu.

Les conséquences hétérogènes des relations diplomatiques sur le commerce : Chapitre 2

Les changements dans l'utilisation des inputs étrangers, accroissant les interdépendances internationales, nous ont amené à repenser les relations entre les partenaires commerciaux. La multiplication des chaînes de production internationales et les liens transfrontaliers des entreprises ont rendu la production domestique de biens dépendante des inputs provenant de sources étrangères. Si, pour quelconque raison, les relations politiques entre deux pays d'une chaîne de production s'aggravaient, cela pourrait entraîner des coûts commerciaux plus élevés pour les échanges entre des entreprises des pays concernés. Cela pourrait se produire soit par des mesures directes drastiques, comme l'augmentation des tarifs ou la suspension des accords commerciaux préférentiels, soit d'une manière plus subtile grâce à des contrôles accrus à la frontière (Beestermoller et al. 2016) ou bien des instruments de financement du commerce plus coûteux (Crozet et Hinz 2017). Dans ce chapitre, co-écrit avec Julian Hinz, nous analysons le lien entre l'état des relations politiques et le commerce au niveau de l'industrie, ce qui permet de mettre en évidence un effet hétérogène par type d'input. Nous pensons que les relations politiques entre les pays comptent d'autant plus pour le commerce de biens *critiques* de l'économie importatrice. Nous suivons la terminologie de Ossa (2015), qui, étudiant l'hétérogénéité de la réponse des importations aux changements de droits de douanes, affirme que « *[...] les importations dans certaines industries sont essentielles au fonctionnement de l'économie , de sorte qu'un arrêt complet du commerce international est très coûteux dans l'ensemble* ». Ainsi, nous définissons comme des biens critiques les biens qui sont utilisés de manière intensive, directe et indirecte, pour la production de biens domestiques.

Le premier apport du chapitre 2 à la littérature est la formulation claire d'un nouveau mécanisme. Il y est expliqué, à l'aide d'un cadre théorique simple, pourquoi il est possible de penser que l'évolution des relations politiques a des conséquences hétérogènes sur les produits échangés. Une dégradation des relations diplomatiques a un effet plus important sur les flux commerciaux pour les inputs critiques que pour les autres inputs. En effet, la conséquence de la modification du prix d'un input sur un output agrégé est déterminé par la *dépendance* de l'économie face à cet input — directement et indirectement à travers les liens entre input-output domestiques. Plus la dépendance est grande, plus l'impact sur l'input agrégé est important, plus il est bénéfique de changer de fournisseur en réponse à un choc politique.

Le deuxième apport du chapitre 2 réside dans l'introduction d'une nouvelle mesure empirique des tensions politiques entre deux partenaires. Inspirés par la littérature en sciences politiques et plus particulièrement dans les relations internationales, nous considérons la convocation par un pays de diplomates étrangers ou bien le rappel de ses propres diplomates sur son territoire comme une dégradation des relations politiques entre deux partenaires. Ainsi, inviter ou rappeler ou expulser des diplomates de haut niveau est utilisé par le bureau des affaires étrangères ou le chef d'état d'un pays comme un instrument diplomatique pour exercer une pression sur un gouvernement étranger. C'est une mesure de dernier recours, si la médiation, la négociation et l'arbitrage ont tous trois échoué. Elle est souvent accompagnée d'une *note verbale* ou *lettre de protestation*, déclaration officielle de désapprobation. Par exemple, en juin 2015, les médias ont largement rapporté la convocation de l'ambassadeur américain à Paris par le gouvernement français concernant « l'espionnage inacceptable des dirigeants politiques français ».[6] Nous construisons une nouvelle base de données d'événements en recueillant des informations sur ces événements diplomatiques à partir de communiqués de presse trouvés sur les sites des ministères des Affaires étrangères de cinq pays poli-

[6]Voir *The Guardian*, 24 juin 2015, `http://www.theguardian.com/world/2015/jun/24/francois-hollande-says-us-spying-on-french-officials-unacceptable-nsa`

tiquement et économiquement importants (France, Royaume-Uni, Russie, Allemagne, Japon). Afin de recueillir ces données, nous avons mis à profit les améliorations des méthodes de collecte de données, notamment le *web scrapping*.

Réexaminer l'impact de la langue sur le commerce : Chapitre 3

L'accès récent à des données dites de « *big data* » amène la possibilité d'une recherche prometteuse en commerce international en permettant l'accès à des informations difficiles, avec une résolution spatiale exceptionnellement élevée et une large couverture géographique. Dans le domaine du commerce international, les « *big data* » ont ouvert la voie à la prolifique littérature théorique qui prend la géographie interne des pays au sérieux (Allen et al. 2014, Cosar et al. 2016, Ramondo et al. 2016 et Redding 2016). Ils relâchent l'hypothèse habituelle selon laquelle un pays présenterait les mêmes caractéristiques sur tout son territoire et considèrent plutôt chaque pays comme une multitude d'emplacements, confrontés à des coûts commerciaux spécifiques. Cela a des conséquences cruciales pour la mesure du commerce international au sein même des pays. Dans le troisième chapitre, lui aussi écrit en collaboration avec Julian Hinz, nous tirons parti de la mise à disposition des données de Twitter pour construire une nouveau proxy pour le partage d'une langue. Nous incorporons ensuite les données de langue commune dans un modèle avec des entreprises et des consommateurs hétérogènes. A l'aide de ce modèle, nous effectuons de nouvelles analyses contre-factuelles pertinentes pour évaluer l'impact de la diversité linguistique entre des pays partenaires et au sein de ceux-ci.

Le premier apport de ce chapitre est de construire un nouveau proxy pour une composante importante des coûts commerciaux non-traditionnels : le partage des langues. Nous récupérons la capacité à parler une langue à partir des données de Twitter. Pour chaque *tweet*, c'est-à-dire un court

message posté sur la le réseau social Twitter, on observe 42 variables. Celles-ci incluent, évidemment, le texte du tweet, mais aussi l'identifiant de l'utilisateur, la langue du profil de l'utilisateur et la langue du tweet lui-même. En outre, pour les tweets géo-localisés, quand l'utilisateur permet à Twitter d'enregistrer l'emplacement GPS de l'appareil au moment de l'envoi du tweet, on a des informations sur la latitude et la longitude à partir desquelles l'utilisateur a tweeté. En utilisant ces tweets géo-localisés, nous pouvons déduire une approximation de la distribution d'une langue dans n'importe quel endroit donné — ville, région, pays. Twitter est un moyen pour les gens de partager des réflexions avec un large public parlant la même langue et avoir des débats sur l'actualité avec cette communauté. Le partage de la langue est donc essentiel pour pouvoir interagir sur cette plate-forme. Twitter a récemment été utilisé comme une source de données majeure dans la recherche économique, principalement en économie politique. Acemoglu et al (2014) l'utilisent pour construire un proxy pour l'engagement politique, tandis que Conover et al. (2011) l'ont utilisé pour construire une mesure de polarisation politique. À notre connaissance, nous sommes les premiers à utiliser ce genre de données pour un travail de recherche en économie internationale. Nous construisons notre mesure de l'utilisation de la langue à partir de près de 1 milliard de tweets uniques collectés entre novembre 2016 et mai 2017, que nous associons à plus de 700 000 utilisateurs uniques de Twitter, identifiés grâce à leur langue et leur emplacement respectifs.

Le deuxième apport est théorique. Bien que la littérature ait reconnu le rôle du partage linguistique, les fondations théoriques micro pour un tel effet ne sont pas claires. Nous développons un modèle dans lequel nous intégrons le langage comme un déterminant majeur des interactions sur le marché. La langue importe autant dans la demande que dans l'offre. En effet, la ou les langue(s) parlée(s) par un consommateur sont susceptibles de façonner sa consommation. Nous supposons qu'un consommateur ne consomme qu'un bien vendu dans sa langue, par exemple, un produit duquel il peut lire et comprendre l'étiquette. Dans un supermarché allemand, il faudrait maîtriser quelques notions d'allemand pour pouvoir identifier le produit

étiqueté « mineralwasser » comme étant de l'eau gazeuse. Sur le plan de l'offre, nous supposons que les entreprises doivent payer un coût fixe pour pouvoir vendre leurs biens dans une langue donnée, c'est-à-dire produire l'étiquette, communiquer avec les consommateurs potentiels, faire connaître leur produit. Le coût fixe d'un investissement dans une langue est proportionnellement lié au nombre de personnes qui parlent cette langue dans leur lieu de résidence. Par conséquent, plus les gens parlent une langue donnée dans leur lieu de résidence et plus l'entreprise a de consommateurs qui parlent cette langue, plus elle est sera susceptible d'investir dans celle-ci.

Enfin, le modèle nous permet d'effectuer des analyses contre-factuelles pertinentes sur le plan de l'évaluation des politiques. En effet, on peut alors évaluer l'impact des changements de diversité linguistique sur le commerce et le revenu réel non seulement entre les pays, mais aussi dans les pays. En 2002, le Conseil européen de Barcelone a fixé un objectif précis : celui que les Européens puissent communiquer grâce à trois langues, leur langue maternelle et deux langues étrangères. Annoncer « l'ambition de l'Union européenne à être unie dans la diversité », [7] revenait à souligner que le plurilinguisme est important pour la cohésion et la compétitivité de l'Union Européenne, ainsi que pour son commerce interne et externe. Pourtant, l'effet de cette politique n'a jamais été quantifié. Notre modèle permet d'évaluer les conséquences d'une telle politique sur le commerce et la répartition du revenu sur le territoire européen.

[7] Voir `http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/71025.pdf` pour Les conclusions du Conseil européen de Barcelone de 2002 et de l'url http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=URISERV:ef0003 pour un résumé de la législation de l'UE concernée.

Introduction

In recent decades, the focus of research in international trade has shifted from a country/industry perspective to a firm perspective. The firm has become the central unit of analysis in the field. This transformation was fueled by theoretical advances (Melitz 2003), new foundations for the gravity equation (Chaney 2008), and the access to confidential firm-level data (Eaton et al. 2004, Bernard et al. 2007); initiating a fruitful dialogue between theory and empirics. Mayer and Ottaviano (2008) confirmed previous stylized facts on internationalization of firms for Europe showing that international activities are concentrated within a handful of very large firms, "the happy few". Yet, other novel data sources appeared in parallel to transaction-level and firm-level data which opened an avenue for promising research in international trade, and participated to deepening our understanding of world trade.

More and more firms are now involved in international supply chains as they source parts, components, or services from foreign countries, and supply inputs to foreign buyers, increasing the complexity of transactions. While theoretical models developed to better understand the contracts monitoring each link in the chain and their implications for the the firm international strategy, global input-output tables allowed the introduction of new measures to quantify the extent of fragmentation of production across borders and internationalization of supply chains.

Advances in computer sciences revolutionized data collecting methods and granted access to previously unreachable sources (web scrapping, big-data

from social media, monitors, sensors etc...).

The present dissertation contributes to this strand of the literature by using global input-output tables to revisit old trade questions (chapter 1 and 2) and proposing original proxies for non-traditional trade costs based on other novel sources (chapter 2 and 3). Before turning to the content of this dissertation, it is necessary to understand not only why all these new sources are a major advance with respect to existing databases, but also how they have improved our understanding of world trade.

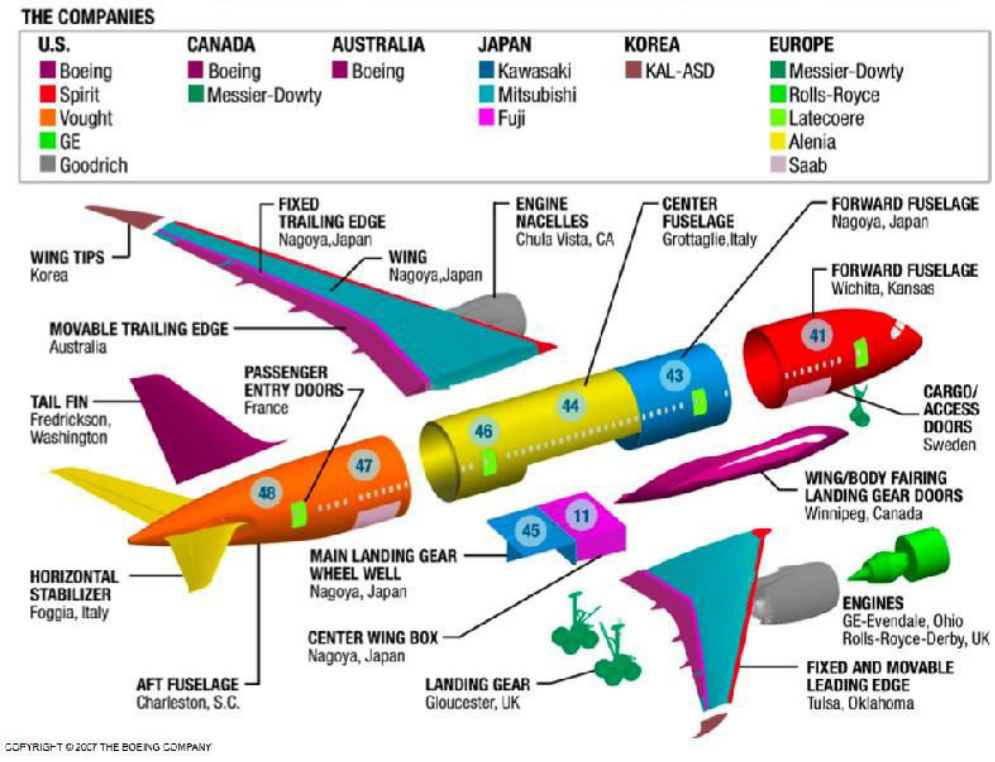
Quantification of international fragmentation of production

The gradual disintegration of production processes across borders became more prominent in the last years. More and more firms now organize production on a global scale and choose to offshore parts, components, or services to producers in foreign and often distant countries. The fragmentation of production is, however, not a new phenomenon. The production of pins in the late eighteen century England as described by Adam Smith in *The Wealth of nations* was fragmented in several stages:

"To take an example, therefore, from a very trifling manufacture; but one in which the division of labour has been very often taken notice of, the trade of the pin-maker; [...] in the way in which this business is now carried on, not only the whole work is a peculiar trade, but it is divided into a number of branches, of which the greater part are likewise peculiar trades. One man draws out the wire, another straights it, a third cuts it, a fourth points it, a fifth grinds it at the top for receiving the head; to make the head requires two or three distinct operations; to put it on, is a peculiar business, to whiten the pins is another; it is even a trade by itself to put them into the paper; and the important business of making a pin is, in this manner, divided into about eighteen distinct operations, which, in some manufactories, are all performed

by distinct hands, though in others the same man will sometimes perform two or three of them. ”

Vertical specialization across borders was first noticed by trade economists several decades ago (e.g., Findlay 1978; Helleiner 1973), and to a certain degree this phenomenon exists since the Great Specialization of the late nineteenth century. What recently increased is the extent to which manufacturing processes were subdivided into stages with each stage located in a different country, with components crossing borders multiple times. Baldwin refers to this phase as the “second unbundling”.



Source: The Boeing company

Figure 3: Boeing 787 supply chains

One of the most prominent examples of such international supply chain is the one of an aircraft. Figure 3 displays the supplier of each major component of the Boeing 787 and the country in which each component is manufactured. The fuselage of the aircraft is produced partially by Spirit in the United States, Kawasaki in Japan, Alenia in Italy, and Vought in the

United States. The passenger entry door are produced by Latecoere in France, the cargo access doors by Saab in Sweden, and the landing gear by Messier-Dowty in the United Kingdom. For the wings, in Nagoya (Japan), Mitsubishi Heavy Industries produces the core and Kawasaki produces the forward fuselage, the tips are produced by KAL-ASD in Korea, and the movable trailing edge by Boeing in Australia. The production of the major components of a Boeing involves at least 17 companies in 9 different countries. The Boeing 787 is then assembled in the Boeing factory in Everett, Washington State. While we know that the aircraft industry is one of many examples of highly fragmented international supply chains, it is a feature that it hard to measure systematically with available aggregate trade statistics. As pointed out by the European Commissioner for Trade, Karel De Gucht *"[...] though we are aware of the rising importance of global value chains, we have so far been unable to properly measure their size, nature and effect. This is because our current statistical apparatus does not capture the domestic activity contained in a traded good or service"*.[8]

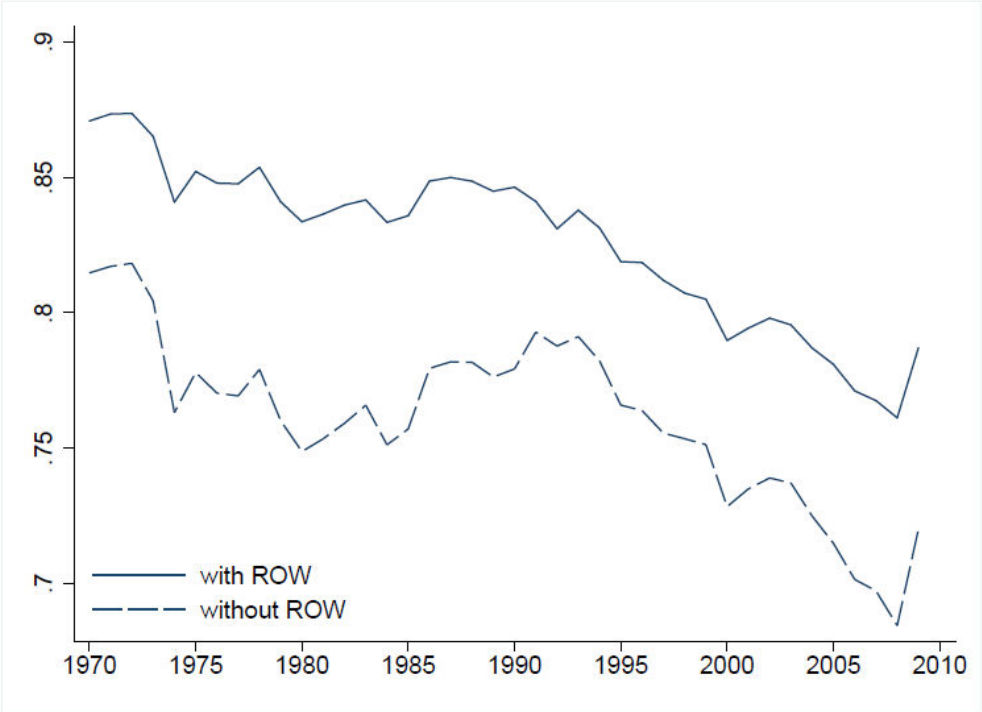
With the development of global input-output tables, trade economists have a new powerful tool to study international supply chains and quantify the extent of international fragmentation worldwide. The concept of global input-output table emerged from the revival of an old literature on input-output accounting with multiple regions going back to Isard (1951) and MILLER (1966), and on trade in intermediates (Sanyal and Jones 1982). A global input-output table not only describes the input use across industries in an economy - as a national input-output would-, but also distinguishes between sourcing countries. Thus, one knows how much the French car industry uses of inputs from the French "rubber and plastic industry" but also from the same industry in Germany, the United Kingdom, the United States, or anywhere else. This enables us to both quantify the cross-country input-output linkages, and to trace the value-added embodied in final goods back to its source.

[8]Available at: `http://trade.ec.europa.eu/doclib/docs/2012/april/tradoc_149337.pdf`

Several initiatives for the development of global input-output tables simultaneously emerged. Using GTAP input-output tables, Johnson and Noguera (2012) built a global input-output table for over 100 countries for various benchmark years. These tables have then been used by (Trefler and Zhu, 2010), Daudin et al. (2011), and Koopman et al. (2014). IDE-JETRO constructed an input-output table covering 8 East Asian countries at five-year intervals between 1985 and 2000. While the OECD assembled input-output tables for OECD countries and major emerging markets, available for various years from 1970 to 2005. As a result of a 3-year project with 11 international partners involved, the WIOD team developed global input-output tables covering 40 countries from 1995 to 2011. This last source has crucial advantages with respect to others. The tables are truly global, and can be consistently used to study changes over time. Additionally, the database includes socio-economic and environmental indicators, which can provide interesting insights while combined with the input-output tables.

While global input-output tables give a clear picture of the global production network at the industry level, they do not display the full structure of the production network at the firm-level. This is very hard to pin down, even with micro-level data. Micro-level data has traditionally revealed exports of individual firms, summed across all buyers; or conversely, imports of individual firms, summed across all sellers by destination, and generally do not distinguish between inputs and final goods. Few sources that allows that distinction[9] are available for one specific country and generally do not differentiate between sourcing countries. The recent access to new buyer-seller data are very promising in that respect. In a recent work, Bernard et al. (2014) use a dataset of Norwegian firms where the identities of both the exporter and the importer are known, and where a firm's annual export transactions can be linked to specific buyers in every destination country, and each firm's annual import transactions can be linked to specific suppliers in every source country.

[9]Chinese or Indian transaction-level data for instance allow for that distinction between imported inputs and final good.



Note: The solid line included shipments to and from the rest of the world (ROW), and the dashed line excluded them.

Figure 4: Evolution of VAX ratio at the world level Johnson and Noguera (2016)

Based on global input-output tables, authors have introduced new measures for quantifying the extent to international fragmentation that drastically improved previous measures relying on aggregate trade statistics and national input-output tables (Feenstra and Hanson 1996, Hummels et al. 2001). More specifically, Johnson and Noguera (2016) have introduced the Value-Added to Export ratio (VAX). The VAX ratio measures the share in export flows that is due to domestic production. In a world without trade in inputs, all the production takes place in one country, hence the ratio equals 1. The world value added to export ratio in the year t is defined as $VAX_t = \frac{\sum_{i \neq j} \sum_s va_{ijt}(s)}{\sum_{i \neq j} \sum_s x_{ijt}(s)}$. According to Fally (2012), the inverse of the VAX ratio at the world level can be interpreted as a weighted av-

erage of the number of border crossings associated with producing one dollar of final goods. Figure 4, taken from Johnson and Noguera (2016), depicts the evolution of the world VAX ratio from 1970 to 2010. Over the period, the VAX ratio decreased steadily, reflecting a significant increase of the average number of border crossings, therefore greater international fragmentation.

These tables allows us to answer a range of important empirical questions: Do traditional trade frictions influence trade in value-added in the same way as gross trade? Are old trade theories relevant for explaining new features of trade in inputs? Does trade in value-added affect perspective on countries' specialization patterns? Does the measurement of the factor content of trade change when accounting for foreign input use? Does a change in foreign input use impact the magnitude of the factor content of trade?

Here are selected examples of interesting works developed along these lines. Noguera (2012) derives a structural gravity equation for trade in value-added, his equation has important differences with the standard gravity. Economic masses, bilateral trade costs, and multilateral resistance terms are scaled by terms that depend on the global input-output structure, and gravity relations with third countries are also determinant.Ito et al. (2016) confirm the relevance of old trade theories to new developments in foreign input uses. Using the WIOD to construct a definition of value-added trade, they show in a gravity regression setting that Hecksher-Ohlin theory does predict manufacturing trade in value-added and that it does so better than for gross trade flows. Koopman et al. (2014) compute a revealed comparative advantage index at the country-sector level using value-added rather than gross exports, which leads to significantly different results. For instance, both China and India show a strong revealed comparative advantage in the finished metal products sector in 2004 (absolute values of RCA at 1.94 and 1.29, respectively). However, when looking at domestic value-added in that sector's exports, both countries ranking in RCA drop precipitously to seventh and fifteenth place, respectively. In fact, for India,

the sector has switched from being labeled as a comparative advantage sector to a comparative disadvantage sector. Unsurprisingly, the ranking for some other countries move up. Regarding the factor content of trade, the traditional assumption of no trade in inputs became untenable with the intensification of foreign input use. Trade economists introduced a new measure of the factor content of trade relaxing this assumption. Reimer (2006) and Johnson (2011) both document significant differences between this new measure and the traditional one. They show that not accounting for international industry linkages overestimates the amount of net factor traded. The intuition is that trade in inputs makes the effective production techniques of a country depend on the techniques of his suppliers. At a global level, as production techniques are interdependent, effective production techniques are more similar. And, this should be all the more true, the more countries are involved in the production chains. Yet, Reimer (2006), Trefler and Zhu (2010), and Johnson (2011) found that the new measure marginally improves the fit of Vanek prediction. By lack of consistent time-series global input-output tables, these contributions do not discuss the impact of recent changes of foreign input use on the magnitude of the factor content of trade.

Proxies for non-traditional trade costs

Progress in computer science and data collection techniques (online scrapping, OCR of non-digitalized archives...), as well as access to previously unreachable data sources seems very promising for building proxies for trade costs. While Hinz (2016) uses annual nighttime satellite imagery to compute theory-consistent distances between all countries and years since 1992, one has reasons to believe that these novel sources of data would be all the more relevant for non-traditional trade costs, and more specifically for what Head and Mayer (2014) called *dark trade costs* i.e. these non-traditional barriers to trade that are observable but hard to pin down.

Language commonality is one of these non-traditional trade costs. The overall quantitative effect of common languages on trade is widely recognized. Meta-analyses point towards an average effect of common language on trade of 0.5 in a gravity setting. Egger and Lassmann (2012) collect data from 701 language effects from 81 academic papers published between 1970 and 2011. The estimates vary from -0.57 to 1.85. The sample average is 0.49 and the standard deviation 0.34. The findings of Head and Mayer (2014) in their handbook chapter are very similar. They focus on 608 estimates of language effect from a restrictive sample of 159 papers. The median in the sample is 0.49, the mean is 0.54 while the standard deviation is 0.44.

As a proxy for language commonality, most papers use the measures introduced by Melitz and Toubal (2014) available for 195 countries.[10] They built a common official language measure based on the CIA World Factbook, where they consider a set of 19 official languages. It is a country-pair-specific dummy that equals one if the two countries have the same official language and zero otherwise. They also provide measures for common native language and common spoken language. For a given country-pair, it is the probability of randomly picking two people that "share" the same language. For each language they take the product of the proportion of people speaking this language in the two countries, and then sum over all languages. To construct these two measures, they need to assess the proportion of people speaking a given language (native or acquired) in each country. To do so, they use several distinct sources. Their main source is the Eurobarometer survey conducted on 28,694 citizens between November and December 2005 in 28 European countries and Turkey. For other countries, Melitz and Toubal (2014) gather information from both Wikipedia and Ethnologue website. Given its large country-coverage, this database constitute a tremendous improvement with regard to previous database for gravity estimation. Yet, there are room from improvement for their measure of spoken language.

[10]The dataset is publicly available on the website of the CEPII.

One major concern is the fact that they convey heterogeneous sources to quantify the proportion of speakers of a given language. Different sources means different years of data collection, different samples, but more importantly different definitions for spoken language. As their measure of language commonality is the product of two proportions, it is all the more crucial that the proportions are defined in a consistent way across countries. One must have a consistent method of assessing the ability of people to speak a language across countries. In that respect, the Eurobarometer survey is ideal as each individual interviewed was asked two specific questions about their language use: "What is your maternal language? " and "Which language do you speak well enough in order to be able to have a conversation, excluding your mother-tongue? ". With these questions, one makes a distinction between native and acquired spoken languages, and ensures that there is a common criteria for the self-assessment of language proficiency. An individual is a German speaker if and only if he can have a conversation in German. Other sources, however, may not be as clear and consistent on their definition of acquired foreign languages. This is a problem as the proportion of people speaking a given language might be significantly different if the ability of speaking a language is assessed by the language studied at school, relying on self-assessment, by certificate of language proficiency or by any other means. As a matter of fact, in Melitz and Toubal (2014) database, countries for which they have used Eurobarometer data have significantly more foreign languages than any other country. For instance, 97 percent of the Australian population speaks English but no other language, 97 percent of the population in the United States speaks English and 16 percent speaks Spanish; while in the United Kingdom 99 percent of the population speaks English, 23 percent of the population speaks French, 9 percent speaks German, 8 percent of the population speaks Spanish. While this might be due to the intrinsic language diversity of European countries, it is very likely to be driven by underlying definitions and methods.

Melitz and Toubal (2014) measure, as most of the other spoken languages measures used in the literature, are at the country-level. Only few studies

have used lower level of disaggregation - regional at most, and usually focus on one country. Egger and Lassmann (2015) uses data from 1990 Census of the Swiss Federal Statistical Office to measure native language within Switzerland. Lameli et al. (2015) uses historical data on the use of German dialect in 101 German region units in the late nineteenth century. Sauter (2012) built a measure of language commonality between Canadian provinces as the probability that any two people from different provinces picked at random will be able to communicate with each other. It only considers English, French and Chinese. For the two official languages of Canada (French and English), he uses information on mother tongue, knowledge of official language and use of language at work from the Census survey; while for Chinese he proxies it by the share of population with Chinese origin in a province. These country-specific studies revealed significant intra-country heterogeneity in language use, which can definitely not be captured by aggregate measures. To study the effect of spoken acquired language, it is then essential to use more disaggregated data. In that respect, social media data, has potential for promising new proxies.

These new sources of data have also the potential for improving proxies for another important non-traditional determinant of trade that is rather hard to pin down: the state of political relations between countries. One strand of the literature has focused on security-related issues, in particular inter- and intra-state conflict (Martin et al., 2008a,b, 2012), "hijacking" of shipments (Anderson and Marcouiller, 2002; Marcouiller, 2000), terrorism (Mirza and Verdier, 2008; de Sousa et al., 2009, 2010) and international piracy (Bensassi and Martínez-Zarzoso, 2012) as proxy for bad political relations. But a number of works have been furthermore interested in non-security-related political and societal features of the trading countries. In the recent literature a popular way to describe bilateral political relations has been to equate it to an aligned foreign policy, proxied by the similarity of voting patterns in the UN General Assembly with data from Voeten and Merdzanovic (2009). The idea implicitly invokes the "my enemy's

enemy is my friend" rationale. Rose (2007) equates political interest to the geopolitical importance of the bilateral partner for a domestic country and finds the number of embassy staffs as an interesting proxy. Nitsch (2007) proxies proximity by official visits of heads of states and members of parliaments. Umana Dajud (2013) measures political proximity of countries along two axis, the political left/right and authoritarianism/libertarianism, using data from the Manifesto Project (Volkens et al. 2013) on the agenda of political parties in elections and from the Polity IV project (Marshall and Jaggers 2002), respectively.

Two papers, to my knowledge, make use of advances in data collection methods, and computer science. Fuchs and Klann (2013) gather precise information on official visits of the Dalai Lama from His Holiness the 14th Dalai Lama's website. They construct a binary dummy variable that takes a value of 1 if the Dalai Lama met with a head of state or head of government, a member of government, a national official representative, or any dignitary listed by the Office of the Dalai Lama of the partner country in a given year. They use it to estimate the effect of Dalai Lama's visits on the host countries' subsequent trade with China.

Hinz (2017) follows Pollins (1989) and Desbordes and Vicard (2009) in constructing quantitative measures of bilateral political relations with event data. He relies on data from the "Global Database of Events, Language, and Tone" (Leetaru and Schrodt 2013). Almost all of the proxies for political relations described above are not directional, i.e. the measures yield the same value for a country pair from o to d and d to o. This may not be an issue when interested in how similar certain policies or points of view from two countries are, it does matter however when interested in how important the countries are for one another. The GDELT dataset allows him to compute such a directional measure. The vast dataset of more than 300 million events since 1979 offers an unsurprisingly very noisy, but incredibly rich view on political events in virtually all countries. The data, which is open source and freely available, is collected via software-read and coded news reports from a variety of international news

agencies. Its wealth of data has excited much of the empirical political science for enabling a true testing of political theories, but to the best of my knowledge Hinz (2017) was the first to used it in economics.

In this dissertation, I contribute to the thriving empirical literature in international trade deepening our understanding of world trade along multiple lines. In chapter 1, I use the time-series dimension of global input-output to quantify the implications of changes in foreign input use on the factor content of trade. Acknowledging the importance of increasing interdependencies between countries, in chapter 2, I introduce a new proxy for a negative shock to political relations between countries and study its heterogeneous effect on traded goods. In chapter 3, using Twitter data, I construct a new proxy for spoken language, which allows me to evaluate the effect of changes in languages diversity on welfare. I will now turn to the content of each chapter in detail.

This Dissertation

Quantifying the implications of foreign input use changes for the Factor Content of Trade: Chapter 1

The factor content of trade is an important concept in international trade, which allows us to view trade not a as an exchange of goods but as a exchange of services of factors. It has been introduced by Vanek to initially test the Hecksher-Ohlin model. Trefler and Zhu (2010) shown that Vanek's measure of the factor content of trade and his prediction is not only valid for Hecksher-Ohlin but also for a broader class of models.[11] More

[11]The Vanek prediction holds in models with the following properties: (i) each country is endowed with f, supply of at least two factors (ii) factors are mobile across firms and industries within a country but immobile across countries (iii) Factor markets are perfectly competitive (iv) Factor supply equals factor demand (v) arbitrary international differences in choice of techniques. The consumption similarity assumption is a necessary and sufficient condition for the Vanek proposition.

importantly, the factor content of trade is a key concept to understand the implications of recent changes in internalization of supply chains for employment and wages - a topic that has been at the center of discussion in the last decades. Burstein and Vogel (2011) show that under some restrictions, changes in the factor content of trade fully determine the impact of trade on relative factor prices. As previously discussed, the recent development of global input-output tables allowed to refine the definition of the factor content of trade, relaxing the untenable assumption of no foreign input use. Previous works found that accounting for foreign input use significantly changed the magnitude of the factor content of trade, while not affecting drastically the tests of Vanek prediction.

Exploiting the time-series dimension of the World Input-Output tables, this chapter makes two distinct contributions to the previous literature studying the impact of foreign input use for the factor content of trade. First, it allows to reconsider the rather puzzling result of this literature. Reimer (2006), Trefler and Zhu (2010), and Johnson (2011) found that a proper measure of the factor content of trade that accounts for foreign input use marginally improves the fit of Vanek prediction. A fair amount of missing trade persists. Their weak findings might be driven by the relative low intensity of cross-border fragmentation in the data they have used. Trefler and Zhu (2010) use GTAP input-output tables from 1997, and Johnson (2011) uses GTAP input-output tables from 2001. Building on the beginning and the end of the period covered by the WIOD, I measure the factor content of trade in 1995 and 2007, two years featuring important differences in foreign input use, with the two measures introduced by the literature. I use these measures to not only compare the impact of introducing foreign input use in the factor content of trade, but also to reassess its impact on the Vanek prediction in these two years. I found that including foreign input use matters more in 2007, but still does not affect the Vanek prediction.

Second, using the correct definition of the factor content of trade, I decompose the changes in the factor content of trade between 1995 and 2007.

Isolating the separate contribution of each element entering the definition of the factor content of trade (the production technology matrix, the trade vector and the input-output matrix), one can clearly study the role of changes in foreign input use on the factor content of trade - which was not possible with previous global input-output tables. I show that over the period, with increasing bilateral trade flows, the factor content of trade has significantly increased. Shrinking differences in production techniques led to a reduction in the factor content of trade. At a first glance, the picture is less straight-forward regarding the contribution of the input-output matrix to changes of the factor content of trade over the period. Distinguishing by country groups, I find that changes in foreign input use led both the capital and high-skilled content of trade of high-income countries to significantly increase, suggesting an increase in specialization in their comparative advantage. This provides additional evidence for the relevance of old trade theories to explain recent developments in international trade and firms choice of production location, which are very likely driven by cost minimization and factor prices. A clear understanding of supply chains is crucial to fully understand their implications for income redistribution and welfare.

The heterogeneous effect of political relations on trade: Chapter 2

Changes in foreign input use led us to rethink relations between partner countries by fostering international interdependencies. The proliferation of international supply chains, the cross-border linkages of firms, has made the domestic production of goods dependent on inputs from foreign sources. Should the political relations between two countries in such a supply chain experience worsen for any given reason, it could be that trade between firms in these countries is subject to higher trade costs. This could happen through drastic direct measures, e.g. increases in tariffs or suspension of preferential trade agreements, or in a more subtle fashion

through increased checks at the border, e.g. as in Beestermöller et al. (2016), or more expensive trade finance instruments, as in Crozet and Hinz (2017). In this chapter, which is a joint work with Julian Hinz, we analyse the relation between political relations and trade at the industry level, allowing for a heterogeneous effect by types of inputs. The main mechanism we presume in driving the heterogeneity is the *dependence* of the economy on the imported input. We suspect that political relations between countries matter more for *critical* goods of the importing economy. We follow Ossa (2015) in the wording, who, studying the heterogeneity of the response of imports to tariffs states, that *"[...] imports in some industries are critical to the functioning of the economy, so that a complete shutdown of international trade is very costly overall"* (Ossa, 2015, p. 266). As such, we define critical goods and inputs those that are used intensively directly and indirectly for the production of goods that are domestically consumed.

The first contribution of chapter 2 is to explicitly formalize a new mechanism, explaining within a simple theoretical framework why there are reasons to believe that a shock to political relations has heterogeneous effects across products. The response of a negative shock to political relations for trade flows is greater for critical inputs than for other inputs as the effect of a change of the price of an input on aggregate output is conditional on how *dependent* the economy is on this input—directly and indirectly through domestic input-output linkages. The greater the dependence, the bigger is the effect on aggregate output, the bigger are the benefits from switching suppliers in the face of political shocks.

The second contribution of chapter 2 lies in the introduction of a new proxy for political tensions between two partners. Motivated by the literature in political sciences, and specifically in international relations, we consider the summoning or recalling by a country of foreign or own diplomats as negative shock to political relations between the two partners. Summoning or recalling high-level diplomats is used as a diplomatic instrument to put pressure on a foreign government. They are considered after mediation,

negotiation and arbitration fails. The summoning, recalling or expulsion of diplomats is a decision taken by the foreign office or the head of state of a country to exert diplomatic pressure on another country. It often goes along with a *note verbale* or *letter of protest*, a formal declaration of disapproval that occurs at that date and is specific to a country pair. For instance, in one recent case in June 2015, the media extensively reported about the summoning of the American ambassador in Paris by the French government over "unacceptable spying on French political leaders".[12] We construct a new event database by collecting information on these diplomatic events from press releases found on the websites of the foreign ministries of five politically and economically important countries (France, UK, Russia, Germany, Japan). To gather this information we made use of improvements in data collection methods, namely web information scrapping.

Revisiting the effect of language on trade : Chapter 3

By providing access to information difficult to obtain by other means, with unusually high spatial resolution, and likely wide geographic coverage, the recent access to so-called big data has opened a promising avenue for research in economics. In the field of international trade, it paved the way to fast growing theoretical literature that takes internal geography seriously (Allen and Arkolakis 2014, Coşar and Fajgelbaum 2016, Ramondo et al. 2016, and Redding 2016). They depart from the usual assumption that countries are fully integrated domestically as if they were a single dot in space and treat countries as a collection of locations that face specific trade costs. This has crucial implications for the measurement of international and intranational trade costs. In the third chapter, based on a collaboration with Julian Hinz, we make use of the availability of Twitter data to built a new proxy for language commonality. We then explicitly incorporate language in a model with heterogeneous firms and consumers. Driven by

[12] See *The Guardian*, 24 June 2015, `http://www.theguardian.com/world/2015/jun/24/francois-hollande-says-us-spying-on-french-officials-unacceptable-nsa`

our model and combined with our new measure of spatial distribution of language, we perform new policy-relevant counterfactuals to evaluate the impact of both between and within country language diversity.

The first contribution of this chapter is to build a new proxy for an important component of non-traditional trade costs: language commonality. We retrieve language ability from Twitter data. For each *tweet*, i.e. a short message posted on the social media platform Twitter, one observes 42 variables. These include, obviously, the text of the tweet, but also the identifier of the user, the language of the user's profile, and the language of the tweet itself. Additionally, for those tweets that are geo-localized, i.e. where the user is allowing Twitter to record the GPS location of the device at the time of sending the tweet, one has information on the latitude and longitude from which the user tweeted. Using these geo-localized tweets, we can derive an approximation of the distribution of language use in any given location—or city, region, country. Twitter is an outlet through which people can share thoughts with a wide audience of speakers of the same language and discuss topics of interests with this community. Language is therefore key for interactions on that platform. Twitter has recently been used as a major source of data in economic research, mostly in political economy. Acemoglu et al. (2014) use it to built a proxy for political mobilization, while Conover et al. (2011) used it to build a measure of political polarization. As far as we know, we are the first to use this kind of data in the context of research in international economics. We build our measure of language use from almost 1 billion unique tweets collected between November 2016 and May 2017. We identify more than 700 thousand unique Twitter users with their respective language and location.

The second contribution is a theoretical one. While the literature has acknowledged the role of language commonality, the theoretical microfoundations for such an effect are unclear. We develop a model in which we explicitly incorporate language as a major determinant of interactions on the market. Language matters both on the demand and the supply side. Indeed, the language(s) spoken by a consumer are likely to shape

his consumption. We assume that a consumer only consumes a good that is sold in his language- for instance, a good for which the label is in his language. In a German supermarket, one would have to know basic German to be able to identify "mineralwasser" as being sparkling water. On the supply-side, we assume that firms have to pay a fixed cost to be able to sell their good in a given language i.e. produce the label, communicate with the potential consumers, advertise their product. The fixed cost of investing in a language is proportionally related to the number of people speaking that language in their location. Therefore, firms will be more likely to invest in a given language the more people speak that language in their location and the closer they are to the consumers who speak that language.

Last but not least, the model allows us to perform policy-relevant counterfactuals. With our model, one can assess the impact of changes of language diversity on welfare not only across countries, but also within countries. In 2002, the Barcelona European Council set the objective that Europeans should be able to communicate in two languages other than their mother tongue. Citing "European Union's aspiration to be united in diversity",[13] it was stressed that multilingualism matters for the European Union's cohesion, competitiveness, internal and external trade. Yet, the effect of such policy have never been quantified. Our model allows to assess the impact of such policy.

[13] See `http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/71025.pdf` for the conclusions of the 2002 Barcelona European Council and `http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=URISERV:ef0003` for a summary of related EU legislation.

1

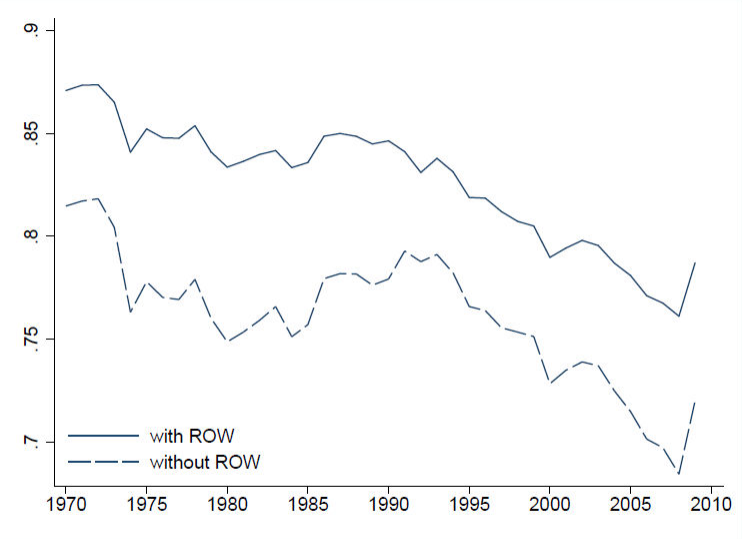
Quantifying the implications of foreign input use changes for the Factor Content of Trade[1]

1.1 Introduction

The nature of international trade changed markedly in recent decades with the emergence of global supply chains. As stressed by Findlay and O'Rourke (2007) "the novelty was quantitative rather than qualitative". The fragmentation of production is not a new phenomenon; the production of pins in the late eighteen century England as described by Smith (1776) was already broken into several stages. What increased is the extent to which manufacturing processes are sub-divided with stages being located in different countries. There is strong quantitative evidence pointing towards an increase of the number of foreign actors involved in the chains. The evolution of the Value Added to Export (VAX)[2] ratio, introduced by

[1]I thank Thomas Chaney, Lionel Fontagné, Keith Head, Marcelo Olarreaga, and Laura Puzzelo for their valuable comments and suggestions.

[2]The VAX ratio measures the share in export flows that is due to domestic production. In a world without trade in inputs, all the production takes place in one country, hence the ratio equals 1. The world value added to export ratio is $VAX_t = \frac{\sum_{i \neq j} \sum_s va_{ijt}(s)}{\sum_{i \neq j} \sum_s x_{ijt}(s)}$.



Note: The solid line included shipments to and from the rest of the world (ROW), and the dashed line excluded them.

Figure 1.1: Evolution of VAX ratio at the world level Johnson and Noguera (2016)

Johnson and Noguera (2012), illustrates such phenomenon. According to Fally (2012), the inverse of the VAX ratio at the world level can be interpreted as a weighted average of the number of border crossings associated with producing one dollar of final goods. Figure 1.1, taken from Johnson and Noguera (2016), depicts the evolution of the world VAX ratio at the world level from 1970 to 2010. The VAX ratio at the world level gradually decreased from 1970 to the beginning of the nineties and plunged afterwards. Johnson (2014) concentrates on the VAX ratio of top exporting countries between 1970 and 2008. His analysis confirms that the decline of the VAX ratio is stronger after the mid-nineties: 1995-2008 accounts for 53.4% in the decrease in the VAX ratio of top exporting countries between 1970 and 2008.

Input-output tables are a crucial element for computing these ratios. The release of global input-output tables, specifically the World Input Output Database (WIOD), has deepened our understanding of the fragmentation

of the supply chains, the location of production along the chains, and the recent changes in input-output linkages (Costinot and Rodriguez-Clare 2014, Timmer et al. 2014, Los et al. 2015). A simple analysis of the input use coefficients in the WIOD suggests that between 1995 and 2007 domestic input use was rather stable, if anything it decreased slightly, meanwhile aggregate foreign use slightly increased. More interestingly, bilateral foreign input use substantially changed over this period. The change is mainly on the extensive margin: there was an important decrease of the number of zero bilateral foreign input use. In other words, countries diversified their sources of foreign inputs[3].

These new features, being quantitatively important, raise new questions in the international trade literature and challenge old theories that do not take into account foreign input use. One has to think of how to best incorporate these features in the traditional trade theories, and how to reassess their main conclusions. The factor content of trade is likely to be affected by such changes. This is an important concept in international trade, which allows us to view trade not as an exchange of goods but as an exchange of services of factors. It has been introduced by Vanek (1963) to initially test the Hecksher-Ohlin model. Trefler and Zhu (2010) showed that Vanek's measure of the factor content of trade and his prediction is not only valid for Hecksher-Ohlin but also for a broader class of models.[4] More importantly, the factor content of trade is a key concept to understand the implications of recent changes in internationalization of supply chains for employment and wages - a topic that has been at the center of discussion in the last decades. Burstein and Vogel (2011) show that under some restrictions, changes in the factor content of trade fully determine the impact of trade on relative factor prices.

[3]Refer to Section 1.3 for more details.

[4]The Vanek prediction holds in models with the following properties: (i) each country is endowed with f, supply of at least two factors (ii) factors are mobile across firms and industries within a country but immobile across countries (iii) Factor markets are perfectly competitive (iv) Factor supply equals factor demand (v) arbitrary international differences in choice of techniques. The consumption similarity assumption is a necessary and sufficient condition for the Vanek proposition.

With trade in inputs, the factors embedded in the net trade of a given country are not necessarily domestic. The factor content of trade has to take into account the factors employed worldwide to produce the country's net trade flows, this is what Deardorff (1982) referred to as the "actual" factor content of trade. The production of the major components of a Boeing 787 produced in the Boeing factory in Everett (Washington State, US) involves at least 17 companies in 9 different countries. The fuselage of the aircraft is produced partially in the United States, Japan, and Italy. The passenger entry doors are produced in France, the cargo access doors in Sweden, and the landing gear in the United Kingdom. For the wings, the core and the forward fuselage are produced in Japan, the tips are produced in Korea, and the movable trailing edge in Australia. To measure the labor content of US exports of 787s, the traditional measure of the factor content of trade would consider that all parts of this plane are produced with US labor, and therefore use the technology matrix of the US to account for labor content; while, exports of 787s actually incorporate the services of American, Australian, British, French, Italian, Japanese, Korean and Swedish labor.

With the increasing internationalization of supply chains, trade economists introduced a new measure of the factor content of trade relaxing the untenable assumption of no foreign input use. Reimer (2006) and Johnson (2011) both document significant differences between this new measure and the traditional one. They show that not accounting for international industry linkages overestimates the amount of net factor traded. The intuition is that trade in inputs renders the effective production techniques of a country dependent on the techniques of his suppliers. At a global level, as production techniques are interdependent, effective production techniques are more similar. And, this should be all the more true, the more countries are involved in the production chains. Yet, Reimer (2006), Trefler and Zhu (2010), and Johnson (2011) found that the new measure marginally improves the fit of Vanek's prediction. Trefler and Zhu (2010) highlight that the main reason for that finding is associated with the departure

from consumption similarity assumption[5] for agricultural, processed food, government services and construction. By lack of consistent time-series global input-output tables, these contributions do not discuss the impact of recent changes of foreign input use on the magnitude of the factor content of trade.

This chapter is the first to quantify how changes in foreign input use impact the factor content of trade in the recent decades. Using the correct measure for the factor content of trade, I analyze its evolution between 1995 and 2007, two years featuring important differences in foreign input use, decomposing the separate contribution of production techniques, trade flows and input-output structure in that evolution.

The only paper that looks at the implications of a change in the input-output matrix for the factor content of trade and the Vanek prediction is Puzzello (2012). She studies how the proportionality assumption[6] affects the factor content of trade and the performance of the Vanek proposition. She finds that the proportionality assumption understates input use, hence biases the factor content of trade. However, as the biases in exported and imported factor services cancel each other out, she shows that the proportionality assumption does not affect the performance of the Vanek proposition.

Exploiting the time-series dimension of the World Input-Output tables, this chapter makes two distinct contributions to the previous literature studying the impact of foreign input use for the factor content of trade. First, it allows to reconsider the rather puzzling result of this literature. Reimer (2006), Trefler and Zhu (2010), and Johnson (2011) found that a proper measure of the factor content of trade that accounts for foreign

[5]Trefler and Zhu (2010) show that the consumption similarity assumption is a necessary and sufficient condition for the Vanek predictions in a specific class of models. Refer to their paper for more details.

[6]When one does not observe input usages by source country and using industry, one can impute these values using a proportionality assumption and data on foreign absorption. For instance, if 30% of Chinese absorption of electronics is sourced from Japan, 30% of any Chinese sector's use of of electronics originates from Japan.

input use marginally improves the fit of Vanek prediction. A fair amount of missing trade persists. Their weak findings might be driven by the relative low intensity of cross-border fragmentation in the data they have used. Trefler and Zhu (2010) use GTAP input-output tables from 1997, and Johnson (2011) uses GTAP input-output tables from 2001. Building on the beginning and the end of the period covered by the WIOD, I measure the factor content of trade in 1995 and 2007, with the two measures introduced by the literature. I use these measures to not only compare the impact of introducing foreign input use in the factor content of trade, but also to reassess its impact on the Vanek prediction in these two years. I found that including foreign input use matters more in 2007, but still does not affect the Vanek prediction.

Second, using the correct definition of the factor content of trade, I decompose the changes in the factor content of trade between 1995 and 2007. Isolating the separate contribution of each element entering the definition of the factor content of trade (the production technology matrix, the trade vector and the input-output matrix), one can clearly study the role of changes in foreign input use on the factor content of trade - which was not possible with previous global input-output tables. I show that over the period, with increasing bilateral trade flows, the factor content of trade has significantly increased. Shrinking differences in production techniques led to a reduction in the factor content of trade. At a first glance, the picture is less straightforward regarding the contribution of the input-output matrix to changes of the factor content of trade over the period. Distinguishing by country groups, I find that changes in foreign input use led both the capital and high-skilled content of trade of high-income countries to significantly increase, suggesting an increase in specialization in their comparative advantage. This provides additional evidence for the relevance of old trade theories to explain recent developments in international trade and firms' choice of production location, which are very likely driven by cost minimization and factor prices. A clear understanding of supply chains is crucial to fully understand their implications for income redistribution and welfare.

The rest of the chapter is structured as follows. Section 1.2 presents the two definitions of the factor content of trade and give intuitions for implications of foreign input use. Section 1.3 presents the data used for our exercise. Section 1.4 quantifies the impact of foreign input use on the factor content and its implications for the Vanek prediction. Section 1.5 concludes.

1.2 The Measurement of the Factor Content of Trade

1.2.1 Definitions of the Factor Content of Trade

The factor content of trade (FCT) examines trade in goods through the lens of trade in services of production factors. In simple terms, for a given country, it is defined as the difference between the factors used to produce its exports minus the factors used to produce its imports. This concept is typically used to test traditional international trade theories, and is a key determinant of factor prices (Burstein and Vogel 2011). To quantify how foreign input use affects the factor content of trade, I introduce two different definitions. In the following, one assumes F factors, N countries and S industries.

The first definition of the factor content of trade, $F1$, is the traditional measure used in the literature which does not account for foreign input use. The factors used in production are necessarily domestic, including intermediate consumption. For country i, $F1$ is a $(1 \times F)$ column vector defined as:

$$F1_i = [B_i(I - A_{T_i})^{-1}X_i] - [\sum_{j \neq i} B_j(I - A_{T_j})^{-1}M_{ij}] \tag{1.1}$$

$$= [\bar{D}_i X_i] - [\sum_{j \neq i} \bar{D}_j M_{ij}] \tag{1.2}$$

B_i denotes country i direct factor requirement matrix of dimension $(F \times S)$. Its coefficients represent the number of factors[7] used to produce one dollar of good in a given industry in country i. A large strand of literature has been devoted to relaxing the untenable assumption of similarity of production technology between countries in the standard Vanek setting. Variant approaches have been adopted: Trefler (1993), specification T1 in Trefler (1995), specification T3 in Davis and Weinstein (2001), Conway (2002), and Debeare (2003). On the contrary to these papers, the choice of techniques are allowed to differ internationally in a more general way here. As in Johnson (2011) we use the observed factor requirement matrix derived directly from the data.

I is the $(S \times S)$ identity matrix. A_{T_i} is a $(S \times S)$ matrix[8] reporting the technical coefficients within country i *i.e.* the value of inputs (in dollars) from industry k in country i used by industry l in country i to produce its final good. As there is no trade in intermediate goods, there is no inter-country input-output linkages. Hence, the matrix $(I - A_{T_i})^{-1}$, so-called Leontief inverse matrix, is composed of all direct and indirect input requirements. The Leontief matrix is country-specific. It is important to note that this matrix can be build from standard national input-output tables.

M_{ij} is a $(1 \times S)$ column vector of imports in i from j and X_i is a $(1 \times S)$ vector that designates country i's aggregate exports. In equation (1.1), the first term denotes the factors used to produce gross domestic output consumed abroad while the second term is the foreign factors used to produce gross foreign output consumed at home. If the f-element of the vector $F1_i$ is positive the country i is a net exporter of the services of factor f *vis-a-vis* the rest of the world, while it is a net importer of the services of that factor is the term is negative.

The second definition, $F2$, takes into account not only domestic but also

[7] Specifically, the number of hours worked and the real fixed capital stock used.
[8] More details about its empirical definition in 1.3.

foreign input use in the measurement of the factor content of trade. It is what Deardorff (1982) called the actual factor content of trade i.e. the factors used worldwide to produce the net trade of a country. As emphasized by Trefler and Zhu (2010), it is the Vanek relevant way of incorporating trade in inputs. To compute this measure, one needs a full global input-output matrix featuring all existing input-output linkages. For country i, $F2$ is defined as:

$$F2_i = B(I - A)^{-1}T_i \tag{1.3}$$

where $B = (B_1, B_2, B_3, ..., B_N)$ is the global matrix of direct factor requirement, its dimension is $(F \times SN)$. T_i is the net trade vector of country i:

$$T_i = \begin{pmatrix} \vdots \\ -M_{i,i-1} \\ X_i \\ -M_{i,i+1} \\ \vdots \end{pmatrix}$$

A is the global input-output matrix of dimension $(SN \times SN)$ composed of all inter-country input-output matrices $A_{i,j}$. The coefficients in $A_{i,j}$ summarize the input purchased by the industries of country j from the industries of country i.

$$A = \begin{pmatrix} A_{1,1} & A_{1,2} & \dots & A_{1,N} \\ A_{2,1} & A_{2,2} & \dots & A_{2,N} \\ \vdots & \vdots & \dots & \vdots \\ A_{N,1} & A_{N,2} & \dots & A_{N,N} \end{pmatrix}$$

Johnson (2011) shows that $F2_i \equiv BY_i$, where Y_i is the vector of net trade in gross output for country i. $F2$ measures the factors used to produce gross domestic output consumed abroad less foreign factors used to produce gross foreign output consumed at home. Gross output consumed abroad includes shipment of final goods to foreign consumers plus shipments of intermediate goods that are embedded in goods consumed

abroad.

To picture more clearly the difference between this measure and the previous one defined in equation (1.2), we can rewrite $F2$ as:

$$F2_i = [D_i X_i] - [\sum_{j \neq i} D_j M_{ij}] \tag{1.4}$$

where D_i the i-th element of the global matrix $D = (D_1, D_2, D_3, ..., D_N)$, the global matrix D being defined as $D = B(I - A)^{-1}$. The two measures are equivalent (i.e. $F1 = F2$) when $\bar{D_i} = D$. This is true if and only if $A_{i,j} = 0$ for all i, j such that $i \neq j$; in other words when there is no foreign input use. In that very special case, A can be written as the following diagonal matrix:

$$A = \begin{pmatrix} A_{1,1} & 0 & \dots & 0 \\ 0 & A_{2,2} & \dots & 0 \\ \vdots & \vdots & \dots & \vdots \\ 0 & 0 & \dots & A_{N,N} \end{pmatrix}$$

1.2.2 The Factor Content of Trade and Foreign Input Use

Before quantifying the implications of foreign input use on the factor content of trade, it is useful to sketch the intuitions in a *2-country* $\times$ *1-good* $\times$ *1-factor* setting[9]. The countries are denoted by 1 and 2, and the only factor is labor l.

How does the factor content of trade change when one introduces foreign input use? The existing literature concludes that not accounting for foreign input use overstates the measured factor content of trade as it biases upward the use of locally abundant factor and biases downward the use of locally non-abundant factor. A simple way to test that in our setting is to define two measures of the factor content of trade using two different input-output matrix. In this environment, the factor requirement

[9]This setting is chosen for exposition purpose.

matrix B can be written $B = (l_1, l_2)$ with l_i the amount of labor in country i, and the trade vector is $T_1 = \begin{pmatrix} x_{12} \\ -x_{21} \end{pmatrix}$ for country 1 and $T_2 = \begin{pmatrix} -x_{12} \\ x_{21} \end{pmatrix}$ for country 2.

The typical global input-output matrix is defined as:

$$A = \begin{pmatrix} a_{1,2} & a_{1,2} \\ a_{2,1} & a_{2,2} \end{pmatrix}$$

with $a_{i,j}$ the use of input from country i by country j. One can define an alternative input-output matrix, $\bar{A}$, with the same total input use but no foreign input use as:

$$\bar{A} = \begin{pmatrix} (a_{1,2} + a_{2,1}) & 0 \\ 0 & (a_{2,2} + a_{1,2}) \end{pmatrix}$$

Abusing the notations, we define F and $\bar{F}$. F refers to the factor content of trade computed using the matrix A while $\bar{F}$ refers to the factor content of trade computed using the matrix $\bar{A}$. The previous literature suggests that $|\bar{F}| > |F|$.

For country 1:

$$F_1 = \frac{1}{det(L)}(l_1(1 - a_{2,2})x_{12} + l_2 a_{2,1} x_{12} - l_1 a_{1,2} x_{21} - l_2(1 - a_{1,1})x_{21}$$
$$\bar{F}_1 = \frac{1}{det(\bar{L})}(l_1(1 - a_{2,2})x_{21} - l_1 a_{1,2} x_{12} + l_2 a_{2,1} x_{21} - l_2(1 - a_{1,1})x_{21}$$

For country 2:

$$F_2 = \frac{1}{det(L)}(l_1(1 - a_{2,2})x_{12} + l_2 a_{2,1} x_{12} - l_1 a_{1,2} x_{21} - l_2(1 - a_{1,1})x_{21}$$
$$\bar{F}_2 = \frac{1}{det(\bar{L})}(l_1(1 - a_{2,2})x_{21} - l_1 a_{1,2} x_{12} + l_2 a_{2,1} x_{21} - l_2(1 - a_{1,1})x_{21}$$

$det(L)$ is the determinant of the Leontief matrix $(I_2 - A)^{-1}$ and $det(\bar{L})$ is the determinant of the Leontief matrix $(I_2 - \bar{A})^{-1}$. In this setting, the

situation in one country is the mirror of the other one. Namely, $F_1 = -F_2$, $\bar{F_1} = -\bar{F_2}$. Further assume that $F_1 > 0$. As $Det(L) > 0$, it is easy to see that if $Det(L) > Det(\bar{L})$ holds, $|F_1| < |\bar{F_1}|$. Using properties of the technical coefficients, one can show that indeed $Det(L) > Det(\bar{L})$. Hence in this simple case, the factor content of trade is lower when there is foreign input use.

Additionally, one can use this simple setting to analyze the effect of an increase in foreign input use, modelled as an increase of a_{12} and a_{21}. The only paper that studies the implications of a change in the input-output matrix is Puzzello (2012). She finds that domestic and foreign component of the factor content of trade are affected in opposite direction by the proportionality assumption. Introducing intermediate goods multipliers as in Johnson and Noguera (2016)) defined as $m_1 = \frac{1}{(1-a_{11})-\frac{a_{12}a_{21}}{1-a_{22}}}$ and $m_2 = \frac{1}{(1-a_{22})-\frac{a_{12}a_{21}}{1-a_{11}}}$ in the expression of the factor content of country 1's trade, we can decompose $F2$ between a domestic and a foreign component as such:

$$F2_1 = l_1 m_1 (x_{12} - \frac{a_{12}}{1-a_{22}} x_{21}) + l_2 m_2 (\frac{a_{21}}{1-a_{11}} x_{12} - x_{21}) \tag{1.5}$$

The first term is the domestic component while the second term is the foreign component of the factor content of trade. a_{12} and a_{21} enter in the four terms in red. We know that: $\frac{\partial m_1}{\partial a_{12}} \geq 0$, $\frac{\partial m_1}{\partial a_{21}} \geq 0$, $\frac{\partial m_2}{\partial a_{12}} \geq 0$ and $\frac{\partial m_2}{\partial a_{21}} \geq 0$. Without further assumptions, the total effect of an increase in a_{12} and a_{21} on $F2$ has no simple expression. Thus, for constant a_{11} and a_{22}, an increase in the use of imported inputs has ambiguous effects on the factor content of trade.

In this simple environment, the factor content of trade is indeed lower when introducing foreign input use but it is yet not clear how an increase in foreign input use affects the factor content of trade. Using the WIOD, I test this empirically and then study the implications for the Vanek prediction.

1.3 Data

The two definitions of the measured factor content of trade require information on bilateral trade flows, direct factor requirements, and input-output matrices. The main source of data is the World Input Output Database[10] (WIOD). It is perfectly suited for such analysis as it provides time-series world input-output tables as well as harmonized data on factor use. The world input-output tables cover 40 countries (27 EU countries and 13 other major countries) and the Rest of the World (RoW) over the period 1995-2011 for 35 industries. It is the only existing input-output tables designed for the purpose of time comparisons, other available input-output tables (GTAP, IDE-Jetro) use a reference year. The factor use data involve four factors of production (capital; high-skilled, medium-skilled, and low-skilled labor) for the same 35 industries from 1995 up to 2007[11]. Another important characteristic of the WIOD for my analysis is that over the period covered (1995-2007) there are significant changes in foreign input use.

The direct factor requirement are computed using data on factor endowment from the Social-Economic Accounts in the WIOD as the elements of B_i represent the number of factor units needed to produce one dollar of output in a given industry in country i. For all types of labor, factor requirement is defined as the number of hours worked by persons engaged in an industry divided by gross output in this industry. To get the number of hours worked by skill-type in an industry, one must multiply total hours worked by persons engaged with the shares in total hours worked by skill-type at the industry level. For capital, factor requirement is proxied by the ratio of real fixed capital stock in a given industry and gross output in this same industry. The definition of the input-output matrix differs

[10] I use the WIOD 2013 release freely accessible on *www.wiod.org*. See Timmer et al. (2015) for details.

[11] New releases of WIOD extend the period covered by factor use and input-output tables. Yet, the focus on 1995 and 2007 has the benefit of abstracting from the crisis period. Using the WIOD 2016 release, Timmer et al. (2016) show that the rapid international fragmentation of production dramatically reverted in 2008.

across definitions of the factor content of trade. In the first definition, $F1$, all individual (35×35) matrices A_{T_i} are the empirical counterparts of the domestic input-output matrices $A_{i,i}$. In A_{T_i}, there are no foreign input use. However, for computational concordance one has to account for the existing imported input use in the data. All foreign inputs are assigned to domestic inputs: $\forall i$, $A_{T_i} = \sum_k A_{k,i}$. For the second definition, $F2$, the (1435×1435) global input-output matrix is derived from world input-output tables. Trade flows are inferred from information in world input-output tables.

While both trade flows and input-output matrices in the WIOD include the rest of the world composite region, the challenge remains in measuring B_{RoW}. I follow a methodology that is consistent with the definition and treatment of the rest of the world in the WIOD. As explained in details in Timmer et al. (2015), the rest of the world is assumed to behave like a representative country that is an average of six emerging countries in the WIOD (Brazil, China, India, Indonesia, Mexico, and Russia). The direct factor requirement matrix of the rest of the world is inferred using data taken from the Penn World Tables 8.0 (Feenstra et al. 2015). For labor, the total number of persons engaged is the sum for all countries in the Penn World Tables excluding the 40 countries in the WIOD (127 countries). To convert it into the number of hours worked, one needs information on average annual number of hours worked. The total number of hours worked is equal to the number of persons engaged in the rest of the world times the average annual number of hours worked in the representative country. Then, to derive the total number of hours worked by skill-type the skill-structure within industry is assumed to be similar to the one in the representative country. Summing for all industries gives the labor endowment for each skill-type for the rest of the world. And in each industry, the labor requirement for each skill-type is the ratio of total number of hours worked by workers of a specific skill-type and the corresponding gross-output. For capital, I employ a similar methodology. Summing the capital stock over all countries but the one in the WIOD gives the capital endowment for the rest of the world. Then, as for

labor, I derive the structure across industry using the structure of the representative country. Dividing by gross output in the WIOD for each industry leads to the capital requirement for the rest of the world.

For the tests of the Vanek prediction, in addition to the measured factor content of trade, I construct the predicted factor content of trade $V_i - s_i V_w$ as in Trefler and Zhu (2010) and Puzzello (2012). V_i is a (1×4) the vector of the factor endowment of country i. For the 40 countries in the WIOD, it is defined as the sum of factor use over all industries within a country. The consumption share s_i is given by $s_i = \frac{GDP_i - TB_i}{\sum_j GDP_j}$ where GDP_i is the Gross Domestic Product taken from the World Bank Development Indicators Database and TB_i is the trade balance computed using the aggregated trade flows in world input-output tables.

The main reason for computing the measures of the factor content of trade in 1995 and 2007 is that the global input-output matrix A changes significantly between 1995 and 2007. The global input-output matrix A is a (1435×1435) matrix as the WIOD covers 41 countries and 35 industries (i.e. a total of 2,059,225 elements). This matrix summarizes all input-output linkages. A typical element of the matrix $A_{ji}(g,h)$ is the value in dollars of the inputs from industry g in country j used for producing one dollar of output in industry h in country i. In the following, we focus on 1,960,000 elements of the matrix A excluding the input coefficients of the rest of the world as there are imputed using the proportionality assumption. There are two types of elements in the matrix A. The elements on the diagonal of the matrix, $A_{ii}(g,h)$, are the domestic input use coefficients. The off-diagonal elements are the bilateral foreign input use, $A_{ji}(g,h)$ with $i \neq j$. We define aggregate foreign input use by summing input use over all foreign sources j, $A_{iF}(g,h) = \sum_{j \neq i} A_{ji}(g,h)$. Table 1.1 reports the median, the mean, the coefficient of variation and the total number of zeros for domestic input use, aggregate foreign input use, and bilateral foreign input use in 1995 and 2007. Unsurprisingly, domestic input use is significantly greater than aggregate foreign input use in both years. Domestic input use is rather stable from 1995 to 2007, if anything it slightly decreased, while

	N	Median	Mean	CV	Zeros
Domestic Use: $A_{ii}(g,h)$					
1995	49,000	0.0025	0.0106	2.43	3,812
2007	49,000	0.0023	0.0105	2.44	3,668
Aggregate Foreign Use: $A_{iF}(g,h)$					
1995	49,000	0.0003	0.0030	4.65	1,567
2007	49,000	0.0004	0.0036	4.51	1,566
Bilateral Foreign Use: $A_{ji}(g,h)$					
1995	1,911,000	3.19 10^{-7}	0.0001	16.10	322,115
2007	1,911,000	6.39 10^{-7}	0.0001	14.00	268,959

Table 1.1: Descriptive Statistics on input use

foreign input use increases slightly. The number of zeros is nearly equal between 1995 and 2007 suggesting that in the aggregate they was no substitution at the extensive margin between domestic and foreign inputs.

Foreign input use being of primary interest, we focus on bilateral foreign input use. The statistics reported in Table 1.1 confirm that the change is rather quantitative than qualitative. In 2007 there 53,156 more links than in 1995 meaning less zeros in the non-diagonal sub-matrices of A. The median bilateral foreign input use doubled over the period. The mean, however, did not change, but this is not very surprising given that the new links are likely to be rather small. It is also informative to compute the relative imported input use defined as $RUI_j(g,h) = A_{ji}(g,h)/A_{ii}(g,h)$. The median of the RUI doubled from 1995 to 2007. The unit input requirements have very small values, therefore a simple comparison can hide significant differences in relative terms. Focusing on the comparison of matched-elements of the matrix A gives a clearer picture. For bilateral input use and relative input use, we compute the ratio of the values for 2007 and 1995, which gives us the change in 2007 relative to 1995. It reduces the sample of coefficients to be compared as these ratios can only be computed for pairs with non-zeros elements. The median of the ratio of bilateral foreign input use is 1.10, and the median of the RUI is 1.47. The median observation experience an increase of nearly 50%. Thus, the magnitude of the change in foreign input use significant. These findings have potentially important implications for factor content calculations.

1.4 Results

1.4.1 Implications for the Factor Content of Trade

Using the WIOD, I compute the factor content of trade according to the two definitions presented in subsection 1.2.1 for 41 countries and 4 factors in 1995 and 2007. For each year, there are 164 observations per definition. These measures enables us to answer two questions: is the factor content of trade smaller when foreign input is taken into account? How is the factor content of trade affected by recent changes in the global input-output matrix?

To analyze how the factor content of trade changes when foreign input use is taken into account, we look at the difference between $F2$ and $F1$ for a given country-factor pair. It is important to keep in mind that $F1$ and $F2$ can take positive or negative values[12]. First, it seems that introducing foreign input use does not change the net status: the sign of $F2$ is different from the sign of $F1$ for 7 observations in 1995 and for 9 observations in 2007 (out of 164). The magnitude of the factor content of trade is however affected. For the observations for which the sign does not change (157 and 155 observations in 1995 and 2007 respectively), one can first look at the sign of $|F2|-|F1|$. If the difference is positive, the factor content computed with foreign input use is greater than the one without foreign input use. On the contrary, if the difference is negative, not taking into account foreign input use overestimate the factor content of trade. The literature and our simple theoretical exercise both suggest that the difference should be negative: $F2$ tend to be lower than $F1$. This is confirmed by the data: 87% of the observations features a positive difference in 1995 and 85% in 2007. To compare the magnitude of the difference across factors, we normalize the factor content of trade for each factor by dividing the value by the corresponding world factor endowment in 1995. Therefore, the

[12]A positive factor content of trade for a given country-factor pair means that the country is a net exporter of the services of that factor, while a negative factor content of trade reflects that the country is a net importer of that factor.

magnitude of the difference has no unit. The results are presented in Table 1.2. For each sample, we report the number of observations, the mean of the absolute difference, the standard deviation and the value of the minimum and the maximum. The first panel of Table 1.2 presents statistics for the full sample. The average difference between $|F2|$ and $|F1|$ is -4.79 in 1995 and -16.58 in 2007. Thus, accounting for foreign input use reduces on average the factor content of trade by 4.79 and by 16.58 in 2007. Splitting the sample between country-factor pairs for which the difference is positive and the ones for which the difference is negative is informative. The average magnitude of the positive difference appears significantly smaller than the magnitude of the negative differences. This suggests that for these country-factor pairs the two measures lead to rather similar measured factor content of trade. The last panel of Table 1.2 describes statistics by factor. The order of magnitude of the difference is rather similar across factors.

As already pointed out the foreign input uses being quantitatively more important in 2007, one expects the impact of taking it into account on the factor content of trade to be substantially greater in 2007 with respect to 1995. A simple comparison of the values of the average difference between 1995 and 2007 in each panel suggests it is indeed the case. For the full sample, the average difference is nearly four times bigger in 2007 than in 1995. For each factor, the increase in the difference between $|F2|$ and $|F1|$ is greater in 2007. Interestingly, the difference between 1995 and 2007 is rather small for capital, but quite pronounce for labor, especially medium-skill labor. Nonetheless, a simple comparison between years might be misleading as other elements entering the definition of the factor content of trade changed between 1995 and 2007, namely trade and factor requirements. To isolate these effects from the direct effect of changes in the input-output matrix, I define $\tilde{F1}^{07}$ and $\tilde{F2}^{07}$ for the year 2007. For these tilde measures, I use the factor requirement matrix, B, and the trade vector, T, in 1995 but the input-output matrix, A, from 2007.

	Obs	Mean	Std Dev	Min	Max
Full Sample					
1995	157	−4.79	11.88	−92.63	1.59
2007	155	−16.58	37.58	−260.50	4.43
Positive Difference					
1995	21	0.36	0.42	0.13	1.59
2007	23	0.96	1.19	0.02	4.43
Negative Difference					
1995	136	−5.58	12.59	−92.63	−0.01
2007	132	−19.64	39.96	−260.50	−0.03
Capital					
1995	38	−4.83	15.32	−95.63	1.26
2007	35	−10.92	32.63	−185.73	4.43
Low-skilled labor					
1995	40	−5.71	13.77	−81.22	0.78
2007	41	−16.48	35.14	−182.38	1.95
Medium-skilled labor					
1995	40	−5.29	11.05	−60.87	0.54
2007	39	−23.48	49.43	−260.50	3.28
High-skilled labor					
1995	39	−3.29	5.27	−25.41	1.59
2007	40	−14.91	30.38	−166.07	2.88

Table 1.2: Descriptive statistics on the difference between $F2$ and $F1$

Building on equations (1.1) and (1.3), they can be written as follows:

$$\tilde{F1}^{07} = B_i^{95}[(I - A_{T_i}^{07})^{-1}x_i^{95}] - [\sum_{j \neq i} B_j^{95}(I - A_{T_j}^{07})^{-1}x_{ji}^{95}] \tag{1.6}$$

$$\tilde{F2}^{07} = B^{95}(I - A^{07})^{-1}T_i^{95} \tag{1.7}$$

Table 1.3 is the replica of Table 1.2 where the statistics for 2007 are com-

	Obs	Mean	Std Dev	Min	Max
Full Sample					
1995	157	−4.79	11.88	−92.63	1.59
2007	149	−7.41	19.46	−128.12	6.66
Positive Difference					
1995	21	0.36	0.42	0.13	1.59
2007	30	1.79	1.97	0.03	6.66
Negative Difference					
1995	136	−5.58	12.59	−92.63	−0.01
2007	119	−9.73	21.15	−128.12	−0.01
Capital					
1995	38	−4.83	15.32	−95.63	1.26
2007	35	−7.19	22.02	−128.12	2.41
Low-skilled labor					
1995	40	−5.71	13.77	−81.22	0.78
2007	38	−7.79	20.78	−113.12	6.66
Medium-skilled labor					
1995	40	−5.29	11.05	−60.87	0.54
2007	38	−8.95	22.08	−115.95	4.12
High-skilled labor					
1995	39	−3.29	5.27	−25.41	1.59
2007	38	−5.70	12.04	−58.43	6.38

Table 1.3: Descriptive statistics on the difference between $F2$ and $F1$ with the corrected measure for 2007

puted using the tilde measures[13] instead of the normal ones. Comparing the values for 1995 with 2007, one is ensured to only capture the effect of changes in the input-output matrix. The previous result is confirmed. The impact of including foreign input use is more substantial in 2007 (however

[13]There are more country-factor pairs for which the sign of $F1$ is different from the sign of $F2$ with the tilde measures than with the non-corrected measures, therefore there are less observations.

smaller than previously), controlling for other trends. For the full sample, the average difference between $|F2|$ and $|F1|$ is -7.41 while it is -4.79 in 1995. Changing the matrix of foreign use multiplies the bias by 1.50.

To answer the second question, I focus on the second definition of the factor content of trade $F2$. The comparison between 1995 and 2007 allows to identify the role played by the input-output matrix in the changes in factor content between these two years. First, it appears that the net trade status is quite stable over this period. The sign of $F2$ in 1995 is different from the sign of $F2$ in 2007 for only 36 observations out of 164. Out of the 128 observations for which the sign does not change, the factor content of trade increased over the period in 84% of the cases.

Each of the three elements entering the definition of the factor content of trade (the factor use matrix B , the input-output matrix A and the trade vector T) determines the changes in the factor content between 1995 and 2007. As we are specifically interested in understanding the role of the changes in the input-output matrix in overall changes of the factor content of trade, we decompose the change in the factor content of trade ($F2$) between 1995 and 2007 as such:

$$
\begin{aligned}
\Delta F2 &= F2_{2007} - F2_{1995} \\
&= B_{07}(I - A_{07})^{-1}T_{07} - B_{95}(I - A_{95})^{-1}T_{95} \\
&= \underbrace{\left[B_{07}(I - A_{07})^{-1}T_{07} - B_{95}(I - A_{07})^{-1}T_{07}\right]}_{\text{production techniques}} \\
&+ \underbrace{\left[B_{95}(I - A_{07})^{-1}T_{07} - B_{95}(I - A_{95})^{-1}T_{07}\right]}_{\text{input use}} \\
&+ \underbrace{\left[B_{95}(I - A_{95})^{-1}T_{07} - B_{95}(I - A_{95})^{-1}T_{95}\right]}_{\text{trade}}
\end{aligned}
$$

The first term captures the contribution of changes in the factor requirement matrix (production techniques or technology) to the overall change in the factor content of trade. The second term captures the contribution

	(1) Term 1 (ΔB)		(2) Term 2 (ΔA)		(3) Term 3 (ΔT)		Obs.
	(a) Increase	(b) Decrease	(a) Increase	(b) Decrease	(a) Increase	(b) Decrease	
Full Sample	13 (10%)	115 (90%)	70 (55%)	58 (45%)	121 (95%)	7 (5%)	128
Capital	6 (20%)	24 (80%)	16 (53%)	14 (47%)	27 (90%)	3 (10%)	30
Low-skilled Labor	0 (0%)	31 (100%)	17 (55%)	14 (45%)	31 (100%)	0 (0%)	31
Medium-skilled Labor	3 (8%)	33 (92%)	17 (47%)	19 (53%)	32 (89%)	4 (11%)	36
High-skilled Labor	4 (13%)	27 (87%)	20 (65%)	11 (35%)	31 (100%)	0 (0%)	31

Table 1.4: Decomposition of the change of the factor content of trade between 1995 and 2007

of changes in the global input-output matrix. The last term captures the contribution of changes in the trade vector. The decomposition is computed for all the observations in our sample, however we will only consider the observations for which the sign of the factor content of trade did not change between 1995 and 2007 (128/164). As the aim is to see if the changes in the input-output matrix trigger an increase or a decrease of the factor content of trade, we focus on the direction of the change rather than on the magnitude.

Table 1.4 summarizes the main features of the decomposition. The first row display the results for the full sample, while the rows 2-4 display the results for each factor separately. For each of the three terms (contribution of changes in the B matrix, in the A matrix and in the T vector), it reports the number of observations that contributed to an increase or a decrease in the sample studied. The respective percentage in the sample is in parenthesis. The contribution of the changes in B and T, term 1 and 3 respectively, are clear. For 90% of the observations in the full sample, the changes in B lead to a decrease of the factor content of trade. This is also true for each individual factor sub-sample. This finding is consistent

	High-income countries			Other countries		
	Term 2 (ΔA)		Obs.	Term 2 (ΔA)		Obs.
	Increase	Decrease		Increase	Decrease	
Capital	11 (73%)	4 (27%)	15	5 (33%)	10 (67%)	15
Low-skilled Labor	12 (63%)	7 (37%)	19	5 (42%)	7 (58%)	12
Medium-skilled Labor	11 (52%)	10 (48%)	21	6 (40%)	9 (60%)	15
High-skilled Labor	14 (70%)	6 (30%)	20	6 (55%)	5 (45%)	11

Table 1.5: Contribution of the input-output matrix in the change of the factor content of trade between 1995 and 2007

with the overall decrease in differences in production techniques across countries over the period. The results are even stronger regarding the contribution of trade. The changes in the trade vector led to an increase in the factor content of trade for 95% of the observations, which is in line with the increase in trade flows over the period. As such this decomposition does not, however, give a clear conclusion regarding the contribution of the input-output matrix. The changes in the input-output matrix led to an increase in the factor content of trade for 55% of the full sample, and splitting by factor is not much more informative.

Evidence suggests that the trend in the involvement in international supply chains differs significantly by country. Timmer et al. (2012) show that the contribution of high-income countries to the total world value added dropped significantly between 1995 and 2008, while the share of China, India and other emerging countries drastically increased. Following Timmer et al. (2012), I split the sample in two groups: high-income countries (15 pre-2004 EU members, Australia, Canada, Japan, South Korea, Taiwan and the United States); and other countries (Brazil, India, Indonesia, Turkey, Russia and the 12 new-EU members). Table 1.5 displays the contribution of the input-output matrix to the factor content of trade

of these two groups of countries separately. For high-income countries, the changes in the input-output matrix contributed to an increase in the capital and high-skilled labor content of trade. Regarding low-skilled and medium-skilled labor, it is however hard to conclude. The results for the other group are not very informative, this is not surprising given it is a rather heterogeneous group. However, the findings for Chinese factor content of trade are interesting. The changes in the input-output matrix led to an increase of Chinese labor content of trade and a decrease of the capital content of trade. These results are in line with the variation in factor share underlined by Timmer et al. (2012) who show that over the same period the capital and high-skilled labor share of high-income countries in manufacturing world value added increased, while their low-skilled and medium-skilled labor share decreased. In a recent paper, Ito et al. (2016) use the WIOD to construct a definition of value added trade, closely related to my second definition of the factor content of trade. They show in a gravity regression setting that Hecksher-Ohlin theory does predict manufacturing trade in value added and it does so better than for gross shipments flows. These findings are another elements in favor of their claim as they suggest that countries further specialize in their comparative advantage with the increase in fragmentation.

1.4.2 Implications for the Vanek prediction

We showed that the factor content of trade is affected by the introduction of foreign input use, then we test whether it has any implications for the Vanek prediction. The Vanek Prediction states that the actual factor content of trade is determined by factor abundance: a country that is abundant in a given factor of production must be a net exporter of the services of that factor. It can be written as follows:

$$F_i = V_i - s_i V_w \tag{1.8}$$

F_i is the vector of country i's actual factor content of trade while the right-hand side is the predicted factor content. V_i is the vector of country i's factor endowments and s_i is country i's share in world consumption. The predicted factor content defines the abundance in each factor for a country i. A country is defined as abundant in a factor f if it has more units of this factor than what it would have if the factors were distributed proportionally to the share in world consumption. This equation is the main prediction of Hecksher-Ohlin-Vanek model. Trefler and Zhu (2010) proved that this prediction holds in a broader class of models[14]. To assess whether this prediction holds empirically three tests are typically performed: a sign test, a Spearman test and a slope test. The sign test gives the probability that the sign of the left-hand side and the right-hand side of the equation match. The Spearman test compares the ranking between the actual and the predicted factor content of trade. The slope test consists in regressing the measured factor content of trade on the predicted one. Another convenient way to analyze the consistency of the prediction is to plot the predicted factor content of trade on the measured one.

The second definition of the measured factor content of trade corrects for the misspecification of the true origin of inputs and is the only Vanek relevant definition to do so (Trefler and Zhu (2010)). One expects the fit of the prediction to be greater for this second measure with respect to the first one. However, previous studies using this definition found rather disappointing results. Trefler and Zhu (2010) use GTAP data for 1997 and Johnson (2011) computes the factor content of trade with GTAP data for 2001. They all conclude that the effect of foreign input use on Vanek is marginal, and that missing trade persists. The point of the subsection is to investigate whether these weak results could be partially triggered by

[14]In models with the following properties: (i) each country is endowed with f, supply of at least two factors (ii) factors are mobile across firms and industries within a country but immobile across countries (iii) Factor markets are perfectly competitive (iv) Factor supply equals factor demand (v) arbitrary international differences in choice of techniques. The consumption similarity assumption is a necessary and sufficient condition for the Vanek proposition.

the low foreign input use for the year in which they perform the test. The change in factor content of trade must be substantial for it to affect the predictions. Performing these tests for two years (1995 and 2007), with recent data featuring sizable changes in foreign input use will shed light on that. Given greater foreign input use in 2007, I expect the marginal effect on the factor content of trade in 2007 to be stronger relatively to 1995.

First, it is important to check that the results of the tests in 1995 are consistent with the results of the literature. Table 1.6 confronts the results of the three tests with the results of Johnson (2011), Trefler and Zhu (2010), and Puzzello (2012), whenever applicable. The sign and magnitude of the results of the three tests are in line with those of the literature. The first definition ($F1$) seems to fit the theory. There is a significant correlation between the rank of the theoretical and the observed factor content of trade: their signs match in 81% and the theory predicts the data accurately with a slope of 0.0981 in 1995. Figures A.1a and A.1b confirms these results. The second measure ($F2$) outperforms the first one for both the Spearman and the sign test but only slightly. The signs between the observed and the predicted factor content of trade match in about 83% of the cases with $F2$ while it does in 81% with $F1$. The differences between Figure A.1a and A.1c are not obvious. We do find a decrease in the magnitude of the coefficient associated to the slope test for 1995. This confirms our prediction that the traditional measure overestimates the amount of net factor traded (see Figure A.2). On Figures A.1a and A.1c, the observations for the rest of the world are circled. It appears that the rest of the world is an outlier for labor. This is likely to be driven by the underlying assumptions we used to computed factor requirements data for the rest of the world. The column (2) of Table 1.6 presents the results of the test for 1995 excluding the observations for the rest of the world. The magnitudes are closer to the estimates of the literature.

Table 1.7 focuses on my results for 1995 and 2007 excluding the rest of the world. Interestingly the results of the tests, whatever the definitions

		(1) 1995 (with ROW)	(2) 1995 (without ROW)	(3) Johnson	(4) TZ	(5) Puzzelo
Spearman Correlation						
	F1	0.74	0.82	0.82		
		(0.00)	(0.00)	(0.00)		
	F2	0.76	0.85	0.82	0.89	0.65
		(0.00)	(0.00)	(0.00)	(0.00)	(0.001)
Sign Test						
	F1	81%	83%	80.%		
	F2	83%	84%	82%	95%	64%
Slope Test						
	F1	0.0981	00.1300	0.2070		
		(0.000)	(0.000)	(0.006)		
	F2	0.0847	0.1144	0.1710	0.3200	0.1905
		(0.000)	(0.000)	(0.005)	(0.000)	(0.002)
R^2						
	F1	0.49	0.81	0.90		
	F2	0.49	0.83	0.92	0.85	0.38
Countries		41	40	60	41	11
Factors		4	4	2	1	2
Observations		164	160	118	41	22
Year		1995	1995	2001	1997	2000

Table 1.6: Test of the Vanek Prediction

of the factor content of trade used, are significantly better for 2007. This might be due to the issues in the measurement of labor endowment in the rest of the world in 1995. My primarily concern is the marginal effect of foreign input use in the two years. The aim is to assess whether the performance of $F1$ versus $F2$ changes in the two years. I expected the relative difference in the fit to be greater in 2007. This is, however, not supported by the data. There is no substantial difference between 1995 and 2007. The Spearman correlation increases by about 0.02 in both 1995 and 2007 using $F2$ relatively to $F1$. Similarly the Sign Test increases by about 2% points in both 1995 and 2007, and the R^2 of the slope test increases by about 2% points in both years. Hence, the effect on the factor content of trade does not pass on to the Vanek prediction, even when the changes on factor content of trade are significant.

		1995	2007
Spearman Correlation			
	F1	0.82	0.92
		(0.000)	(0.000)
	F2	0.85	0.94
		(0.000)	(0.000)
Sign Test			
	F1	83%	92%
	F2	84%	94%
Slope Test			
	F1	0.1300	0.2330
		(0.000)	(0.000)
	F2	0.1144	0.1920
		(0.000)	(0.000)
R^2			
	F1	0.81	0.90
	F2	0.83	0.92
Countries		40	40
Factors		4	4
Observations		160	160

Table 1.7: Results excluding Rest of the World

1.5 Conclusion

This chapter carefully analyzed how the factor content of trade is affected by foreign input use. Capitalizing on the time dimension of world input-output tables and consistent data on factor use in the WIOD, we were able to study not only the implication of introducing foreign input use in the definition of the factor content of trade, but also the implication of changes in foreign input use. Given the rapid international fragmentation of the last decades, this is of high relevance, yet was absent from previous works.

The present analysis confirms the results of the previous literature showing that the factor content of trade is affected by the introduction of foreign

input use. And, it suggests that the low improvement of the fit of Vanek prediction was not due to a low level of fragmentation in their data. This analysis further shows that a change in foreign inputs does affect the factor content of trade. The capital and high-skilled factor content of trade of high-income countries increased over the period, suggesting a further specialization in their comparative advantage.

Using the 2016 release of the WIOD, Timmer et al. (2016) show that the rapid international fragmentation of goods dramatically reverted in 2008, and seems to stalled since 2011. In light of our results, one has to be very cautious in deriving direct general implications of these changes for the factor content of trade and for factor prices.

2

Critically important: The heterogeneous effect of politics on trade[1]

2.1 Introduction

"Multinationals are very nervous now, and they should be. [...] In the past, only some sectors—mining, oil and gas, commodity companies—had to worry about geopolitics. Now companies that make fizzy drinks or handbags or chocolate are finding their supply chains, their markets, their operations completely blown apart by geopolitical risks and unfavorable treatment."

— Mark Leonard, co-founder of the
European Council on Foreign Relations[2]

[1]Joint work with Julian Hinz (Kiel Institute for the World Economy; E-mail: mail@julianhinz.com). We would also like to thank Lionel Fontagné, Matthieu Crozet, Thomas Chaney, Jeffrey Nugent, Maria Bas, Keith Head, Vincent Vicard, Ariell Reshef, Holger Görg, and participants of the GSIE seminar, ETSG 2015, ERF Forum 2016, SMYE 2016, UBC trade research group, and the Doctorissimes for fruitful discussion and comments.

[2]From "The great unraveling of globalization", Washington Post by Jeffrey Rothfeder on April 24, 2015.

The proliferation of international supply chains makes the domestic production of goods increasingly dependent on inputs from foreign sources. By expanding their sourcing portfolio to foreign suppliers, firms and by extension entire economies are more prone to the trade effects of adverse bilateral political shocks. As trade issues have (re-)entered the limelight of politics, understanding the effects and channels through which politics impact trade is of vital importance. In this chapter, we analyze the relation between political relations and trade at lower levels of aggregation, allowing for a heterogeneous effect by types of inputs. We show that a negative shock to political relations as a more pronounced effect on trade of *critical* goods[3] provided that the price dispersion on the input market is small. As critical goods we define foreign inputs used intensively directly and indirectly for the production of goods that are domestically consumed.[4]

We develop a simple theoretical model to illustrate the proposed mechanism. Political tensions increase the price of the input with the trading partner. The impact on trade flows will depends on whether the importer switches supplier. The first element of the choice of strategy after the shock depends on the difference between the magnitude of the shock and the price gap on the input market. For sectors with a high price-gap, the domestic economy will not switch supplier after a shock. If the price gap is low, and hence the second best is now cheaper, the strategy of the domestic economy will be determined by the dependence of the input. The greater the dependence, the higher the benefits from switching are, the more likely the domestic economy will switch supplier.

Our empirical analysis aims at testing our theoretical prediction in reduced form. We compute a measure of dependence of an economy on imported inputs that is directly derived from the theoretical model and test the proposed mechanism in a gravity framework. As political relations and

[3]We follow Ossa (2015) in the wording, who states that "[...] imports in some industries are critical to the functioning of the economy, so that a complete shutdown of international trade is very costly overall" (Ossa, 2015, p. 266).

[4]Note that we use "industry", "good" and "product" interchangeably as in the model each industry produces one good and the data needed for the empirical analysis is only available at aggregated industry level. The concept holds for any level of aggregation.

trade are possibly prone to endogeneity (i.e. political relations are likely to be affected by trade levels), we exploit a negative exogenous shock to political relations to test our prediction: the summoning or recalling by major countries of foreign or own diplomats, respectively. Summoning or recalling high-level diplomats is used as a diplomatic instrument to put pressure on a foreign government. They are considered after mediation, negotiation and arbitration fails. The summoning, recalling or expulsion of diplomats is a decision taken by the foreign office or the head of state of a country to exert diplomatic pressure on another country. It often goes along with a *note verbale* or *letter of protest*, a formal declaration of disapproval that occurs at that date and is specific to a country pair. For instance, in one recent case in June 2015, the media extensively reported about the summoning of the American ambassador in Paris by the French government over "unacceptable spying on French political leaders".[5] We construct a new event database by collecting information on these diplomatic events from press releases found on the websites of the foreign ministries of five politically and economically important countries (France, UK, Russia, Germany, Japan).[6] As bigger countries exercise their political power regardless of trade ties, focusing on these countries ensures the exogeneity of the events studied. Using these events as a proxy for a negative shock to bilateral political relations, we estimate the heterogeneous impact with *monthly* UN Comtrade import data (United Nations Statistics Division, 2015) of these countries vis-à-vis the rest of the world from January 2010 to December 2014.

Results from the empirical exercise point to the conclusion that political relations indeed do matter in the choice of the sourcing partner for today's interdependent economies and, importantly, more so for critical products in markets with low price dispersion. This provides evidence for the mechanism proposed in the theoretical model.

[5] See *The Guardian*, 24 June 2015, `http://www.theguardian.com/world/2015/jun/24/francois-hollande-says-us-spying-on-french-officials-unacceptable-nsa`

[6] The United States does not make this information publicly available. China does make this piece of information public but it cannot be retrieved.

The chapter is related to an extensive literature on the connection between trade and political relations. A growing body of research is looking into the nexus of political relations between countries and their bilateral trade, as non-traditional determinants of trade have been recognized as a primary source in explaining the *dark matter* of trade cost (Head and Mayer, 2014). Head and Mayer (2013) acknowledge the role of political history, as colonial legacies, through common languages, legal systems or currencies, as well as past conflicts have been shown to have a lasting impact on bilateral trade. However, it seems questionable to reduce the influence of political determinants of trade flows to historical episodes and those of conflict and colonial legacy. For almost half a century the Cold War never once "got hot", yet certainly constituted a major obstacle to trade and global economic integration.[7] One strand of the literature investigates the influence of bilateral political relations on aggregate trade flows. These focus by and large on security-related issues, in particular inter- and intra-state conflict (Martin et al., 2008a,b, 2012), "hijacking" of shipments (Anderson and Marcouiller, 2002; Marcouiller, 2000), terrorism (Mirza and Verdier, 2008; de Sousa et al., 2009, 2010) and international piracy (Bensassi and Martínez-Zarzoso, 2012).

A number of works have furthermore pointed to the importance of non-security-related political and societal features of the trading countries. Yu (2010) studies the impact of political (democratic) institutions in the gravity equation and Umana Dajud (2013) finds positive coefficients for similarity in foreign policy and political ideology of trading partners. Rose (2007) shows that diplomatic representation may foster trade: he estimates that each additional foreign mission increases exports by 6–10 %.

Some recent works point to the implications of changes in the political relations for trade flows: Michaels and Zhi (2010) estimate an 8 percent drop in bilateral trade in intermediate inputs between the US and France

[7] See also Findlay and O'Rourke (2007) for the history of the connection between the pattern and evolution of trade and long-term economic and political development.

as a response to the French opposition to the Iraq war in 2003. Similarly, Yazigi (2014) reports a marked drop in exports and imports from civil war-ridden Syria to European countries, yet increases with allied Russia and Iran. Mityakov et al. (2012), emphasizing heterogeneity across sectors and the motivation of "energy security", show that a one standard deviation decrease in political distance, as measured through similarity of UN General Assembly voting, is associated with a 14 percent decrease in US imports.

Others find more mixed evidence: Nitsch (2007) shows that official visits of heads of states have on average a positive effect on export of an 8–10 % increase. However, these results are very sensitive to the type of visits and much less robust for imports. Fuchs and Klann (2013) estimate the effect of the foreign trips of the Dalai Lama on the host countries' subsequent trade with China. They only find a significant effect for meetings with the countries' top political leaders and only for the period of 2002-2008, while the effect also only lasts one year. Davis et al. (2012) estimate the effect of political relations on imports and exports of state-owned enterprises (SOE). Here the idea is that governments directly influence the firms' behavior, implying a heterogeneity in the effect. Adverse bilateral political events are indeed found to lead to a reduction in imports and exports. As hypothesized, the relationship is stronger for imports by SOEs, but yields mixed results for exports.

The literature acknowledges that political relations have an effect on trade. Yet, little is known about the mechanisms at play as most of the analyses have focused on aggregate flows. We complement the existing literature by suggesting a channel through which political relations affect trade. We hypothesize that political relations matter more for critical goods provided that the price dispersion on the input market is small. We test this prediction empirically at the industry-level using an novel proxy for negative political relations, a measure for price dispersion and a new measure of economic dependence.

A common point of concern in the literature is the estimation of the effects of political relations on trade in cross-section analyses and the connected issue of endogeneity. In response to this, a variety of different strategies have been employed to circumvent the endogeneity issue of political relations with economic outcomes. Kuziemko and Werker (2006) exploit the rotation of UN security council non-permanent membership to assess the connection between foreign aid and political support at international organizations. Romalis (2007), studying the effect of trade on growth, uses the trade policy of the United States as an instrument for the openness of developing countries. Fisman et al. (2014) take another approach and perform an event study, where they analyze the performance of Japanese and Chinese firms with exposure in the respective other market after nationalist episodes following the publication of a revisionist history textbook in Japan and a near-collision of a Chinese trawler with a Japanese coast guard vessel. To address the issue of endogeneity in our present case, we explore the effect on trade flows brought about by *exogenous* political shocks. We exploit the summoning or recalling of the ambassador (or other high-ranking members of the diplomatic staff) of a country as an exogenous negative shock to bilateral political relations to study how trade flows react.

The remainder of the chapter is organized as follows. In section 2.2 we develop a simple model to illustrate the proposed mechanism. In section 2.3 we compute a measure of dependence directly derived from the model. In section 2.4 we test the proposed mechanism using this measure in an event study. Section 2.5 concludes.

2.2 Theory

Most of the papers studying the connection between political relations and trade use aggregate trade flows.[8] We aim to show that it is key to look at the effect of political relations at lower levels of aggregation, namely the industry or product level, as it is likely to be heterogeneous. A shock to political relations could have a stronger impact on trade of particularly sensitive, critical inputs, i.e. inputs that the firms in the economy use intensively for final good production. The model presented in this section gives the intuitions as to why this may be so. The model is related to Acemoglu et al. (2012) in its depiction of input-output linkages in the context of the propagation of shocks.

In the following, we sketch a simple model in which a two-sector economy uses labor, domestic and imported foreign inputs. Political relations are assumed to enter variable trade costs. An increase of political tensions then translates into an increase of trade costs, which in turn leads to an increase of the price of the input.

Assuming political relations to enter as a variable trade cost is commonplace in the literature. In his theoretical framework, Yu (2010) models variable trade costs to explicitly depend on the level of democratization of the importing country. Mirza and Verdier (2008) include costs due to the threat of terrorism in a generic measure of transaction costs, arguing that terrorism threats create uncertainty and anxiety, which induce economic agents to become more aware about potential harm when conducting any transaction in the respective country. Umana Dajud (2013) measures political proximity as a variable element of the trade cost function.

[8] With the notable exception of Davis et al. (2012) who disaggregate by ownership structure, see above.

2.2.1 Basic Setting

Assume a setting in which the domestic economy produces two goods, x and y. The production of good x requires labor l_x, a domestic input y_x, and foreign inputs m_x and n_x. The production of good y analogously requires labor l_y, x_y, m_y and n_y. The production functions are of Cobb-Douglas type such that

$$x = l_x^{\lambda_x} y_x^{\beta_x} m_x^{\gamma_x} n_x^{\delta_x} \tag{2.1}$$

$$y = l_y^{\lambda_y} x_y^{\alpha_y} m_y^{\gamma_y} n_y^{\delta_y} \tag{2.2}$$

$$\text{where} \quad \lambda_x + \beta_x + \gamma_x + \delta_x = \lambda_y + \alpha_y + \gamma_y + \delta_y = 1$$

The exponents in equations (2.1) and (2.2) denote the respective technical coefficients. The total production of a good produced domestically can be either used as input in the other sector or consumed, such that $x = x_y + x_c$ and $y = y_x + y_c$. Foreign goods are only used as inputs in the domestic economy, such that $m = m_x + m_y$ and $n = n_x + n_y$. Let p_x, p_y, p_m, and p_n denote the price of the respective good in the domestic economy. Labor is mobile and thus the wage w is equal in both sectors. Foreign inputs will be imported from the cheapest available source.

The representative consumer in the domestic economy has a Cobb-Douglas utility of the form $U = x_c^{\eta} y_c^{1-\eta}$. The consumer disposes over 1 unit of labor such that she receives an income of w and hence maximizes her utility under the budget constraint $p_x x_c + p_y y_c = w$. As a result, the representative consumer spends a share η of her revenue on x and the rest on y. We thus have $x_c = \eta \frac{w}{p_x}$ and $y_c = (1-\eta)\frac{w}{p_y}$.

Our model is a framework for understanding the effect of a specific exogenous shock, a sudden worsening of political relations. The production function being of Cobb-Douglas type, the model does not allow for a change in production technologies or a substitution between foreign and domestic inputs as a response to a shock. Since our analysis focuses on short-term effects of a shock, it is a credible assumption. In the short-run,

production technology cannot adjust. However, it is important to stress that the trade pattern can change after the shock. The domestic economy might substitute between inputs from different foreign sources.

The framework puts the emphasis on one channel and properly identifies the mechanisms at play. Other potential channels are ruled out of the analysis. As there are no imported final goods, competition on the final goods market is not affected by a shock to political relations. As there are no exports of final goods, the shock does not change the access to a foreign market for domestic final goods producers.

The first step in developing the model is to choose the supplier for each imported input (m and n) from all potential sources. To ship the goods from a foreign source i, the domestic economy incurs an iceberg trade costs τ_i. The price of a foreign input k sourced from i in the domestic market is then $p(d)_{k,i} = \tau_i p_{k,i}$, with $p_{k,i}$ the price of the input k in origin i. The domestic economy will source m and n from the cheapest available sources. A shock to trade costs with one partner might affect trade patterns, and hence the price of the inputs in the domestic economy.

Once the choice of the foreign input supplier is determined, in each sector the representative firm maximizes profits. The total amounts of the goods in the economy are therefore:

$$\begin{pmatrix} x \\ y \\ m \\ n \end{pmatrix} = \begin{pmatrix} 0 & \frac{p_y}{p_x}\alpha_y & 0 & 0 \\ \frac{p_x}{p_y}\beta_x & 0 & 0 & 0 \\ \frac{p_x}{p_m}\gamma_x & \frac{p_y}{p_m}\gamma_y & 0 & 0 \\ \frac{p_x}{p_n}\delta_x & \frac{p_y}{p_n}\delta_y & 0 & 0 \end{pmatrix} \begin{pmatrix} x \\ y \\ m \\ n \end{pmatrix} + \begin{pmatrix} x_c \\ y_c \\ 0 \\ 0 \end{pmatrix}$$

At this point the resemblance to the Leontief matrix becomes clear, so that the unit output for the goods in the economy can simply be retrieved by inverting, so that

$$\begin{pmatrix} x \\ y \\ m \\ n \end{pmatrix} = \frac{1}{1-\alpha_y\beta_x} \begin{pmatrix} 1 & \frac{p_y}{p_x}\alpha_y & 0 & 0 \\ \frac{p_x}{p_y}\beta_x & 1 & 0 & 0 \\ \frac{p_x}{p_m}\gamma_x + \frac{p_x}{p_y}\beta_x\frac{p_y}{p_m}\gamma_y & \frac{p_y}{p_m}\gamma_y + \frac{p_y}{p_x}\alpha_y\frac{p_x}{p_m}\gamma_x & 1 & 0 \\ \frac{p_x}{p_n}\delta_x + \frac{p_x}{p_y}\beta_x\frac{p_y}{p_n}\delta_y & \frac{p_y}{p_n}\delta_y + \frac{p_y}{p_x}\alpha_y\frac{p_x}{p_n}\delta_x & 0 & 1 \end{pmatrix} \begin{pmatrix} x_c \\ y_c \\ 0 \\ 0 \end{pmatrix}$$

Focusing on imported inputs m and n, we have

$$\begin{pmatrix} m \\ n \end{pmatrix} = \frac{1}{1-\alpha_y\beta_x} \begin{pmatrix} \frac{p_x}{p_m}(\gamma_x + \beta_x\gamma_y) & \frac{p_y}{p_m}(\gamma_y + \alpha_y\gamma_x) \\ \frac{p_x}{p_n}(\delta_x + \beta_x\delta_y) & \frac{p_y}{p_n}(\delta_y + \alpha_y\delta_x) \end{pmatrix} \begin{pmatrix} x_c \\ y_c \end{pmatrix} \tag{2.3}$$

The domestic economy is considered as being more *dependent* on input m than on input n, i.e. m is more critical than n in that the economy needs more of it for final consumption, if and only if

$$x_c\frac{p_x}{p_m}(\gamma_x + \beta_x\gamma_y) + y_c\frac{p_y}{p_m}(\gamma_y + \alpha_y\gamma_x) > x_c\frac{p_x}{p_n}(\delta_x + \beta_x\delta_y) + y_c\frac{p_y}{p_n}(\delta_y + \alpha_y\delta_x)$$

Hence, this measure of *dependence* is a weighted mean of each sector's dependence to an input; each sector's dependence is a function of direct use of the input and indirect input use which depends on domestic cross-sectoral linkages.

2.2.2 Impact of a change in political relations

In this stylized two-sector setting with imported inputs, we now consider the effect of a change in political relations on trade patterns. We make the simplifying assumption that before the shock the domestic economy sources both inputs m and n from the same country, denoted 1 in what follows. 1 is the cheapest option available in the market for the two inputs. We further assume that ex-ante production technologies in 1 are such that the prices of inputs m and n from 1 in the domestic economic are: $p(d)_{m,1} = p(d)_{n,1} = \tau_1 p_1$ with τ_1 the iceberg trade cost between 1 and the

domestic economy, and p_1 the price of inputs in country 1. Let ε_k be the ex-ante price gap in the domestic economy between the cheapest source for input k (i.e. country 1) and the second best, denoted 2 (i.e. potentially any country). As country 1 is the first best for the two inputs, by definition $\varepsilon_k > 0$.

We now assume that political relations between the domestic economy and its sourcing country deteriorates. Following the existing literature, we hypothesize political relations to affect variable trade costs. Hence, a negative shock to political relations between the domestic economy and its initial supplier is modeled as an increase of τ_1. Call τ_1' the new level of trade costs such that: $\tau_1' = \tau_1 + \xi$ with $\xi > 0$. After the shock, the domestic economy has to choose a strategy given the new set of prices. As the only elements that changed in the set of prices are the prices of the input from the initial supplier, the initial supplier is not necessarily the cheapest source for inputs anymore. Ex-post the price of input m from 1 in the domestic economy is $p(d)'_{m,1} = \tau_1' p_1$ and the price of input n from 1 in the domestic economy is $p(d)'_{n,1} = \tau_1' p_1$. We define ζ as the price difference for inputs from 1 in the domestic economy due to the shock (i.e. $p(d)'_{k,1} = p(d)_{k,1} + \zeta$ where $\zeta = \frac{\xi}{\tau_1} p(d)_{k,1}$). If the domestic economy were to change supplier for a given input, it would incur switching costs in the short-run, denoted sc.[9] The impact of the shock on trade patterns crucially depends on whether the domestic economy change its input supplier following the shock.

Therefore, in the short-run the domestic economy faces a trade-off for each input between the benefits of switching supplier (if any) versus the cost associated to the switch. The domestic economy decides to switch suppliers only for the inputs for which the benefits outweigh the costs. We assume sc to be identical across inputs. As shown in appendix B.1, an increase in the price of an input leads to a decrease in aggregate output. The greater the price increase, the greater the decrease in total output is.

[9] In a recent paper, Barrot and Sauvagnat (2016) show that switching costs between trade partners are substantial in the short-run. They are also a key element in recent models of firm's sourcing decisions Antràs et al. (2014).

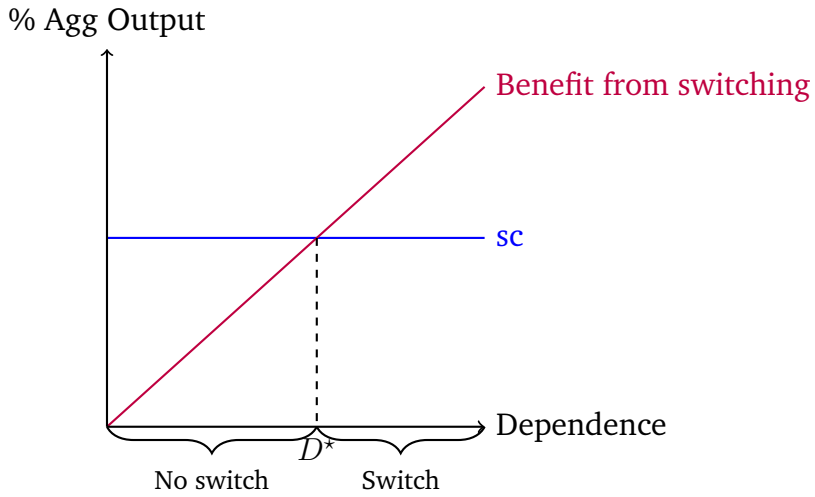


Figure 2.1: Trade-off for $\varepsilon_k < \zeta$

Minimizing the increase in price by switching to a relatively cheaper input (if any) would then minimize the output loss due to the shock. In that case, the loss in output due to the shock will be smaller when switching than the loss in output due to the shock when not switching. The greater the difference between the loss in output when switching versus not switching, the higher the benefits from switching are. One can compute the benefits from switching for each input in our simple framework.[10] For input m the benefits from switching are:

$$\left|\frac{\partial \log(\text{AO})}{\partial p_m}\right|_{switch} - \left|\frac{\partial \log(\text{AO})}{\partial p_m}\right|_{\overline{switch}} = (\zeta - \varepsilon_k)\frac{1}{p_m}(\eta(\gamma_x + \beta_x\gamma_y) + (1-\eta)(\gamma_y + \alpha_y\gamma_x))$$

For input n the benefits from switching are:

$$\left|\frac{\partial \log(\text{AO})}{\partial p_n}\right|_{switch} - \left|\frac{\partial \log(\text{AO})}{\partial p_n}\right|_{\overline{switch}} = (\zeta - \varepsilon_k)\frac{1}{p_n}(\eta(\delta_x + \beta_x\delta_y) + (1-\eta)(\delta_y + \alpha_y\delta_x))$$

[10] For further details on computations see appendix B.1.

More generally, the benefits from switching can be written as:

$$BS_k = (\zeta - \varepsilon_k) Dep_k$$

If $\varepsilon_k \geq \zeta$, there is no benefit from switching as country 1 is still the cheapest source, even with the increase in trade costs. Trade with the input supplier will decrease as a result of the increase in price, but input trade patterns won't change. If $\varepsilon_k < \zeta$, country 1 is no longer the cheapest source for inputs. As the magnitude of the benefits of switching are an increasing function of dependence, the strategy will be conditional on the value of dependence. There is a threshold value of dependence such that the benefits of switching are greater than the switching costs. For inputs with a level of dependence above that threshold, the domestic economy will switch supplier. For these specific inputs, trade patterns will change as the domestic economy will stop importing this input for country 1, and will start importing it for the initial second best supplier. Figure 2.1 illustrates the trade-off in this specific case. $D^\star$ denotes the dependence level at which the economy is indifferent between switching and not switching. For non-critical inputs such that $D < D^\star$, it is not worth adjusting. The difference in damages on aggregate output is marginal compared to switching costs. For these inputs, there is no change in trade patterns following the shock.

While the intensity of the shock to political relations, ζ, is constant across input, the value of ε_k may vary between inputs. The greater the initial price gap between the first and second best supplier, the greater ε_k is. For a given shock, there is a value $\varepsilon^\star$ such that $\zeta - \varepsilon_k = 0$. In input markets such that $\varepsilon_k > \varepsilon^\star$, the domestic economy will not switch supplier, no matter the dependence of the product. The value of ε_k crucially depends on the type of competition on the input market. In a market where the competition is fierce, the price gap between the first and the second best is likely to be very small, while it is likely to be high in a market where each player has a strong market power. Therefore, the greater the competition, the lower ε_k is. As shown by Naldi (2003), if the size of the players on the market is

assumed to follow a Zipf distribution, the Zipf parameter can be taken as a measure of competition on the market. The larger the Zipf parameter, the more unbalanced the distribution is and the greater ε_k is.

From our simple framework, we can then derive the following testable prediction:

Prediction. *After a negative shock to political relations with a trade partner, trade flows with this partner decrease for all products. The response is more pronounced in highly competitive sectors. For these sectors, the decrease will be more pronounced for critical products, as the likelihood to switch is higher.*

Before testing this prediction in section 2.4 in a reduced-form setting, we introduce the measure of dependence, which we use to identify critical products.

2.3 Measure of dependence

The measure of dependence of a country on imported inputs can be derived directly from the concept of *dependence* from section 2.2 and constructed using data from input-output tables. Following equation (2.3), we know that

$$\begin{pmatrix} m \\ n \end{pmatrix} = \frac{1}{1-\alpha_y\beta_x} \begin{pmatrix} \frac{p_x}{p_m}(\gamma_x + \beta_x\gamma_y) & \frac{p_y}{p_m}(\gamma_y + \alpha_y\gamma_x) \\ \frac{p_x}{p_n}(\delta_x + \beta_x\delta_y) & \frac{p_y}{p_n}(\delta_y + \alpha_y\delta_x) \end{pmatrix} \begin{pmatrix} x_c \\ y_c \end{pmatrix}$$

Normalizing by the total consumption of the economy and expressed in matrix form, we call the vector

$$\text{dependence}_j = A_m(I - A_d)^{-1}F \tag{2.4}$$

where A_m is the matrix of the values of *imported* inputs by sector and A_d the matrix of the values of *domestic* inputs by sector. F is the vector of final consumption shares. The interpretation of the vector is straightforward:

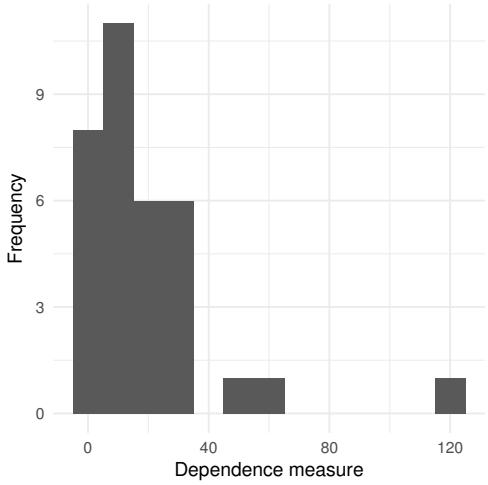
each element denotes the required value of foreign input of the respective commodity for 1 unit value of final consumption in the economy j. The higher the necessary imported value, the more dependent the country is on the input. The concept is related to those developed by the flourishing literature on value-added trade.[11] Here one of the key concept is the "import content of exports", i.e. the share of foreign value-added in a given domestic industry. The angle of analysis of our measure is different as it focuses on the input rather than on the final product. We are interested in how much an imported input matters for final consumption, directly and indirectly.

Note that by construction of the measure the technology is assumed not to change in face of a price shock. This ad-hoc assumption should not be problematic in the current context as the adjustment of technology can safely be assumed to take considerable time. Furthermore, the implications for this *dynamic* effect on the economy are ambiguous. On the one hand, a technology adjustment would mitigate price shocks to some degree. On the other hand, an adjustment would likely be costly and only pay off over the longer term. As our following empirical analysis focuses on rather short-run effects using monthly data, we believe the assumption is reasonable.

To get an idea of the veracity of the measure, we compute the measure for the United States using input-output tables from the Bureau of Economic Analysis with data on 389 industries. The results are displayed in table B.1. The ranking and magnitude appear to be sensible, with petroleum, manufacturing and electronic inputs dominating the top ranks. Unfortunately input-output tables of this high detail are a rarity for a wider country coverage. For the empirical analysis to follow in section 2.4, we use the global input-output table for the year 2008[12] from the World Input Output Database, commonly used in the related literature on global value chains, most notably by Timmer et al. (2014) and Koopman et al. (2014).

[11] See e.g. Johnson and Noguera (2012).

[12] Relying on data from 2008 ensures the exogeneity of the input coefficients for the event study.



(a) Histogram of dependence for USA

	WIOD Industry	Dependence
1	Coke, Refined Petroleum and Nuclear Fuel	115.50
2	Public Admin and Defence	55.49
3	Transport Equipment	50.20
4	Renting of M&Eq and Other Business Activities	34.62
5	Financial Intermediation	34.11
6	Chemicals and Chemical Products	33.40
7	Construction	28.59
8	Basic Metals and Fabricated Metal	28.00
9	Food, Beverages and Tobacco	25.33
10	Electrical and Optical Equipment	22.66

(b) Top 10 US critical industries

Figure 2.2: Histogram of dependence measure and top 10 US critical industries (Imported value by industry per 1000 USD GDP)

The table covers 40 countries[13] for 35 sectors (both manufacturing and services) which maps with NACE revision 2 sectoral definition. Figure 2.2a shows the histogram and table 2.2b displays the ranking of the most critical products for the United States, i.e. those it is dependent on. A comparison with the more detailed results from table B.1 shows consistent figures by ranking and magnitude across different levels of aggregation of the used input-output tables.

As a robustness exercise, we use data from GTAP (Aguiar et al., 2012), which covers more countries than WIOD. However, as the primary purpose of these tables was to be used in CGE quantification of the impact of agricultural trade policies, the definition of the 47 sectors has a significant bias towards agriculture. Refer to section B.3 in the appendix for more details.

[13] 27 EU countries and 13 other major countries in the world including the US and China.

2.4 Event Study

Having computed the measure of dependence by country and industry, we now test the prediction of the model from section 2.2. We follow Fuchs and Klann (2013) and perform an event study. The theory above suggests that there are two crucial elements determining the trade response to a negative shock to political relations: the price dispersion on the market and the *dependence* on the domestic economy on inputs. As the identification of the effect of political relations on trade flows is prone to endogeneity issues, we explore its effect brought about by *exogenous* political shocks. Here, we exploit the summoning and recalling of a high-level diplomat of a country, i.e. the ambassador or another member of the permanent diplomatic staff, as a negative shock to bilateral political relations in order to study how trade flows react using monthly trade data for five major importers from 2010 to 2014. These major importers, who are also important players on the political arena, exercise their political power regardless of trade ties. The diplomatic events studied can therefore be assumed to be exogenous.

2.4.1 Data on diplomatic events

Summoning or recalling high-level diplomats is used as a diplomatic instrument to put pressure on a foreign government. They are considered after mediation, negotiation and arbitration fails. We believe these events make for a reasonable proxy for an adverse shock to bilateral political relations. The summoning, recalling or expulsion of diplomats is a decision taken by the foreign office or the head of state of a country to exert diplomatic pressure on another country. It often goes along with a *note verbale* or *letter of protest*, a formal declaration of disapproval that occurs at that date and is specific to a country pair. This declaration, as opposed to news reports, is an official statement by the government. We can distinguish between two directions of actions. The one direction is the

summoning of a diplomat of a foreign country in the home country. In the extreme case, the protest yields the (temporary) expulsion of the ambassador and the diplomatic staff, or even the closure of the embassy in the home country. In this case, it is often the sign of a strong concern from the home country towards the foreign country. In the other direction, a country can recall its own ambassador or the entire diplomatic staff from a foreign country. In the extreme, this action yields a temporary closure of the embassy in the foreign country.

In general, the endogeneity of trade and political relations is an obvious identification issue. One might reasonably raise the concern that any government will try to keep its own economy afloat for the sake of popularity and therefore by all means aim to maintain a positive level of bilateral political relations with important trading partners. However, we suspect that this is more prevalent for small countries. We hypothesize that bigger countries exercise their political power regardless of trade ties, whose diplomatic events would therefore be exogenous.

As stated by Rozental and Buenrostro (2013) in their chapter in the Oxford Handbook of Modern Diplomacy, "a state aspiring to adopt a global leadership role—such as any one permanent member of the United Nations Security Council—has to maintain ties with almost all countries and regions, while middle and smaller powers must prioritize their objectives and diplomatic resource". While governments of "small" countries may thus hesitate to exercise this tool of foreign policy—it could be costly in both political and economic terms—"big" countries are much less constrained in their policy making. They summon and recall diplomats of any country—not only from "small" trading partners but from major ones as well.

We therefore focus our analysis on the actions taken by the countries of Germany, France, United Kingdom, Japan and the Russian Federation, as they are lead actors in the political arena as well as in trade, combining

roughly 25 % of world imports between them.[14] The selected five countries have repeatedly made use of summoning or recalling of an ambassador as a foreign policy tool. We have collected information on these events from official press releases available on the website of each Ministry of Foreign Affairs,[15] using keyword searches such as "ambassador summoned", "ambassador recalled", "withdraw of diplomatic staff", "embassy closure".

An ambassador can be summoned or recalled for several reasons. Here are some examples of events. In November 2010, Russia summoned the Canadian ambassador over new visa requirements for Russian nationals. In February 2011, France summoned the Mexican ambassador regarding the situation of the French-national Florence Cassez.[16] In July 2012, Japan summoned the Chinese ambassador to protest against the entry of patrol ships into disputed territorial waters. In March 2013, Germany summoned the Chinese ambassador to condemn the attack on a German journalist. In June 2014, the British Foreign Office summoned the Egyptian ambassador following an Egyptian court guilty verdicts against Egyptian and international journalists.[17] A complete list of events can be found in table B.4.2 in the appendix.[18]

To confirm that our sample of big countries exercise their political power regardless of trade ties, we analyze the link between the probability of having an event for a given country pair (i.e. summoning or recalling of an ambassador of country o by country d) and bilateral aggregate trade at the beginning of the period studied. To identify a country pair for

[14]Three of the five countries—France, the United Kingdom and the Russian Federation—are permanent members of the UN Security Council.

[15]Appendix B.4.1 lists the direct weblinks to the different websites.

[16]See *Le Monde*, 11 February 2011, `http://www.lemonde.fr/ameriques/article/2011/02/11/bras-de-fer-franco-mexicain-autour-du-cas-de-florence-cassez_1478412_3222.html`

[17]Details on the Foreign Office website: `https://www.gov.uk/government/news/foreign-secretary-appalled-by-verdicts-on-journalists-in-egypt`

[18]Notably absent from the list of countries are the United States and China, whose foreign policy clearly shapes global events and likely influences trade flows. Unfortunately, however, the US State Department does not make public instances in which these instrument of diplomacy are used, and Chinese Ministry of Foreign Affairs does publish press releases but it is impossible to retrieve them.

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
0	461	0.66	.09	1.90	0.49	0.84
1	43	1.31	0.58	3.80	0.14	2.48
combined	504	0.72	0.10	2.14	0.53	0.90
diff		-0.65	0.33		-1.32	0.02

$diff = mean(0) - mean(1)$ $t = -1.91$
$Ho : diff = 0$ degrees of freedom $= 502$

$Ha : diff < 0$ $Ha : diff \neq 0$ $Ho : diff < 0$
$Pr(T < t) = 0.0278$ $Pr(|T| > |t|) = 0.0557$ $Pr(T > t) = 0.9722$

Table 2.1: Mean test on trade share for two groups (treated/non-treated)

which an event occurred over the studied period, we construct a dummy variable that equals 1 if an event occurred at least once during the period 2010–2014.

We first perform a simple mean test by splitting the sample of country-pairs between two groups: the first one being country pairs with a dummy variable equal to one; the second one being the rest. We test if the average trade share (share of a given partner in import flows) in 2010 is significantly different for the two groups. Results presented in Table 2.1 show that country-pairs with an event trade significantly more than other country pairs. This rejects the hypothesis that our five importers are less likely to summon ambassadors from important trade partners. One might worry that this biases our estimates. However, as the effect of trade on tensions is positive, if anything, our coefficient is an underestimation of the true coefficient.

We then regress the probability of an event occurring for a given country pair on import shares in 2010. See Table 2.2. The findings of the mean test are confirmed; there is a positive but not statistically significant relation between trade and the probability of an event occurring.

VARIABLES	Dummy= 1 if event
share of imports	0.05
	(0.03)
Constant	-1.41***
	(0.085)
Observations	504

*** p<0.01, ** p<0.05, * p<0.1

Table 2.2: Probit Test for exogeneity

2.4.2 Data on monthly trade flows

Given the characteristics of our events we expect a short-term impact on trade flows, similar to the observed effect of Dalai Lama visits in Fuchs and Klann (2013).[19] In consequence, we opt for an analysis using data with monthly trade flows. Unfortunately monthly trade data has only in recent years seen more widespread availability. The most prominent (and free to access) is UN Monthly Comtrade (United Nations Statistics Division, 2015). For the purpose of this study, we extract data on the imports of France, UK, Russia, Germany, Japan vis-à-vis the rest of the world—241 countries and territories—from January 2010 to December 2014, totaling 60 months. To map our dependence measures with trade flows, we aggregate them to 16 manufacturing sectors in WIOD.

2.4.3 Estimation strategy

The idea of the event study is to compare trade flows before and after the event for countries which experience a shock in political relations relative to other country pairs.[20] We take the logarithm of the left-hand-

[19] It is also likely to have a much less severe impact than military conflicts or more structural security issues like domestic political instability (Martin et al., 2008a,b, 2012).

[20] As there is a small number of country pairs that do not entertain bilateral diplomatic representations, e.g. North Korea and France do not have official diplomatic relations, we only consider country pairs that do have embassies or consulates in one another in the analysis.

side variable, monthly trade flows from source to destination country by industry, in order to be able to interpret the estimated coefficient on the treatment variable in terms of a percentage change in imports. To meet the idea of a difference-in-differences approach, we employ a large set of fixed effects to control for unobservable characteristics of the involved countries and country-pairs.

The approach we take is, in effect, akin to the estimation of a gravity equation of international trade.[21] We control for all exporter and importer specific characteristics with respective fixed effects. We furthermore control for everything country-pair specific, but time-invariant, such as the two countries' bilateral political history, with country-pair fixed effects. The inclusion of fixed effects improves upon the gravity specification of Fuchs and Klann (2013), who estimate a "naive" gravity equation with GDP data.

Per usual in difference-in-difference estimations, the shock is constructed as a dummy variable, *Treatment*, that is time and country pair-specific. It is equal to 1 for a given country pair after it experienced an event detailed above. As we expect a heterogeneous effect at the industry level, we first interact the treatment variable, i.e. the shock to political relations, with the level of competition, or rather concentration of suppliers, on the input market. We proxy it by the Herfindahl index of exports by industry over countries, *Concentration*.[22] The greater the Herfindahl index, the lower is the level of competition on the market. Consistent with our model, we additionally interact this term with the logarithm of our measure of dependence. We normalize the dependence measure by the respective country's average dependence to make the interpretation straightforward.

[21] See Head and Mayer (2014) for a review of the state-of-the-art on the gravity framework.

[22] Naldi (2003) shows that the Herfindahl index can be expressed as a function of the Zipf's parameter provided that firm size follows a Zipf law.

The equation we estimate is therefore

$$\begin{aligned}\log(X_{odkt}) = \delta_0 \cdot \text{Treatment}_{odt} \\ + \delta_1 \cdot \text{Treatment}_{odt} \times \text{Concentration}_k \\ + \delta_2 \cdot \text{Treatment}_{odt} \times \text{Dependence}_{dk} \\ + \delta_3 \cdot \text{Treatment}_{odt} \times \log(\text{Dependence}_{dk}) \times \text{Concentration}_k \\ + F_{ok} + F_{dk} + F_{odk} + \epsilon_{odkt} \qquad (2.5)\end{aligned}$$

where F_{okt} and F_{dkt} capture all exporter $\times$ industry and importer $\times$ industry characteristics and F_{odk} their bilateral relations.[23] Standard errors are clustered at the exporter $\times$ importer $\times$ industry $\times$ month level.

For the interpretation of each coefficient, it is important to keep in mind that the reference is an industry with a perfectly competitive market with no concentration of suppliers, i.e. a Herfindahl index of zero, and an average level of dependence of the respective country.[24] The coefficient on the *Treatment* variable, δ_0, is the average effect for the reference. δ_0 is expected to be negative. The coefficient of the interaction between *Treatment* $\times$ *Concentration*$_k$, δ_1, then shows the average elasticity of the imports to the competition on the market. According to our prediction, we expect a more concentrated market to have a lower response in trade after a negative shock to political relations, thus δ_1 should be positive. The coefficient of the interaction between *Treatment* $\times$ *Dependence*$_{dk}$, δ_2, should be negative as the likelihood to switch supplier increases with the level of dependence on input for a highly competitive market. The coefficient on the interaction between *Treatment* $\times$ *Dependence*$_{dk}$ $\times$ *Concentration*$_k$, δ_3, is expected to be positive as the relevance of dependence shrinks with the increase in market concentration.

[23] In some specifications we additionally add a time dimension to the country-specific fixed effects and let the bilateral fixed effect F_{odkm} vary by (calendar-) month to account for potential country pair-specific seasonality.

[24] As the logarithm of a country's mean dependence is $log(1) = 0$. The normalization of the dependence measure has no effect on the results.

Owing to the log values in equation (2.5), we cannot account for potential zero trade flows, i.e. the absence of any imports from the source to the destination country, while they may be particularly instructive in our case. The extreme scenario in which the country would completely stop importing goods from the partner with whom there was an event will not show up in our estimation. To address zero flows, the gravity literature has turned to the use of the PPML estimator following Santos Silva and Tenreyro (2006). In our case, however, the PPML estimator does not converge, likely to be due to the massive amount of fixed effects in our estimations.[25]

2.4.4 Main Results

The results for our prediction are presented in table 2.3. Columns (1) and (2) report the coefficients for estimating equation (2.5) using imports from all 241 countries with two different sets of fixed effects. For this sample, we have a total of 40 events.[26] A sudden shock to bilateral political relations, on average, i.e. for an average dependence industry with no market concentration, negatively impacts trade between two countries. The average drop in imports in reaction to a shock to political relations for the reference group is estimated to be $exp(-0.083)-1 = 8\%$.[27] This magnitude of the effects mirrors very well the results from related literature. As noted above, Michaels and Zhi (2010) find a 8 % drop in bilateral trade between France and the US in response to the Iraq war, while Nitsch (2007) reports an increase of 8–10 % in exports after the visit of a head of state.

[25] Aside from addressing the zero flow issue, Santos Silva and Tenreyro (2006) highlight the potential bias arising from a heteroscedasticity of the error terms, which we cannot address here either.

[26] For the few country-pairs for which we observe several events over the period, we consider the date of the first one to construct the treatment variable.

[27] The coefficient estimated with the dependence measure computed on GTAP data and trade data accordingly aggregated to GTAP sectors is slightly lower, ranging between 3 and 6 %. See appendix B.3.

	Dependent variable:	
	log(imports)	
	(1)	(2)
Treatment	-0.083^{***}	-0.083^{**}
	(0.027)	(0.041)
Treatment x Concentration	0.699^{**}	0.672
	(0.300)	(0.499)
Treatment x log(Dependence)	-0.069^{***}	-0.061^{*}
	(0.022)	(0.035)
Treatment x Concentration x log(Dependence)	0.571^{***}	0.486^{*}
	(0.167)	(0.272)
Fixed effects	ctry-dt,ctry-ind, pair-ind	ctry-ind-dt, pair-ind-mo
Observations	410,303	410,303
R^2	0.913	0.964
Adjusted R^2	0.908	0.922
Note:	*p<0.1; **p<0.05; ***p<0.01	

Table 2.3: Event study - Political shock and heterogeneous effect by dependence

The coefficients on the interactions of the treatment with concentration and dependence also yield the expected signs. The former yields a positive coefficient of about 0.7, albeit insignificant in a specification with very strong fixed effects. The magnitude is plausible, given that the mean concentration value is 0.09, yielding a net decrease in affected imports for the average concentration industry of $\exp(-0.083+0.09\times0.699)-1 = 1.6\%$. Similarly, the interaction of the treatment variable with the dependence measure yields sensible results in direction and magnitude. A one-standard deviation increase in the (log normalized) dependence (1.2) yields a net average drop in affected imports of 15.2%.

Finally, the triple interaction of *Treatment*, *Concentration* and *Dependence* yields the outcome our theory suggest. The lower the concentration of the market, i.e. the lower the price dispersion on the market , the more the dependence on the respective input matters for a reduction (or lack

	Dependent variable:		
	log(imports)		
	(1)	(2)	(3)
Treatment	−0.082***	−0.055*	−0.085***
	(0.028)	(0.029)	(0.030)
Treatment x Concentration	0.624*	0.452	0.675**
	(0.333)	(0.352)	(0.314)
Treatment x log(Dependence)	−0.079***	−0.060***	−0.042*
	(0.022)	(0.023)	(0.024)
Treatment x Concentration x log(Dependence)	0.563***	0.382**	0.364**
	(0.181)	(0.183)	(0.175)
Fixed effects	ctry-dt,ctry-ind, pair-ind	ctry-dt,ctry-ind, pair-ind	ctry-dt,ctry-ind, pair-ind
Sample	Top 50	w/o Arab league	w/o Russia
Observations	237,463	371,827	359,753
R^2	0.929	0.918	0.914
Adjusted R^2	0.926	0.914	0.910
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 2.4: Robustness test — Country samples

thereof) in its imports.

2.4.5 Robustness tests

We conduct a series of robustness test to validate the findings against a number of potential concerns, related to the sample or other influencing variables.

It could be that the results are driven by the sample of countries chosen for the tests. In table 2.4 we re-estimate equation (2.5) on three other samples. One concern is that the coefficients from our benchmark estimation are driven by outliers, (very) small economies that for other reasons than bilateral political relations decrease their exports to the 5 countries of interest after being "treated" by one of the political events described above. In column (1) we report the coefficients when selecting only the top 50 largest economies out of the 241 countries present in the data as input suppliers. The coefficients on the terms of interest retain the same sign and stay within a standard error of the baseline results in table 2.3, despite

the number of observations being cut by 42 %.

A concern could be that the results are driven by the events occurring in connection with the so-called Arab spring, which falls right into the time window of the data we use. The summoning of the respective Ambassadors was relatively common, resulting in 31 such recorded instances.[28] The events coincided with security crises in these countries that could equally cause a sharp decline in imports, driving the reported results. We therefore re-run the estimation of equation (2.5) on only non-Arab league countries. We find that this concern is not merited. Column 2 of table 2.4 reports coefficients of slightly smaller, but still very plausible, magnitudes.

Another concern could be on the side of the importing country, as we were only able to collect data on political events from 5 major geopolitical players. One of the countries, Russia, could be of particular concern, as it could be argued that the country conducts its foreign policy structurally differently from Western countries and Japan. We therefore rerun the estimation without events involving the Russian Federation. Column (3) of table 2.4 again shows that this concern is not merited, with estimated coefficient again very similar to those of the benchmark regression.

Aside from the proposed concept of critical inputs the economy depends on, the results could be driven by industry-specific factors that are not captured by the employed fixed effects. It could be that certain industries, labor or skill intensive ones, react different to a sudden change in bilateral political relations than others. We test this assertion by estimating equation (2.5) with an additional interaction of indicators derived from the WIOD dataset on the labor and skill intensity of sectors. Table 2.5 shows that these concern again are not merited. Neither the interaction with labor intensity, nor the interaction with skill intensity are significant, and the coefficients of interest retain the same sign and stay within a standard error of the results of the benchmark specification reported in table 2.3.

The econometric results give empirical support to the theoretical model

[28] See appendix B.4.2 for the list of events.

	Dependent variable:	
	log(imports)	
	(1)	(2)
Treatment	-0.119^{*}	-0.098^{**}
	(0.063)	(0.041)
Treatment x Concentration	0.697^{**}	0.680^{**}
	(0.300)	(0.302)
Treatment x log(Dependence)	-0.072^{***}	-0.071^{***}
	(0.022)	(0.022)
Treatment x Concentration x log(Dependence)	0.587^{***}	0.573^{***}
	(0.168)	(0.167)
Treatment x Labor Intensity	0.061	
	(0.091)	
Treatment x Skill Intensity		0.084
		(0.161)
Fixed effects	ctry-dt,ctry-ind, pair-ind	ctry-dt,ctry-ind, pair-ind
Observations	410,303	410,303
R^2	0.913	0.913
Adjusted R^2	0.908	0.908
Note:	*p<0.1; **p<0.05; ***p<0.01	

Table 2.5: Event study — Robustness checks with industry specific measures

sketched in section 2.2. The results underline that the response of industries to political shocks is heterogeneous. The decrease in trade flow is stronger for critical inputs provided that the price dispersion on the input market is small. As laid out in the model in section 2.2, the impact of a change in prices on total output and consumer utility, as a consequence of an abrupt change in political relations and transmitted by a change in bilateral trade costs, is more severe for these products. Therefore a government, charged with securing the welfare of its citizens, would opt to rely on politically friendly partners for these critical inputs, or swiftly switch to more favorable ones in case of sudden cooling of political relations. This effect is conditional on the switching costs, as high costs to change

the supplier would mute the response to a political shock. The results resonate with the existing literature and emphasize an explicit mechanism, the concept of critical inputs, through which political relations impact trade flows as a component of bilateral trade costs.

2.5 Conclusion

In this chapter we extend the literature on the link between politics and trade by suggesting a mechanism through which political relations affect the exchange of goods. Most of the previous studies look at the impact of the deterioration or improvement of bilateral political relations on aggregate flows. Our contribution is to extend the existing body of research by exposing the heterogeneity of the impact by product/industry. Estimations on aggregate trade flows are hiding important characteristics of the effect that become visible at lower levels of aggregation. Our hypothesis is that imports of critical products, those on which the importing economy is very dependent on, are affected much more gravely than others. Countries are dependent on certain products that contribute directly and indirectly through input-output linkage relatively more to total output than other inputs.

We sketch a simple model that illustrates the mechanism at play by building on existing models of economic shock propagation. The model predicts that price shocks on imported inputs that—through direct and indirect use by way of domestic linkages—contribute to total production relatively more than others, have a stronger adverse effect. The model allows us to derive a measure of dependence of an economy on certain products/industries that can be taken directly to the data.

We compute this measure of dependence for 129 countries and 47 industries using data from GTAP 8. We then conduct an event study that exploits abrupt and unanticipated political shocks to test the proposed mechanism: the recalling and summoning of high-level diplomats. After

testing for exogeneity of the events the econometric results support the hypothesis of a heterogeneous impact of political relations on imported inputs, driven by price dispersion and the country's dependence on them.

Our study contributes to a growing literature that aims to shed light on the "dark" trade costs, those that can be observed but are difficult to quantify. The proposed mechanism supports the hypothesis that the impact of political relations—a component of dark trade costs that has been highlighted before—is heterogeneous and conditional on a country's dependence on certain inputs. At the same time, the mechanism clearly only tells part of the story. As it is well known that firms are not homogeneous either, we wonder about their role and influence in the "great game" of international relations. With growing influence of multinationals, they have grown from spectators to actors. As intriguing as these topics are, we refer them to future research.

3

Now We're Talking: Quantifying the Effect of Languages on Trade[1]

3.1 Introduction

"If I'm selling to you, I speak your language. If I'm buying, dann müssen Sie Deutsch sprechen."

— Willy Brandt, former German Chancellor

In 2002, the Barcelona European Council set the objective that Europeans should be able to communicate in two languages other than their mother tongue. Citing "European Union's aspiration to be united in diversity",[2]

[1] Joint work with Julian Hinz (Kiel Institute for the World Economy; E-mail: mail@julianhinz.com). We thank Thomas Chaney, Anne-Célia Disdier, Keith Head, and Lionel Fontagné for their comments and suggestions.

[2] See `http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/71025.pdf` for the conclusions of the 2002 Barcelona European Council and `http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=URISERV:ef0003` for a summary of related EU legislation.



Figure 3.1: Distribution of tweets by language in Europe. Different colors represent different languages.

it was stressed that multilingualism matters for the European Union's cohesion, competitiveness, internal and external trade. While there is ample evidence that language generally is an important determinant of trade, previous studies lack micro-foundations to give clear predictions regarding the impact of language diversity on trade and rely on highly aggregated measures for language use.

In this chapter, we introduce a novel source of data for the spatial distribution of language use. We then incorporate language explicitly in a model with heterogeneous firms and consumers. Driven by our model and combined with our new measure of spatial distribution of language, we evaluate the impact of languages by performing general equilibrium simulations with instructive counterfactual distributions of language.

We retrieve the spatial distribution of language use from Twitter data. For each *tweet*, i.e. a short message posted on the social media platform Twitter, one observes 42 variables. These include, obviously, the text of the tweet, but also the identifier of the user, the language of the user's

profile, and the language of the tweet itself. Additionally, for those tweets that are geo-localized, i.e. where the user is allowing Twitter to record the GPS location of the device at the time of sending the tweet, one has information on the latitude and longitude from which the user tweeted. Using these geo-localized tweets, we can derive an approximation of the distribution of language use in any given location—or city, region, country. Twitter is an outlet through which people can share thoughts with a wide audience of speakers of the same language and discuss topics of interests with this community. Twitter has recently been used as a novel source of data in economic research, mostly in pertaining to questions of political economy. Acemoglu et al. (2014) use the social network's data to built a proxy for political mobilization, while Conover et al. (2011) use it to build a measure of political polarization. Language is key for interactions on this platform. Sloan et al. (2013) have exploit tweets to proxy language proficiency. The geographers Barratt, Cheshire and Manley mapped Twitter tongues in New York City using 8.5 million geo-located tweets collected between January 2010 and February 2013.[3] While English is by far the most popular language, they identify significant diversity in language use in the different neighborhoods.

As far as we know, we are the first to use this kind of data in the context of research in international economics. We build our measure of language use from almost 1 billion unique tweets collected between November 2016 and May 2017. We identify more than 700 thousand unique Twitter users with their respective language and location. Figure 3.1 displays the distribution of tweets by language in Europe. Each color represents a distinct language. One can clearly recognize the borders of European countries as the most dominant colors relate to the official languages. Nonetheless, one can also easily spot European regions with strong language minorities. In Catalonia, in the northeastern Spain, where people mostly speak Catalan, the dots predominantly have a different color than those in the rest of Spain.

[3] See figures C.1 and C.2 in the appendix.

The theoretical model we set up explicitly incorporates this diversity of language use. Each consumer speaks one language that she draws from a language distribution specific to the place (city, region, country) where she lives. Buyer and seller need to communicate to establish the transaction, thus firms and consumers can only trade if they share a common language. Each consumer will choose to consume the differentiated good that maximizes her utility among all the varieties that are offered by sellers (local or global) in her language in her location. The choice is conditioned by idiosyncratic taste shocks. In each location, firms draw their productivity and then decide in which language(s) to offer their products based on expected demand, before observing the taste shock's realization. For each language, firms pay a fixed cost that depends on the availability of residents in the firm's location that speak a given language. In the aggregate, the model leads to a structural gravity equation where language enters as a separate determinant of trade.

The model's structural gravity equation is then used for quantification exercises. We feed the model with the data on the spatial distribution of languages and quantify the local welfare impact of four different hypothetical policy measures with respect to the benchmark. The benchmark is computed using observed local production and the observed distribution of languages. We first study the effect of having a common European language. Then, as an indirect test of the role of within-country language diversity, we evaluate the effect of eliminating within-country language diversity in European countries. In this scenario, the population in each location in Europe only speaks the respective country's official language(s). Finally, we study the effect of two separate country-specific policies.

We find that having a common language in Europe is clearly positive for welfare of all locations in Europe. The magnitude of the effect, however, is heterogeneous across locations. Locations with a high share of English speaking population, such as the United Kingdom and Ireland gain relatively less than other locations in Europe, as the hypothetical European language replaces the continents current de-facto "lingua franca", English.

On the contrary, the elimination of all foreign languages in European countries has a negative impact on welfare throughout. The greatest losses are observed in locations in Ireland, the Benelux countries, Switzerland and Eastern Europe. These results suggest strong welfare gains from foreign spoken languages.

The overall quantitative effect of common languages on trade is widely recognized. Meta-analyses point towards an average elasticity of trade to a common language of about 0.5, i.e. a 50 % increase of trade in case of a common language vis-a-vis an otherwise identical trade relationship.[4] Typically, common language is proxied by a dummy that equals 1 if the countries share an official language and 0 otherwise. More closely related to this chapter, recent works consider a broader definition of language commonality. Following Melitz (2008), language commonality is defined as the probability of randomly "picking" two people in different countries that share the same language, which allows to distinguish official language from native and spoken language. They provide evidence that language as a means of communication between partners matters for trade. Melitz and Toubal (2014) construct a database on official, spoken and native language for 195 countries and use it to separately identify different channels through which language affect trade (communication versus culture and trust). Fidrmuc and Fidrmuc (2016) reaffirm the importance of the knowledge of foreign languages for trade using the Eurobarometer survey on spoken languages in 29 European countries.[5] For trade between their sample of 29 European countries, the coefficient on common spoken language (English, French, German) is 0.336 for the full sample and 1.097 for east-west country-pairs. Building on this existing literature, we focus

[4] Egger and Lassmann (2012) collect data from 701 language effects from 81 academic papers published between 1970 and 2011. The estimates vary from -0.57 to 1.85. The sample average is 0.49 and the standard deviation 0.34. The findings of Head and Mayer (2014) in their handbook chapter are very similar. They focus on 608 estimates of language effect from a restrictive sample of 159 papers. The median in the sample is 0.49, the mean is 0.54 while the standard deviation is 0.44.

[5] The languages included in their study are all EU official and regional languages, plus a set of non EU languages. See also figure 3.2 for a comparison between Eurobarometer data and our language measure derived from Twitter data.

on language as a vector of communication.

A key problem for the econometric identification of the effect of language on trade is that the coefficient of common language is likely to be biased by confounding factors. Papers such as Egger and Lassmann (2015), Lameli et al. (2015), and Sauter (2012) perform within country analyses to identify a causal impact of common language. Egger and Lassmann (2015) quantify the impact of native language on trade using spatial regression discontinuity design in the context of a multilingual country, Switzerland. They estimate semi-elasticities of common native language of 0.248 for the logarithm of the import value and 0.307 for the logarithm of the number of transactions. Sauter (2012) provides evidence of the importance of the communication channel at the intranational level using Canadian intra-provincial trade data for 38 industries (agriculture, manufacturing and services). He shows that the effect of spoken language on trade is stronger for industries that rely more on oral communication.

Despite the strong empirical evidence for the importance of languages for trade, almost all of these papers lack theoretical micro-foundations for the impact and typically do not quantify the general equilibrium effect of changes in the language distribution of a location. A rare exception to general equilibrium implications are Egger and Toubal (2016), who identify the general equilibrium effects of a five-percent increase in common spoken native and acquired languages across all 195 country-pairs on welfare. They show that the overall positive impact on welfare is heterogeneous across countries. Countries with smaller GDPs, bigger population and to a lesser extent more linguistically diverse tend to gain more, according to their exercise.

Measuring the language distribution at the level of a location, this chapter also contributes to the growing literature that suggest that taking internal geography seriously is essential to studying trade issues.[6] Following Ramondo et al. (2016), we depart from the usual assumption that countries

[6]See e.g. Allen and Arkolakis (2014), Coşar and Fajgelbaum (2016), Ramondo et al. (2016), Redding (2016) and Hinz (2016).

are fully integrated domestically as if they were a single dot in space. Instead, we treat countries as a collection of locations that face specific trade costs.

The remainder of the chapter is organized as follows. In section 3.2 we introduce our measure of language distribution using Twitter data. In section 3.3 we develop a micro-founded model with heterogeneous consumers and firms that allows for heterogeneity in spoken languages of economic agents. Finally, in section 3.4 we use the model and data and run several counterfactual analyses using different language distributions to evaluate the status quo of language diversity and study the impact of a change in the spatial distribution of languages on trade and welfare. Section 3.5 concludes.

3.2 A new proxy for spoken language using Twitter data

In gravity equations, language commonality is a standard component of bilateral trade costs, along with distance, contiguity, colonial links, free-trade agreements, or common currency. As a proxy for language commonality, most papers use the measures introduced by Melitz and Toubal (2014) available for 195 countries.[7] They built a common official language measure based on the CIA World Factbook, where they consider a set of 19 official languages. It is a country-pair-specific dummy that equals one if the two countries have the same official language and zero otherwise. They also provide measures for common native language and common spoken language. For a given country-pair, it is the probability of randomly picking two people that "share" the same language. For each language they take the product of the proportion of people speaking this language in the two countries, and then sum over all languages. To construct these two measures, they need to assess the proportion of people speaking a

[7]The dataset is publicly available on the website of the CEPII.

given language (native or acquired) in each country. To do so, they use several distinct sources. Their main source is the Eurobarometer survey conducted on 28,694 citizens between November and December 2005 in 28 European countries and Turkey. For other countries, Melitz and Toubal (2014) gather information from both Wikipedia and Ethnologue website. Given its large country-coverage, this database constitute a tremendous improvement with regard to previous database for gravity estimation. Yet, there are room from improvement for their measure of spoken language.

One major concern is the fact that they convey heterogeneous sources to quantify the proportion of speakers of a given language. Different sources means different years of data collection, different samples, but more importantly different definitions for spoken language. As their measure of language commonality is the product of two proportions, it is all the more crucial that the proportions are defined in a consistent way across countries. One must have a consistent method of assessing the ability of people to speak a language across countries. In that respect, the Eurobarometer survey is ideal as each individual interviewed was asked two specific questions about their language use: "What is your maternal language? " and "Which language do you speak well enough in order to be able to have a conversation, excluding your mother-tongue? ". With these questions, one makes a distinction between native and acquired spoken languages, and ensures that there is a common criteria for the self-assessment of language proficiency. An individual is a German speaker if and only if he can have a conversation in German. Other sources, however, may not be as clear and consistent on their definition of acquired foreign languages. This is a problem as the proportion of people speaking a given language might be significantly different if the ability of speaking a language is assessed by the language studied at school, relying on self-assessment, by certificate of language proficiency or by any other means. As a matter of fact, in Melitz and Toubal (2014) database, countries for which they have used Eurobarometer data have significantly more foreign languages than any other country. For instance, 97 percent of the Australian population speaks English but no other language, 97 percent of

the population in the United States speaks English and 16 percent speaks Spanish; while in the United Kingdom 99 percent of the population speaks English, 23 percent of the population speaks French, 9 percent speaks German, 8 percent of the population speaks Spanish. While this might be due to the intrinsic language diversity of European countries, it is very likely driven by underlying definitions and methods.

Using Twitter data, we propose a new measure for spoken languages available for a great number of countries (i.e. the countries where Twitter is used by a significant proportion of the population). Twitter is an outlet through which people can share thoughts with a wide audience of speakers of the same language and discuss topics of interests with this community. Language is key for interactions on this platform. As Sloan et al. (2013), researchers in social sciences have exploited tweets to proxy language proficiency. The first advantage of using Twitter is that it provides a standard way of assessing spoken languages over a large sample of countries. Indeed, each of the tweets carries, next to the written message itself, further information about the tweet and the user. Among the variables is a Twitter-generated variable on the language of the tweet itself, using a machine learning algorithm. A user then is defined as a language speaker if he tweets at least once in this language. The underlying assumption is that if a person decides to tweet in a given language it is a proof of his ability to speak and understand this language. Given that Twitter is mostly about sharing content and discussing with the community, this assumption seems reasonable. Under these circumstances, it would not be rational for a user to tweet in a language he is not able to understand. It is important to stress that we focus on the number of individuals that tweet in a language rather than on the number of tweets in a given language. While the number of tweets in a language is likely to be influenced by the trends, the topics, the interests, the choice of tweeting in one language should not. To built our measure, we recorded 1 percent of geolocated globally sent tweets between November 2016 and May 2017—clocking in at around 60 per second and totalling nearly 1 billion. As shown in Figure 3.2, our data aggregated at country-level is

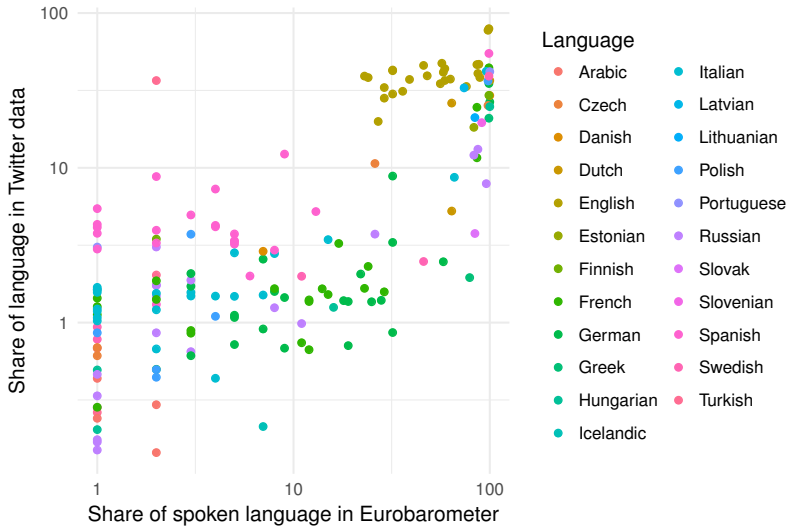


Figure 3.2: Share of spoken languages in Eurobarometer and on Twitter, correlation of 0.74.

consistent with the Eurobarometer survey for European countries.

On top of the language of the tweet, for the tweets from users who allows Twitter to record the GPS location of the device, Twitter provides the latitude and longitude from which the user tweeted. Thus, using Twitter data, we can build a consistent measure for spoken language at country-level but also at any geographic level (region, department, city, a location). Melitz and Toubal (2014) measures, as most of the other spoken languages measures used in the literature, are at the country-level. Only few studies have used lower level of disaggregation - regional at most, and usually focus on one country. Egger and Lassmann (2015) uses data from 1990 Census of the Swiss Federal Statistical Office to measure native language within Switzerland. Lameli et al. (2015) uses historical data on the use of German dialect in 101 German region units in the late nineteenth century. Sauter (2012) built a measure of language commonality between Canadian provinces as the probability that any two people from different provinces picked at random will be able to communicate with each other, but only considers English, French and Chinese. For the two official languages of Canada (French and English), he uses information on mother tongue, knowledge of official language and use of language at work



Figure 3.3: Distribution of tweets by language in Europe. Different colors represent different languages.

from the Census survey; while for Chinese he proxies it by the share of population with Chinese origin in a province. These country-specific studies revealed significant intra-country heterogeneity in language use, which can definitely not be captured by aggregate measures. To study the effect of spoken acquired language, it is then essential to use more disaggregated data. Twitter data in that respect is a great step forward.

Figure 3.3 shows that there is a large diversity in language use not only across countries, as displayed in figure 3.1, but also *within*. Here we plot all tweets in minority languages in Europe, that is to say we remove those sent in the respective country's majority language.[8]

Other promising sources for data on language use at lower level of disaggregation are the UK Census and the American Community Survey. Questions on language use were integrated with the same aim to help central government, local authorities to provide services for non-English

[8]Note again the Spanish region of Catalonia that has retained its color.

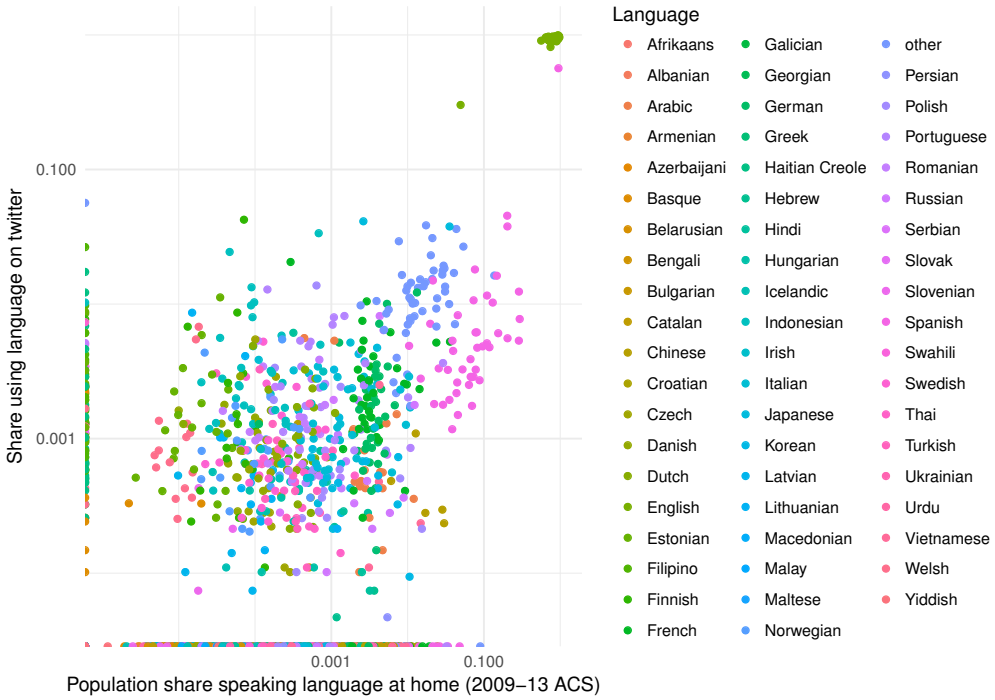


Figure 3.4: US population and unique Twitter users by language for US States.

speakers. Thus, they concentrate on native rather than acquired foreign language. Interviewees in the UK Census were asked what is their " main language" while they were asked about " language spoken other than English at home" in the American Community Survey. Our measure is more general than any of these two measures, in the sense that it includes both native language and acquired foreign language. One does not expect a perfect correlation between these two measures and ours, but they should be at least consistent with one another. We aggregate our measure at US state-level in order to compare it with US American Community Survey.

Figure 3.4 plots the measure of spoken language at home taken from the American Community survey 2009-2013 for each of the 50 US States against our measure aggregated at the state-level. There is a clear positive correlation between the two measures. We then aggregate the responses on " main language" from the 2011 UK Census data to a grid of 6 arc minutes, i.e. one tenth of a degree yielding 3023 unique locations in

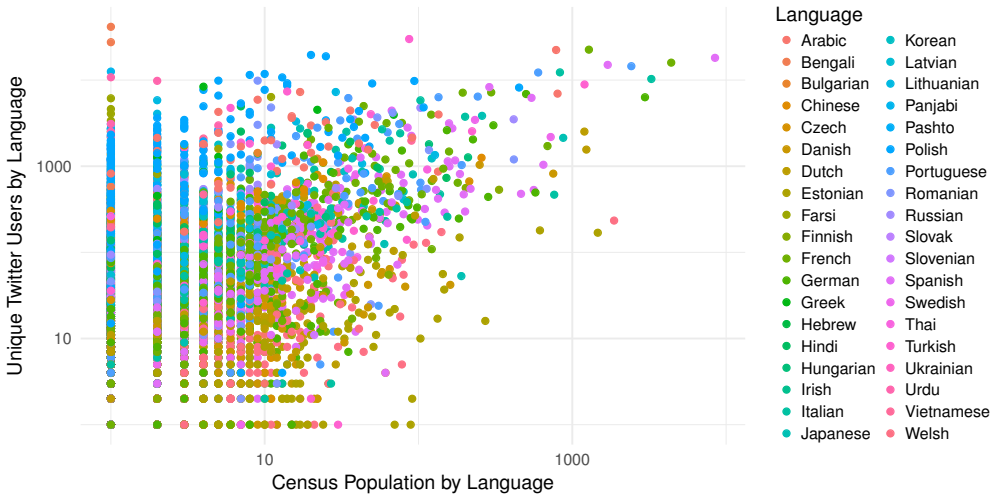


Figure 3.5: UK population and unique Twitter users by language aggregated to grid, correlation 0.45

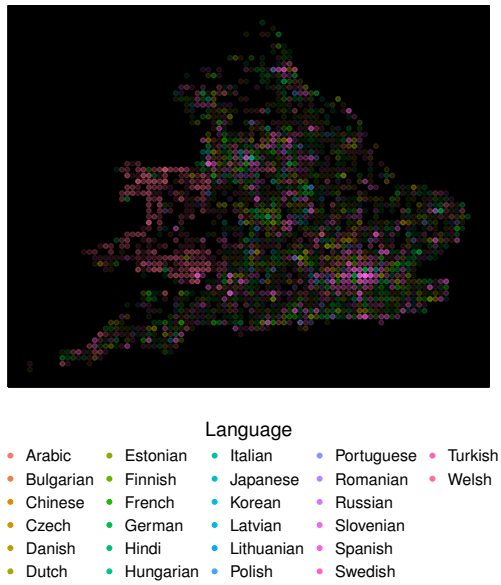


Figure 3.6: Geographic distribution of most tweeted minority language aggregated to grid

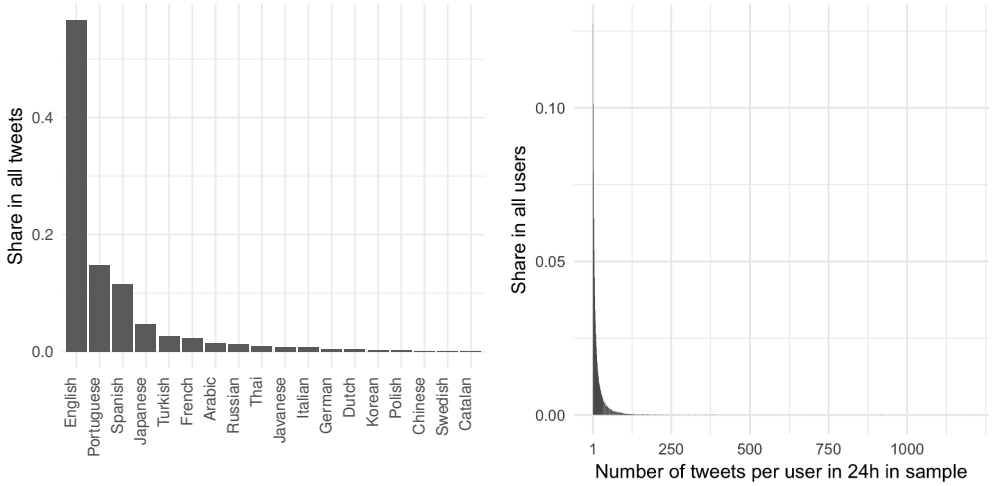
the UK, and aggregate our language measure to the same level. Figure 3.5 plots the measure of main language taken from the 2011 UK Census against ours. The correlation between the two measures is positive. Figure 3.6 displays the geographic distribution of most tweeted minority language aggregated to the previously defined grid. Consistently with figure 3.3 for

Europe as a whole, it shows diversity in language use within UK borders. These are additional evidence that our measure is able to capture both inter and intra country heterogeneity of language use.

In order to use the data for our purpose, however, we clean it in several respects. First, not every tweet may be sent from a human, as so-called *bots*, automatic non-human contributors to the service, make up a significant share of tweets. We follow Chu et al. (2012) and detect humans by the device used to tweet and limit the data to those tweets sent out from mobile devices and the official Twitter app. More specifically we restrict the sample to tweets emitted from the following list of devices and Twitter apps: "Twitter for Nokia", "Twitter for iPhone", "Twitter for Android", "Twitter Web Client", "Twitter for iPad", "Twitter for Windows", "Twitter for BlackBerry". The share of tweets by bots turns out to be about 15 %. Second, we are interested in the use of languages by humans, and not their frequency of using Twitter. As figure 3.7b shows for a sample of 24 hours, most tweet rarely, but some are avid users with about 1 tweet per minute. Hence, we restrict the sample to only *one* tweet per user and language after removing so-called *retweets*.[9] Over the time span from November 2016 to May 2017, out of a sample of about 1 billion tweets, we observe 516,367 unique human Twitter users that use 73 different languages to tweet. 18 percent of users tweet in more than one language, resulting in 722,044 unique language-user observations.

One might worry that Twitter data is biased toward urban areas given that people living in these areas might be more prone to use Twitter that people living in rural areas. We use 2011 UK Census population data aggregated at the same grid as for previous figures to test this hypothesis. For each cell in the grid, we match the number of observed unique Twitter users in our sample with the observed UK population. Figure 3.8 displays the geographic distribution of unique Twitter users, this seems to replicate quite well the distribution of the population in the UK territory. We plot

[9] *Retweets* are essentially a way to relay *tweets* of other users. Hence they may show basic understanding of a given language, but may not necessarily capture the ability for active use of that language.



(a) Share of tweets per language in 24h **(b)** Tweets per user in 24h

Figure 3.7a only shows those languages whose share is larger or equal than 1 percent. Other languages in the data in order of frequency over the captured 24 hours include Finnish, Greek, Ukrainian, Czech, Danish, Serbian, Hebrew, Norwegian, Hungarian, Vietnamese, Romanian, Hindi, Farsi, Croatian, Bulgarian, Latvian, Malaysian, Slovak, Basque, Irish, Belarussian, Urdu, Bengali, Bosnian, Albanian and Afrikaans.

Figure 3.7: Descriptive statistics for Tweets over select 24h sample

the UK Census population in each cell against the number if observe unique twitter users in Figure 3.9. The correlation between the two measures being of 0.72, we can confidently state that Twitter are spread in a representative way in the UK.

3.3 Gravity with Language

The model explicitly incorporates language as a major determinant of interactions on the market. Language matters both on the demand and the supply side. Consumers are heterogeneous in terms of language, each consumer speak exactly one "core" language.[10] We assume that a consumer

[10]The consumer may speak other language. But for her consumption choices' the only one that matters is the "core" language or to paraphrase the UK Census, "main language". The "core" language is the one that she prefers to use, which may be different from her mother-tongue.

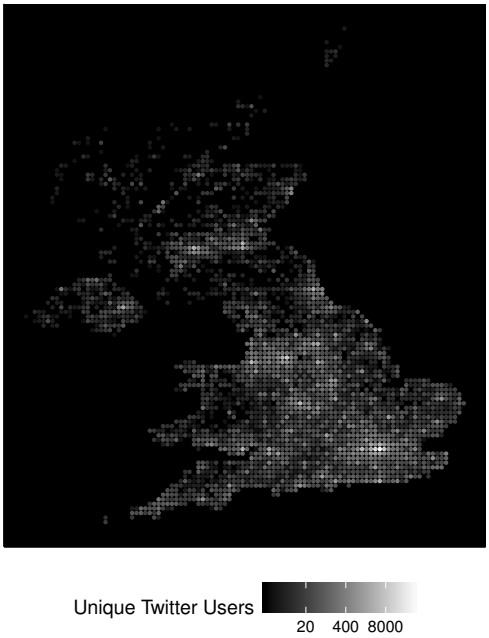


Figure 3.8: Geographic distribution of unique Twitter users aggregated to grid

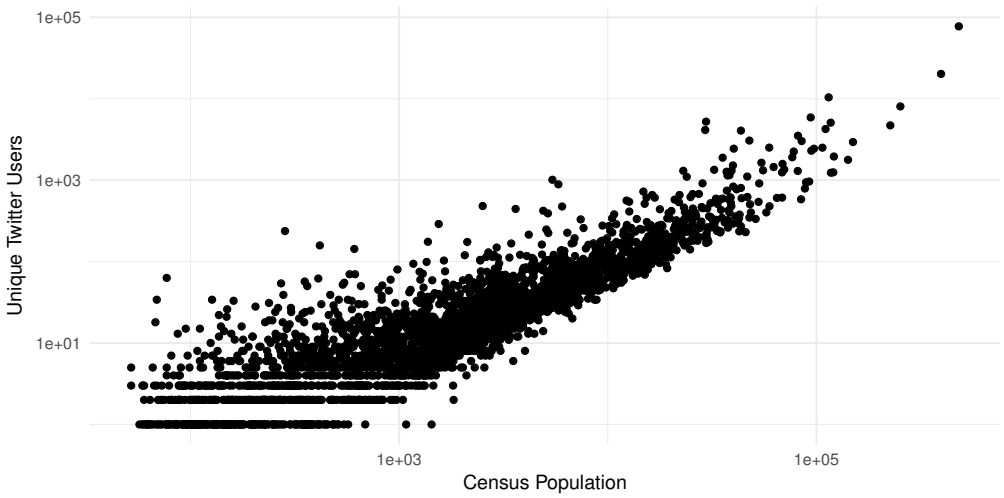


Figure 3.9: UK population and unique Twitter users aggregated to grid, correlation 0.72

will eventually consumes only the goods sold in that language- a good for which the label, the manual or the commercials are in her language. This is deemed crucial to fully understand the characteristics of the product. In a German supermarket, one would have to know basic German to be

able to identify "mineralwasser" as being sparkling water. On the supply-side, firms, are heterogeneous in terms of productivity, which eventually influences the language(s) they choose to sell in. We assume that firms have to pay a fixed cost to be able to sell their good in a given language i.e. produce the label, communicate with the potential consumers, advertise their product.[11] The fixed cost of investing in a language is proportionally related to the number of people speaking that language in their location. Therefore, firms will be more likely to invest in a given language the more people speak that language in their location and the closer they are to the consumers who speak that language. Echoing Willy Brandt's quote, firms are the ones who adjust to the consumers' language requirements.

3.3.1 Distribution of Languages across Space

Any given location t has a distribution of languages from which a local resident j draws her "main" language. ω_t follows a generalized Bernoulli distribution and can take discrete outcomes such as "German" or "Xhosa". Let $\mathbf{l}_{jl}(\omega_t) = [\omega_t = l] \in \{0, 1\}$ then denote an indicator of j's draw from the local language distribution. Furthermore—and at the risk of abusing the notation—let $\mathbf{l}_{tl}$ denote the share of residents at t who drew the realization l.

3.3.2 Demand

Consumer j located in d (destination) and who speaks language l derives utility from the consumption of a differentiated good q_i produced by firm i located in o (origin). She could in principle pick any of all available variety on her local market. Yet, she gets an infinite disutility in consuming a product that is not sold in her main language. As she chooses the variety that maximize their utility, she will pick a product in the set of

[11] We do not assume that firm change the core characteristics of the product.

varieties offered in the language that she speaks. Conditional on a firm i selling her product in language l, whether her variety is actually chosen by consumer j depends on the idiosyncratic term ϵ_{ij}. For readability, the respective additional subscripts to i and j are suppressed when not necessary. Following Anderson et al. (1992), the conditional direct utility function is then given as

$$\tilde{U}_{ij} = \mathbf{l}_{jl}(\omega_d) q_{ij} \epsilon_{ij}$$

Maximizing utility subject to income e_j and prices p_{id} this yields the consumer's log conditional indirect utility

$$\tilde{V}_{ij} = \ln e_j - \ln p_{id} + \ln \mathbf{l}_{jl}(\omega_d) + \ln \epsilon_{ij}$$

p_{id} is the price of firm i's variety when delivered to location d. With ϵ_{ij} varying over consumer-firm pairs, consumers and firms in the same locations make different choices to match. Further assuming ϵ_{ij} to be Fréchet-distributed with shape parameter θ, the probability of consumer j in d choosing the variety produced by firm i is given by

$$\begin{aligned} \mathbf{P}\left(\tilde{V}_{ij} > \tilde{V}_{hj} \; \forall \; h \neq i\right) &= \mathbf{l}_{dl} \frac{p_{id}^{-\theta}}{\sum_{h \in \Omega_d} p_{hd}^{-\theta}} \\ &= \mathbf{l}_{dl} p_{id}^{-\theta} P_d^{\theta} \end{aligned} \tag{3.1}$$

where Ω_{dl} is the set of firms offering their products in d in language l, and therefore $P_{dl} = \left[\sum_{h \in \Omega_{dl}} p_{hd}^{-\theta}\right]^{-1/\theta}$ is the price index for those goods sold in d. Expected demand for variety i offered in language l in destination d is then

$$\begin{aligned} \mathbf{E}(Q_{idl}) &= E_d P_{dl}^{\theta} p_{id}^{-1} (\mathbf{l}_{dl} p_{id}^{-\theta}) \\ &= E_d P_{dl}^{\theta} p_{id}^{-1-\theta} \mathbf{l}_{dl} \end{aligned} \tag{3.2}$$

where $E_d = \sum_{j \in d} e_j$ is the total expenditure in d. Expected demand for a variety i offered in language l across all locations is correspondingly

$$\mathbf{E}(Q_{il}) = \sum_d E_d P_{dl}^{\theta} p_{id}^{-1-\theta} \mathbf{l}_{dl} \tag{3.3}$$

3.3.3 Language investments

As in Head et al. (2017) and Eaton et al. (2013) there is a finite number of firms N_o in location o that each draw a parameter a_i from the distribution of marginal costs $G(a)$. The cost of the local input bundle is denoted c_o and transportation costs to the destination location d are iceberg τ_{od}. Firms further decide which language they offer their products. Selling a product in a given language implies labelling the product in that language, translating the manual, advertising the product in that language, and interacting with potential consumers in that language. It does not imply a change of the core characteristics of the product. To be able to sell their product in a given language, firms have to make an investment. We assume that they have to pay a fixed cost F_{ol} that depends on the availability of residents in the firm's location o that speak a language l. The intuition is as follows: the more people speak a language in a location, the easier it is for firms to employ someone who speaks this language, the lower the fixed cost F_{ol} is. It is important to note that here we are interested in workers language skills, i.e. not only the "main" language but all the languages spoken in a location matter.[12] Firms learn their efficiency and decide on selling their products in a given language and pricing prior to the consumer's draw of ϵ_{ij}. Firm i's expected profit from selling their products in language l in d are then

$$\mathbf{E}(\Pi_{idl}) = (p_{id} - \tau_{od} c_o a_i) \cdot \mathbf{E}(Q_{idl}) - \alpha_{idl} F_{ol} \tag{3.4}$$

where $\sum_d \alpha_{idl} = 1$, as each destination needs to cover part of the firm's fixed cost to sell in language l. With small enough firms the price charged

[12] F_{ol} is relates to a broader definition of spoken language.

by firm i in destination d is

$$p_{id} = \tau_{od} c_o a_i [(\theta + 1)/\theta] \tag{3.5}$$

Combining these prices with equations (3.1) and (3.2) and plugging into equation (3.4) yields

$$\begin{aligned} \mathbf{E}(\Pi_{idl}) &= (p_{id} - \tau_{od} c_o a_i) \cdot \mathbf{E}(Q_{idl}) - \alpha_{idl} F_{ol} \\ &= \lambda (\tau_{od} c_o a_i)^{-\theta} E_d P_{dl}^{\theta} \mathbf{l}_{dl} - \alpha_{idl} F_{ol} \end{aligned}$$

with $\lambda = \theta^{\theta}(\theta+1)^{-(\theta+1)}$. Whether a firm in o sells in language l, i.e. is part of the set of firms Ω_l, depends on whether

$$\begin{aligned} & \mathbf{E}(\Pi_{il}) > 0 \\ \Leftrightarrow \sum_d \lambda (\tau_{od} c_o a_i)^{-\theta} E_d P_{dl}^{\theta} \mathbf{l}_{dl} - \alpha_{id} F_{ol} &> 0 \\ \Leftrightarrow \lambda (c_o a_i)^{-\theta} \sum_d \tau_{od}^{-\theta} E_d P_{dl}^{\theta} \mathbf{l}_{dl} &> F_{ol} \end{aligned}$$

Hence the marginal cost cut-off for a firm from location o to sell in language l is given by

$$\begin{aligned} a_{ol}^{\star} &= \left[\lambda^{-1} c_o^{\theta} F_{ol} \left(\sum_d \tau_{od}^{-\theta} E_d P_{dl}^{\theta} \mathbf{l}_{dl} \right)^{-1} \right]^{-1/\theta} \\ &= c_o^{-1} \left(\lambda^{-1} F_{ol} \right)^{-1/\theta} \Phi_{ol}^{-1} \end{aligned}$$

with $\Phi_{ol} = \left(\sum_d \tau_{od}^{-\theta} E_d P_{dl}^{\theta} \mathbf{l}_{dl} \right)^{-1/\theta}$ being the outward multilateral resistance term of location o in language l. Only the firms in o with a marginal cost lower or equal to this cut-off will sell their products in language l. We denote this subset of firms Ω_{ol}, with N_{ol} being the number of firms in this subset. The cost cut-off negatively depends on the fixed-cost of investing in language l in o. The more people speak a language in o, the easier it is for firms to invest in language l.

To identify this subset of firms, we need to further specify a. We assume

that firms draw their marginal cost a_i from an underlying Pareto distribution bounded between 0 and 1 with shape parameter γ[13]. As in Crozet and Koenig (2010) the marginal cost is then distributed as

$$P(\tilde{a} \leq a) = G(a) = a^{\gamma}$$

where γ is an (inverted) measure of the heterogeneity of firms. The expected number of firms in o that will sell their products in language l is then given by

$$\begin{aligned} N_{ol} &= N_o \cdot P(a \leq a^{\star}_{ol}) \\ &= N_o \cdot G(a^{\star}_{ol}) \end{aligned} \tag{3.6}$$

3.3.4 Gravity

Multiplying firm-level demand and price functions, and summing over firms i yields the *expected* gravity between locations o and d in language l:[14]

$$\begin{aligned} E(X_{odl}) &= \sum_{h \in \Omega_{ol}} p_{hd} E(Q_{hdl}) \\ &= \sum_{h \in \Omega_{ol}} (\tau_{od} c_o a_h [(\theta+1)/\theta])^{-\theta} E_d P_{dl}^{\theta} \mathbf{l}_{dl} \\ &= \lambda(\theta+1) c_o^{-\theta} E_d P_{dl}^{\theta} \mathbf{l}_{dl} \tau_{od}^{-\theta} \sum_{h \in \Omega_{ol}} a_h^{-\theta} \end{aligned} \tag{3.7}$$

The sums over the productivity draws $\sum_{h \in \Omega_{ol}} a_h^{-\theta}$ reflect the extensive and intensive margin of firms in the gravity equation. Given the assumption of drawing the marginal cost parameter from a Pareto distribution, these

[13] Consistently with the literature, we assume that $\gamma > \theta$.

[14] Note that in the following we drop the "in expectations" notation for the ease of reading.

sums can be expressed as

$$\begin{aligned}\sum_{h\in\Omega_{ol}} a_h^{-\theta} &\approx N_{ol}\frac{1}{G(a_{ol}^{\star})}\int_0^{a_{ol}^{\star}} a^{-\theta}\, dG(a)\\ &= N_{ol}\frac{\gamma}{\gamma-\theta}a_{ol}^{\star\,-\theta}\end{aligned} \tag{3.8}$$

so that

$$\begin{aligned}E(X_{odl}) &= \lambda(\theta+1)c_o^{-\theta}E_d P_{dl}^{\theta}\mathbf{l}_{dl}\tau_{od}^{-\theta}\sum_{h\in\Omega_{ol}} a_h^{-\theta}\\ &= \lambda(\theta+1)c_o^{-\theta}E_d P_{dl}^{\theta}\mathbf{l}_{dl}\tau_{od}^{-\theta}N_{ol}\frac{\gamma}{\gamma-\theta}a_{ol}^{\star\,-\theta}\\ &= \lambda^{-1}(\theta+1)\frac{\gamma}{\gamma-\theta}\times N_{ol}\times E_d P_{dl}^{\theta}\times\tau_{od}^{-\theta}\times\Phi_{ol}^{\theta}F_{ol}\mathbf{l}_{dl}\\ &= \lambda^{\frac{\gamma}{\theta}-1}(\theta+1)\frac{\gamma}{\gamma-\theta}\times N_o c_o^{-\gamma}\times E_d P_{dl}^{\theta}\times\tau_{od}^{-\theta}\times\Phi_{ol}^{-(\gamma-\theta)}F_{ol}^{-(\frac{\gamma}{\theta}-1)}\mathbf{l}_{dl}\end{aligned} \tag{3.9}$$

Summing over all languages yields gravity between locations o and d for all languages

$$\begin{aligned}E(X_{od}) &= \sum_l X_{odl}\\ &= \lambda^{\frac{\gamma}{\theta}-1}(\theta+1)\frac{\gamma}{\gamma-\theta}\times N_o c_o^{-\gamma}\times E_d P_d^{\theta}\times\tau_{od}^{-\theta}\times\sum_l \mathbf{l}_{dl}\Phi_{ol}^{-(\gamma-\theta)}F_{ol}^{-(\frac{\gamma}{\theta}-1)}\end{aligned} \tag{3.10}$$

We define Φ_o as the outward multilateral resistance term of location o. We can then write X_{od} as follows:

$$E(X_{od}) = G\times\frac{Y_o}{\Phi_o^{-\theta}}\times\frac{E_d}{P_d^{-\theta}}\times\phi_{od} \tag{3.11}$$

where $G=\lambda^{\frac{\gamma}{\theta}-1}(\theta+1)\frac{\gamma}{\gamma-\theta}$, $Y_o = N_o c_o^{-\gamma}$, and $\phi_{od}=\tau_{od}^{-\theta}\times L_{od}$. The language

term L_{od} is defined as:

$$\begin{aligned} L_{od} &= \sum_{l} \mathrm{l}_{dl} \times \frac{\Phi_{ol}^{-(\gamma-\theta)}}{\Phi_{o}^{\theta}} F_{ol}^{-(\frac{\gamma}{\theta}-1)} \\ &= \sum_{l} \mathrm{l}_{dl} \times \frac{\Phi_{ol}^{\theta}}{\Phi_{o}^{\theta}} \frac{F_{ol}^{1-\frac{\gamma}{\theta}}}{\Phi_{ol}^{\gamma}} \\ &= \sum_{l} \mathrm{l}_{dl} \times \mathrm{l}_{ol} \end{aligned} \tag{3.12}$$

This language term is interestingly rather close to the measures used in the literature for proxying common language in a gravity equation as it is the probability that two people picked at random in two different locations can interact with one another. However, while the usual measure used in the literature use the same proxy for origin and destination, our model advocates for a slight difference in the measurement of the language at the origin (supply-side driven) and the destination (demand-side driven). l_{dl} is the share of consumer in destination d for whom l is their "main" language in our model. l_{ol} is a bit more complex. It depends negatively on F_{ol}, which is a function of the number of workers in location o that can speak language l, no matter if l is their main language or not, and of the market-access on location o to consumers speaking l.

3.4 Counterfactuals

3.4.1 Computing counterfactuals

As our model delivers a structural gravity that is very close to the general structural gravity equation of Anderson and Van Wincoop (2003), in the following we adopt their modular approach to evaluate the general equilibrium effects of changes of language distribution at the level of a location. For the sake of simplification, we abstract from the extensive margin of firms and rewrite the multilateral resistances terms as

$$P_d = \left[\sum_o \frac{Y_o}{\Phi_o^{-\theta}} \phi_{od} \right]^{-\frac{1}{\theta}} \tag{3.13}$$

$$\Phi_o = \left[\sum_d \frac{E_d}{P_d^{-\theta}} \phi_{od} \right]^{-\frac{1}{\theta}} \tag{3.14}$$

Then, combining equations (3.11), (3.13), and (3.14), flows from location o to location d can be expressed as a function of $\mathbf{l}_{ol}$:

$$X_{od}(\mathbf{l}_{ol}) = \frac{Y_o}{\Phi_o(\mathbf{l}_{ol})^{-\theta}} \frac{E_d}{P_d(\mathbf{l}_{ol})^{-\theta}} \phi_{od}(\mathbf{l}_{ol}) \tag{3.15}$$

A different distribution of languages in location o (or d for that matter), e.g. instead of $\mathbf{l}_{ol}$ assuming a counterfactual distribution of $\mathbf{l}'_{ol}$, affects directly the trade cost $\phi_{od}(\mathbf{l}'_{ol})$, but also indirectly the multilateral resistances, i.e. $\Phi_o(\mathbf{l}'_{ol})^{-\theta}$ and $P_d(\mathbf{l}'_{ol})^{-\theta}$.

The respective multilateral resistance terms under a counterfactual distribution of languages with $\phi'(\mathbf{l}'_{ol})$ can be computed by iteratively solving the following system of matrix equations:

$$(P')^{-\theta} = \phi'(\mathbf{l}'_{ol})^{\mathrm{T}} \left(Y \otimes (\Pi')^{-(\theta+1)} \right) \tag{3.16}$$

$$(\Phi')^{-\theta} = \phi'(\mathbf{l}'_{ol}) \left(X \otimes (P')^{-(\theta+1)} \right) \tag{3.17}$$

where $(\Phi')^{-\theta}$ and $(P')^{-\theta}$ are vectors of (counterfactual) outward and inward multilateral resistances. $(\Phi')^{-(\theta+1)}$ and $(P')^{-(\theta+1)}$ are vectors of elementwise inverses of $(\Phi')^{-\theta}$ and $(P')^{-\theta}$, and $\otimes$ denotes the elementwise product. Iterating over equations (3.16) and (3.17) until convergence yield the modular counterfactual flows of goods between all locations under a counterfactual distribution of languages.

3.4.2 Counterfactuals

We now proceed to the computation of several instructive scenarios with counterfactual distributions of languages across space. These counterfactuals allow us to evaluate the status quo, as well as the effects of certain hypothetical policy measures on the welfare of each location. We limit the presentation of the results to the geographical space of Europe, while taking all other non-European countries into account in the computation itself. In the following, welfare is defined as real consumption, i.e. expenditure discounted by the price index. We aggregate the data to a spatial resolution of 30 arc minutes, or 0.5 degrees, yielding 3,408 locations in Europe. A location is then an area in which the average distance is 14.8 kilometers.

In order to compute counterfactual outcomes using equation (3.15), we need to make a number of assumptions. First, we treat each country outside Europe as a single location.[15] This simplifying assumption is necessary for computational purposes and due to the imperfect data coverage in some countries, and likely leads to distortions in European locations close to those countries. From here on we refer to all locations and other countries simply as locations. Second, we proxy for production and expenditure by country GDP[16] and spatially distribute shares by density of Twitter users for our 3,408 locations in Europe. Third, we specify trade costs ϕ_{od}, in addition to language, to be determined by wide-recognized standard gravity covariates. These include the bilateral distance, the existence of an economic integration agreements between the respective locations, as well as a common currency. Following the meta-analysis conducted by Head and Mayer (2014), we assume the elasticity of trade to distance to be -0.89, to an FTA to be 0.47, and to a common currency to be 0.87. Data on distances between countries are taken from Hinz (2016) and computed with Hinz's method for those between locations.[17] Data

[15] In that respect, the United States (as any other non-European country) is considered as one location with one language distribution.

[16] GDPs are taken from the World Bank Development Indicators database in 2006.

[17] Distances between locations and countries are computed as the sum of the distance

on FTAs and Currency Unions are taken from CEPII. Furthermore, we set these variables to 1 within countries and within locations.

We compute the common language variable L_{od} between locations using the derived distribution of languages across space according to equation (3.12) as

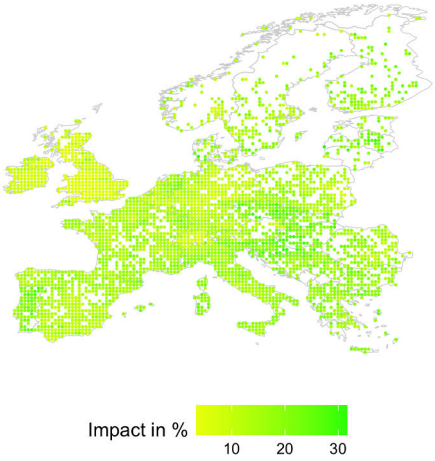
$$L_{od} = \sum_{l} \mathbf{l}_{ol}\mathbf{l}_{dl} \tag{3.18}$$

As previously discussed, in principle, one must use different proxies for $\mathbf{l}_{dl}$ and $\mathbf{l}_{dl}$. This is however not possible in practise as Twitter does not allow a distinction between core and other spoken languages. For the counterfactual, we use our measure of language use in a given location computed with Twitter data to compute the language term between all locations in Europe. As Twitter does not cover the whole universe considered in our counterfactuals, for the language use in countries outside the EU, we use data on spoken languages from Melitz and Toubal (2014). Again following Head and Mayer (2014) we set the elasticity of trade to a shared language to 0.49.

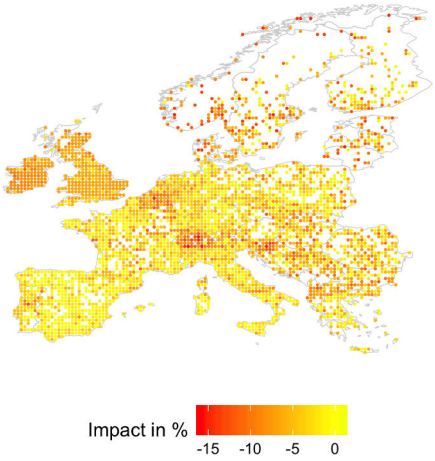
Cross-country integration

We first use our model to compute counterfactual welfare for distributions of languages that characterize cases of cross-country integration (or lack thereof) in Europe. One extreme scenario would be a common European language, spoken by all inhabitants of the continent. In the other extreme scenario, we quantify the economic value of the current diversity of languages within Europe by moving from the current language distribution to a situation where there is no within-country language diversity, i.e where the only spoken language within a country is the official language(s). In a sense this is the language-equivalent to autarky—hence evaluating the

to the "host" country of the location and the distance of the location to the "average" location in that country.



(a) Welfare impact of a hypothetical new common European language spoken by every inhabitant next to local languages.



(b) Welfare impact of eliminating within-country language diversity from European countries and allowing only domestic language.

Figure 3.10: Welfare impact of cross-country integration

status quo.

Scenario 1: Common European language We create an additional language and attribute it to all locations in Europe, and Europe exclusively.[18] The expected effect is positive: enabling frictionless communication across the vast European continent should increase welfare significantly. The results of this scenario are reported in figure 3.10a. The effect is indeed clearly positive on the welfare of European locations. Everyone in Europe benefits from the removal of the language barrier. However, the magnitude of the effect is heterogeneous across locations. Locations in the United Kingdom and Ireland would gain relatively less than other locations in Europe, while Eastern European locations gain more. The reason behind this is clear: English was already spoken in many locations, hence the change in easy of communication is less drastic for the British Isles than for most of continental Europe.

Scenario 2: Impact of within-country language diversity In a second scenario we evaluate the current status quo of language diversity—by imposing the analogous situation to a move from free trade to autarky: removing language diversity. Only official domestic languages are now spoken in the respective European countries. The expected impact is negative: Trade is largely limited to within-country exchanges between locations, except for those with other countries sharing the official language inside and outside of Europe. This dramatically effects the price index of affected countries. From figure 3.10b, we see that the elimination of within-country language diversity in European countries indeed has a strong negative impact on welfare. Implicitly, it points toward the importance and economic value of language diversity and foreign languages. The greatest losses are observed in locations in Ireland, the Benelux countries, Switzerland and Eastern Europe. The results from this scenario underline the anticipation of positive economic effects of multilingualism outlined in the Barcelona objectives. Another observation relating to scenario 1 is

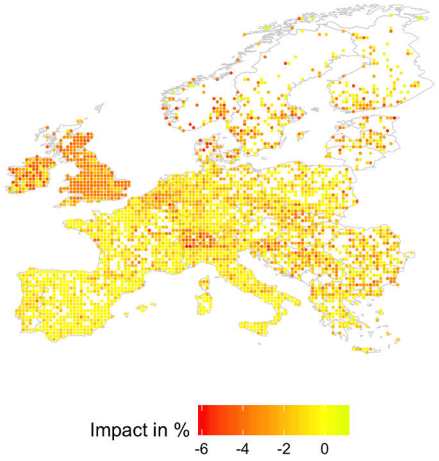
[18]Another possibility would of course be to pick an existing European language, like English or French. The results would impact results however, as countries like the UK, or France, would see only minor changes, as little changes there. Furthermore, countries outside of Europe also speaking this existing language would influence the impact.

noteworthy: the change in welfare of moving to homogeneous countries in terms of language is quantitatively smaller than moving to a shared European language. This points to large gains still waiting to be realized from educational policies towards multilingualism.

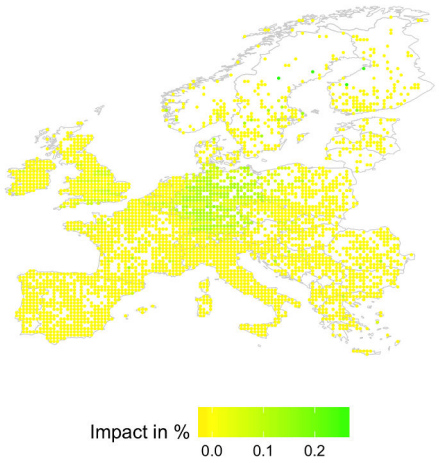
Country-specific policies

We now refocus to analyze the effect of country-specific policies. We first look at the impact of eliminating all foreign languages in the United Kingdom. In times of Brexit and uncertainty for citizens from other EU member states living in the UK, this scenario may be particularly instructive and, unfortunately, more realistic than the previous two. In the last scenario we consider another counterfactual distribution of languages that is also not entirely unrealistic in light of recent migration flows. We here assume a scenario in which 10 percent of the population in Germany speaking is speaking Arabic.

Scenario 3: Elimination of all foreign languages in the United Kingdom In this scenario we evaluate the extreme case of a return to an exclusively English-speaking United Kingdom. As in scenario 2, it can also be interpreted as the current welfare gains from language diversity. The expected impact is overall negative, in particular for the United Kingdom. As shown in Figure 3.11a, all locations in the United Kingdom indeed experience a reduction in welfare following this policy. Ireland, next door neighbor with English as the most dominant language as well, is similarly harshly affected. While most of continental Europe is not as severely affected, locations in Eastern Europe and the Benelux countries also experience a moderately high reduction in welfare. This is likely to stem from two sources: Either the location exhibits a high share of those languages that were eliminated from the UK, hence decreasing possible trade links there; Or the respective location hosts a significant English-speaking population that is now faced with lower demand or supply from



(a) Welfare impact of eliminating all foreign languages from the United Kingdom.



(b) Welfare impact of 10 percent of population speaking Arabic in Germany.

Figure 3.11: Welfare impact of migration

the United Kingdom. Overall, the magnitude of the effect is significantly smaller than the one in scenario 2.

Scenario 4: Migration of Arabic-speaking population to Germany In the final scenario we analyze the effects of a significant increase in the number of Arabic-speaking people in Germany to 10 % of the overall

population. The scenario is not too far removed from reality, as in the past years migration flows to Germany have been increasing, in particular driven by refugees from the Middle East. The results of the last scenario are reported in 3.11b. The increase in people speaking Arabic in Germany has, compared to the previous scenarios, a rather small, but positive effect for locations in Germany. Noticeable is also a slight positive increase in a number of other European locations. These are characterized by already having a significant share of citizens speaking Arabic.

The four counterfactual scenarios showcase the value of the model set up in section 3.3. Fueled with data on actual and counterfactual spatial distributions of language, in our case with novel data derived from Twitter as introduced in section 3.2, we can use the framework to evaluate the status quo of language diversity, as well as provide estimates for the impact of certain policy measures. Three broader lessons can be learned: The magnitude of the welfare effects of common languages and language diversity, both in terms of reaped gains and those still to be reaped, are substantial; the impact of hypothetical changes to the language distribution is highly heterogeneous across space; and hypothetical changes to the distribution in one country can affect locations in other countries that share similar characteristics.

3.5 Conclusion

In this paper, we reassess the role of language as a vector for communication in trade. We incorporate this idea explicitly into a model of intra- and international trade that yields a structural gravity equation. The theoretical setup allows us to perform policy relevant counterfactual exercises. As such, we extend the existing literature along three lines. First, we provide micro-foundations for the effect of languages on trade. In the spirit of Willy Brandt's quote, the consumers speak a given language, while the firms get

to choose in which language they want to offer their products. A consumer can only buy a good that is offered in her own language. Thus the firm's decision is determined by her productivity, the fixed cost of offering her product in a given language and how "close" her location is to the speakers of that language. Second, extracting information from a sample of 1 billion geo-localized tweets, we derive the first measure of spoken language at the level of a location. This measure reveals important heterogeneity of spoken languages across locations within a country. Unsurprisingly, the urban areas are significantly more linguistically diverse than the rural ones. Changes in language use, or foreign languages training are likely to affect differently these areas. Finally, using this new measure and the structural gravity setup from the model, we are able to quantify hypothetical policy measures and instructive counterfactual situations affecting language use in different locations in Europe. Language, through its effect on trade costs, is important for welfare. Consistently with the Barcelona objectives, our exercises show that both language commonality across European countries as well as language diversity within country have a positive effect on welfare.

Conclusion

In this dissertation, each of the chapters made use of recently available data and advances in computer sciences to shed light on important questions in the field of international trade. In chapter 1, I used the time-series dimension of global input-output tables to quantify the implications of changes in foreign input use on the factor content of trade. Acknowledging the importance of increasing interdependencies between countries, in chapter 2, I introduced a new proxy for a negative shock to political relations between countries and study its heterogeneous effect on traded goods. In chapter 3, using Twitter data, I constructed a new proxy for spoken language, which allowed me to evaluate the effect of changes in languages diversity on trade and real income. While these chapters constitute an important step forward, I believe there is a promising avenue for further research in that direction.

Research in international trade has seen a dramatic shift from macroeconomic to microeconomic questions in the past decade with the availability of firm-level data. The analysis of data generated by interactions on social networks, electronically recorded transactions and even physical sensors can provide a deeper understanding of the traits and behaviors of the actors in international trade. In order to harness the full potential of these new types of data, applying cutting- edge analytical techniques of machine learning, such as sentiment analysis and neural networks, is essential, as the data is often either unstructured, too big for conventional statistical analysis, or both. In analog to advances to the heterogeneity introduced into trade models on the supply side, one needs to gain a better under-

standing of heterogeneity on the demand side. Building on chapter 3, one would like to go a step further and exploit the full dimension of the network created by Twitter users. Matching user profile information (characteristics, followers, interests) with tweets (geolocalization and content), we will be able to get a better picture of the heterogeneity of consumers across and within countries. The network of Twitter users is particularly interesting for studying a wide range of questions related to international trade as firms, too, are often represented on Twitter. On top of that, the network transcends political borders: Twitter users are spread out all over the world with national and international connections. Analyzing this network can provide new insights on how consumers' connections shape firms' behaviour on international markets.

Another interesting topic to address are the traded products themselves. Existing evidence suggests that the observed patterns of diversification of exporters (within firms and across destinations) display a clear departure from a model of random diversification. Previous work points to the existence of different forms of firm, market and consumer heterogeneity shaping the product mix sold by exporters in the different destinations they serve. Using a data-driven approach, one could exploit the richness and synergies associated with datasets linking customs data at the firm-destination-product level with other micro-level data. Machine-learning algorithms could be used to robustly extract structural relations among firms, products and destinations out of the extremely noisy heterogeneity that is observable in the data. This new evidence will certainly guide further theoretical advances in modeling multi-product firms and exporters' behaviours.

Finally, on the topic of firms involved in international trade, it seems very promising to link official firm-level data with data from professional social networks to study questions related to trade and labor markets. Data from services such as LinkedIn would not only allow us to look beyond education-levels and wages as the only employee characteristics, but also permits us to create a network of connections between firms using

employees' networks.

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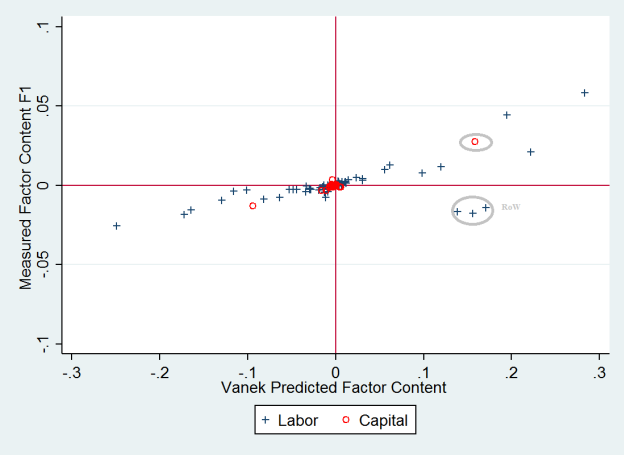
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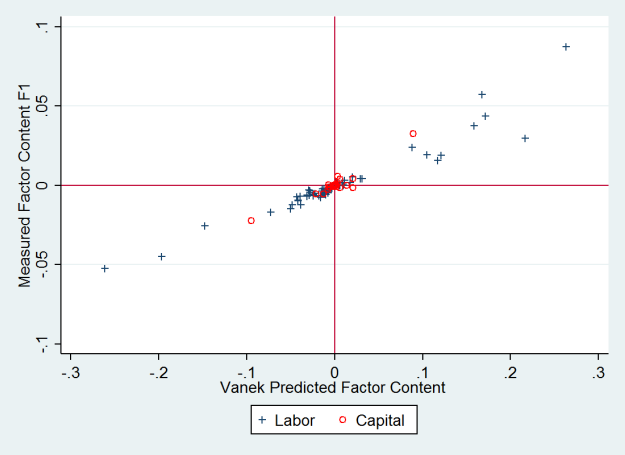
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Appendix A

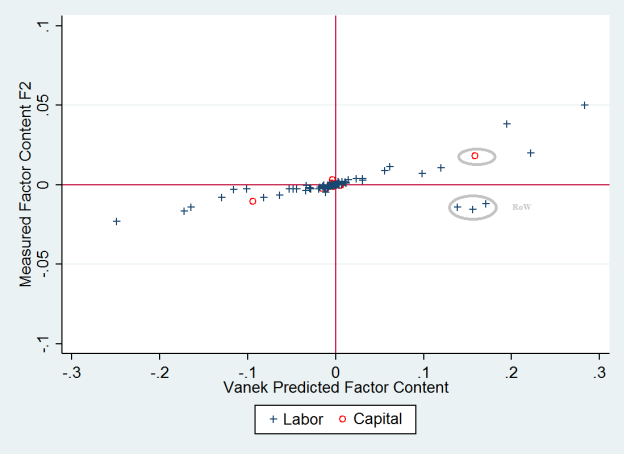
Foreign input use changes and the Factor Content of Trade



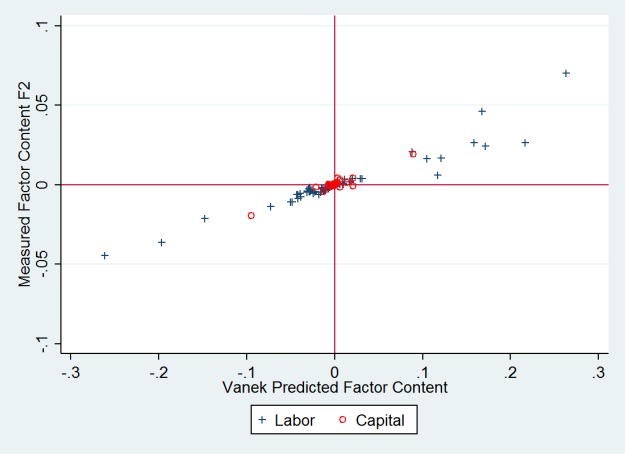
(a) F1 1995



(b) F1 2007

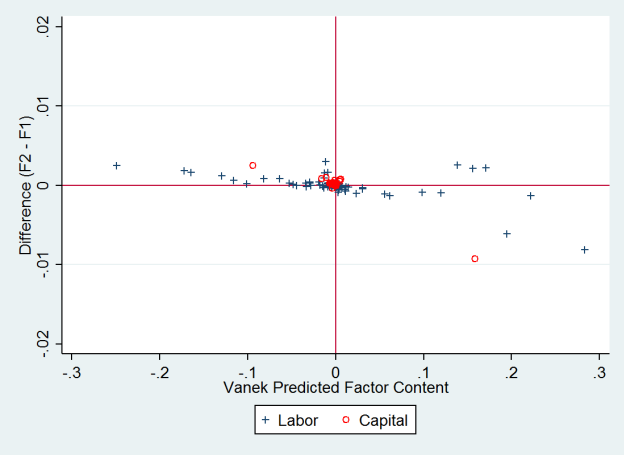


(c) F2 1995

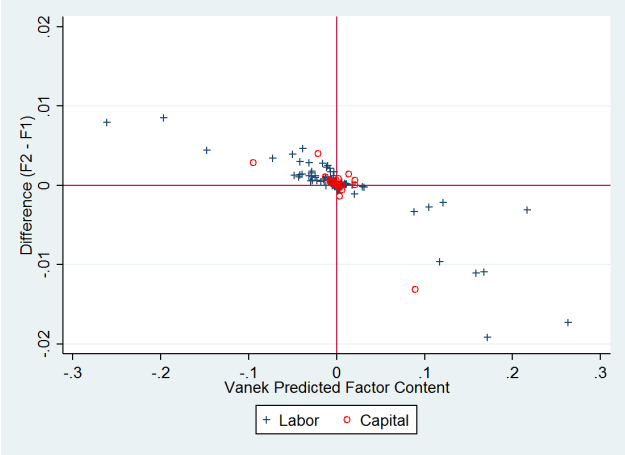


(d) F2 2007

Figure A.1: FCT and Vanek Prediction



(a) Difference 1995



(b) Difference 2007

Figure A.2: Difference in FCT

Appendix B

The heterogeneous effect of political relations on trade

B.1 Impact of a change in input price on aggregate output

We show that a shock to the price of a critical input on which the economy is *dependent* has a greater impact on domestic aggregate output than a shock to other imported inputs. The intuition is the following: an increase in the price of an input decreases production of sectors proportionally to their use. This leads to an increase of the price of these goods. As these goods are used as intermediate inputs by other sectors, the shock is transmitted to other sectors. The production of the other sectors declines. The greater domestic input linkages, the greater is the decline. Therefore, the stronger direct and indirect use of imported foreign inputs, the more dependent is an economy on this input, the greater is the effect on aggregate output.

We first study the effect of an increase in p_m on aggregate output. Focusing on sector x, from the firm profit maximization problem in that sector we know that the demand for input m in x is

$$m_x = \frac{p_x x \gamma_x}{p_m}$$

Taking the derivative with respect to p_m, we have

$$\frac{\partial m_x}{\partial p_m} = -\frac{m_x}{p_m}$$

Hence, when the price of m increases, the demand for m in x decreases. Given the Cobb-Douglas production function, this leads to a decrease in the output of x

$$\frac{\partial x}{\partial p_m} = -\frac{\gamma_x}{p_m} x$$

This is the *direct* effect of an increase in the price of m on x. As x decreases,

the price of x increases. From the firm profit maximization in x we have

$$p_x = \frac{wl_x}{x\lambda_x}$$

Taking the derivative with respect to x

$$\frac{\partial p_x}{\partial x} = -\frac{p_x}{x}$$

As x is used as an input by y, the change in the price of x has an effect on production of y.
From the firm profit maximization in y we have that

$$x_y = \frac{p_y y \alpha_y}{p_x}$$

Taking the derivative with respect to p_x yields

$$\frac{\partial x_y}{\partial p_x} = -\frac{x_y}{p_x}$$

When p_x increases, x_y decreases. This leads to a decrease in y indirectly

$$\frac{\partial y}{\partial p_x} = -\frac{\alpha_y}{p_x} y$$

The increase in the price of m therefore has a *direct* effect on the production of x that is governed by its technical coefficient γ_x and an additional *indirect* effect on the production of y through domestic linkages by way of the technical coefficient α_y.

Symmetrically, the increase in price of m has a direct effect on sector y and an indirect effect on sector x. The total effect of a change in the price of m on the production of each sector is the sum of the direct and indirect effect. The effect of a change of the price of m on sector x therefore is

$$\begin{aligned} \text{TE}_x^m &= -\frac{1}{p_m}\gamma_x x + \frac{\partial x}{\partial p_y}\frac{\partial p_y}{\partial y}\frac{\partial y}{\partial p_m} \\ &= -\frac{1}{p_m}(\gamma_x + \beta_x \gamma_y)x \end{aligned}$$

The effect of a change of the price of m on sector y is

$$\begin{aligned}\text{TE}_y^m &= -\frac{1}{p_m}\gamma_y y + \frac{\partial y}{\partial p_x}\frac{\partial p_x}{\partial x}\frac{\partial x}{\partial p_m} \\ &= -\frac{1}{p_m}(\gamma_y + \alpha_y\gamma_x)y\end{aligned}$$

We can calculate the total effect of a change of the price of n on both sectors using the same reasoning. The total effect of a change of the price of n on sector x is

$$\text{TE}_x^n = -\frac{1}{p_n}(\delta_x + \beta_x\delta_y)x$$

The total effect of a change of the price of n on sector y is

$$\text{TE}_y^n = -\frac{1}{p_n}(\delta_y + \alpha_y\delta_x)y$$

If we define aggregate output (AO) as $\text{AO} = x^\eta y^{1-\eta}$. The total effect of a change of the price of m on $\log(\text{AO})$ is

$$\begin{aligned}\frac{\partial \log(\text{AO})}{\partial p_m} &= \eta\frac{\partial ln(x)}{\partial p_m} + (1-\eta)\frac{\partial ln(y)}{\partial p_m} \\ &= \frac{\eta}{x}\frac{\partial x}{\partial p_m} + \frac{1-\eta}{y}\frac{\partial y}{\partial p_m} \\ &= -[\eta\frac{1}{p_m}(\gamma_x + \beta_x\gamma_y) + (1-\eta)\frac{1}{p_m}(\gamma_y + \alpha_y\gamma_x)]\end{aligned}$$

Similarly, the total effect of a change of the price of n on $\log(\text{AO})$ is

$$\frac{\partial \log(\text{AO})}{\partial p_n} = -[\eta\frac{1}{p_n}(\delta_x + \beta_x\delta_y) + (1-\eta)\frac{1}{p_n}(\delta_y + \alpha_y\delta_x)]$$

The effect on aggregate output of a change in p_m is greater than the effect of a change in p_n if and only if

$$|\frac{\partial \log(\text{AO})}{\partial p_m}| > |\frac{\partial \log(\text{AO})}{\partial p_n}|$$

which is equivalent to

$$\eta(\gamma_x + \beta_x\gamma_y) + (1-\eta)(\gamma_y + \alpha_y\gamma_x) > \frac{p_m(1-\beta_x\alpha_y)}{p_n + p_m}$$

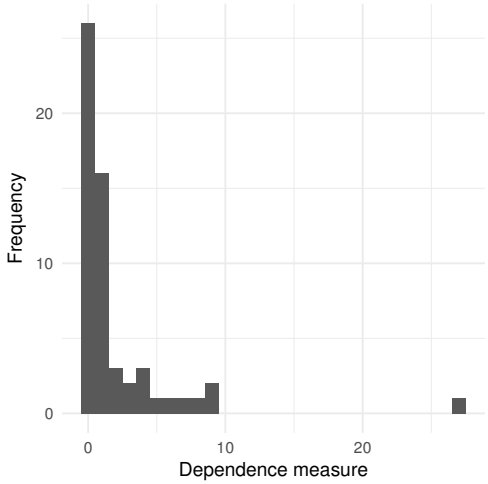
We show previously that this condition is true if and only if the domestic economy is more dependent on m than on n. Aggregate output is more affected by change in p_m than by a change in p_n if it is more dependent on m than on n. In other words, a similar shock on the price of an input will have different effect on aggregate output conditional on its level of dependence. An increase in the price of a critical input will lead to higher damages on aggregate output than a same increase in the price of a non-critical input.

B.2 Dependence measure with BEA Input-Output table

	BEA Industry	Dependence
1	Oil and gas extraction	13.12
2	Petroleum refineries	4.14
3	Insurance carriers	3.31
4	Iron and steel mills and ferroalloy manufacturing	1.73
5	Other motor vehicle parts manufacturing	1.62
6	Computer terminals and other computer peripheral equipment manufacturing	1.36
7	Pharmaceutical preparation manufacturing	1.26
8	Management consulting services	1.21
9	Other basic organic chemical manufacturing	1.19
10	Motor vehicle gasoline engine and engine parts manufacturing	1.17
11	Semiconductor and related device manufacturing	0.84
12	Other electronic component manufacturing	0.81
13	Motor vehicle transmission and power train parts manufacturing	0.81
14	Other plastics product manufacturing	0.72
15	Fishing, hunting and trapping	0.70
16	Telephone apparatus manufacturing	0.69
17	Plastics material and resin manufacturing	0.67
18	Primary smelting and refining of nonferrous metal (except copper and aluminum)	0.66
19	Other engine equipment manufacturing	0.64
20	Broadcast and wireless communications equipment	0.63
21	Motor vehicle electrical and electronic equipment manufacturing	0.63
22	Motor vehicle steering, suspension component (except spring), and brake systems manufacturing	0.63
23	Valve and fittings other than plumbing	0.54
24	Other fabricated metal manufacturing	0.52
25	Aircraft engine and engine parts manufacturing	0.49
26	Fertilizer manufacturing	0.49
27	Veneer, plywood, and engineered wood product manufacturing	0.47
28	Architectural, engineering, and related services	0.45
29	Alumina refining and primary aluminum production	0.44
30	Sawmills and wood preservation	0.43
31	Paper mills	0.43
32	Motor and generator manufacturing	0.42
33	Other aircraft parts and auxiliary equipment manufacturing	0.40
34	Computer storage device manufacturing	0.40
35	Air transportation	0.38
36	Lighting fixture manufacturing	0.38
37	Glass and glass product manufacturing	0.37
38	Fruit and tree nut farming	0.37
39	Communication and energy wire and cable manufacturing	0.36
40	Petrochemical manufacturing	0.36
41	Hardware manufacturing	0.36
42	Tire manufacturing	0.35
43	Aluminum product manufacturing from purchased aluminum	0.33
44	Surgical appliance and supplies manufacturing	0.32
45	Advertising, public relations, and related services	0.32
46	Other basic inorganic chemical manufacturing	0.32
47	Audio and video equipment manufacturing	0.31
48	Fabric mills	0.30
49	Flavoring syrup and concentrate manufacturing	0.30
50	Clay product and refractory manufacturing	0.30

Table B.1: Top 25 US critical industries with BEA Input-Output table

B.3 Dependence measure and estimation with GTAP data



(a) Histogram of dependence for USA

	GTAP Industry	Dependence
1	Petroleum & Coke:	26.97
2	Chemical Rubber Products	8.97
3	Other Crops	8.74
4	Motor Motor vehicles and parts	7.71
5	Other Machinery & Equipment	7.34
6	Wearing Apparel	5.74
7	Water transport	4.77
8	Raw milk	4.47
9	Paddy Rice	4.12
10	Electronic Equipment	3.83

(b) Top 10 US critical industries

Figure B.1: Histogram of dependence measure and top 10 US critical industries (Imported value by industry per 1000 USD GDP)

	Dependent variable:	
	log(imports)	
	(1)	(2)
Treatment	-0.051^{***}	-0.037^{*}
	(0.019)	(0.019)
Treatment x log(Dependence)	-0.035^{***}	-0.014^{*}
	(0.007)	(0.008)
Fixed effects	ctry-dt,ctry-ind, pair-ind	ctry-ind-dt, pair-ind-mo
Observations	357,190	357,190
R^2	0.906	0.962
Adjusted R^2	0.902	0.918
Note:	*p<0.1; **p<0.05; ***p<0.01	

Table B.2: Robustness test — GTAP Data

B.4 Press releases from Ministries of Foreign Affairs

B.4.1 Links to websites of Foreign Ministries

▷ France: `http://www.diplomatie.gouv.fr/en/`

▷ Germany: `http://www.auswaertiges-amt.de/`

▷ Japan: `http://www.mofa.go.jp`

▷ Russian Federation: `http://www.mid.ru/`

▷ United Kingdom:

`http://www.gov.uk/government/organisations/foreign-commonwealth-office`

B.4.2 List of events

Table B.3: List of events

Date	Origin	Destination	Event type	Comments
18/02/2010	France	Israel	summon CA	about murder of a Hamas member in Dubai
01/03/2010	Russia	Estonia	summon Ambassador	unfriendly action by authorities
14/07/2010	Russia	United States	summon Ambassador	protest apprehension of Russian citizen abroad
10/08/2010	Russia	Thailand	summon Ambassador	extradition of citizen to USA
01/09/2010	UK	Kenya	summon HC	about President Bashir of Sudan's visit to Kenya
27/09/2010	Japan	China	summon Ambassador	express concerns about detained Japanese nationals in China
14/10/2010	Russia	Canada	summon CA	confiscation and arrest of crew of cruise ship
01/11/2010	Russia	Japan	summon Ambassador	protest to protest presidents travel to disputed island
03/11/2010	Russia	Canada	summon CA	new visa requirements
19/11/2010	Russia	Canada	summon Ambassador	protest about damaged consulate
17/12/2010	Russia	United States	summon Ambassador	military exercise in South Korea
17/12/2010	Russia	South Korea	summon Ambassador	military exercise in South Korea
22/12/2010	Germany	Belarus	summon Ambassador	opposition arrests
20/01/2011	Germany	Belarus	summon Ambassador	accusations of plot
11/02/2011	France	Mexico	summon Ambassador	concerning situation of Florence Cassez
17/02/2011	France	Iran	summon Ambassador	concern about Spanish diplomate arrest
21/02/2011	UK	Libya	summon Ambassador	concern about violence in Lybia
02/03/2011	UK	Yemen	summon CA	concern over escalating violence in Yemen

Table B.3 — *Continued on next page*

Table B.3 — *Continued from previous page*

04/03/2011	Germany	Taiwan	summon Ambassador	executions
16/03/2011	UK	Libya	summon Ambassador	discuss situation in Lybia
24/03/2011	Germany	Yemen	summon Ambassador	political situation
19/04/2011	UK	Malawi	summon CA	about considering declaring the British HC persona non grata
26/04/2011	Germany	Syria	summon Ambassador	violence in Syria
27/04/2011	France	Syria	summon Ambassador	condemnation of violence in Syria
27/04/2011	UK	Syria	summon Ambassador	stop violence
28/04/2011	UK	Malawi	expulsion of HC	after expulsion of British HC
01/05/2011	UK	Libya	expulsion of Ambassador	following attack on British residence in Tripoli
13/05/2011	UK	Syria	summon Ambassador	concern about the ongoing situation in Syria
25/05/2011	Japan	South Korea	summon Ambassador	protest against members of parliament on disputed islands
31/05/2011	Germany	Syria	summon Ambassador	torture of children and teenagers
02/06/2011	Russia	Pakistan	summon Ambassador	demand investigation into deaths of four citizens
04/06/2011	Germany	Yemen	closure of German embassy	due to dangerous internal conflict
09/06/2011	Iran	UK	summon CA	UK CA was summoned by Iranian mfa
28/06/2011	UK	Syria	summon Ambassador	over allegations of Syrian Embassy intimidation
06/07/2011	Russia	Sweden	summon CA	protest court ruling
10/07/2011	France	Syria	recall its Ambassador for consultations	protest against demonstrations in front of the French embassies
12/07/2011	Germany	Syria	summon Ambassador	voilence and attacks on embassies
13/07/2011	UK	Syria	summon Ambassador	ensure Syrian Ambassador protects diplomatic mission

Table B.3 — *Continued on next page*

Table B.3 — *Continued from previous page*

27/07/2011	France	Burundi	summon Ambassador	Patrice Faye sentence
27/07/2011	UK	Libya	expulsion of all diplomatic staff	condemnation of Qadhafi's regime
11/08/2011	France	Ukraine	summon Ambassador	About the Timochenko case
25/08/2011	Japan	China	summon Ambassador	protest against Chinese boat in territorial waters
29/09/2011	Germany	Iran	summon Ambassador	protest death penalty sentence against pastor
13/10/2011	UK	Syria	summon Ambassador	concern about reports suggesting harassment and intimidation of Syrian diplomats in UK
14/11/2011	France	Syria	summon Ambassador	concerning assaults in diplomatic entities in Syria
15/11/2011	France	Syria	recall its Ambassador for consultations	concerns about situation in Syria
16/11/2011	France	Israel	summon Ambassador	about the raid in Gaza
27/11/2011	Iran	UK	expulsion of British Ambassador	following a vote at the Iranian Parliament
29/11/2011	UK	Iran	summon CA	storming of British Embassy in Teheran
30/11/2011	France	Iran	recall its Ambassador for consultations	concerns about assaults in British embassy
30/11/2011	UK	Iran	expulsion of all diplomatic staff	in response to the assault on the British Embassy in Teheran ("closing of Iranian embassy in London by UK")
30/11/2011	UK	Iran	closure of British Ambassy(Teheran)	in response to the assault on the British Embassy in Teheran
16/12/2011	UK	Uruguay	summon Ambassador	response to 25th Dec Mercosur statement about Falkland Islands

Table B.3 — *Continued on next page*

Table B.3 — *Continued from previous page*

23/12/2011	Turkey	France	recall its Ambassador for consultations	protest against French law proposal
02/01/2012	Congo	France	summon Ambassador	about assault of Leon Kengo Wa Dondo in Paris
06/02/2012	UK	Syria	summon Ambassador	Siege in Homs; condemnation of atrocities
07/02/2012	France	Syria	recall its Ambassador for consultations	concerns about situation in Syria
07/02/2012	Germany	Syria	summon Ambassador	spying on opposition in Germany
09/02/2012	Germany	Syria	expulsion of diplomats	four embassy staffers expelled
20/02/2012	France	Rwanda	recall its Ambassador for consultations	Kigali refuses to accept Helene Le Cal as new French Ambassador
22/02/2012	UK	Syria	summon Ambassador	stop violence in Homs
28/02/2012	France	Belarus	summon Ambassador	protest against Bielorus' decision to expel Polish and UE ambassadors
29/02/2012	UK	Belarus	recall its Ambassador for consultations	Belarus' decision to recall their Ambassadors to Poland and the EU in response to EU sanctions
29/02/2012	UK	Belarus	summon Ambassador	Belarus' decision to recall their Ambassadors to Poland and the EU in response to EU sanctions
29/02/2012	UK	Argentina	summon CA	response to Argentina's threat to trade
01/03/2012	UK	Syria	withdrawal diplomatic staff	all diplomatic staff
03/03/2012	Germany	Iran	summon Ambassador	call for release of pastor
21/03/2012	Japan	Syria	closure of Japanese embassy	deteriorating security situation
06/04/2012	France	Hungary	summon Ambassador	concerns about situation of foreign investors in Hungary

Table B.3 — *Continued on next page*

Table B.3 — *Continued from previous page*

13/04/2012	UK	North Korea	summon Ambassador	concerns about satellite launch
28/05/2012	UK	Syria	summon CA	UK's condemnation of the appalling massacre which took place in al-Houleh
29/05/2012	UK	Syria	expulsion CA and diplomates	response to killing in el-Houleh
29/05/2012	Germany	Syria	expulsion of diplomats	ambassador expelled
03/07/2012	Japan	Russia	summon Ambassador	protest against visit of Russian prime minister on disputed island
11/07/2012	Japan	China	summon Ambassador	protest against entry of patrol ships into disputed territorial waters
12/07/2012	Japan	China	summon Ambassador	protest against entry of patrol ships into disputed territorial waters (again..)
12/08/2012	Japan	Russia	summon Ambassador	express concerns about situation in Georgia
14/08/2012	Germany	Belarus	summon Ambassador	protest closing of Swedish embassy
15/08/2012	Japan	China	summon Ambassador	protest against landing of activist ships on disputed islands
20/09/2012	Germany	Belarus	summon Ambassador	protest visa rejecting of election observers
03/10/2012	Russia	Libya	summon CA	attack on embassy in Tripolis
30/10/2012	UK	Burma	summon CA	concern about the violence in Rakhine State
15/11/2012	UK	Spain	summon Ambassador	concerns regarding incursions into British Gibraltar Territorial Waters
03/12/2012	France	Israel	summon Ambassador	concerns about settlement in colonies
03/12/2012	UK	Israel	summon Ambassador	concern about settlement policy
03/12/2012	Germany	North Korea	summon Ambassador	protest missile test
12/12/2012	UK	North Korea	summon Ambassador	condemnation satellite launch

Table B.3 — *Continued on next page*

Table B.3 — *Continued from previous page*

12/12/2012	Russia	Nigeria	summon Ambassador	ship crew detained
12/12/2012	Germany	North Korea	summon Ambassador	protest rocket launch
13/12/2012	Japan	China	summon Ambassador	protest against entry of aircraft and ships into disputed territory
08/02/2013	Japan	China	summon Ambassador	protest against entry of Chinese ship into territorial waters
13/02/2013	France	Iraq	call for minister meeting	Situation of Nadir Dendoune
01/03/2013	Germany	China	summon Ambassador	protest attack on German journalist
05/04/2013	Germany	North Korea	summon Ambassador	concern about tensions on Korean peninsula
13/05/2013	Russia	United States	summon Ambassador	unclear
01/07/2013	Germany	United States	summon Ambassador	spying on Germany
11/07/2013	Russia	Montenegro	summon Ambassador	situation of citizen
02/08/2013	UK	Spain	summon Ambassador	delays at the Gibraltar border
20/08/2013	Japan	Egypt	summon Ambassador	call for peaceful solution to domestic conflict
19/09/2013	Russia	Netherlands	summon Ambassador	flying flag close to Russian shore
03/10/2013	Russia	Libya	withdrawal diplomatic staff	following attack on Russian embassy
08/10/2013	Russia	Netherlands	summon Ambassador	protest about Russian diplomat attacked
16/10/2013	Russia	Costa Rica	summon Ambassador	extradition of citizen to USA
21/10/2013	France	US	summon Ambassador	spying on France
12/11/2013	Russia	Poland	summon Ambassador	protest about violence around embassy
19/11/2013	UK	Spain	summon Ambassador	serious incursion into British Gibraltar Territorial Waters

Table B.3 — *Continued on next page*

Table B.3 — *Continued from previous page*

23/11/2013	Japan	China	summon CA	protest against Chinese declaration of territorial extent
25/11/2013	Japan	China	summon Ambassador	protest against Chinese declaration of territorial extent
24/01/2014	France	Ukraine	summon Ambassador	concerns about violence in Ukraine
24/01/2014	Germany	Ukraine	summon Ambassador	concerns about violence in Ukraine
20/02/2014	UK	Ukraine	summon Ambassador	over violence in Ukraine
24/02/2014	France	Morocco	summon Ambassador	discuss situation of M.Hammouchi
25/02/2014	France	Morocco	Ministers meeting	discuss about diplomatic incident with French ambassador in DC
01/03/2014	UK	Russia	summon Ambassador	concerns about situation in Ukraine
02/04/2014	UK	Spain	summon Ambassador	concern at the incursion into British Gibraltar Territorial Waters
03/04/2014	Russia	Germany	summon Ambassador	statement of German Minister of Finance
07/04/2014	UK	Burma	summon Ambassador	call for urgent restoration of humanitarian access
07/04/2014	Germany	North Korea	summon Ambassador	concern about Nuclear test
29/04/2014	Germany	Egypt	summon Ambassador	urgent appeal against death sentences
19/05/2014	UK	Sudan	summon CA	concern at the decision to sentence MYII to death for apostasy
26/05/2014	Japan	China	summon Ambassador	protest against entry of military aircraft into territory
11/06/2014	Japan	China	summon Ambassador	protests against two Chinese military jets which flew abnormally close to two Japan's Self Defence Force
12/06/2014	Japan	China	summon Ambassador	protest against entry of military aircraft into territory (again..)
23/06/2014	UK	Egypt	summon Ambassador	concerning verdicts against Egyptian and international journalists

Table B.3 — *Continued on next page*

Table B.3 — *Continued from previous page*

13/07/2014	Russia	Ukraine	summon CA	protest killing of citizen by shelling
17/07/2014	UK	Spain	summon Ambassador	concern at the activity of a Spanish Navy vessel in Gibraltar the day before
19/07/2014	UK	Russia	summon Ambassador	urged Russian Authorities to secure access to flight MH17 crash site
04/08/2014	UK	Ethiopia	summon CA	concern about arrest of a Briton
15/08/2014	UK	Russia	summon Ambassador	account for reports overnight of Russian military vehicules crossing the border into Ukraine
18/08/2014	Turkey	Germany	summon Ambassador	activities about Federal Intelligence Agency
13/10/2014	UK	Thailand	summon CA	concern about the investigation into murders of HW and DM

Appendix C

Quantifying the Effect of Languages on Trade

C.1 Twitter tongues map for NYC

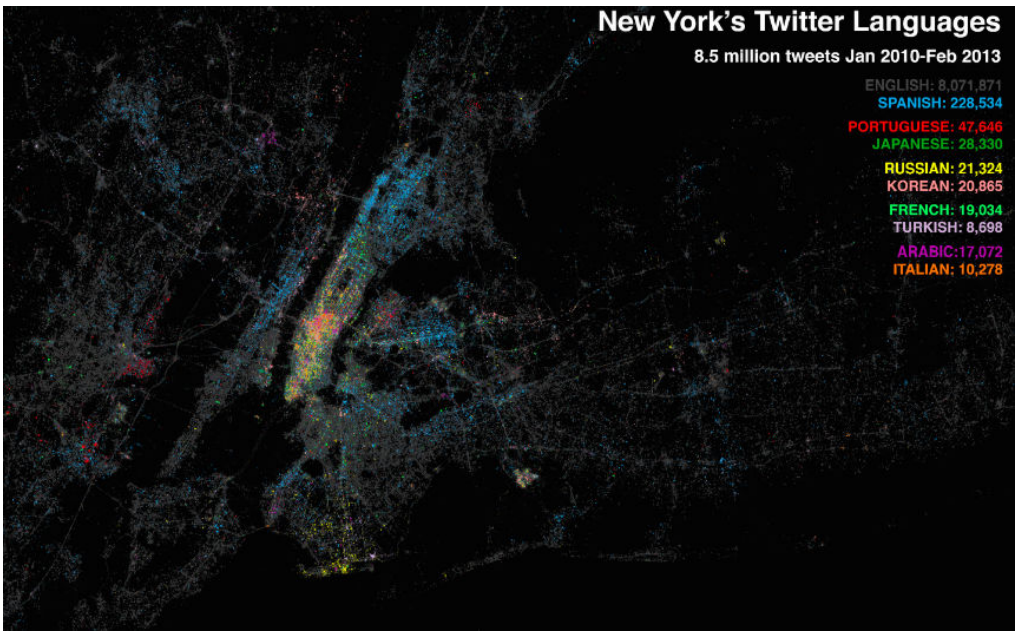


Figure C.1: Top 10 Languages in NYC by J. Barratt, J. Cheshire, and E. Manley

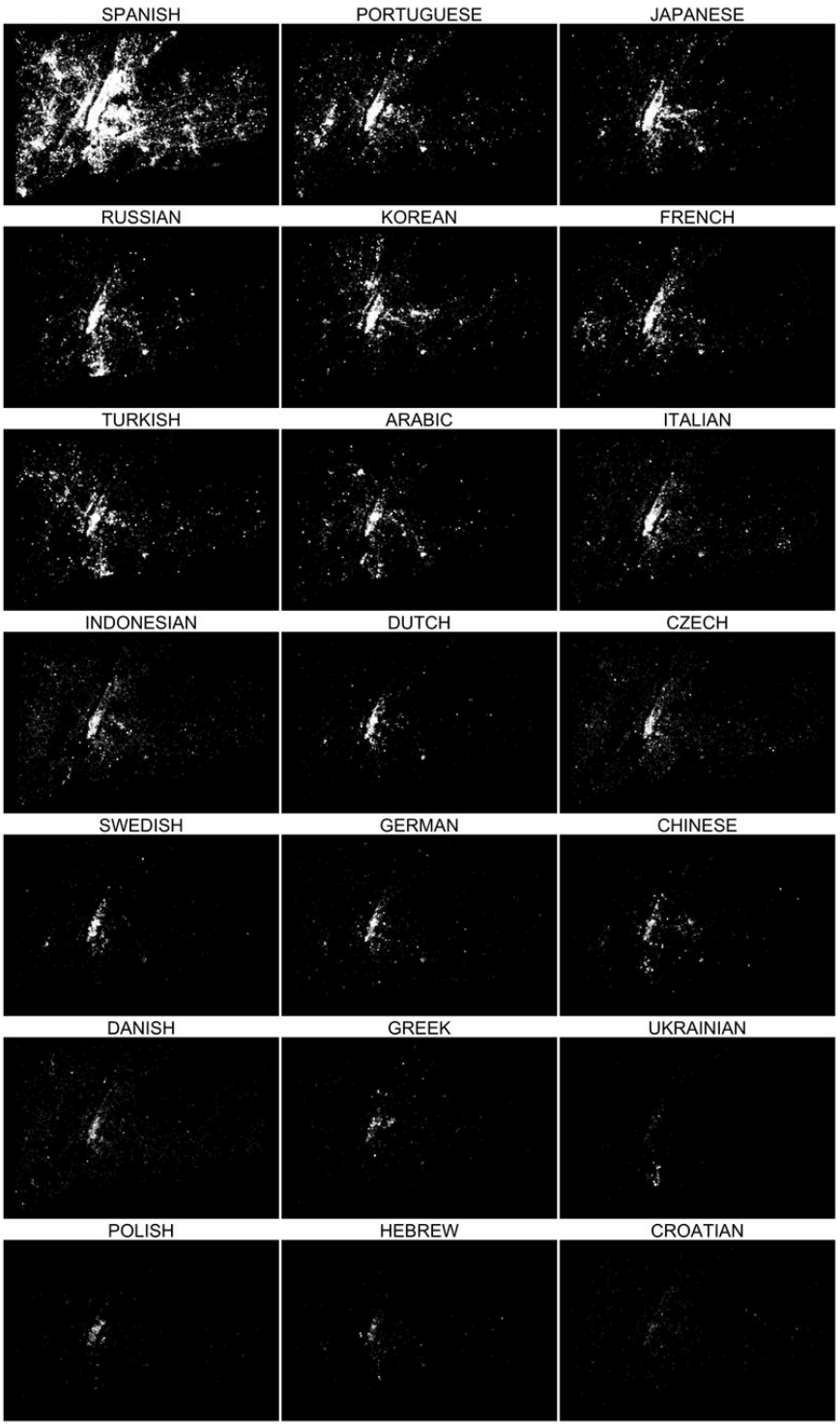


Figure C.2: Top 24 Languages in NYC by J. Barratt, J. Cheshire, and E. Manley.

Essais en Commerce International : Fragmentation Internationale de la Production et Coûts au Commerce

La présente thèse contribue au renouveau de la littérature empirique en commerce international en s'intéressant tout particulièrement à la fragmentation internationale de la production et aux coûts au commerce non-traditionnels. Dans le chapitre 1, je quantifie les conséquences de l'évolution de l'utilisation d'inputs étrangers sur le contenu factoriel du commerce en tirant profit des nouvelles caractéristiques des tableaux entrées-sorties mondiaux. Les variations du contenu factoriel du commerce sont conditionnées par la place des pays dans les chaînes de production mondiales. Le chapitre 2 analyse les liens entre les relations diplomatiques et le commerce à la lumière de l'interdépendence croissante entre pays découlant de l'internationalisation des chaînes de production. Conjointement avec Julian Hinz, nous montrons, grâce à une nouvelle mesure d'un choc diplomatique, que l'impact de ce choc sur le commerce dépend crucialement du type de bien considéré. Enfin, dans le chapitre 3 co-écrit avec Julian Hinz, nous introduisons une nouvelle mesure empirique des langues parlées à l'aide des données de Twitter. Nous l'utilisons ensuite pour évaluer l'incidence de la diversité des langues sur le commerce et le revenu réel en Europe.

Mots-clés : Commerce international, fragmentation internationale de la production, équation de gravité, coûts au commerce non-traditionnels

Essays in International Trade: International Fragmentation of Production and Trade Costs

In this dissertation, I contribute to the thriving empirical literature in international trade by looking specifically at the international fragmentation of production and non-traditional trade costs. In chapter 1, using the new features of global input-output tables, I quantify the impact of the recent changes in foreign input use on the factor content of trade. I found that the changes in the factor content of trade are driven by each country position in the global supply chains. The chapter 2, analyzes the links between political relations and trade in light of the growing interdependency between countries. In this joint work with Julian Hinz, using a new proxy for a negative shock to political relations between countries, we show that the impact of such a negative shock is crucially heterogeneous across traded goods. Finally, in chapter 3 co-authored with Julian Hinz, we introduce a new measure for spoken languages based on Twitter data. We then use this measure to evaluate the effect of changes in language diversity on trade and real income in different locations in Europe.

Keywords: International trade, international fragmentation of production, gravity framework, non-traditional trade costs