



# International trade and environment : the role of environmental regulations

Thaís Núñez Rocha

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# **International trade and environment: the role of environmental regulations**

Thaïs Núñez-Rocha

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# 1

## Résumé

L'étude des effets du commerce international sur l'environnement donne lieu à un débat généralisé. Au cœur de l'analyse se trouvent des questions économiques fondamentales telles que les canaux de transmission de ces effets, mais aussi plusieurs défis méthodologiques. Jusqu'à présent, le contexte théorique se concentre sur l'étude des canaux de transmission de ces effets. Dans ce qui suit, je vais expliquer la façon dont j'évalue ces défis et pourquoi l'étude de la réglementation environnementale est d'une importance fondamentale pour traiter les effets du commerce sur l'environnement.

Tout d'abord, j'explique les trois canaux par lesquels le commerce international affecte l'environnement : l'échelle, la technique et les effets de composition. Dans cette perspective, je passe en revue la littérature sur la base de l'analyse théorique à quelques-unes des contributions empiriques qui émergent.

Deuxièmement, je soulève les principaux défis auxquels est confrontée l'évaluation des effets du commerce et de l'environnement sur un cadre empirique. Ensuite, je me concentre sur les différences entre les pays en matière de réglementation environnementale, compte tenu de leur niveau de développement. Ceci conduit à l'introduction de la principale

caractéristique commune reliant les trois chapitres de cette thèse.

Troisièmement, j'expose les différences en matière de réglementation environnementale comme étant la principale incitation à l'émergence possible d'effets de déchets et de nuisances. En conséquence, je présente les deux premiers chapitres de cette thèse, qui portent sur les expéditions de substances dangereuses des pays développés vers les pays en développement. Cette analyse est poursuivie en mettant particulièrement l'accent sur certains produits et sur des accords environnementaux internationaux spécifiques.

Enfin, je présente un moyen plus général d'évaluer l'effet du commerce international sur l'environnement. Ainsi, dans le troisième chapitre de cette thèse, je présente une étude empirique basée sur le commerce international et la théorie de la croissance. En particulier, j'examine l'effet des réglementations environnementales des pays sur les différents résultats environnementaux, y compris le commerce international. Ce travail évalue également la causalité inverse entre les résultats environnementaux et les déterminants de la pollution.

## **1.1 Commerce international et environnement : de la théorie à l'étude empirique**

Y a-t-il un impact du commerce croissant sur l'environnement ? Il s'agit d'un débat controversé tant pour la politique commerciale que pour les préoccupations environnementales. Même s'il est établi que les effets du commerce sur l'environnement sont complexes, il existe de bons efforts pour les évaluer en trois effets distincts. Une des premières études évaluant cette relation est Taylor and Copeland (2004) et Grossman and Krueger (1991). Ces études traitent de l'impact environnemental du commerce à travers trois effets d'échelle, de technique et de composition. Ces trois effets ont ensuite été développés dans une approche théorique et empirique

combinée par Copeland and Taylor (2013), permettant une fragmentation de l'effet de composition. Ces travaux mettent en évidence l'importance de considérer que les différences de réglementation environnementale incitent à déplacer la pollution vers les pays moins réglementés.

L'effet d'échelle est connu pour générer un impact négatif sur l'environnement. Avec toutes les autres choses constantes, une augmentation de la participation au commerce international augmente la production, ce qui entraîne par conséquent une augmentation de la pollution associée à ce processus de production.

L'intégration des marchés internationaux peut impliquer, selon certains accords commerciaux, des transferts de technologie. Ces nouvelles technologies adoptées qui sont potentiellement plus propres, pourraient réduire la pollution due à des processus de production moins polluants.

De même, le type de production qu'un pays peut avoir peut influencer l'effet net de la pollution. L'effet de composition se concentre sur la dotation en facteurs des pays. Un pays dont la production est à forte intensité de main-d'œuvre entraînera un niveau de pollution plus faible qu'un pays à forte intensité de capital. Néanmoins, cet effet de composition aborde non seulement les différences de dotation en facteurs mais aussi une caractéristique plus liée aux politiques, comme les différences de réglementation environnementale entre pays.

Les études analysant ces effets sont nombreuses, c'est pourquoi ici je ne discuterai que de la littérature la plus pertinente pour cette thèse. Une des premières études utilisant des techniques théoriques et empiriques pour tester les effets du commerce ouvert sur l'environnement est Taylor et al. (2001). Leurs résultats montrent un effet du commerce sur l'environnement, par l'effet de composition, en utilisant les concentrations de dioxyde comme polluant. Les auteurs affirment que le commerce est positif pour l'environnement. En outre, ils soulignent la nécessité de tenir compte des différences dans les réglementations environnementales et de l'absence de variables de substitution pouvant être utilisées, en particulier

pour les pays en développement.

Aussi dans l'étude de Dean (2002), les résultats indiquent un résultat négatif dans l'effet de la composition et un résultat positif dans l'effet de la technique, ce qui l'emporte sur le premier. Cette étude observe l'effet du commerce sur la pollution de l'eau en Chine avec un modèle tenant compte des effets sur la pollution et indirectement par la croissance des revenus, capturant ainsi les effets du commerce et de la croissance. Cependant, ce travail ne tient pas compte de la réglementation environnementale de manière explicite.

Cole and Elliott (2003) mettent l'accent sur l'effet de la composition pour étudier les dotations en facteurs et la réglementation environnementale dans la perspective de la courbe de Kuznets. Leurs résultats montrent qu'il n'y a pas de réponse simple mais qu'il est nécessaire d'analyser chacun en particulier. Ils affirment que l'impact du commerce dépend du polluant et de la mesure utilisée.

Dans une section transversale centrée sur les polluants atmosphériques locaux, l'article de Frankel and Rose (2005) traite de la simultanéité entre le commerce et l'environnement, ils concluent que l'ouverture au commerce pourrait avoir des effets bénéfiques sur l'environnement. Je soutiens que, pour donner des réponses plus précises sur l'effet du commerce sur l'environnement, il serait plus approprié d'établir un cadre des données de panel à cause de l'effet de la population et de la tendance temporelle. Ce sont des facteurs importants qui ne sont pas pris en compte dans le cadre d'une coupe transversale.

Seules quelques-unes de ces études évaluent la question de la simultanéité entre le revenu et la pollution. Ainsi Managi et al. (2009) est la première étude qui tient compte de cela. Ils comprennent également le niveau de développement des pays utilisant une division de pays OCDE et Non-OCDE. Leurs estimations montrent que ce n'est pas aussi simple. L'effet bénéfique sur l'environnement varie en fonction du polluant et du pays.

Une bonne évaluation de l'effet des accords commerciaux régionaux est l'étude de Baghdadi et al. (2013) où, dans un cadre de données de panel, contrôlant les effets endogènes, les auteurs montrent que les accords avec des dispositions environnementales ont un impact favorisant la convergence des émissions. Au contraire, les accords sans dispositions environnementales ne contribuent pas à la convergence des émissions. Néanmoins, si la convergence est vers le haut ou vers le bas est toujours une question ouverte.

Dans une section transversale, Ben Kheder and Zugravu (2012) affirme que les réglementations environnementales sont un facteur important pour attirer les industries polluantes. Le principe essentiel des effets de la pollution est de déplacer les industries polluantes vers des pays avec une réglementation environnementale plus indulgente. Dans ce contexte, il y a des investissements qui sont faits dans ces pays afin de déplacer ces industries. Néanmoins, lorsque la réglementation environnementale devient plus stricte dans les pays développés, cela peut générer un effet pervers favorisant le déplacement des déchets vers les pays en développement. Kellenberg (2012) étudie ce phénomène et soulève également l'émergence de l'effet refuge. L'auteur souligne également la nécessité de prendre en compte les différences de réglementation environnementale entre les partenaires commerciaux, ces différences génèrent une augmentation des déchets importés dans les pays de réglementation environnementale moins strictes.

La tentative de construire une variable représentant la réglementation environnementale soulève un défi. Cependant, elle permet de tenir compte de l'incitation qui s'inscrit dans un contexte où un pays a une réglementation environnementale moins stricte envers son partenaire commercial. Dans une telle situation, le commerce pourrait avoir un effet négatif sur l'environnement, non seulement parce que le pays aurait une production sale, mais aussi parce que le pays peut être pollué par ses partenaires commerciaux soit par un effet de havre de pollution ou soit par un effet de havre de déchets, comme dans les articles susmentionnés.

## 1.2 L'effet de la réglementation environnementale

Les différences de régulation environnementale sont étudiées dans le cadre de l'effet de composition. Dans ce qui suit, je présente des articles qui utilisent des variables proxy pour représenter la réglementation environnementale. Cependant, la recherche sur les effets de la réglementation environnementale sur les résultats environnementaux dans une économie ouverte, en dehors de l'étude de Frankel and Rose (2005) le reste de la littérature, en général, se concentre sur des polluants spécifiques, des régions ou des années, et ne comprennent pas toujours l'effet du commerce (Botta and Koźluk (2014), Sauvage (2014), Copeland (2003), Misra and Pandey (2005) Kellenberg (2009) et Pratt and Mauri (2005)).

Il existe deux études qui sont une bonne tentative pour aborder la question de la réglementation environnementale. D'une part, Botta and Koźluk (2014) soulignent l'absence d'une mesure de comparaison fiable de la réglementation environnementale. Ils proposent un indice qui, toutefois, ne concerne que les pays de l'OCDE et se réfère uniquement à la pollution du climat et de l'air. D'autre part, dans l'article de Frankel and Rose (2005), les auteurs analysent les polluants atmosphériques et d'autres résultats environnementaux. Ils évaluent également la question de la simultanéité, mais leur stratégie est transversale et ne prend pas en compte la rigueur de la réglementation environnementale.

Il est également intéressant de noter que les résultats de Botta and Koźluk (2014) montrent que les différentes mesures de la rigueur de réglementation environnementale ne sont pas fortement corrélées, ce qui montre qu'elles capturent différents phénomènes. Brunel and Levinson (2013) soulignent également l'aspect multidimensionnel de la rigueur de la réglementation environnementale et soulignent le fait que l'utilisation d'une seule mesure de la réglementation environnementale génère un manque de robustesse dans les résultats. Cela est dû à la faible corrélation

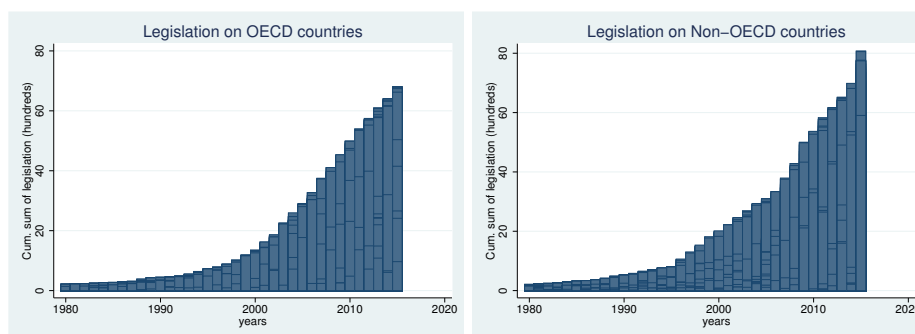
entre les différentes mesures de la rigueur de réglementation environnementale.

Dans ce contexte, je construis différents index pour la régulation environnementale et je les utilise dans différents contextes dans chaque chapitre de ma dissertation. Avec ces variables de proxy, je saisis les caractéristiques variables du pays et du temps, et je les applique différemment selon les résultats environnementaux spécifiques étudiés.

Cette dissertation intègre l'analyse de différents résultats environnementaux avec des mesures nouvelles et complémentaires de la régulation environnementale dans un ensemble de données de panel. En plus de cette notion de réglementation environnementale, l'étude d'accords environnementaux internationaux spécifiques est également évaluée. En particulier, mon analyse se concentre sur l'interaction entre les pays à différents stades de développement, avec pour objectif de capter les différences «institutionnelles» entre pays dans le domaine environnemental. Je suis convaincue que ces différences jouent un rôle important dans l'étude de l'évolution des résultats environnementaux.

### **1.3 La réglementation environnementale et l'environnement**

Le rôle de la réglementation environnementale est d'une importance cruciale pour la protection de l'environnement dans tous les pays. Le niveau de pollution d'un pays varie selon les caractéristiques du pays (effet de composition : facteur de dotation). En outre, les pays ont tendance à produire davantage pour accroître le commerce (effet d'échelle). Dans le cadre du commerce, même s'il y a un transfert de technologie dans le cadre de cette coopération internationale (effet technique), ce transfert de technologie semble une solution qui prend plus de temps et se limite aux caractéristiques des pays et à leurs partenaires commerciaux. En revanche,



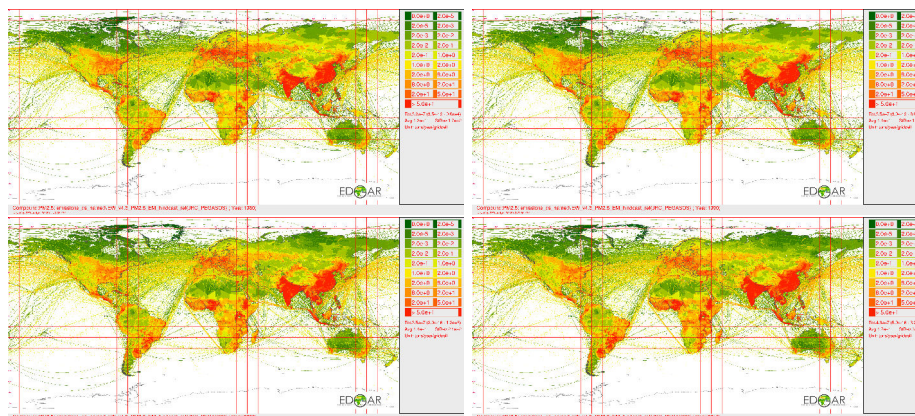
**Figure 1.1:** Législation Environnementale période 1980-2010

la réglementation environnementale est un reflet des institutions des pays, et elle peut être promue comme un objectif politique.

La régulation environnementale est, en outre, la variable qui pourrait se déplacer plus facilement que les autres déterminants. Comme la réglementation environnementale est liée au niveau de revenu, il est normal de constater qu'elle fonctionne parallèlement à l'effet sur le revenu. La figure 1.1 montre comment la réglementation environnementale (représentée comme intensité de la législation) évolue dans le temps pour les pays de l'OCDE et non-OCDE. Pour les pays de l'OCDE et des pays non membres de l'OCDE, la croissance de la réglementation environnementale a une tendance positive, mais elle ne prend que pour les pays de l'OCDE une forme concave. Cela pourrait impliquer que, dans la logique des pays stabilisant leurs niveaux de pollution, le besoin d'une réglementation environnementale croissante sera également stabilisé. Par ailleurs, dans ces pays, il existe des réglementations mieux établies. Cependant, pour les pays non membres de l'OCDE, il y a encore une transition à faire et elle montre là aussi une forme convexe (figure 1.1 à droite).

Les pays développés ont des réglementations environnementales plus strictes que les pays en développement. En outre, ils ont pollué plus dans le passé et sont encore les principaux pollueurs dans certains types de pollution (la pollution de gaz à effet de serre vient encore des pays de l'OCDE). Globalement, il y a une augmentation de la pollution, mais





Source: Emissions database for global atmospheric research

**Figure 1.2:** Emissions de PM2.5 période 1980-2010

aussi la source de cette pollution va géographiquement vers les pays du Sud, les pays en développement. L'augmentation de la réglementation environnementale pourrait aider ces pays à protéger leur environnement.

En revanche, la pollution augmente dans le monde entier. À titre d'illustration, la figure 1.2 montre que les émissions de PM2.5 augmentent dans le monde entier, mais sont également déplacées du nord vers le sud. Dans cette thèse, j'évalue les effets de l'augmentation et du déplacement de la pollution sous ses différentes formes. Ainsi j'évalue le rôle que les différents niveaux et les différentes évolutions des réglementations environnementales peuvent avoir dans le déplacement de la pollution des pays développés vers les pays en développement.

## 1.4 Une thèse en trois chapitres

Cette thèse vise à contribuer à la compréhension de la relation entre le commerce et l'environnement, en mettant l'accent sur le rôle des différences de réglementation environnementale entre pays développés et pays en développement. La communauté internationale, les économistes et les autres spécialistes des sciences sociales s'intéressent depuis longtemps à

cette relation. Cependant, ce n'est que récemment que les chercheurs ont commencé à étudier ce sujet empiriquement. Cela est dû à l'émergence des préoccupations environnementales comme une question de politique majeure et aux avancées dans les outils statistiques et économétriques disponibles pour évaluer les résultats contre-factuels, qui identifient les relations causales. Les progrès de l'informatique et de l'accès aux données ont amélioré notre capacité d'estimer les composantes, dans ce cas, associées à la réglementation environnementale qui sont les plus pertinentes pour l'étude des effets du commerce sur l'environnement.

Le premier chapitre établit un lien entre la littérature qui étudie le commerce international et celle qui étudie l'environnement. Cette littérature suggère l'émergence de pays en développement comme des paradis de déchets pour leurs homologues développés, en raison des différences de réglementation environnementale entre les partenaires commerciaux. Ce chapitre analyse l'efficacité de la formalisation de la Convention de Bâle dans l'Union européenne (*UE-WSR*), en étudiant l'impact du *UE-WSR* sur le commerce des déchets dangereux, puis sur les pays en développement, divisés en régions.

Ce chapitre a été motivé par le fait que l'Union européenne (UE) a ratifié la convention et l'amendement d'interdiction (interdisant les expéditions d'envois de déchets dangereux des pays développés aux pays en développement). Même si l'amendement n'a pas encore entré en vigueur, il s'agit déjà d'un signal d'engagement de la part de l'UE. Par conséquent, il est intéressant de savoir si les importations de déchets dangereux dans les pays en développement en provenance de l'UE diminuent. En outre, j'examine si les pays moins développés de l'UE deviennent des paradis pour les déchets des pays les plus développés. Étant donné que les pays les plus développés de l'UE ne sont pas autorisés à envoyer des déchets dangereux dans des pays en voie de développement, cela pourrait les inciter à les envoyer vers les pays moins développés de l'UE.

La Convention de Bâle crée un instrument pour contrôler les transferts

de déchets. Si un pays veut envoyer des déchets vers un autre pays, l'exportateur doit obtenir l'accord de l'autorité d'importation du pays importateur, cette procédure passe par la Convention de Bâle et est appelée Consentement préalable en connaissance de cause (PIC-Prior Informed Consent).

Afin de quantifier les différences en matière de réglementation environnementale, mon analyse s'inspire de plusieurs allégations formulées par des pays en développement après l'entrée en vigueur de la Convention de Bâle en 1992. Ces allégations affirment que le PIC légitime ce qui était illégal auparavant (Kellenberg (2012)), permettant ainsi l'acheminement de déchets dangereux vers leurs frontières. La raison principale des pays qui déposent des plaintes est que ce processus pourrait être susceptible de corruption, surtout lorsque des entreprises peu scrupuleuses et des incitations élevées sont impliquées.

Pour cette raison, après Ben Kheder and Zugravu (2012), je construis un indice de réglementation environnementale composé, qui comprend trois caractéristiques différentes mais aussi complémentaires, notamment pour la qualité des institutions. J'utilise certains indices de corruption, la ratification des accords internationaux sur l'environnement (AIE) et un indice de performance environnementale pour tenir compte du niveau de qualité de l'environnement.

Les résultats montrent peu de preuves d'un effet de havre de déchets dans les pays de l'UE les moins développés. Ces résultats sont confirmés par des mesures de réglementations environnementales agrégées et désagrégées. Cependant, une ratification croissante des traités pourrait conduire à une diminution des importations de déchets pour les pays les moins développés de l'UE. Dans l'analyse régionale, il n'y a aucune preuve de l'efficacité du *EU-WSR*. Ces résultats donnent un aperçu de l'efficacité des engagements européens sur le commerce des déchets, indiquant qu'il n'y a pas de réponse simple.

Par conséquent, pour examiner en détail le fonctionnement et le rôle des

accords internationaux sur l'environnement, je me concentre donc sur les accords environnementaux suivants : la Convention de Rotterdam sur les produits chimiques dangereux et la Convention de Stockholm sur les polluants organiques persistants, ces deux accords découlant de la Convention de Bâle. Les produits concernés par ces deux conventions ne peuvent pas être considérés comme des déchets dangereux, car ils ne sont pas des déchets en soi, mais ils peuvent être des intrants et / ou des sous-produits de la production.

Il est important de noter que les produits concernés par la Convention de Rotterdam et la Convention de Stockholm ont été prouvés comme dangereux pour la santé et l'environnement. Selon "l'American Occupational Safety and Health Administration", les produits chimiques dangereux sont toxiques et réactifs et ont un grand potentiel de nuisance à la santé quand ils sont libérés.

Ces deux conventions ont été inspirées par les mêmes incitations que la Convention de Bâle et ont été développées en utilisant également les mêmes instruments (PIC et Ban). La Convention de Bâle a été adoptée en 1992 avec la procédure PIC susmentionnée. Étant donné que cet instrument a permis d'accroître les envois de déchets (Kellenberg (2012)), la communauté internationale s'est efforcée de mettre en œuvre l'interdiction d'amendement de la Convention de Bâle en 1995. Cet amendement d'interdiction consiste à interdire de manière permanente les envois de déchets dangereux des pays développés vers les pays en développement. Malheureusement, à ce jour, il n'a pas été adopté. Il convient de noter que si la Convention de Rotterdam utilise la procédure PIC, la Convention de Stockholm utilise une interdiction pour certains produits.

Le second chapitre étudie donc les recherches récentes qui ont mis en doute l'efficacité des accords internationaux sur l'environnement (AIE), dont certains sont perçus comme une tentative des pays de construire une image positive à l'échelle internationale, ratifiant les accords sur l'environnement, sans faire d'effort dans leur application. Ce document

se concentre sur deux accords environnementaux qui ont des aspects communs avec la Convention de Bâle parce qu'ils se concentrent sur les biens potentiellement dangereux pour la santé et l'environnement lorsqu'ils sont libérés dans la nature ou avec de mauvaises procédures d'élimination.

Ce chapitre évalue explicitement les effets de la ratification et de l'adoption de ces accords sur les importations de produits chimiques dangereux et de polluants organiques persistants. Puisqu'une auto-sélection des pays dans la ratification de ces conventions pourrait être un problème, le modèle utilise des contrôles pour atténuer l'endogénéité de la décision de ratifier.

Les résultats de ce chapitre soulignent l'effet partiel de ces deux conventions. Plus précisément, ils soulignent que lorsqu'on évalue le PIC, qui est un accord moins restrictif, les importations de produits chimiques dangereux du Nord vers le Sud ne sont réduites que lorsque l'exportateur ratifie la Convention de Rotterdam. Lors de l'évaluation de l'interdiction des polluants organiques persistants, les importations sont réduites lorsque l'importateur ratifie la Convention de Stockholm.

Il est intéressant de noter ici que l'effet sur l'interdiction est presque deux fois plus grand que le PIC, cela pourrait être dû au niveau différent de rigueur des instruments.

Le cadre commun entre ces deux chapitres est double. D'une part, ils analysent la variation des flux croissants de produits dangereux des pays développés vers les pays en développement. D'autre part, ils utilisent différentes variables de l'exigence de la réglementation environnementale et d'une manière différente. Toutefois, comme je l'ai déjà mentionné, même si ces deux études posent des problèmes méthodologiques, en utilisant des données de panel et un grand nombre de pays, ce qui serait intéressant à savoir, c'est si les résultats environnementaux des pays s'améliorent ou s'empirent. Je crois qu'il donne un complément cohérent à ma thèse pour étudier l'effet de la rigueur du droit environnemental sur les résultats environnementaux des pays, lors de l'intégration

du commerce international.

Le défi majeur pour répondre à cette question réside, comme expliqué précédemment, sur la manière d'évaluer la simultanéité possible de la réglementation environnementale et des résultats environnementaux, ce qui crée une source d'endogénéité (Brunel and Levinson (2016) et Frankel and Rose (2005)). De plus, un autre défi est de choisir une mesure de rigueur de la réglementation environnementale comparable, au niveau du pays, sur un ensemble de données de panel.

Le troisième et dernier chapitre de cette thèse analyse l'effet de la sévérité de la réglementation environnementale sur les résultats environnementaux au niveau des pays. Dans ce chapitre, le modèle de Frankel and Rose (2005) est pris comme point de départ, puis il est étendu à des données de panel et on ajoute une variable de la rigueur de la réglementation environnementale.

La variable de rigueur de la réglementation environnementale est ici composée de lois environnementales adoptées par les pays au fil du temps. Cette variable est construite comme une variable de comptage du nombre de lois d'un pays en tenant compte du stock initial de lois d'un pays donné, comme la somme de toutes les lois des périodes précédentes de l'étude. En outre, la variable de réglementation environnementale est complétée par une variable d'application qui permettra de comprendre que ces lois sont effectivement mises en œuvre.

Cette recherche est une tentative d'inclure les efforts que les pays déploient sur la réglementation environnementale, au niveau local. Dans ce chapitre, je prends en compte les déterminants de la pollution et aussi l'effet de revenu et d'ouverture, en mesurant les deux derniers dans une première étape. De plus, la causalité inverse entre les résultats environnementaux et la réglementation environnementale est abordée. Et, comme test de robustesse, nous avons estimé l'effet retardé de ces lois, et aussi nous avons abordé l'effet de l'exclusion des pays fédéralistes.

Les résultats montrent que l'intensité des lois environnementales semble avoir un effet améliorant les résultats environnementaux. Cet effet est particulier aux résultats environnementaux et à la loi. Ces effets sont spécifiques aux paramètres et aux polluants utilisés, confirmant les résultats des études antérieures. De plus, on met en question aussi certaines conclusions antérieures tirées de la littérature concernant l'effet bénéfique du commerce sur l'environnement.

La variable proxy d'application utilisée dans ce travail semble réduire la pollution seulement dans certains résultats, mais elle est moins importante dans la réduction de la pollution que les lois de notre modèle. Néanmoins, il fonctionne efficacement avec la zone forestière, augmentant et diminuant également les émissions de PM2.5.

L'effet du commerce sur l'amélioration des résultats environnementaux est particulier aux pays de l'OCDE et ne concerne que les émissions de PM2.5. En revanche, on constate un effet croissant pour les pays non membres de l'OCDE dans les émissions de NO2. De plus, l'ouverture commerciale augmente la pollution de l'eau pour les pays non membres de l'OCDE. Ces résultats remettent en question les travaux antérieurs sur l'effet d'ouverture montrant de façon constante une diminution de la superficie forestière.

L'effet de la rigueur de la réglementation environnementale (comprise comme l'intensité des lois environnementales) sur les résultats environnementaux, confirme Barrett (2006). Ce travail confirme également l'effet de la réglementation environnementale en excluant les pays fédéralistes, et l'effet de la réglementation environnementale comme variable retardée.

## 1.5 Résultats principaux

Premièrement, il n'y a pas de diminution du commerce des déchets de l'Union européenne vers les pays en développement, même si les pays

européens adhèrent à la Convention de Bâle, un accord international sur l'environnement pour contrôler et éliminer le commerce des déchets. La raison principale pourrait être le manque de rigueur du présent Accord, en raison du fait que l'interdiction de ce commerce ne peut entrer en vigueur en raison du manque de pays ratifiant.

Deuxièmement, les Accords internationaux sur l'environnement ont pour effet de diminuer les importations de substances dangereuses, mais cela reste un effet partiel et dépend du contexte de l'Accord. Elle a un effet lorsque les pays en développement ratifient un accord qui implique une interdiction de réduire les importations de substances dangereuses à l'intérieur de leurs frontières. En revanche, lorsque l'Accord a une restriction moins exigeante qui n'implique pas une interdiction, il est plus important que les pays développés s'engagent à ne pas envoyer ces substances, ratifiant ainsi l'Accord.

Troisièmement, les réglementations environnementales exprimées en tant que lois environnementales peuvent avoir un effet d'amélioration des résultats environnementaux. Leur application est également importante, mais l'intensité des lois reste le facteur le plus important. L'ouverture dans un pays peut avoir des effets néfastes sur l'environnement.

## 1.6 Méthodologies

Dans la thèse, je me concentre sur le modèle de gravité à effets fixes, intégrant les paramètres utilisés dans la littérature sur la croissance. Enfin, mon analyse est également partiellement complétée par une méthode d'analyse d'impact comme le modèle des différences des différences.

Dans le premier chapitre, je me concentre sur un règlement du Parlement européen approuvé en 2006 (qui entre en vigueur en 2007) et destiné à interdire les transferts de déchets dangereux vers les pays en développement (EU-WSR). Ce règlement est une formalisation de la Convention de Bâle



et de son Amendement d'interdiction relatif aux déchets dangereux. En utilisant ces informations dans un cadre d'expérimentation quasi-naturelle, je construis une variable binaire pour les paires de pays où les pays exportateurs sont les *UE-15*<sup>1</sup> et les pays importateurs sont *UE-10*<sup>2</sup> qui tendent à avoir des réglementations environnementales plutôt laxistes. Cette variable binaire est couplée à une variable de période, qui distingue les périodes avant et après 2007, année de l'adoption du règlement. Enfin, je considère l'interaction entre ces deux variables et la variable de gradient de la réglementation environnementale.

À cette spécification de différence en différences, je joins à un modèle de gravité pour estimer l'effet des accords bilatéraux basés sur les politiques sur les flux commerciaux bilatéraux (Head and Mayer (2014)), en suivant les développements les plus récents de la spécification de gravité (Baier and Bergstrand (2007), Santos Silva and Tenreyro (2011)).

Un aspect important à considérer dans l'estimation des effets d'une politique visant à modifier les tendances commerciales est l'auto-sélection des paires de pays dans le commerce des produits ciblés, car cela génère un biais d'endogénéité dans les estimations. Pour résoudre ce problème, j'utilise des méthodes avec le modèle de gravité à effets fixes bilatéraux, dans une spécification du modèle en log-linéaire avec de données de panel. De plus, les facteurs de résistance multilatérale (MRF), qui représentent les différences de prix relatifs entre pays par rapport à tous leurs partenaires commerciaux, sont inclus dans le modèle (Anderson and Van Wincoop (2004) et Head and Mayer (2014)). Dans le cadre d'un ensemble de données de panel, ces facteurs varient au fil du temps, ils sont basés sur des effets fixes variant en fonction de l'exportateur et de l'importateur, ce qui permettra non seulement de prendre en compte les effets des prix, mais aussi toute hétérogénéité non observable qui varie avec le temps

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<sup>1</sup>L'Allemagne, l'Autriche, la Belgique, le Danemark, la France, la Finlande, l'Allemagne, la Grèce, l'Irlande, l'Italie, le Luxembourg, les Pays-Bas, le Portugal, l'Espagne, la Suède

<sup>2</sup>Chypre, la République tchèque, l'Estonie, la Hongrie, la Lettonie, la Lituanie, Malte et la Pologne. La Bulgarie et la Roumanie ne sont pas encore obligées de suivre ce règlement

pour chaque origine et pour chaque destination. En outre, des effets fixes bilatéraux sont utilisés pour contrôler les déterminants invariants dans le temps.

Un des principaux défis à relever lorsque l'on travaille avec des modèles de gravité est que la variable dépendante prend souvent la valeur de zéro. Cela est particulièrement vrai avec le commerce de produits tels que les substances dangereuses qui sont rarement échangées. Pour faire face à ce problème, le modèle est estimé avec deux types d'approches. Tout d'abord, sous une forme log-linéaire, une telle procédure ne tient pas compte des zéros dans la variable dépendante. Néanmoins, pour tester la robustesse des résultats et traiter les zéros de la variable dépendante, on utilise un modèle pseudo-Poisson de maximum de vraisemblance (Santos Silva and Tenreyro (2011)) sous différents sous-ensembles d'effets fixes. Avec ce paramètre, nous considérons le montant négocié et aussi la décision de négocier ou non. Cependant, dans ce modèle, il n'est pas possible d'utiliser des effets fixes par pays en raison des problèmes de convergence.

Le deuxième chapitre utilise également le modèle de gravité qui est considéré comme le facteur déterminant dans l'estimation de l'effet des accords bilatéraux basés sur les politiques sur les flux commerciaux bilatéraux (Feenstra (2003)). Plus récemment, elle a également été utilisée pour estimer les effets des Accords Multilatéraux Environnementaux (AME) sur le commerce (Kellenberg and Levinson (2014)) et, dans la plupart des cas, la méthodologie a été empruntée à la littérature sur les accords commerciaux. Nous basons notre principale spécification de pointe du modèle de gravité sur Baier and Bergstrand (2007).

Comme dans le premier chapitre, une question importante dans l'estimation des effets des AME sur le commerce est le fait que l'auto-sélection des paires de pays dans les AME crée peut-être un biais d'endogénéité dans les estimations. Par exemple, les partenaires commerciaux qui ratifient les conventions pourraient être ceux pour lesquels le commerce des HC ou des POP ne croît pas. La procédure de ce chapitre est la même que

celle du chapitre précédent. J'utilise la nature des données de panel et j'inclus trois ensembles d'effets fixes qui tiennent compte des facteurs non observés qui varient dans le temps pour l'exportateur et l'importateur séparément. Dans ce cas, j'utilise des données désagrégées à travers la dimension pays-paire-produit (pays-paire - ou "dyadic" - produit effets fixes).

Dans le troisième chapitre, le point de départ est une approche adoptée par Frankel and Rose (2005) et Baghdadi et al. (2013). La contribution consiste à ajouter la variable de rigueur de la réglementation environnementale pour analyser son impact sur le résultat environnemental respectif. Pour ce faire, les résultats environnementaux (émissions par exemple) s'expliquent par l'ouverture, le revenu, la population, la capacité des terres, l'application de la loi et la rigueur de la réglementation environnementale.

Pour surmonter les problèmes de simultanéité avec les effets du degré d'ouverture (commerce international) et du revenu (PIB), dans une première étape, j'applique une procédure de variable instrumentale pour ces deux effets, en utilisant des variables géographiques pour le premier et pour le deuxième, l'indice de capital humain, l'investissement et la population. Ce qui contribue à démêler le problème d'endogénéité et permet également de prendre en compte l'effet échelle, l'effet technique et l'effet de composition (facteur de dotation de l'effet de composition). Les valeurs prédites sont ensuite utilisées dans une deuxième étape dans laquelle j'étudie l'effet des lois nationales et internationales, conditionnelles à l'ouverture et au niveau de revenu, dans un modèle à effet fixe.

De plus, pour traiter la possible causalité inverse des lois environnementales avec les résultats environnementaux, deux instruments différents sont utilisés. Dans une première spécification du modèle, une variable institutionnelle qui contrôle l'application des lois est utilisée. Deuxièmement, une variable qui peut être corrélée avec le nombre de lois, mais pas nécessairement avec les résultats environnementaux, est utilisée. On a trouvé pour cela deux variables, une variable appelé "règle de droit" qui

montre la perception de la confiance des agents aux règles de la société et une autre variable qui contient les lois dans un sujet non lié aux résultats environnementaux utilisés, dans ce cas, les lois liées à l'alimentation et la nutrition.

## 1.7 Contributions

Le premier chapitre contribue à la littérature car il utilise des techniques de données de panel afin de démêler la simultanéité possible de la formalisation et il inclut également l'indice composite de la réglementation environnementale. Cet indice a de multiples dimensions afin d'évaluer les différentes caractéristiques de la réglementation environnementale (Brunel and Levinson (2013)). Il contient également des informations sur trois indicateurs complémentaires comme dans Kheder and Zugravu (2012).

L'avantage d'utiliser un tel indice est qu'il capte la solidité des institutions, l'état réel des résultats environnementaux et la ratification des traités. Ces trois composantes sont liées au commerce des déchets. La pertinence des institutions pour le commerce s'est avérée importante dans Rodriguez and Rodrik (2001), à la pollution dans Barrett et al. (2000) et dans Candau and Dienesch (2015). Ma recherche est la première étude à inclure la qualité des institutions dans l'analyse du commerce des déchets.

En outre, ce chapitre étudie uniquement les déchets dangereux en raison de leur potentiel polluant. Ce travail explore l'effet de refuge pour les déchets dans les pays de l'UE moins développés et dans les pays en développement par régions. Cette séparation sur différents groupes de pays permet de tirer des conclusions plus précises sur les déterminants en vigueur lors de l'étude du commerce des déchets.

Dans le deuxième chapitre, la contribution vient d'une étude visant à déterminer si l'entrée en vigueur des conventions modifie les flux commer-

ciaux des produits en question. Pour cela on utilise un modèle de gravité, qui atténue l'endogénéité de la ratification de ces conventions, à partir de données commerciales hautement désagrégées de HC et des POP. En outre, on constate que l'utilisation de données agrégées, comme dans les travaux précédents, peut biaiser les résultats.

La contribution du troisième chapitre consiste à examiner l'effet de la réglementation environnementale sur les résultats environnementaux, en tenant compte des effets du commerce et du revenu. En outre, on crée une mesure, comparable entre pays, de réglementation environnementale. Celle-ci est un indice de l'intensité des lois environnementales, par sujet environnemental.

Enfin, il convient de mentionner que la production la plus importante de cette thèse est l'ensemble de données générées. Le premier et le deuxième chapitre utilisent un ensemble de données désagrégées à six chiffres de déchets dangereux, de produits chimiques dangereux et de polluants organiques persistants pour les périodes 2003-2010 pour le premier chapitre et 1995-2012 pour le deuxième. En outre, ces deux chapitres utilisent des variables de gravité à niveau pays-temps, une variable binaire pour la séparation des pays membres de l'OCDE et des pays non membres de l'OCDE et la ratification de la convention de la Bâle, de la Convention de Rotterdam et de la Convention de Stockholm.

Le premier chapitre comporte également un indice de réglementation environnementale composé, utilisé sous une forme agrégée et désagrégée, qui, outre les variables de ratification de convention, utilise une variable de performance environnementale et une variable de qualité institutionnelle composée d'indices de corruption.

Puisque les trois chapitres utilisent un modèle de gravité, un ensemble de variables de gravité (y compris le commerce) fait partie de la production.

Dans le troisième chapitre, j'applique les estimations en deux étapes. En conséquence, je crée une variable d'éloignement pour l'estimation

de l'ouverture et aussi l'ensemble des variables de croissance pour la première étape de la procédure de variable instrumentale du revenu. À ces variables, nous ajoutons les résultats environnementaux et l'intensité de la réglementation, de l'application et des instruments environnementaux.

## 2

# Introduction

The study of international trade effects on the environment raises a widespread debate. At the core of the analysis lie fundamental economic issues such as the channels of transmission of these effects, but also several methodological challenges. So far, the theoretical background has concentrated on the investigation of the transmission channel. In what is to follow I will explain the way I assess these challenges and how the study of environmental regulations is of fundamental importance when addressing the effects of trade on the environment.

Firstly, I explain the three channels whereby international trade affects environment: the scale, technique and composition effects. In this perspective, I overview the literature on the basis of the theoretical analysis to some of the emerging empirical contributions.

Secondly, I examine the main challenges facing the assessment of trade and environment effects on an empirical framework. Then, I focus on countries' differences in environmental regulation, taking into account their level of development. This leads to the introduction of the main common characteristics connecting the three chapters of this dissertation.

Thirdly, I expose environmental regulation differences as the main incentive to the possible emergence of waste and pollution haven effects.

Consequently, I present the first two chapters of this dissertation, which focus on the shipments of hazardous substances from developed to developing countries. This analysis is pursued with a particular emphasis on certain products and also specific International Environmental Agreements.

Finally, I present a more general way of assessing the effect of international trade on the environment. Thus, in the third chapter of this dissertation, I present an empirical study grounded in international trade and growth theory. In particular, I examine the effect of countries environmental regulations on different environmental outcomes, including international trade. This work also assesses the reverse causality between the environmental outcomes and the determinants of pollution.

## **2.1 International trade and environment: from theory to empirics**

Does increasing trade impact the environment? This is a controversial debate for both trade policy and for environmental concerns. Even though it is established that the effects of trade on the environment are complex, there are good efforts in evaluating them in three separate effects. One of the earliest studies assessing this relationship is Taylor and Copeland (2004) and Grossman and Krueger (1991). These studies address the environmental impact of trade through three effects, namely scale, technique and composition. These three effects were then developed in a combined theoretical and empirical approach by Copeland and Taylor (2013), allowing a fragmentation of the composition effect. These works highlight the importance of considering that environmental regulation differences create an incentive for displacing pollution to the less regulated countries.

The scale effect is known to generate a negative impact on the environment. With all other things remaining equal, an increase in participation in



international trade increases production which consequently comes with an increment of the associated pollution on that production process.

Integrating the international markets can imply, according to some trade agreements, technology transfers. These new adopted technologies that are potentially cleaner, could possibly decrease pollution due to less pollutant production processes.

In the same way the type of production that a country may have can influence the net effect of pollution. The composition effect concentrates on the factor endowments of countries. A country with labor-intensive production will result in lower level of pollution than a country which is capital-intensive. Nevertheless, this composition effect addresses not only factor endowment differences, but also more policy-related characteristics, such as environmental regulation differences among countries.

Studies analysing these effects are numerous, which is why here I will only discuss the most relevant literature for this dissertation. One of the first studies using theoretical and empirical techniques to test the effects of open trade on the environment is Taylor et al. (2001). Their results show an effect of trade on the environment, through the composition effect, using dioxide concentrations as pollutant. Authors claim that trade is positive for the environment. Additionally, they highlight the need to take into account differences in environmental regulations, and the lack of proxy variables that could be used, specially for developing countries.

Also Dean (2002) results point out a negative outcome in the composition effect and a positive outcome in the technique effect, the latter outweighing the former. This study observes the effect of trade on water pollution in China with a model accounting for effects on pollution and through income growth indirectly, thus, capturing trade and growth effects. However, this work does not take into account environmental regulations in an explicit way.

Cole and Elliott (2003) focus on the composition effect to study the

factor endowments and the environmental regulation in a Kuznets' Curve perspective. Their results show that there is no straightforward answer but that there is a need to analyse each in particular. They claim that the impact of trade depends on the pollutant and on the measure used.

In a cross section setting focusing on local air pollutants, the paper of Frankel and Rose (2005) addresses simultaneity between trade and environment, they conclude that openness to trade could have beneficial effects on the environment. I argue that in order to give more accurate responses about the effect of trade on the environment, a panel-data setting would be more suitable, since the population effect matters and so does the time trend. These two are important factors which are not captured in a cross-section setting.

Only a few of these studies assess the simultaneity issue between income and pollution. However Managi et al. (2009) is the first study taking this into account. They also include the level of development of countries using an OECD and Non-OECD country type division. Their estimates show that it is not as straightforward. The beneficial effect on the environment varies, depending on the pollutant and the country.

A good assessment of the Regional Trade Agreements effect is the study of Baghdadi et al. (2013) in which, in a panel data setting, controlling for endogenous effects, authors show that Agreements with environmental provisions have an impact promoting emissions convergence. On the contrary, agreements without environmental provisions do not contribute to emission convergence. Nevertheless, whether the converge is up or down is still an open question.

In a cross-section setting, Ben Kheder and Zugravu (2012) argue that environmental regulations are an important drive for attracting polluting industries. The main principle of the pollution haven effects is to displace polluting industries to countries with lenient environmental regulations. In this context, there are some investments that are made in those countries in order to displace such industries. Nonetheless, when the environmental

regulation becomes stricter in developed countries, this could generate a perverse effect, promoting a displacement of waste to developing countries. Kellenberg (2012) studies this phenomenon and also raises the emergence of waste haven effects. The author also emphasises the need to take into account the environmental regulation differences between trading partners. These differences generate an increase in the waste imported in countries with less strict environmental regulations.

An attempt to build a variable representing the environmental regulation raises a challenge. However, it allows to take into account the incentive arising from a context in which a country has a less strict environmental regulation towards his trading partners. In such situation, trade could have a negative effect on the environment, not only because the country would have dirty production, but also because the country can receive pollution from trade partners either through a pollution haven effect or a waste haven effect, as showed in the above-mentioned articles.

## **2.2 The effect of environmental regulation**

Environmental regulation differences are studied as part of the composition effect. In what follows I present articles that use proxy variables to represent environmental regulation. Apart from the study of Frankel and Rose (2005), research about the effects of environmental regulation on environmental outcomes in an open economy concentrates on specific pollutants, regions or years, and do not always include the effect of trade (Botta and Koźluk (2014), Brunel and Levinson (2013), Sauvage (2014), Copeland (2003), Misra and Pandey (2005) Kellenberg (2009) and Pratt and Mauri (2005)).

Two studies are a good attempt to approach the environmental regulation issue. On one hand, Botta and Koźluk (2014) underline the lack of a reliable comparable measure of environmental regulation. They propose an index. However this index only concerns OECD countries and only refers

to climate and air pollution. On the other hand, in the article by Frankel and Rose (2005), the authors analyse air pollutants and other environmental outcomes. They also assess the simultaneity issue, nonetheless, their strategy is in cross-section and does not take into account environmental regulation stringency.

It is also worth noting that Botta and Koźluk (2014) findings show that different measures of environmental stringency are not strongly correlated, which shows that they are capturing different phenomena. Brunel and Levinson (2013) also underline the multidimensional aspect of the environmental regulation stringency and point out the fact that using only one measure of environmental regulation generates a lack of robustness in the results. This is due to the low correlation between the different measures of environmental regulation stringency.

In this context, I construct different indexes for environmental regulation and I use them in different settings in each chapter of my dissertation. With these proxy variables I capture country and time varying characteristics, and I also apply them differently, according to the specific environmental outcome studied.

This dissertation integrates the analysis of different environmental outcomes with new and complementary measures of environmental regulation in a panel data-set. Additionally to this notion of environmental regulation, the study of specific International Environmental Agreements is also assessed. Particularly, my analysis focuses on the interaction between countries with different stages in development, with the objective of capturing "institutional" differences between countries in the environmental scope. I am convinced that those differences play an important role when studying the evolution of the environmental outcomes.

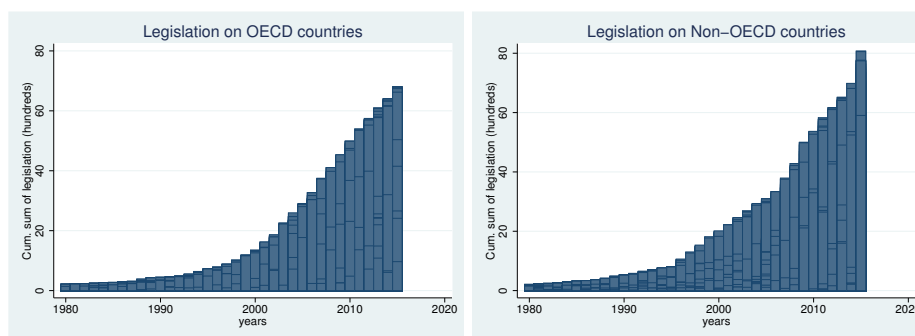
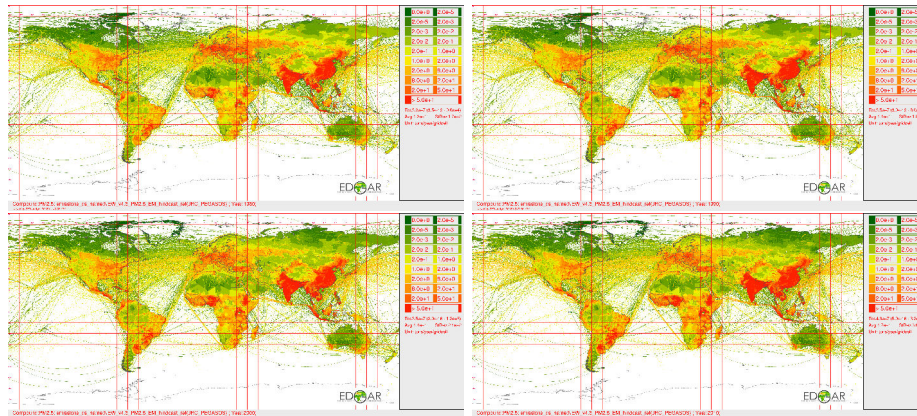


Figure 2.1: Environmental Legislation from 1980-2010

## 2.3 Environmental regulation and the environment

The role of environmental regulation is of crucial importance for the protection of the environment in all countries. The level of pollution of a country will vary according to the characteristics of the specific country (composition effect: factor of endowment). Countries also tend to produce more in order to trade more (scale effect). In the process of trading, even if there is a transfer of technology as a part of this international cooperation (technique effect), this technology transfer seems a solution which is more time-consuming and which is restricted to the countries' characteristics and also to their trade partners. Contrarily, environmental regulations, reflect countries' institutions, and they can be promoted as a policy target.

Environmental regulation is, furthermore, the variable that could move more easily than the other determinants. As the environmental regulation is linked to the level of income, it is normal to find that it runs in parallel with the income effect. Figure 2.1 shows how environmental regulation (proxied as legislation intensity) evolves in time for OECD and Non-OECD countries. For OECD and Non-OECD countries there is a positive trend in the growth of environmental regulation. Nevertheless, only for OECD countries does it take a sort of concave form. This could imply that, in the logic of countries stabilising their levels of pollution, the need to increase



Source: Emissions database for global atmospheric research

**Figure 2.2:** PM2.5 Emissions from 1980-2010

environmental regulations will also be stabilised. In those countries there are better and well established regulations. However, for Non-OECD countries, there is still a transition to make and it still shows a convex form (figure 2.1 right).

Developed countries have stricter environmental regulations than developing countries. They have also polluted more in the past and are still the main polluters in certain types of pollution (greenhouse gas polluters are still OECD countries (Boden et al. (2011))). Globally, there is an increase in pollution, and this pollution is geographically moving to southern countries, i.e. developing countries. The increase in environmental regulations could help those countries to protect their environment.

On the other hand, pollution is increasing worldwide, as an illustration, Figure 2.2 shows how emissions of PM2.5 are increasing worldwide, but are also being displaced from North to South. In this dissertation I assess these effects of increasing and displacing pollution in its different forms, assessing the role that different levels and different evolutions of environmental regulations can have in the displacement of pollution from developed to developing countries.

## 2.4 A three-chapter dissertation

This dissertation seeks to contribute to the understanding of the relationship between trade and environment, with a focus on the role of environmental regulation differences among developed and developing countries. The international community, economists and other social scientists have long been interested in this relationship. However, it is only recently that researchers have begun to study this topic empirically. This is due to the emergence of environmental concerns as a major policy issue and to advances in the statistical-econometric tools available to evaluate counter-factual outcomes, which identify causal relationships. Advances in computer science and data access have improved our ability to estimate the components, in this case, associated with environmental regulations that are most relevant to the study of the effects of trade on the environment.

The first chapter establishes a link between the literature studying international trade and the one studying the environment. This literature suggests the emergence of developing countries as waste havens for their developed counterparts, due to environmental regulation differences between trade partners. This chapter analyses the effectiveness of the Basel Convention formalisation in the European Union (*EU-WSR*), by studying the impact of the *EU-WSR* on hazardous waste trade, first on the less developed EU countries, and then on developing countries, divided into regions.

This chapter was motivated by the fact that the European Union (EU) ratified the convention and the ban amendment (Forbidding shipments of hazardous waste from developed to developing countries). Even considering that the amendment has not been forced yet, it is already a signal of commitment on the part of the EU. Consequently, it is interesting to know if hazardous waste imports in developing countries coming from the EU decrease. Additionally, I investigate if less developed countries of the EU are becoming waste havens for the more developed ones. Since the EU most developed countries are no allowed to send hazardous waste to

developing countries, this could incite those countries to send them to less developed countries of the EU.

The Basel Convention creates an instrument to check shipments of waste. If a country wants to send waste to another country, the exporter should get an acceptance from the importing authority of the importing country. This procedure passes through the Basel Convention and is called Prior Informed Consent (PIC).

In order to quantify the environmental regulation differences, my analysis is inspired by several claims made by developing countries after the Basel Convention entered into force in 1992. These claims assert that the PIC legitimates what was illegal before (Kellenberg (2012)), allowing shipments of hazardous waste to their frontiers. The main rationale of the countries placing the complaints is that this process might possibly be subject to corruption, especially when unscrupulous enterprises and high incentives are involved.

For this reason, following Ben Kheder and Zugravu (2012), I construct a composed environmental regulation index, which includes three different but yet complementary country characteristics, specifically to take into account the quality of the institutions. I use some corruption indexes, International Environmental Agreements (IEAs) ratification and an environmental performance index to consider the level of environmental quality.

Results show weak evidence of waste haven effect in the less developed EU countries. These results are confirmed by measures of aggregated and disaggregated environmental regulations. However, an increasing ratification of treaties could lead to a decrease in imports of waste in the less developed countries of the EU. In the regional analysis, there is no evidence of the efficiency of the *EU-WSR*. These findings provide insights into the efficacy of European engagements on waste trade, indicating that there is no simple answer to this.



Consequently, to explore more in detail the functioning and the role of the International Environmental Agreements, I concentrate on the following Environmental Agreements: the Rotterdam Convention on hazardous chemicals and the Stockholm Convention on persistent organic pollutants, both Agreements deriving from the Basel Convention. The products concerned by these two conventions cannot be considered as hazardous waste, because they are not waste per se but they might be inputs and/or by-products of production.

Importantly, the products concerned by the Rotterdam Convention and the Stockholm Convention have been proven to be dangerous for the health and the environment. According to the American Occupational Safety and Health Administration, hazardous chemical products are toxic and reactive and have a great potential for damaging health when released.

These two conventions were inspired by the same incentives as the Basel Convention and were developed using also the same instruments (PIC and a Ban). The Basel Convention was adopted in 1992 with the PIC procedure above-mentioned. Since this instrument has proved to increase waste shipments (Kellenberg (2012)), the international community made an effort to implement the ban Amendment of the Basel Convention in 1995. This Ban Amendment consists in permanently forbidding the hazardous waste shipments from developed to developing countries. Unfortunately, to this date, it has not been adopted. It is worth noting that while the Rotterdam Convention uses the PIC procedure, the Stockholm Convention uses a ban on certain products.

The second chapter, consequently, studies the recent research that has questioned the effectiveness of International Environmental Agreements (IEAs), some of which are seen as an attempt of countries to built a positive image internationally, ratifying the environmental agreements but not putting much of an effort into their application. This paper focuses on two environmental agreements, which have common aspects with the Basel Convention, because they concentrate on *goods* that are potentially

very dangerous to health and environment when released in nature or when released with bad disposal procedures.

This chapter explicitly evaluates the effects of ratification and adoption of these agreements on the imports of hazardous chemicals and persistent organic pollutants. Since a self-selection of countries ratifying these conventions might be an issue, the model uses controls to mitigate the endogeneity of the decision to ratify.

The results of this chapter point out the partial effect of these two conventions. More precisely, they highlight that when assessing the PIC, which is a less restrictive agreement, imports of hazardous chemicals from North to South are only reduced when the exporter ratifies the Rotterdam Convention. When assessing the ban on persistent organic pollutants, imports are reduced when the importer ratifies the Stockholm Convention.

It is interesting to note here that the effect on the ban is almost twice larger than the PIC, this could be due to the different levels of strictness of the instruments.

The common framework among those two chapters is twofold. On the one hand, they analyse the change in increasing flows of hazardous products from developed to developing countries. On the other hand, they use different environmental regulation stringency variables and do this in a different manner. However, as mentioned before, even if these two studies are challenging in terms of methodological issues, as they use panel data and a large group of countries, ultimately what would be interesting to know is if countries' environmental outcomes, as a whole, are getting better or worse. I believe it gives a coherent complement to my dissertation to study the effect of environmental law stringency on countries' environmental outcomes, when integrating international trade.

The big challenge when answering this question lies, as explained before, on how to assess the possible simultaneity of environmental regulation and environmental outcomes, which creates a source of endogeneity (Brunel

and Levinson (2016) and Frankel and Rose (2005)). Additionally, there is the challenge of how to choose an environmental regulation stringency metric, comparable at country-level and with a panel data-set setting.

The third and last chapter of this dissertation investigates the effect of environmental regulation stringency on environmental outcomes at country-level. In this chapter, the model of Frankel and Rose (2005) is taken as starting-point and then it is extended to a panel data-setting. An environmental regulation stringency variable is also added.

The environmental regulation stringency variable here is composed of environmental legislation passed by countries over time. This variable is constructed as a counting variable of the number of laws of a country taking into account the initial stock of laws of a given country, as the sum of all the laws in the previous periods of the study. Also the environmental regulation variable is complemented by a variable of enforcement that will capture that these laws are actually being implemented.

This research is an attempt to include the efforts that countries are displaying on environmental regulation, at a local level. In this chapter, I take into account determinants of pollution and also income and openness effect, instrumenting the two latter in a first stage. Also, the reverse causality between environmental outcomes and environmental regulation is addressed. And as robustness tests we estimated the lagged effect of these laws, and we also addressed the effect of excluding Federalist countries.

Results show that the intensity of the environmental laws appears to have an effect improving environmental outcomes. This effect is particular to the environmental outcome and the law. These effects are specific to the metrics and the pollutants used, confirming the results of previous studies. Additionally, I also question some previous conclusions from the literature regarding the beneficial effect of trade on the environment.

The enforcement proxy variable used in this work appears to reduce pollution only in certain outcomes. Yet it is less important in decreasing

pollution than the laws in our model. Nevertheless, it works efficiently with Forest area, increasing and also decreasing PM2.5 emissions.

The effect of trade improving environmental outcomes is particular to OECD countries and only for PM2.5 emissions. Contrarily, an increasing effect for Non-OECD countries in NO2 emissions is found. In addition, openness increases water pollution for Non-OECD countries. These results challenge previous works about openness effect consistently showing a decrease in forest area.

The effect of environmental regulation stringency (understood as the intensity of environmental laws) on the environmental outcomes, confirms. Results, when excluding Federalist countries and when using the Environmental Laws as a lagged variable, also confirm Barrett (2006).

## 2.5 Main results

First, there is no decrease in waste trade from the European Union to developing countries, even if European countries engage in the Basel Convention, an International Environmental Agreement meant to control and eliminate waste trade. The main reason could be a lack of strictness of this Agreement, due to the fact that the ban of this trade cannot enter into force due to a lack of ratifying countries.

Secondly, on the other hand the International Environmental Agreements have an effect decreasing the imports of hazardous substances, but this is still a partial effect and depends on the context of the Agreement. It has an effect when developing countries ratify an Agreement that implies a ban to decrease imports of dangerous substances on their territories. Contrarily, when the Agreement has a less demanding restriction which does not imply a ban, then it is more important that developed countries engage in not sending these substances, thus ratifying the Agreement.

Thirdly, environmental regulations expressed as environmental laws, can have an effect improving environmental outcomes. Enforcement is also important, but the intensity of laws remains the most important factor. Openness in a country can lead to detrimental effects on the environment.

## 2.6 Methodologies

In the thesis, I focus on the gravity model with fixed-effects, incorporating metrics used in the literature on growth. Finally, my analysis is also partly complemented with an impact analysis method, as is the differences-in-differences model.

In the first chapter, I focus on a regulation of the EU parliament. This regulation intended to ban shipments of hazardous waste to developing countries (*EU-WSR*). It was approved in 2006 and came into force in 2007. This regulation is a formalisation of the Basel Convention and of its related Ban Amendment on hazardous waste. Using this information in a quasi-natural experiment setting, I construct a dummy variable for bilateral trading pairs where exporting countries are the *EU-15*<sup>1</sup> and importing countries are *EU-10*<sup>2</sup>. The *EU-10* tend to have rather lax environmental regulations. This dummy variable is coupled with a period variable, which distinguishes periods before and after 2007, the year in which the regulation was adopted. Finally, I consider the interaction between these two variables and the Environmental Regulation Gradient variable.

To this difference-in-differences specification I join a gravity model to estimate the effect of policy-based bilateral agreements on bilateral trade flows (Head and Mayer (2014)), following the most recent developments of the gravity specification (Baier and Bergstrand (2007), Santos Silva and Tenreyro (2011)).

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<sup>1</sup>*EU-15*=Austria, Belgium, Denmark, France, Finland, Germany, Greece, Ireland, Italy Luxembourg, Netherlands, Portugal, Spain, Suede, United Kingdom

<sup>2</sup>*EU-10*=Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta and Poland. Bulgaria and Roumania not yet obliged to follow this regulation

An important issue to consider, in the estimation of the effects of a policy aimed at changing trade patterns, is the self-selection of country pairs when trading the targeted products, because this generates an endogeneity bias in the estimates. In order to deal with this issue, I use a method with a gravity setting, bilateral fixed-effects with a log-levels specification in a panel data-set. Also, multilateral resistant factors (MRF), which represent relative-price differences across countries with respect to all their trading partners, are included in the model (Anderson and Van Wincoop (2004) and Head and Mayer (2014)). In a panel data-set framework, since these factors vary over time, they are proxied using time-varying exporter and importer fixed effects, which will capture not only price effects, but also all the unobservable heterogeneity that varies over time for each origin and for each destination. Furthermore, bilateral fixed effects are used to control time invariant determinants.

One of the main challenges to face when working with gravity models is that the dependent variable often takes the value of zero. This is especially true with trade in products such as hazardous substances that are rarely traded. In order to deal with this problem, the model is estimated with two types of approaches. First, in a log-linear form; such procedure does not account for the zeros in the dependent variable. Nevertheless, to test the robustness of the results and deal with the zeros in the dependent variable, a pseudo-Poisson maximum likelihood (ppml) model (Santos Silva and Tenreyro (2011)) is used under different subsets of fixed effects. With this setting we consider the amount traded and also the decision to trade or not. However, in this model it is not possible to use country-time fixed effects due to convergence problems.

The second chapter also uses the gravity model which is considered the workhorse in estimating the effect of policy-based bilateral agreements on bilateral trade flows (Feenstra (2003)). More recently, it has also been used to estimate the effects of MEAs on trade (Kellenberg and Levinson (2014)) and in most cases the methodology has been borrowed from the literature on trade agreements. We base our main state-of-the-art

specification of the gravity model on Baier and Bergstrand (2007).

As in the first chapter an important issue in the estimation of the effects of MEAs on trade is the fact that the self-selection of country pairs into MEAs possibly creates an endogeneity bias in the estimates. For instance, trade partners that ratify the conventions might be those for which trade in HCs or in POPs is not growing. The procedure in this chapter is the same as in the previous chapter. In short, I exploit the panel nature of the data and include three sets of fixed effects that account for unobserved factors varying over time for the exporter and the importer separately. In this case, I use disaggregated data across the country-pair-product dimension (country-pair- or "dyadic"-product fixed effects).

In the third chapter, the starting point is an approach adopted from Frankel and Rose (2005) and Baghdadi et al. (2013). The contribution is to add the environmental regulation stringency variable to analyse its impact on the respective environmental outcome. In order to do so, the environmental outcome (emissions for example) is explained by openness, income, population, land capacity, enforcement and the environmental regulation stringency (environmental laws).

In order to overcome the simultaneity problems with the openness (international trade) and income (GDP) effects, in a first stage I apply the instrumental variable procedure to these two effects, using the geographical variables in case of the former and human capital index, investment and population in the latter. This helps to disentangle the endogeneity problem and also allows to take into account the scale, technique, and the composition effect (the factor of endowments role of the composition effect). The predicted values are then used in a second stage in which I study the effect of the national and international laws, conditional to the openness and income level, in a fixed-effect model.

To address the possible reverse causality within the environmental laws and their outcomes, two different instruments are used. In a first specification of the model, an institutional variable that takes the enforcement the

laws into account (Government Effectiveness) is used. Secondly, a variable that can be correlated with the number of laws but not necessarily with the environmental outcomes is used. For this we found two variables: the rule of law, which shows the perception of agents' confidence in society rules and also laws that are unrelated to the environmental outcomes used, in this case food and nutrition laws.

## 2.7 Contributions

The first chapter contributes to the literature as it uses panel data techniques in order to disentangle the possible simultaneity of the formalisation and it also includes the composite environmental regulation index. This index has multiple dimensions in order to assess different features of the environmental regulation (Brunel and Levinson (2013)). It also contains information about three complementary indicators as in Kheder and Zugravu (2012).

The advantage of using such an index is that it captures the solidity of institutions, the actual state of the environmental outcome and the ratification of treaties. These three components are related to waste trade. Relevance of institutions to trade has been proven important in Rodriguez and Rodrik (2001), to pollution in Barrett et al. (2000) and in Candau and Dienesch (2015). My research is the first study to include institution quality in waste trade analysis.

Additionally, this chapter studies only hazardous waste due to their polluting potential. This work explores the waste haven effect both in the less developed EU countries and in developing countries by regions. This separation on different country-group allows to give more precise conclusions on the determinants in force when waste trade is studied.

In the second chapter, the contribution comes from a study investigating whether the enforcement of the conventions alters trade flows in the



products in question. In order to do this, we use a gravity model that mitigates endogeneity of convention ratification, with disaggregated trade data of hazardous chemicals and persistent organic pollutants. In addition, we find out that using aggregated data as in previous works can bias the results.

The third chapter's contribution lies in addressing the effect of environmental regulation on environmental outcomes, taking into account trade and income effects. In addition, we create a measure of environmental regulation, comparable between countries. This one is an index of environmental laws intensity, by environmental subject.

Last but not least, it is worth mentioning that the largest outcome of this dissertation is the data-set generated. The first and second chapter use a six-digit disaggregated data-set of hazardous waste, hazardous chemical and persistent organic pollutants, for periods 2003-2010 for the former and 1995-2012 for the two latter. They also use gravity variables at a country-time level, a OECD dummy variable and a dummy variable for convention ratification for the Basel; the Rotterdam and the Stockholm Convention.

The first chapter also has a composed environmental regulation index used in an aggregated and disaggregated form. Besides the convention ratification variables, it uses an environmental performance variable and an institutional quality variable, composed of corruption indexes.

Since the three chapters use a gravity model, a set of gravity variables (including trade) is part of the output. In the third chapter, I apply estimations in two stages. As a consequence, I create a remoteness variable for the openness estimation in the first stage and we also have the set of growth variables for the income first stage. To those variables we add the environmental outcomes and the intensity of environmental regulation, enforcement and instruments.

## 3

# Waste haven effect: unwrapping the impact of environmental regulation

### 3.1 Introduction

In this paper I examine if the formalisation of the Basel Convention in the European Union, creates a waste haven effect for the less regulated countries of the European Union. Since European countries signed the Basel Convention, they engaged into stopping sending shipments of hazardous waste to developing countries. Restricted to send hazardous waste to developing countries, the bigger producers of hazardous waste, that are the richer countries of the Union could be tempted to change the direction of trade to those less developed and less regulated countries of the European Union.

In addition, even if the Ban Amendment of the Basel Convention that prohibits shipments of hazardous waste from developed to developing countries is not yet in force, the European Union engagements should have an effect on decreasing shipments of hazardous waste to developing

countries. So, I observe if this is the case.

The relationship between trade and environment has raised a great deal of interest among economists, despite the fact that simultaneity of the two poses serious empirical challenges, because when trade increases the environmental damage tends to increase as well. Additionally, even if the simultaneity issue is addressed, whether trade has a positive or negative impact on the environment has not lead to a consensual answer yet.

In the theoretical part of the literature, conventionally, to assess the environmental impact of trade, works highlight three main channels: the scale effect, due to the increasing magnitude of trade, the technique effect, i.e. the impact that new technologies may have on pollution intensity, and the composition effect, caused by a change in the type of production in place (Grossman and Krueger (1991)). This paper focuses on the latter effect, by controlling for scale and technique effect. Following Copeland (2003), the composition effect is broken down into its two driving forces: factor of endowments and environmental regulation differences.

In order to estimate this effect empirically, there are some challenges to tackle. In general, empirical research concentrates in cross-sectional studies, observing environmental impact of trade through emissions as in Cole and Elliott (2003) Frankel and Rose (2005), Managi et al. (2009) and Baghdadi et al. (2013) or industry location as channel of attraction of possible pollution haven effect (Ben Kheder and Zugravu (2012), Dean et al. (2009)). The literature is much less extensive when it comes to estimating the hazardous waste trade, despite the natural intuition that some negative effect is likely to be found. Exporting hazardous waste to countries with lenient environmental regulation saves the cost from industry relocation, Jug and Mirza (2005) support the fact that environmental regulation has an impact in trade flows. From a policy point of view, this is unfortunate, because waste trade harms the country's environmental quality, not even leaving much of an investment, as it is the case in the pollution haven effect.

According to Misra and Pandey (2005), hazardous waste when mishandled in the environment, they may have both short- and long-term effects on both human and environmental systems. Improper treatment, storage, and disposal of hazardous waste can result in contamination during possible exposures, and potential adverse health and environmental impacts. In the case of this study, even if the flow of hazardous waste shipped from developed to developing countries represents less than 3% of total trade, irresponsible waste management practises can create hazardous conditions and considerable risks to human health. In general, any toxic component can cause severe health consequences and even death if taken by humans in sufficiently large amounts.

Moreover, there are some products considered in the Basel Convention that are of primary concern because even in small doses they can cause adverse health impacts. Some anecdotal evidence show that irresponsible management of heavy metals included in some devices as in this analysis "Waste and scrap of primary cells, primary batteries and electric articles" are highly toxic even in low doses, especially to those repeatedly exposed to them. Those substances can have effects on the nervous system, kidneys and other organs. Effects of particular concern are those caused by lead and mercury on the development of the nervous system in children. Other chemicals including some brominated flame retardants can build up in human bodies from repeated exposures. And for some chemicals there is evidence of long term effects including those on brain development and on the whole immune system. Many chemicals in electronic devices are also persistent in the environment.<sup>1</sup> There are illegal and legal waste shipments (Bernard (2011)), but in the framework of this study, due to data-availability, I only study legal shipments.

Among the studies that directly address waste trade, several are based on cross-sectional data. They consider the phenomenon as a pollution haven effect, either including capital abundance (Baggs (2009)), or including

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<sup>1</sup><http://www.greenpeace.org/international/en/news/features/poisoning-the-poor-electroni/>

the analysis of environmental regulation differences between countries (Kellenberg (2012)). Also these two papers concentrate on all waste and not only hazardous waste. In order to take into account for endogenous simultaneity between trade and environment, panel-data offer a better setting; this is in line with Kellenberg and Levinson (2014), although their analysis is not extensive in terms of disentangling the groups of countries or regions which are the most (or the least) affected by this trade, and the composition effect, including the differences in environmental regulation between countries, is not directly investigated.

This article is most closely related to Kellenberg (2012) and Kellenberg and Levinson (2014).

Kellenberg (2012) uses cross-sectional data-set from the 2003-2004 and also directly assesses the environmental regulation difference issue. He uses the Global Competitiveness Report, as a proxy of the environmental regulation, this index is based on a report having answers of company executives ranking the enforcement of environmental regulations at country-level. The findings of this paper are that environmental regulation across countries are an important determinant of waste trade in developing countries.

Kellenberg and Levinson (2014) uses a panel framework and test the effect of the Basel Convention, and the Ban ammendment in the shipments of waste from developed to developing countries. However, this work uses all types of waste, since non-hazardous waste can also be recycled and reused, they are not considered directly a threat to developing countries environment.

This analysis differs from Kellenberg (2012) and Kellenberg and Levinson (2014) in several respects, some are methodological and others are conceptual, but all of them give more accurate results for policy recommendations.

Firstly, in the methodological part, there are two innovations of this work.

On one hand, this analysis uses a set of fixed effects on a panel data-set in order to mitigate the possible endogeneity of the formalisation (Baier and Bergstrand (2007)). This endogeneity could be a result of countries selecting themselves into the formalisation, depending on their volume of waste trade. On the other hand, the environmental regulation index used is a composite index, this index has multiple dimensions in order to assess different features of the environmental regulation (Brunel and Levinson (2013)). The study of Ben Kheder and Zugravu (2012) contains information about three complementary indicators, but in this case, those that are relevant for waste trade are taken into account. The advantage of using such index is that it captures the solidity of institutions, the actual state of the environmental outcome and the Treaty ratification, as a protection from pollution from abroad. Relevance of institutions to trade has been proven important in Rodriguez and Rodrik (2001) and to pollution in Barrett et al. (2000) and in Candau and Dienesch (2015), the present paper is the first study to include institution quality in waste trade analysis. These contributions are developed in detail in the empirical strategy and results sections.

Secondly, in the conceptual differences, here only hazardous waste are analysed due to their polluting potential, and also because non-hazardous waste can also be recycled and used as raw materials. The work of Kellenberg and Levinson (2014) also concerns a panel data framework but works with all types of waste, and uses only two groups of countries, the developed and the developing ones. This work goes one step forward and explores the waste haven effect both in the less developed EU countries and in developing countries; this separation between different country-groups, allows to give more precise conclusions on the determinants at stake when waste trade is studied. Finally, developing countries are also separated into regions to examine more closely the effect in each region.<sup>2</sup>

The remainder of this paper is organised as follows. Section 2 introduces the international context on waste trade and some stylised facts. Section

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<sup>2</sup>For a list of countries by region refer to the Appendix section Table A.6.

3 describes the empirical strategy. The results are presented in section 4. Section 5 concludes.

## 3.2 International context on hazardous waste trade

In the late eighties, claims made by developing countries attracted the attention of the International community. Those complaints were mainly addressed by African developing countries, claiming that waste was being illegally disposed of in their territories. Their efforts resulted in the Basel Convention on waste trade, which entered into force in 1992. In its early days, the instrument implemented by the convention was the Prior Informed Consent (PIC), a formal mechanism allowing a country to send waste shipments to another country, conditional on the 'prior consent' of the corresponding importing authority.

Some years later, developing countries claimed that waste trade in fact increased over time (Kellenberg (2012)). This situation led to the adoption of the Basel Ban Amendment in 1995. The Ban Amendment is intended to clearly prohibit shipments of hazardous waste from developed to developing countries<sup>3</sup>. Yet, because of the lack of sufficient ratifying members, such instrument is still not in force. The effect of these two instruments, in case of the Basel Convention, have shown no effect (Kellenberg and Levinson (2014)).

The first goal of the Basel Convention is addressed through a number of general provisions requiring the United States to apply the basic principles of environmentally sound management of waste.<sup>4</sup> A number of prohibitions are designed to achieve the second objective i.e. hazardous waste can not be exported to Antarctica, a State which is not a member of the Basel

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<sup>3</sup>Countries that are restraint to ship hazardous waste to developing countries are: members of the OECD, EC, Liechtenstein

<sup>4</sup>From Basel Convention article number four.

Convention<sup>5</sup>. The parties may, however, enter into bilateral or multilateral agreements on the management of hazardous waste with other parties or non-parties, provided that the agreements are not less environmentally sound than the Basel Convention.<sup>6</sup> Every case of a transboundary movement is not in principle prohibited, it can only take place if it is a solution that respects the environment, if the principles of environmentally sound and non-discriminatory management are respected, and if it is conducted in accordance with the regulatory system of the Convention.

The regulatory system is the cornerstone of the Basel Convention originally adopted. Based on the concept of Prior Informed Consent, it requires that, before the export can take place, the State authorities must inform the concerned authorities from the States of import and transit by providing detailed information on the intended movement. The movement will only take place if and when all States concerned have given their written consent.<sup>7</sup> The Basel Convention also provides for cooperation between the parties, ranging from the exchange of information on issues relating to the implementation of the Convention on technical assistance, especially to developing countries.<sup>8</sup> The Secretariat is required to facilitate and support this cooperation, acting as a clearing house.<sup>9</sup> In the case of a transboundary movements of hazardous waste that have been made illegally, that is in violation of Articles 6 and 7, or cannot be completed as planned, the Convention assigns responsibility to one or more of the States concerned, and imposes a duty to ensure safe disposal, or by re-importation into the State of production or otherwise.<sup>10</sup>

However, all the European Union (EU) members signed the Basel Convention and committed to the Ban Amendment. To formalise this commitment, it had then to be written in the official journal of the EU, whence an EU

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<sup>5</sup>Ibid

<sup>6</sup>From Basel Convention article number eleven.

<sup>7</sup>From Basel Convention article number six and seven.

<sup>8</sup>From Basel Convention article number ten and thirteen.

<sup>9</sup>From Basel Convention article number sixteen

<sup>10</sup>From Basel Convention article number eight and nine.



regulation on shipments of waste was created (*EU-WSR*).<sup>11</sup> The formalisation of the Basel Convention in the EU was passed in 2006 and it entered into force in 2007. It includes the Ban Amendment, despite the fact that the latter has been not enforced up to now. Even if European countries were to engage into not sending hazardous waste to developing countries, no legal binding procedure nor enforcing authority exist to settle potential cases of non compliance.

Being restricted to sending waste to developing countries, the former and richer EU countries (the *EU-15*)<sup>12</sup> could be tempted to exchange their waste trading partners for their neighbours, the newly arrived and especially less developed countries (*EU-10*)<sup>13</sup>, which also have laxer environmental regulations (See Figure 3.1).<sup>14</sup>

### 3.2.1 Assessing the effect of the formalisation of the Basel convention

To see if increased trade was due to *EU-WSR*, I estimate first a simple difference-in-difference regression; results are shown in Table A.1 and A.2 in appendix. The difference-in-difference estimation is a good tool to see the effect of the formalisation on the concerned countries. Nevertheless; since this model does not take into account the Multilateral Resistant Factors needed to account for time-variant and time invariant effects of flows of trade, it is not the most appropriate to disentangle the effect of the formalisation and to use the Environmental Regulation Gradient. However, with this simple model, we can have a first observation, even if

<sup>11</sup>Council Regulation. No 1013/2006 of European parliament and of the council of 14 June 2006 on shipments of waste. It will be in force from, 12:1-98, 2007.

<sup>12</sup>*EU-15*=Austria, Belgium, Denmark, France, Finland, Germany, Greece, Ireland, Italy Luxembourg, Netherlands, Portugal, Spain, Suede, United Kingdom

<sup>13</sup>*EU-10*=Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta and Poland. Bulgaria and Roumania not yet obliged to follow this regulation

<sup>14</sup>Please note that the names of the groups as *EU-15* and *EU-15* are corresponding to the number of member of each group and not to the year that they join the European Union

biased, of the effect on waste imports after the formalisation. It is worth noting that when using the gravity model the magnitude of trade in each group of country and also significance change once adding all the controls, with these two models we can also observe the magnitude and direction of the bias.

Table A.1 shows *EU-10* waste imports coming from the *EU-15* after the *EU-WSR*; this is the treatment group. As control group, the waste exports of the *EU-15* to three groups of countries are considered. First, all countries of the world except the *EU-10*, second the OECD non-EU and third developing or non-OECD countries. Results vary in magnitude depending on the group, but in all cases there is an increase in trade, although results are not significant in the difference-in-differences estimation. These effects are in line with the main results from results section (3.4) in which there also is an increase of trade after the *EU-WSR* for the treated group, with significant effects in groups (1) and (2), this with aggregated and disaggregated measures of environmental regulation.

In the regional analysis, the treatment groups are the African, Asian and American developing countries whose waste imports are coming from the EU. As control groups, I consider their imports coming from non-EU OECD countries. All of them are studied before and after *EU-WSR*. Table A.2 shows the results. A decrease in waste trade is observed in the African and American regions, although the results lose significance in the difference-in-differences estimator. In the case of Asia, the waste trade increases, but results are not significant. These results are the same in terms of significance with the main results of the gravity estimation.

### 3.3 Empirical strategy

#### 3.3.1 Data

The key point in evaluating the effectiveness of the *EU-WSR* is to correctly define hazardous waste. To select the appropriate products, I refer to the definition of hazardous waste contained in the text of the Basel Convention "A substance in order to be defined as hazardous waste, it must both be listed and possess a characteristic such as being explosive, flammable, toxic, or corrosive. Also, a product could enter in this category if it is defined as or considered to be a hazardous waste under the laws of either the exporting country, the importing country, or any of the countries of transit".<sup>15</sup>

The data-set used here is a matching process of these two sources of information: the COMTRADE data-set and the Basel Convention data-set, in time period 2003-2010<sup>16</sup>. Due to the PIC the Basel Convention has information about the shipments of waste of countries reported to the importing authority, with the 6-digit HS codes a matching process was done of the shipments in the Basel Convention registers and the COMTRADE data-set. The advantage of such combination is that the number of observations is almost doubled, taking into account possible mislabelling or irregular shipments.

The type of products selected are those that have disposable waste in their description and/or in their name. Such definition includes industrial waste, municipal waste, waste oils, pharmaceutical waste, organic solvents waste, hydraulic fluids waste, brake fluids and anti freeze fluids waste, chemical products waste, primary cells waste, metal scrap, primary batteries and electric articles waste. For a full list of the products with their 6-digit

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<sup>15</sup>This study concentrates only on hazardous waste, the broader definition of waste includes also non hazardous waste which could be recycled and hence become raw material or input of production.

<sup>16</sup>This data-set comes from Centre d'Etudes Prospectives et d'Informations Internationales CEPII

harmonised system (HS) codes, refer to Table A.3 in the appendix.

### 3.3.2 Variables

As explanatory variables, in order to represent the period  $(post)_t$  after the *EU-WSR* and the country-group, a set of dummies is used. The country-groups are listed in Table 3.1.<sup>17</sup> Moreover, following Kellenberg (2012), I also take into account cost differences because there could be a specialisation effect in some countries due to lower disposal costs, rather than environmental regulation differences within countries.

Variable	Obs.	Mean	Std. Dev.	Min	Max
Ln(Haz. Waste)	12303	1080946	4084948	0	2145889
Haz. Waste	48048	1861866	3.18e+07	0	2.09e+09
Post	48048	.5	.5000052	0	1
UE15i	48048	.1794872	.3837637	0	1
UE10i	48048	.1153846	.3194889	0	1
Africa	48048	.1282051	.3343216	0	1
Asia	48048	.1923077	.3941176	0	1
America	48048	.2820513	.4500029	0	1
OCDE	48048	.4230769	.4940525	0	1
OECD non EU	48048	.1666667	.3726819	0	1
Gov_eff	48048	.5113005	.9555204	-1.516216	2.373091
Reg_qual	48048	.5091098	.8911559	-2.210257	1.924344
Rule_law	48048	.3566957	1.01921	-1.841827	1.99964
Control_corr	48048	.3753363	1.070749	-1.48841	2.552692
Basel	48048	.9358974	.2449381	0	1
Rotterdam	48048	.6570513	.4746995	0	1
Stockholm	48048	.6682692	.4708398	0	1
MEAS_waste	48048	.8153045	.2369243	.25	1
Env. Performance	48048	56.0641	8.765502	34	78
Institution efficiency index (average)	48048	42.62651	19.26505	2.07e-07	77.89241
Env. Performance (average)	48048	50.14569	19.9216	0	100
Treaty Rat. (average)	48048	81.53045	23.69243	25	100
Environmental regulation	48048	10.23723	1.260319	6.654867	13.06232

Table 3.1: Summary statistics

<sup>17</sup>For more detail about the environmental regulation proxy variables, please refer to Appendix section Environmental regulation gradient (A)

The dependent variable is the aggregated waste trade. It has been constructed using total volume imported (this is measured as the weight of the shipment in tones) aggregated from the 6-digit HS, concerning the specific products that are subject to the definition of the waste mentioned above. The countries that do not trade certain products for the entire period under study are excluded from the main analysis. Even then, the quantity of zeros in the dependent variable is important.

Import' volume rather than value is used because it makes more sense from an environmental point of view (Kellenberg (2012)) and because, as waste is not a regular product, the direction of the payment is not well established. Inside the products considered, there could be some of them that are exported to extract some material e.g. electronic devices. Others could be exported just to dispose of them at a lower cost. For this reason at lower costs either labour costs or environmental costs. For this reason there is no clear way to know if the payment value corresponds to the the importer country or the exporter country.

### 3.3.3 Environmental regulation gradient

Studying hazardous waste imports derives its relevance from the polluting potential of such products. Hazardous waste can have detrimental effects on the environment if there are not environmental regulations adequate to their disposal. These detrimental effects can be seen as causing particular damage in developing countries. Just as those countries have not created the waste products or by-products, they are also unlikely to be able to manage their treatment or disposal in an environmentally friendly way (Briggs (2003)).<sup>18</sup> There are also some anecdotal evidence about waste causing severe damage when badly disposed of or disposed of without any

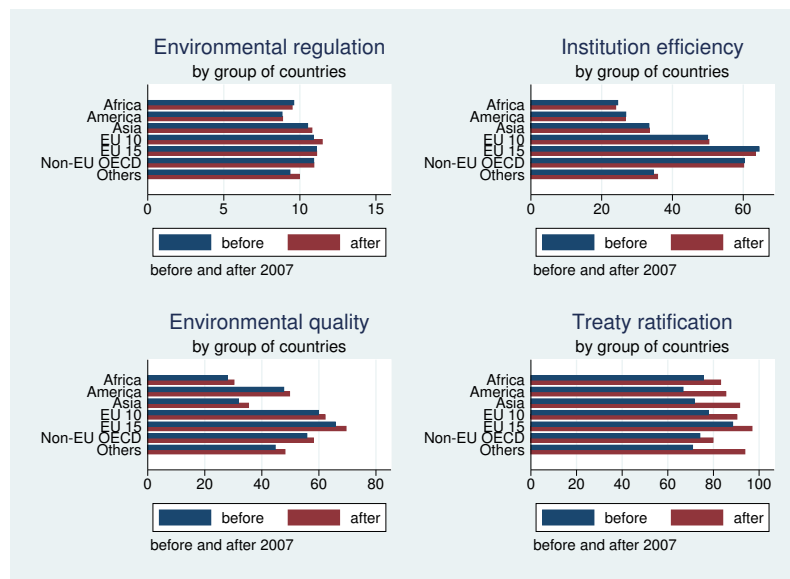
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<sup>18</sup>"Scope of the Chemicals and Waste Subprogramme" (UNEP and Harmful Substances at a glance Division of Technology, Industry and Economics United Nations Environment Programme (UNEP) International Environment House. June 2010), <http://www.unep.org/chemicalsandwaste/About/tabid/258/Default.aspx>.

standard.<sup>19</sup>

If a country has an advantage disposing hazardous waste with the same standards as a developed country would dispose of them, a phenomenon of specialisation is emerging, which is also captured in the model.

Furthermore, if a waste haven effect exists, developing countries' environment and health indicators could be affected not only by lax environmental regulations inside a country, but also by stricter environmental regulations with trading partner countries. Measuring the difference in environmental regulations between countries helps identifying this effect, specifically in the case of waste imports, that cannot be considered as an imported "good", but rather as an environment-harming "bad".



Note: For units of the this graph please refer to table 3.1 the (average) variables

**Figure 3.1:** Components of the environmental regulation for hazardous waste

The claims made by developing countries about the increased imports of hazardous waste after the enforcement of the Basel Convention pointed to the fact that institutions could be corrupted. This fact could have lead to increased waste imports or maintained trends in this trade, as underlined

<sup>19</sup>Africa, trash from the West, nuclear waste trafficking, and chemical weapons. The case of Somalia. <https://www.youtube.com/watch?v=Dze8a-81DcQ>. Electronic Waste in Ghana. <https://www.youtube.com/watch?v=pr1zQrXM7s>

by Kellenberg and Levinson (2014).

According to Ben Kheder and Zugravu (2012) and Brunel and Levinson (2013) a composed index of environmental regulations is necessary to measure the multidimensional features of the matter and to capture fundamental aspects such as the institutional efficiency, environmental damage and Treaty ratification.

The environmental regulation variable is estimated as an aggregated variable composed of these three indexes; estimations of these three complementary variables are also conducted in a disaggregated form in order to account for their individual effect. Further explanation about each variable is to be found in the appendix.

The environmental regulation gradient (ERG)  $ERG_{ijt} = (E_{jt} - E_{it}) / [(E_{jt} + E_{it})/2]$  that captures the differences between countries, is constructed following Kellenberg (2012). The gradient will increase as the differences in environmental regulation within a couple of countries trading waste increases, either because one country makes his regulation stricter or because the other makes it looser. The construction of the environmental regulation gradient, the normalisation of the three proxy variables and the estimation of the aggregated gradient are detailed in the Appendix, section A.

### 3.3.4 Model specification

In 2006, the EU parliament approved a regulation intended to ban shipments of hazardous waste to developing countries *EU-WSR*. This regulation is a formalisation of the Basel Convention and of its related Ban Amendment on hazardous waste. Using this information, I construct an indicator variable for bilateral trading pairs where exporting countries are the *EU-15* and importing countries are *EU-10*; this dummy variable is coupled with a period variable, which distinguishes periods before and

after 2007, the year in which the regulation entered into force. Finally, the interaction between these two variables and the ERG is considered.

To this difference-in-differences specification is joined a gravity model of trade as the workhorse in estimating the effect of policy-based bilateral agreements on bilateral trade flows (Head and Mayer (2014)) and following the most recent developments of the gravity specification (Baier and Bergstrand (2007), Santos Silva and Tenreyro (2011)).

An important issue in the estimation of the effects of a policy aimed at changing trade patterns is that potential self-selection of country pairs into more or less trading of the targeted products generates an endogeneity bias in the estimates.

In order to mitigate endogeneity, several techniques are adopted. Firstly, to decrease the endogeneity bias by incorporating bilateral effects in a log-level specification, panel data-set methods are used. Secondly, Multilateral Resistance Factors (MRF), which represent relative price differences across countries with respect to all their trading partners, are included in the model (Anderson and van Wincoop (2004)). In a panel data-set framework, since these factors vary over time, they are proxied using time dummies and exporter, and, importer fixed effects, which capture the unobservable heterogeneity that varies over time for each origin and for each destination. Furthermore, bilateral fixed effects are used to control for time invariant determinants. A drawback of this specification is that we cannot use time-varying exporter and importer fixed effects to capture price effects. Nevertheless, log of GDP per capita for each country is used in order to mitigate this problem. These variables also control for a possible disposal price differences from developed to developing countries.

One of the main challenges to face when working with empirical trade models is that in estimating a gravity model, the dependent variable often takes the value of zero, which creates problems of convergence in the model. This is especially true with trade in products such as hazardous waste. In order to deal with this drawback, the model is first estimated



in a log-linear form; such procedure does not account for the zeros in the dependent variable, because of convergence problems. Nevertheless, to test the robustness of results and deal with the convergence issue, a pseudo-Poisson maximum likelihood (ppml) model (Santos Silva and Tenreyro (2011)) is used under different subsets of fixed effects. Further explanation is in the robustness subsection.

The empirical form of the gravity model of trade adopted here is due to Anderson and van Wincoop (2004); it has a log-linear form given by:

$$\ln M_{ijt} = \ln Y_{it} + \ln Y_{jt} - \ln Y_t^W + (1 - \sigma) \ln t_{ijt} - (1 - \sigma) \ln P_{it} - (1 - \sigma) \ln P_{jt} \quad (3.1)$$

in which  $\ln M_{ijt}$  refers to imports of country  $i$  coming from country  $j$  in year  $t$ .<sup>20</sup>  $\ln Y_{it}$ ,  $\ln Y_{jt}$  and  $\ln Y_t^W$  represent GDP of country  $i$ , GDP of country  $j$  and GDP of the world, respectively.  $\ln t_{ijt}$ ,  $\ln P_{it}$  and  $\ln P_{jt}$  stand for the so-called MRF and  $\sigma$  is the elasticity of substitution of all goods.

Due to the presence of trade costs and MRF, the estimation of Equation 3.1 is not direct. In the gravity literature the trade cost function,  $t_{ijt}$  is assumed to be a linear function of a number of trade barriers, namely, the time-invariant determinants of trade flows, including distance, common border, common colonial past and common language dummies and the time-varying policy variables (membership in multilateral agreements such as RTAs, MEAs, WTO, etc.).

In order to combine the policy impact analysis and the gravity one, Equation 3.3.4, rejoins the difference-in-differences estimation and the gravity model. To control for the MRF, a set of  $\theta$  dummy variables is added to the empirical specification of Equation 3.1, as the fixed-effects of the model. They represent importer, exporter, time and bilateral fixed-effects. Our

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<sup>20</sup>Imports are used instead of exports, because they are known in the trade literature for being more reliable.

variable of interest  $(ERG * post * treat)_{ijt}$  varies by country-pair time. For this reason I use the set of fixed-effects chosen. The group of dummy variables of our fixed effect, represent the trade costs and the MRF.

$$\begin{aligned} \ln M_{ijt} = & \beta_0 + \beta_1(ERG)_{ijt} + \beta_2(post)_t + \beta_3(treat)_{ij} + \beta_4(post * treat)_{ijt} + \\ & \beta_5(ERG * post)_{ijt} + \beta_6(ERG * treat)_{ijt} + \beta_7(ERG * post * treat)_{ijt} + \\ & \beta_8(\ln(GDPpc)_{it}) + \beta_9(\ln(GDPpc)_{jt}) + \theta_{1i} + \theta_{2jt} + \theta_3 FE_{ij} + \theta_{4t} + \mu_{ijt} \quad (3.2) \end{aligned}$$

here, the dependent variable  $\ln M$  represents the imports of waste in logs,  $(ERG)$  is the environmental regulation gradient,  $(post)$  the period after the EU-WSR and  $(treatgroup)$  the country-group<sup>21</sup>. Additionally, the model contains the interactions of the three variables  $(ERG * post * treat)$  and  $(\ln(GDPpc)_{it})$  and  $(\ln(GDPpc)_{jt})$  to control for costs differences. The remaining variables are country and time dummy variables, bilateral fixed effects, and an idiosyncratic error term. The coefficient of interest is  $\beta_7$ , which represents the effect of the EU-WSR in the specific country-group while taking into account the differences in environmental regulations.

Regressions are performed using fixed-effects regression. In addition, when using the orthogonal projection as the aggregated form of ERG, standard errors are bootstrapped. In the case of the disaggregated form of the ERG standard errors are clustered.

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<sup>21</sup>This variable, when using all the set of fixed effects is dropped

## 3.4 Results

### 3.4.1 Main results

Estimation results for the flow of imports of the 10 EU countries from the 15 called *EU-10 15* are presented in Table 3.2. The control country-groups are: the world, the OECD non-EU and the non-OECD countries. The second one would be the best candidate as control group.<sup>22</sup> GDP of importer and exporter is used to control for cost differences; the elasticity associated to the latter variable is almost systematically non significant.

The variable, representing the interaction between the difference-in-differences estimator and the environmental regulation, is not significant in its aggregated form, suggesting that for the *EU-10* after 2007 the environmental regulation differences did not have an increasing impact on waste imports. Nevertheless, the partial effect of the variable of period  $(ERG * post)_{ijt}$  is positive and significant, suggesting an increase in waste trade due to environmental regulation differences in groups (1) and (3). In addition, the partial effect of  $(post * treat)_{ijt}$  also suggests an increase in trade for the groups (1) and (2) after the formalisation.

Decomposing the ERG variable in its three complementary elements in Table 3.3, first it is observed that there is an increase of waste being shipped to *EU-10* from *EU-15* in variables  $(post)_t$  and  $(post * treat)_{ijt}$ .

As the partial effects for group (1) and (3) there is an increase of trade due to differences in environmental performance after the formalisation. In the case of increasing institution efficiency differences between *EU-10* and *EU-15* there is a considerable increase in waste imports for *EU-10* from *EU-15*.

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<sup>22</sup>Ideally, the best control group would be represented by the OECD non-EU countries that are the least developed or similarly developed as the *EU-10*. But the available data about waste shipments is not sufficient to conduct the estimation and aggravates the zero problem in the dependent variable.

As for the total effect, there is no increase in waste trade of the *EU-10* from *EU-15* after the formalisation enter into force for our group *EU-10* and *EU-15*. For groups (1) and (2) there is a decrease in waste trade when differences in environmental performances are observed. Also, when analysing differences in treaty ratification there is a decrease in waste trade for group (3).

OLS EU 10-15			
AGGREGATED ENVIRONMENTAL REGULATION PROXY			
VARIABLES	(1) CG: WORLD	(2) OECD NON-EU	(3) Developing NON OECD
Post	1.296*** (0.420)	1.237 (0.961)	1.154 (0.783)
Environmental reg. gradient	-1.025 (1.270)	-0.429 (3.326)	-2.771* (1.522)
Post x 10-15	1.491*** (0.414)	1.870*** (0.541)	-1.073 (1.666)
Environmental reg. gradient x post	1.925* (1.025)	3.001 (2.364)	3.110*** (1.003)
Environmental reg. gradient x 10-15	-3.284 (4.130)	-2.123 (6.895)	3.014 (17.61)
Env. reg. grdt. x post x 10-15	-0.0932 (4.903)	-3.622 (4.914)	-15.24 (19.88)
Ln(GDP).i	-0.850** (0.418)	-0.716 (0.899)	-0.882 (0.549)
Ln(GDP).j	-1.464 (1.052)	-1.305 (1.765)	-1.624 (1.626)
	-0.772 (0.860)	1.032 (2.176)	-1.421 (1.012)
Partial effect Environmental reg. Gradient x Post	1.925*	3.001	3.110***
Partial effect post x 10-15	1.491***	1.870***	-1.073
Total effect	0	0	0
Observations	4,045	1,255	2,451
R-squared	0.025	0.075	0.016
Number of ij	787	230	543
Time dummy	YES	YES	YES
Country and time dummies	YES	YES	YES
Bilateral FE	YES	YES	YES
Percentage of zeros	53,1%	41,0%	62,3%
Dependent variable	ln Imports	ln Imports	ln Imports
Bootstrap	YES	YES	YES
Robust standard errors in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			

**Table 3.2:** Effect of *EU-WSR* on the *EU-10* aggregated ERG

Concerning our second question Table 3.4 show results for developing countries with the aggregated form of ERG. There is a partial effect increasing trade due to environmental regulation differences for Asia and a partial effect decreasing imports of waste for Asia and America.

In the disaggregated form of the ERG Table 3.5, for Africa, there is an

OLS EU 10-15			
DISAGGREGATED ENVIRONMENTAL REGULATION PROXY			
VARIABLES	(1) CG: THE WORLD	(2) OECD NON-EU	(3) Developing NON OECD
Post	<b>1.408***</b> (0.490)	1.363 (0.846)	<b>1.353*</b> (0.696)
Post x 10-15	<b>3.015***</b> (0.821)	<b>3.785***</b> (0.851)	1.661 (1.392)
Env. performance gradient	0.146 (1.120)	-2.233 (3.804)	1.528 (1.469)
Env. performance gradient x 10-15	2.176 (4.415)	2.234 (5.773)	11.77 (9.295)
Env. performance gradient x post	<b>0.400**</b> (0.202)	-0.00317 (0.765)	<b>0.409*</b> (0.226)
Env. perf. grdt. x post x 10-15	<b>-3.723*</b> (1.910)	<b>-6.557***</b> (2.411)	4.212 (2.606)
Institution efficiency gradient	<b>-2.176*</b> (1.246)	-3.957 (3.236)	<b>-3.701***</b> (1.431)
Institution efficiency gradient x 10-15	2.693 (4.710)	3.418 (5.489)	<b>19.66**</b> (7.878)
Institution efficiency gradient x post	-0.158 (0.358)	-0.0225 (1.111)	0.0949 (0.421)
Institution efficiency grdt. x post x 10-15	-2.400 (2.107)	-1.916 (2.490)	-1.665 (3.344)
Treaty ratification gradient	0.289 (0.233)	0.554 (0.676)	0.207 (0.318)
Treaty ratification gradient x 10-15	0.412 (1.028)	0.149 (1.286)	-0.0474 (2.673)
Treaty ratification gradient x post	-0.443 (0.315)	-0.141 (0.437)	-0.321 (0.349)
Treaty ratification grdt. x post x 10-15	-1.798 (1.605)	-2.531 (2.272)	<b>-7.393***</b> (2.446)
Ln(GDP).i	<b>-1.013**</b> (0.484)	-1.034 (0.865)	<b>-1.118*</b> (0.585)
Ln(GDP).j	-1.857 (1.129)	-2.154 (1.703)	-2.192 (1.423)
RTA	-0.408 (0.892)	2.681 (1.962)	-1.374 (0.900)
Partial effect env. performance gradient x post	<b>0.400**</b>	-0.00317	<b>0.409*</b>
Partial effect institution efficiency gradient x 10-15	2.693	3.418	<b>19.66**</b>
Total effect env. performance	<b>-3.723*</b>	<b>-6.557***</b>	<b>0</b>
Total effect institution efficiency	<b>0</b>	<b>0</b>	<b>0</b>
Total effect treaty ratification	<b>0</b>	<b>0</b>	<b>-7.393***</b>
Observations	4,045	1,255	2,451
R-squared	0.036	0.108	0.022
Number of ij	787	230	543
Time dummy	YES	YES	YES
Country dummy	YES	YES	YES
Bilateral FE	YES	YES	YES
Percentage of zeros	53,1%	41,0%	62,3%
Dependent variable	ln Imports	ln Imports	ln Imports
Bootstrap	YES	YES	YES
Robust standard errors in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			

Table 3.3: Impact of EU-WSR on the EU-10 disaggregated ERG

increase of Waste imports when the difference in environmental performance, as a partial effect, is stressed. Treaty ratification, after the formalisation, appear to have a decreasing effect in the imports of waste.

For Asia there is no significant effect in the disaggregated form, possibly the proxies of environmental regulation cancel each other out, in the disaggregated form of the model.

For America we observe that there are partial effects decreasing the waste imports for America. Nevertheless, there is a total effect of treaty ratification that increases the waste imports.

OLS Developing-EU			
AGGREGATED ENVIRONMENTAL REGULATION PROXY			
VARIABLES	Africa-EU	Asia-EU	America-EU
<b>Post</b>	-0.0900 (1.597)	-0.861 (0.890)	-0.817 (0.979)
<b>Environmental reg. gradient</b>	0.688 (6.191)	<b>4.479***</b> (1.638)	-1.228 (2.606)
<b>Post x Af/As/Am - EU</b>	0.679 (0.878)	0.147 (0.327)	-0.602 (0.634)
<b>Environmental reg. gradient x post</b>	-2.450 (6.967)	-3.145 (2.782)	0.222 (2.639)
<b>Environmental reg. gradient x Af/As/Am - EU</b>	7.370 (6.545)	<b>-4.141*</b> (2.483)	<b>-7.627*</b> (3.940)
<b>Env. reg. grdt. x post x Af/As/Am - EU</b>	-0.771 (7.514)	5.560 (3.510)	3.816 (3.783)
<b>Ln(GDP).i</b>	-1.351 (0.925)	1.014 (0.801)	-0.328 (0.961)
<b>Ln(GDP).j</b>	0.972 (2.231)	0.112 (0.622)	<b>2.705*</b> (1.542)
<b>RTA</b>	1.834 (1.937)	0.0596 (0.514)	0.591 (0.595)
<b>Partial effect of environmental reg. gradient</b>	0.688	<b>4.479***</b>	-1.228
<b>Partial effect of environmental reg. gradient x Af/As/Am - EU</b>	7.370	<b>-4.141*</b>	<b>-7.627*</b>
Observations	593	1,499	980
Number of ij	164	290	286
R-squared	0.034	0.033	0.045
Time dummy	YES	YES	YES
Country dummy	YES	YES	YES
Bilateral FE	YES	YES	YES
Percentage of zeros	77,5%	56,1%	82,2%
Dependent variable	ln Imports	ln Imports	ln Imports
Bootstrap	YES	YES	YES
Robust standard errors in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			

**Table 3.4:** Effect of *EU-WSR* on developing countries aggregated ERG

OLS Developing-EU			
DISAGGREGATED ENVIRONMENTAL REGULATION PROXY			
VARIABLES	Africa-EU	Asia-EU	America-EU
Post	<b>-4.516**</b> (1.904)	-0.120 (0.836)	-1.343 (1.024)
Post x Af/As/Am	1.780 (1.972)	-0.107 (0.533)	-0.145 (0.709)
Env. performance gradient	-0.646 (4.141)	0.0410 (2.440)	<b>-5.956**</b> (2.782)
Env. performance gradient x Af/As/Am	<b>10.04*</b> (5.132)	-1.546 (3.197)	6.997 (4.584)
Env. performance gradient x post	1.070 (0.732)	0.249 (0.379)	0.895 (0.712)
Env. perf. grdt. x post x Af/As/Am	1.008 (1.016)	0.781 (0.491)	-2.014 (1.225)
Institution efficiency gradient	4.671 (4.635)	-0.367 (2.311)	-0.872 (2.685)
Institution efficiency gradient x Af/As/Am	-6.280 (5.751)	-3.699 (2.660)	-0.738 (4.652)
Institution efficiency gradient x post	2.071 (1.619)	0.624 (0.599)	<b>-1.309**</b> (0.551)
Institution efficiency grdt. x post x Af/As/Am	-0.871 (1.899)	-0.960 (0.917)	1.017 (0.983)
Treaty ratification gradient	2.063 (1.499)	0.270 (0.531)	<b>-1.621**</b> (0.697)
Treaty ratification gradient x Af/As/Am	-3.039* (1.703)	0.285 (0.570)	1.640 (1.033)
Treaty ratification gradient x post	<b>-2.589***</b> (0.788)	-0.263 (0.332)	-0.482 (0.341)
Treaty ratification grdt. x post x Af/As/Am	1.103 (2.302)	-0.134 (0.776)	<b>1.928*</b> (1.104)
Ln(GDP) <sub>i</sub>	-1.318 (1.051)	-0.409 (0.771)	0.933 (1.084)
Ln(GDP) <sub>j</sub>	2.280 (2.255)	0.0435 (0.690)	<b>3.113**</b> (1.579)
RTA	<b>3.080**</b> (1.438)	0.124 (0.505)	0.694 (0.572)
Partial effect Env. Performance	0	0	<b>-5.956**</b>
Partial effect Env. Performance x Af/As/Am	<b>10.04*</b>	0	0
Partial effect institution efficiency	0	0	<b>-1.309**</b>
Partial effect Treaty ratification	0	0	<b>-1.621**</b>
Partial effect Treaty ratification x post	<b>-2.589***</b>	0	
Total effect Treaty ratification	0	0	<b>1.928*</b>
Observations	593	1,499	980
Number of ij	164	290	286
R-squared	0.101	0.052	0.059
Time dummy	YES	YES	YES
Country dummy	YES	YES	YES
Bilateral FE	YES	YES	YES
Percentage of zeros	77,5%	56,1%	82,2%
Dependent variable	ln Imports	ln Imports	ln Imports
Bootstrap	YES	YES	YES
Robust standard errors in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			

Table 3.5: Impact of EU-WSR on developing countries disaggregated ERG

### 3.4.2 Robustness

Concerning robustness tests, I first estimate the same model, using different specifications of ppml models, so as to mitigate the zero problem in the dependent variable. Secondly, I apply the same model to the BACI data-set (Gaulier and Zignago (2010)) to see if the results found are not driven by our data-set.<sup>23</sup>

For the ppml model, some convergence problems emerged. This is particular to this case to the fact that since waste trade is an uncommon type of trade, the dependent variable takes the value of zero for 74% of the observations. To face the challenge that this represents, different sets of fixed effects and dummy variables were used in order to make the model converge. In the case of *EU-10* imports, setting the OECD non-EU countries as control group,<sup>24</sup> a decrease of waste trade is perceived as a result of environmental regulation differences. The  $\beta_7$  coefficient is negative and significant in the aggregated form of the ERG and in two of the variables in the disaggregated approach, the environmental performance and the Treaty ratification, but is positive and significant for the Institution efficiency gradient. Refer to table 3.6

It is not possible with the results obtained to assert there is a waste haven effect because some decreased trade is observed, but nevertheless, decreasing Institution efficiency in the *EU-10* countries vis-a-vis their *EU-15* can be a possible channel for increased waste imports and to assert for a waste haven effect. These results highlight the drawback of the log-linear form in gravity models, that cannot account zero values in the dependent variable. They also highlight the difference between the OLS model and the ppml model. In the first one we can take into account the quantity of flow of imports and in the second one the decision to import

<sup>23</sup>BACI data-set is the World trade database developed by the CEPII at a high level of product disaggregation. [http://www.cepii.fr/cepii/fr/bdd\\_m\\_odele/presentation.asp?id=1](http://www.cepii.fr/cepii/fr/bdd_m_odele/presentation.asp?id=1)

<sup>24</sup>This control group was the only one that converged with country-time dummies and fixed-effects.



or not, plus the quantity traded.

In the case of the regional analysis, the ppml model could only converge for Africa. However, there is no significant total effect of the environmental regulation in the aggregate form, but a negative significant effect for differences in environmental performances. Nevertheless, this result is only for specifications of the model without country-time dummies. For the other two regions, in Asia there is no effect in the case of the aggregated form of the environmental regulation variable and an increase of waste imports in the disaggregated form, due to Treaty ratification differences. In the case of the American region, there is a decreasing effect of imports due to differences in environmental regulation. In the disaggregated form of the environmental regulation, this effect is due to environmental performance differences. Nevertheless, there are no country-time dummies used due to convergence problems, so these last two results are to be taken cautiously. A summary of the results is displayed in Table 3.7, while full results are available upon request.

Replicating the same estimations with the BACI data-set Table A.7, for *EU-10 15* with the aggregated ERG we observe partial effects increasing waste imports for groups (1) and (2). In the case in the case of *EU-10 15* in its disaggregated form, there is a an decreasing effect for group (2) and an increasing effect for group (3), when differences in environmental performance are observed. Contrarily, when analysing differences in treaty ratification, there is a decrease in all groups of waste imports, after the formalisation.

For the regional analysis in Table A.8 for the aggregated form of the ERG we observe that there is a total effect increasing waste for Asia, even if there are decreasing partial effects for the same region. In the disaggregated form of the ERG, there is also an increase of waste imports for Asia. These contradictory results could be due to a mismatch between information reported by countries to the Basel Convention and to the

world trade organisation.<sup>25</sup>

The consideration of all models estimated suggests that we cannot assert a Waste Haven Effect for the less developed countries of the EU. Nevertheless, taking into account the decision of importing waste or not, along with the ppml model, we can observe that differences of environmental regulation between less developed countries of the EU and more developed countries of the EU decrease imports of waste after the *EU-WSR*. In the case of developing countries analysed by regions there is no evidence of the efficacy of the *EU-WSR* which is in line with the literature Kellenberg (2012).

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<sup>25</sup>Full results are available upon request.

ppml EU 10-15		ppml EU 10-15	
AGGREGATED ERG		DISAGGREGATED ERG	
VARIABLES	(2) OECD NON-EU	VARIABLES	(2) OECD NON-EU
<b>post</b>	-62.21 (196.3)	<b>post</b>	<b>-174.6***</b> (56.12)
<b>10-15 dummy</b>	-57.44 (192.3)	<b>10-15 dummy</b>	<b>175.0**</b> (88.22)
<b>Environmental reg. gradient</b>	420.9 (2,467)	<b>Env. performance gradient</b>	-145.0 (135.5)
<b>post x 10-15</b>	53.58 (202.8)	<b>Env. performance gradient x post</b>	<b>215.1*</b> (111.8)
<b>Environmental reg. gradient x post</b>	-338.7 (1,023)	<b>Env. perf. grdt. x post x 10-15</b>	<b>-14.07***</b> (4.193)
<b>Environmental reg. gradient x 10-15</b>	<b>25.84**</b> (12.72)	<b>Institution efficiency gradient</b>	241.8 (226.7)
<b>Env. reg. grdt. x post x 10-15</b>	<b>-9.274*</b> (5.051)	<b>Institution efficiency gradient x post</b>	<b>254.8**</b> (100.3)
<b>Total effect Environmental reg. gradient x post</b>	<b>-9,274</b>	<b>Institution efficiency grdt. x post x 10-15</b>	<b>10.41**</b> (4.190)
Percentage of zeros	41	<b>Env. trade barriers gradient</b>	10.46 (6.467)
Observations	2,128	<b>Env. trade barriers gradient x 10-15</b>	<b>4.583*</b> (2.734)
Time dummy	YES	<b>Env. trade barriers grdt. x post x 10-15</b>	<b>-27.13***</b> (9.286)
Country and time dummy	YES		
Bilateral FE	YES		
Dependent variable	Imports		
df_m			
Robust standard errors in parentheses		<b>Total effect Env. perf. grdt. x post x 10-15</b>	<b>-14,07</b>
*** p<0.01, ** p< 0.05, * p<0.1		<b>Total effect Institution efficiency grdt. x post x 10-15</b>	<b>10,41</b>
		<b>Total effect Env. trade barriers grdt. x post x 10-15</b>	<b>-27,13</b>
		Percentage of zeros	41
		Observations	2,128
		Time dummy	YES
		Country and time dummy	YES
		Bilateral FE	YES
		Dependent variable	Imports
		Robust standard errors in parentheses	
		*** p<0.01, ** p< 0.05, * p<0.1	

Table 3.6: Pseudo poisson maximum likelihood EU 10-15

ppml Developing-EU				ppml Developing-EU			
VARIABLES	Africa-EU	Asia-EU	America-EU	VARIABLES	Africa-EU	Asia-EU	America-EU
post	129.6 (199.4)	<b>1.543***</b> (0.453)	<b>1.449***</b> (0.461)	post	-2.352 (2.237)	-1.559 (1.198)	<b>3.035***</b> (0.953)
Africa/Asia/America - EU dummy	14.69 (35.72)	<b>-2.122***</b> (0.331)	<b>-5.360***</b> (0.728)	Af/As/Am dummy	1.277 (2.939)	-1.932 (1.864)	<b>-7.196***</b> (2.395)
Environmental reg. gradient	457.6 (798.3)	<b>5.117*</b> (2.667)	-0.768 (2.481)	post x Af/As/Am	1.166 (2.366)	0.952 (1.171)	0.469 (1.051)
post x Af/As/Am - EU	-13.74 (34.77)	-0.160 (0.562)	0.734 (0.528)	Env. performance gradient	-0.507 (1.832)	0.487 (2.355)	<b>9.840**</b> (4.556)
Environmental reg. gradient x post	-460.8 (784.0)	<b>8.809**</b> (3.479)	-0.532 (0.931)	Env. performance gradient x Af/As/Am	2.114 (1.746)	<b>1.597*</b> (0.913)	-2.465 (1.589)
Environmental reg. gradient x Af/As/Am - EU	<b>-10.55*</b> (5.995)	<b>-5.607***</b> (1.971)	<b>8.021**</b> (3.349)	Env. performance gradient x post	<b>3.790***</b> (1.352)	<b>-0.543**</b> (0.272)	<b>4.212*</b> (2.554)
Env. reg. grdt. x post x Af/As/Am - EU	-2.245 (6.292)	-0.542 (7.436)	<b>-11.00**</b> (5.078)	Env. perf. grdt. x post x Af/As/Am	<b>-3.400**</b> (1.621)	0.546 (0.817)	<b>-4.795*</b> (2.908)
GDP/capita gradient	<b>-6.718**</b> (2.635)	-2.164 (1.749)	1.350 (1.918)	Institution efficiency gradient	-2.775 (2.465)	<b>-4.607**</b> (1.849)	7.392 (5.554)
Total effect Env. reg. grdt. x post x Af/As/Am - EU	0	0	-11.00	Institution efficiency gradient x Af/As/Am	-2.961 (2.042)	-2.635 (1.847)	1.213 (1.385)
				Institution efficiency gradient x post	-0.546 (1.724)	<b>1.997***</b> (0.649)	<b>-2.961*</b> (1.639)
				Institution efficiency grdt. x post x Af/As/Am	1.265 (1.710)	-1.574 (1.142)	-0.251 (2.182)
Percentage of zeros	78	46	89	Env. trade barriers gradient	0.271 (1.658)	0.166 (0.696)	<b>-1.589**</b> (0.807)
Observations	2,640	3,416	5,520	Env. trade barriers gradient x Af/As/Am	0.704 (1.743)	<b>-0.745*</b> (0.402)	2.177 (1.612)
Time dummy	YES	YES	YES	Env. trade barriers gradient x post	-0.337 (0.553)	0.104 (0.0769)	0.646 (0.628)
Country dummy	YES	YES	YES	Env. trade barriers grdt. x post x Af/As/Am	0.743 (1.308)	<b>2.136**</b> (0.971)	-0.794 (2.417)
Country and time dummy	<b>YES</b>	<b>NO</b>	<b>NO</b>	GDP/capita gradient	-2.274 (2.212)	-3.151 (1.969)	2.834 (1.754)
Bilateral FE	YES	YES	YES				
Dependent variable	Imports	Imports	Imports	Total effect Env. perf. grdt. x post x Af/As/Am	-3.4	0	<b>-4.795</b>
Robust standard errors in parentheses				Total effect Env. trade barriers grdt. x post x Af/As/Am	0	<b>2,136</b>	0
*** p<0.01, ** p< 0.05, * p<0.1							
				Percentage of zeros	78	46	89
				Observations	2,640	3,416	5,520
				Time dummy	YES	YES	YES
				Country dummy	YES	YES	YES
				Country and time dummy	<b>NO</b>	<b>NO</b>	<b>NO</b>
				Bilateral FE	YES	YES	YES
				Dependent variable	Imports	Imports	Imports
				Robust standard errors in parentheses			
				*** p<0.01, ** p< 0.05, * p<0.1			

Table 3.7: Pseudo poisson maximum likelihood on developing countries

### 3.5 Conclusions

As differences in environmental regulations can be incentives for trans-boundary movements of pollutants, in this paper I show robust evidence of increasing waste flows in the less developed countries of the EU, as a consequence of the *EU-WSR*. Nevertheless, these results are not particular to an environmental regulation difference, at least not in the way it is specified in this paper. Treaty ratification could have an effect in decreasing waste flows in the less developed countries of the European Union.

Results contribute to the literature by providing evidence in a more precise way about hazardous waste trade. The effects of the European engagements along with the *EU-WSR* could be positive for the EU zone, but there is no consistent effect for developing countries. This work also underlines that the *EU-10* could also be emerging as importers of hazardous waste as well as the developing countries, as previous works have pointed out.

Additionally, I show that using a disaggregated form of the ERG helps studying the different features of the ERG in a more detailed manner. Similarly, the regional separation contributes to observe differences in waste imports across groups of developing countries.

Illegal waste trade is responsible for the majority of the damage in developing countries. This research concerns only legal waste trade, nevertheless, I consider that the study of these legal flows helps to have an idea of the size of the problem of illegal waste trade. Specially, when observing the magnitude of the legal shipments, that should supposedly be already avoided.

The aftermath is that differences in environmental regulations are not only a concern for developing countries, but to all countries exposed to a gap in regulation with regard to the trading partners. Nevertheless, results lead to believe that reinforced institutions are likely to be effective in inverting this trend.

## 4

# **Are international environmental agreements effective? The case of trade in hazardous chemicals and persistent organic pollutants<sup>1</sup>**

## **4.1 Introduction**

The main rationale for signing International Environmental Agreements (IEAs) is to prevent developing countries from becoming pollution or waste havens. Developing countries may fail in the effective implementation of ratified treaties and in turn enforce national environmental regulations. Consequently, unscrupulous individuals and firms could take advantage of these lax or non-existent regulations to send hazardous chemicals (HCs) and persistent organic pollutants (POPs) among other dangerous products to developing countries. To prevent this from happening, IEAs could act as a vehicle through which a better institutional framework is established

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<sup>1</sup>Joint work with Inmaculada Martínez-Zarzoso (University of Gottingen: imartin@gwdg.de)

in the sending countries. This could help prevent these firms from sending these dangerous or harmful products to developing countries.

This paper is motivated by the recent interest in evaluating the effects of international environmental agreements (IEAs) on environmental quality, and by the growing importance of trade in waste and dangerous products over time. Most existing agreements classified as IEAs are legally binding intergovernmental treaties, which aim at preventing or reducing human impact on the environment. Among the numerous IEAs that have been signed, around 730 are multilateral environmental agreements or MEAs (MEAs involve at least three governments), but many of them entail only minor changes to previous commitments. A number of recent MEAs focus on products with hazardous properties, which require specific know-how and equipment for their disposal. Most developed countries have these capacities, however, due to increasingly stringent environmental regulations, it may be cheaper for producers to export harmful products to developing countries, rather than recycle them in the country of origin. In this way, the cost of generating these hazardous products has shifted to less developed countries that do not usually have the appropriate technology to treat those imported products or the required regulations regarding the appropriate use and disposal procedure. According to Kellenberg (2012), world trade in waste grew by approximately 67 percent between 2002 and 2007 (191 million tonnes).

As a political response to the growing export of toxic waste from developed to developing countries, the Basel Convention on the control of transboundary movements of hazardous waste and their disposal was adopted in 1989 and enforced starting in 1992. The convention mainly contained certain commitments and guiding principles, e.g. trade was to be agreed upon and consented to (Prior Informed Consent Procedure) by the importing country and signatory states should refrain from trade in hazardous waste with non-signatory countries. Given its lack of effectiveness, the Ban Amendment (still not enacted because it lacks sufficient signatory parties) was added in 1995 by a few signatory countries in

order to ban exports from OECD to non-OECD countries, but since large exporters of waste did not ratify it (e.g. the US) and it is still not adopted, it may have led to the emergence of trade diversion effects.

Most of the early research evaluating the effects of MEAs found that they were generally ineffective, confirming the outcomes of the corresponding theoretical models (Barrett (1994); Carraro and Siniscalco (1993)). A good survey of such research is presented in Mitchell (2003). However, the question of the effectiveness of the agreements continues to be relevant and ultimately it remains an empirical question. To the best of our knowledge, the effects of the most recent agreements concerning waste have only been evaluated by Kellenberg and Levinson (2014). They investigate whether the Basel Convention and the Ban have resulted in less waste being traded among ratifying countries. The paper finds that the Basel Convention and Ban seem to have had no effect on the growth of international hazardous waste and almost no effect on shipments from developed to developing countries. As a consequence, the author suggests linking the IEAs to trade sanctions to strengthen their effectiveness.

In this paper we go a step further and evaluate the effects on trade from two other existing conventions on hazardous chemicals and pesticides, namely the Rotterdam Convention and the Stockholm Convention. We hypothesise that the ratification of these conventions should have had a direct effect on trade in the products in question, which are HCs in the case of the Rotterdam Convention and POPs in the case of the Stockholm Convention. Both conventions deal with products that could be harmful to human health and are therefore undesirable without the appropriate use and treatment to reduce or eliminate the damage they may cause. In particular, HCs (as classified by the American Occupational Safety and Health Administration) are both toxic and reactive and have great potential in causing damaging health effects when they are released.

Relatively low-level exposures to these substances are linked to cancer, birth defects, genetic damage, miscarriages and even death. In regards to



the products covered by the second convention, POPs, it has been shown that these products also have non-negligible negative effects on human health and the environment. Some of the identified effects are cardiovascular disease, cancer, obesity, and diabetes. They are also considered hormone disrupts, which can alter the normal functioning of the endocrine and reproductive systems in humans and wildlife.

To investigate whether the entry into force of the conventions alter trade flows in the products in question, we estimate a gravity model of trade using highly disaggregated trade data (6-digit Harmonised System (HS) Classification) of HCs and POPs among 88 countries and over the period from 1995 to 2012. More specifically, we would like to find out whether shipments from OECD to non-OECD countries have been reduced when the trading partners have ratified either of the two agreements.

The results indicate that when the exporter ratifies the Rotterdam Convention fewer hazardous chemicals are shipped from OECD countries to non-OECD countries. In the case of the Stockholm Convention, smaller amounts of persistent organic pollutants are shipped from OECD-ratifying countries to non-OECD countries when the importer ratifies the treaty. Moreover, the results are robust to the inclusion of country and time fixed effects and country-pair-product fixed effects, which control for Multilateral Resistance Factors (MRF) and time-invariant and product specific unobservable heterogeneity. These results are substantially different to Kellenberg and Levinson (2014) and point towards the effectiveness of both conventions in reducing trade in waste.

The rest of the paper is structured as follows. Section 2 presents the related theories and main hypotheses, summarises the closely related empirical literature and describes the conventions. Section 3 describes the data and variables and outlines the empirical strategy and model specification. Next, Section 4 presents the main results and Section 5 outlines the results of several robustness checks. Finally, Section 6 concludes.

## 4.2 Environmental treaties on waste, hazardous chemicals and persistent organic pollutants: Theory and Evidence

### 4.2.1 Theory and main hypotheses

A number of authors have investigated the effectiveness of MEAs in reducing pollution or improving environmental quality. The early theoretical models conclude that most MEAs tend to be ineffective due to the free-rider problem<sup>2</sup>. Indeed, the findings tend to show that global agreements can only work if the abatement targets are far below the optimum level (Barrett (1994); Carraro and Siniscalco (1993)). The free-rider problem could be overcome by establishing a central authority with coercive power, but in the case of international environmental issues, this solution seems unlikely. Nevertheless, more recent literature (summarised in Carraro (2014)) suggests that these predictions might be too strong and pessimistic. For instance, if countries involved in the agreements are risk averse and the environmental damage attached to non-compliance is uncertain, countries may be willing to comply and to cooperate. This could be the case of hazardous waste, since most countries are aware of the detrimental effects on the environment and individual's health. In these cases, it could be enough to have the right institutions to encourage cooperation and compliance (Carraro and Siniscalco (1998); and Ecchia and Mariotti (1998)). Some countries may show more interest in controlling or stopping these activities than others and non-state actors may also play an important role. As such, the ratification of agreements will be influenced by different incentives. Indeed, already in 1994, developing countries (G-77) and environmental NGOs argued for a decision to ban the trade of waste at the Second Conference of Parties held in Geneva

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<sup>2</sup>Here the free-rider problem occurs when some countries can benefit from lower global emissions without investing in clean technologies or implementing environmental regulations, because other countries do it for them.

that materialized in the Basel Ban Amendment. According to Battaglini and Harstad (2016) under incomplete contracting environment and considering that MEAs fit this setting, significant participation is feasible under well-specified conditions and hence the free-rider problem could be substantially reduced.

The effectiveness of the MEAs also depends on the existence of optimal environmental policies at the country level. One reason why the authors find that MEAs fail to be effective is the existence of differences between countries in terms of environmental regulations and the fact that poor countries are in many cases not able to internalise the environmental externalities generated by producing or using products that can cause a negative environmental externality. According to Rauscher (1997), international trade in hazardous waste might be biased towards the importing country if environmental externalities are not internalised. In this case, waste -or dangerous products- producing countries may have incentives to export their waste to countries with lower environmental standards for waste disposal (Fikru (2012)). Moreover, the attraction of *bad*-products imports by developing countries could be supported by the prevalence of low-cost disposal and organized crime (Clapp (1997)), and the latter is negatively correlated with the level of environmental regulations (Kellenberg and Levinson (2013)).

The pollution haven hypothesis (PHH) states that polluting industries will tend to export their pollution to countries with less stringent environmental regulations. Applied to waste, the PHH (or waste haven effect, according to Kellenberg (2012)) implies that increasing differences in environmental standards between countries will cause a greater trade flow of waste from a more stringent country to a lax country. Improvements in the international monitoring of waste could have unexpected consequences on the movement of waste across countries, depending on the presence of an illegal channel and of the possibility to reclassify waste as used goods (Bernard, 2015).

According to Bernard (2015), larger differences in environmental regulations between trading countries induce polluting industries to delocalize where the standards are relatively weak. This, together with the fact that institutions often fail to create the necessary environmental regulations in developing countries, results in the need to implement additional mechanisms to control and deter trade in dangerous goods. Another option to overcome the lack of adequate institutions or regulatory framework in developing countries could be based on a developed-country policy approach. Yokoo and Kinnaman (2013) find that a tax imposed on the consumption of new durable goods in developed countries combined with a waste tax set below the domestic external cost of disposal, could be sufficient to achieve global efficiency. In order to effectively do so, MEAs could be used as additional policy instruments to prevent the imports of dangerous substances by developing countries.

In general, we expect more stringent regulations concerning the production and use of hazardous products to generate an incentive to send those dangerous substances to countries with lax environmental regulations. In the case of the two conventions examined in this paper, the Rotterdam and the Stockholm conventions, we hypothesise that the ratification of these conventions should have had a negative direct-effect on trade in the products covered by the conventions that are respectively HCs in the former and POPs in the latter. More specifically, we expect the amount of dangerous substances sent from OECD countries to ratifier-non-OECD countries to decrease, according to the PHH. Hence, the effect will materialize for North-South trade rather than for North-North trade, given that the environmental standards and facilities for disposal are more similar in developed countries and that the conventions will mainly have an effect on trade between countries with very different environmental regulations Kellenberg and Levinson (2014).

### 4.2.2 Empirical evidence

This subsection summarises the main results found in the related literature regarding the empirical evaluation of the influence of MEAs. We begin with the general findings and then narrow the focus to papers that evaluate the effectiveness of treaties and conventions on hazardous waste and products.

A general and fairly complete overview of the effects of environmental agreements is offered by Mitchell (2003), Mitchell (2006). He finds that bearing in mind the number of existing agreements (more than 1000 MEAs in 2013), only a subset of them have been empirically evaluated. There are several reasons for the lack of scientific research in this area. First, the available data on the relevant environmental quality indicators has been scarce until recent years and it is somewhat difficult to identify the expected effects of specific agreements. Second, some agreements target multiple environmental problems and it is not obvious which environmental indicator should be investigated. Finally, the endogeneity of participation in the agreement hinders the precise identification of the effect.

Mitchell (2003) points to somewhat mixed results regarding the identifiable effectiveness of MEAs. For some, there is clear evidence of a positive effect on the targeted environmental-quality indicator, as is the case of Parson (2003), Wettestad (2001) and Greene (1998), which evaluated the ozone agreements and found a reduction in the consumption of chlorofluorocarbons (CFCs) in industrialised countries, perhaps also due to the existence of close substitutes for these products or to the fact that the manufacturing sector has been declining in these countries.

In other cases, the evaluations show no effect, for example concerning the international whaling agreements, which was widely believed to have had an impact in the current stable stock levels until Schneider and Pearce (2004) showed that market forces -and not the ratification of the

agreement- were leading to the declining catch. Skjaerseth (2001) and Haas (1990) show the Mediterranean Pollution Plan to have had little effect on marine pollution. Finally, some conflicting outcomes are put forward in Munton et al. (1999), who emphasize that the results of many studies are highly susceptible to the chosen methodology.

Another major international agreement is the Kyoto protocol, for which a few authors have found mixed evidence of its effectiveness. Aichele and Felbermayr (2012) analyse the impact of ratifying the Kyoto Protocol on countries' CO<sub>2</sub> emissions between 1997 and 2007. In order to overcome the problem of self-selection into the protocol, the authors use a country's membership in the International Criminal Court (ICC) to instrument the Kyoto variable, its spatial lag and restrict the data to a sample of 40 countries. Their findings indicate that countries with Kyoto commitments emit on average about 8 percent less CO<sub>2</sub> than countries without. Using an alternative identification strategy that is able to address the self-selection issue, namely a matching diff-in-diff estimator, Grunewald and Martinez-Zarzoso (2016) consistently find a 7-10 percent reduction in CO<sub>2</sub> emissions to being attributable to the adoption of the Kyoto protocol. Mazzanti and Musolesi (2009) also find the Kyoto Protocol has a negative effect on CO<sub>2</sub> emissions for the northern EU country group. This stands in contrast to the Almer and Winkler (2015) study, in which they test for the existence of a reduction in emissions in 15 Annex B countries with binding emission targets and find that CO<sub>2</sub> emissions are not below what they would have been in the absence of the protocol. They claim that binding emission targets violates the common trend assumption made in previous studies and that not addressing the opposing trend could invalidate the results. However, Grunewald and Martinez-Zarzoso (2016) could not reject the parallel trend assumption when restricting the sample to high-income countries (see figure 2, page 11). The possible divergence in the results could be instead due to the way in which the counterfactual sample is constructed in Almer and Winkler (2015).

Given the diversity of the agreements in terms of content, scope and

targeted environmental outcomes, we now focus on papers that evaluate the effectiveness of agreements involving the trade of waste, hazardous chemicals and persistent organic pollutants. Trade in waste and dangerous substances is a relatively new area of research and Baggs (2009) was one of the first authors to study this topic. He analyses the determinants of hazardous waste using a gravity model with country characteristics for the period from 1994 to 1997. He interprets the negative coefficient of per capita income (only significant at the ten percent level) for the importer countries as an indication of the existence of a waste haven effect. Behind this interpretation is the idea that GDP per capita could be a proxy for the stringency of environmental regulations. Hence, assuming that citizens demand more environmental quality when they become richer, lower amounts of waste should be exported to countries with higher GDP per capita. Since there were no multilateral agreements limiting trade in waste in the study period, the author cannot analyse their effects on bilateral trade. Additionally, no environmental regulation differences are explicitly included in the analysis, and proxying those with GDP per capita might be problematic, given that differences in income per capita may also reflect wage differences across countries.

Assuming that environmental regulation differences matter, Kellenberg (2012) uses waste imports for a cross-section of 92 countries in 2004 consisting of 62 HS categories of waste at the 6-digit product disaggregation (HS) level. He finds that the ten largest exporters are OECD countries, while China, Turkey and South Korea are the largest importers. He also estimates a gravity model that includes a Basel ratification dummy, which is statistically significant and negative in two specifications. However, the authors are not able to control for the endogeneity of the Basel-ratification in a cross-sectional setting, and for this reason, the results cannot be interpreted as causal.

Subsequently, Kellenberg and Levinson (2014) estimate the effect of the Basel Convention and the following Ban Amendment on waste trade for a sample of 60 waste HS6 products using data for 117 countries over the

period from 1988 to 2008. The authors aggregate the annual tonnes of waste traded for the 60 categories and omit the country pairs with zero waste trade. The main results, after controlling for multilateral resistance terms (MRT) and endogeneity by using panel data techniques and time invariant controls, show no clear evidence supporting the effectiveness of the Basel Convention and the Ban Amendment. In particular, no decrease in bilateral waste trade was observed for country-pairs that have ratified the Basel Convention. Only when using a restricted sample, is some evidence found. In our empirical application, we will follow a similar estimation strategy to Kellenberg and Levinson (2014) to analyse the effectiveness of the Stockholm and Rotterdam conventions in reducing the trade of their respective targeted products. The main difference in strategy is that we estimate the gravity model using trade at the 6 digit disaggregation level –without aggregating– to be able to control for any unobserved heterogeneity that is country-pair-product specific and time-invariant and that could represent factors such as product-specific differences in comparative advantages or in production techniques among a pair of countries.

#### **4.2.3 The Conventions**

The Basel Convention emerged as a result of the claim by developing countries, especially African countries, that waste was being improperly disposed of in their territory. This convention was adopted in 1989 and entered into force in May 1992. Its main objective was to control international shipments of hazardous waste and the development of appropriate management techniques.

The instrument used at the beginning was a mandatory Prior Informed Consent (PIC). The available evidence shows that the Basel Convention was not a strong enough commitment to reassure all involved parties. It drew further criticism from developing countries for the fact that the PIC provision of the Basel Convention legitimated a waste trade that



had previously been illegal Kellenberg (2012). As a result, a few signatory countries added the Ban Amendment in 1994. Nevertheless, this Amendment, which was intended as a ban on all waste trade from OECD countries to non-OECD countries, is still not enforced today. This means that there may still be hazardous waste shipments to developing countries from industrialised ones, especially since the United States of America, one of the largest waste exporters, has not yet ratified the Basel Convention Kellenberg (2012). Moreover, its effectiveness is also unclear according to Kellenberg and Levinson (2014).

On the other hand, there is clear awareness about the potential threat of products such as HCs and POPs. Some of these products are more production by-products, rather than dangerous waste in its pure definition, but they have also been linked to health and environmental problems. The Rotterdam and the Stockholm conventions emerged in response to problems posed by these products, which we will discuss in greater detail below.

The urgency of controlling and restricting trade in these substances relies on the fact that being exposed to some pollutants remains a major source of health risks throughout the world, though these risks are generally higher in developing countries, where poverty and lack of investment in modern technology combined with weak environmental regulations cause higher pollution-related health problems Briggs (2003). More specifically, Johnson (1997) states that uncontrolled hazardous waste and other sources of unplanned releases of hazardous substances into the environment are a concern due to its impact on human health and ecological damage. Infants and young children are the most vulnerable to these effects (Gavidia et al. (2009)).

Studies have also linked POP exposure to population declines, diseases and abnormalities in a number of wildlife species. Wildlife can also act as sentinels for human health, highlighting the potential effects on humans. Some evidence has led scientists to investigate POP exposure in

humans; it is known that individuals are mainly exposed to POPs through contaminated foods, less common exposure include drinking contaminated water and direct contact with the chemicals. In people and other mammals alike, POPs can be transferred through the placenta and breast milk to developing offspring<sup>3 4</sup>.

The Rotterdam Convention is an answer to food security and pesticides use. One of the first voluntary Codes of Conduct in support of increased food security, to protect human health and the environment was adopted in 1985 in a Food and Agriculture Organization Conference. Due to the considerable growth in chemical production and trade during the past three decades, concerns have been raised about the potential risks posed by hazardous chemicals and pesticides. Countries lacking adequate infrastructure to monitor the import and use of these chemicals are particularly vulnerable. The main aim of the convention was to establish voluntary standards of conduct for all public and private entities engaged in, or associated with, the distribution and use of pesticides<sup>5</sup>. A list of products subject to the convention according to Annex III of the convention can be found in Table B.2 in the Appendix.

The Rotterdam Convention replaced the PIC, a procedure requiring the creation of voluntary codes of conduct and information exchange systems on hazardous chemicals and pesticides introduced with the Basel Convention, with a mandatory PIC procedure. It was adopted in 1998, ratification began in 1999 and entered into force in 2004, at which time it became legally binding for its parties (see Table B.1 in the Appendix for ratification dates by country). It has a narrower focus than the Basel

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<sup>3</sup>It should be noted, however, that despite this potential exposure, the known benefits of breast-feeding far outweigh the suspected risks.

<sup>4</sup>"Persistent Organic Pollutants: A Global Issue, A Global Response" (United States Environmental Protection Agency. Content created in 2002 and updated in December 2009.), <https://www.epa.gov/international-cooperation/persistent-organic-pollutants-global-issue-global-response>.

<sup>5</sup>"Scope of the Chemicals and Waste Subprogram" (UNEP and Harmful Substances at a glance Division of Technology, Industry and Economics United Nations Environment Program (UNEP) International Environment House. June 2010), <http://www.unep.org/chemicalsandwaste/About/tabid/258/Default.aspx>.

Convention and the Ban, and it may also have different implications for trade. More specifically, the Rotterdam Convention applies to chemicals that are banned or severely restricted by a party, including 28 hazardous pesticides and 11 chemicals (See Table B.2 in Appendix). The chemical review committee (CRC) is the subsidiary body in charge of assessing the products that should be subject to the PIC procedure. The procedure is similar to that of the early days of the Basel Convention; parties can exchange those HCs with prior agreement between the parties involved. Although it does not yet include an explicit ban on the products traded, the importers can decide against importing a given product subject to the PIC procedure (see the next two paragraphs). As shown in Kellenberg (2012), waste trade increased after the parties ratified the Basel Convention, but fell after the Ban amendment was added. For these reasons, one might expect to see an increase in trade in HCs after ratification of the Rotterdam Convention.

More specifically, the Rotterdam Convention encourages the sharing of responsibilities and cooperation between the countries in international trade of dangerous chemicals, including some pesticides and industrial chemicals. Pesticides chemicals used to fight against organisms considered harmful includes insecticides, fungicides, herbicides and parasiticides (e.g. they prey on insect pests, respectively, fungi, "weeds" and parasitic worms). HCs are those, among others, which have the virtue of limiting the flammability of products. Food is the primary source of exposure mainly through animal products, namely fish, meat, eggs, and dairy products. Both substances are undesirable due to its persistence in the environment (long life), bioaccumulation potential, its high toxicity and its ability to travel long distances via atmospheric transport.

The obligations that ratifying the Rotterdam Convention carries, refer to the future imports of chemicals listed in the Annex III (Art. 10 of the convention). Ratifying parties have the obligation to submit to the Secretariat any import decision concerning the future import of a given chemical within 9 months after the date of dispatch. A database with all

import responses submitted by the parties is available on the convention's website. On the database it is shown that the final decision for most chemicals is a "non consent to import" among most countries. For example, for Aldrin there have been 120 submissions since 1993 (only 40 after 2004), out of which 113 have resulted in a "non consent to import" response, only 4 have received a "consent to import" (the importers were Congo, Nepal, Tanzania and Zimbabwe), and the remaining 3 obtained a "consent to import only subject to specific conditions" (Korea, Singapore and Zambia). Interestingly, all the final decisions after 2004 received a negative answer.

The Stockholm Convention was adopted in 2001 and entered into force in May 2004. It covers chemicals that are highly toxic, persistent, bio-accumulate and move long distances in the environment (POPs). The main aim of the convention is to restrict or eliminate the production and use of all intentionally produced POPs and the minimization of unintentionally produced POPs (e.g. dioxins and furans). The list of products subject to the convention includes the pesticides used to control the pests and diseases for various crops (aldrin, chlordane, dieldrin, endrin, heptachlor, hexachlorobenzene (HCB), mirex and toxaphene) and the industrial chemical polychlorinated biphenyls (PCBs), with the latter slated for elimination. Both types of chemicals have unforeseen effects on human health and the environment.

The subsidiary body responsible for assessing whether additional products should be subject to the convention and for making recommendations is the Persistent Organic Pollutants Review Committee (POPRC).

Among the intentionally produced POPs are chemicals used in agriculture, disease control, manufacturing or industrial processes (e.g., in electrical transformers and large capacitors, as hydraulic and heat exchange fluids, and as additives to paints and lubricants) and DDT, which is still used to control mosquitoes that carry malaria in some parts of the world. Otherwise, dioxins are unintentionally produced as a result from some

industrial processes and from combustion (e.g. municipal and medical waste incineration and backyard burning of trash<sup>6</sup>).

Regarding the obligations of the parties in the Stockholm Convention, they must take the necessary measures to eliminate the production and use of the chemicals listed under Annex A, to restrict the production and use of those listed under Annex B and to reduce the release of those listed under Annex C.

The parties are also obliged to ensure that the export and import of POPs listed in annex A (see Table B.3 in the Appendix) or B <sup>7</sup> of the convention, comply with the strict requirements laid out. In particular, imports are only allowed for the purpose of environmentally sound disposal or for a specific use permitted for the party under the convention, whereas exports are only permitted when safer alternatives are not available in the market. Nevertheless, there is no specific procedure defined under the Stockholm Convention for the international trade of POPs. In the case where a POP fall within the scope of the Basel or the Rotterdam conventions (as for example aldrin), the control procedures provided by these conventions apply to the import, transit or export of the corresponding product. Moreover, exporting to a non-party of the convention is only allowed when the non-party has provided an annual certification to the exporting party that ensures a minimization or prevents releases, disposes of the chemicals in an environmentally sound manner and respects provisions of Annex B. A registry of specific exemptions is maintained and regularly updated after decisions adopted after the Conference of the Parties, which also takes into account expired exceptions (Art. 4 of the convention). A list of exemptions is provided in parts VI and VII of Annex A, as well in Annex B. In addition to these obligations concerning Annex A and B POPs, parties

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<sup>6</sup><https://www.epa.gov/international-cooperation/persistent-organic-pollutants-global-issue-global-response>pops.

<sup>7</sup>Parties must take measures to restrict the production and use of the chemicals listed under Annex B in light of any applicable acceptable purposes and/or specific exemptions listed in the Annex. Annex B includes the pesticide DDT and the industrial chemical Perfluorooctane sulfonic acid (PFOS), its salts and perfluorooctane sulfonyl fluoride (PFOS-F).

must also take measures to reduce the unintentional release of POPs listed under Annex C<sup>8</sup>, with the ultimate purpose of minimizing and eventually eliminating their use.

Summarising, the conventions focus on explicit lists of products and the reduction or elimination of production and trade in said products. We thus restrict the sample of products in our analysis of waste trade to only these products. This will allow us to analyse the two existent provisions in place for these conventions, the PIC used in the Rotterdam Convention and the Ban (elimination) in the Stockholm Convention and will facilitate the comparison with results from previous studies, particularly with Kellenberg and Levinson (2014). The Stockholm Convention is expected to have a greater impact than the Rotterdam Convention due to the stronger provisions in the former.

## 4.3 Empirical Strategy

### 4.3.1 Data and Variables

The first step in evaluating the effectiveness of the conventions is the correct identification of the products involved. Since there were a number of changes in the product codes in the harmonised system during the period under study (1995-2012), we make use of the different versions of the HS classification, namely the 1992, 1996, 2002, 2007, 2012 versions and follow the same products over time. To select the products affected by the two conventions, we take the list of products published in the corresponding text of the conventions<sup>9</sup>.

The text of the Rotterdam Convention was written before 1998 and refers

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<sup>8</sup>Chemicals listed under Annex C are Hexachlorobenzene (HCB), Pentachlorobenzene, Polychlorinated biphenyls (PCB), Polychlorinated dibenzo-p-dioxins (PCDD), Polychlorinated dibenzofurans (PCDF) and Polychlorinated naphthalenes.

<sup>9</sup><http://www.pic.int/> and <http://chm.pops.int/> respectively.

to the HS codes in the 1996-HS system (6 digits); those codes are then converted into 1992-HS using BACI<sup>10</sup>.

Original trade data are provided by the United Nations Statistical Division (COMTRADE database). BACI is constructed using a procedure that reconciles the declarations of the exporter and the importer. The data that we use in this study are coded using the 1992-HS classification. International trade data contain import and export flows, as reported by each country in its national statistics. We choose to work with import data (as reported by the importer) because it is known in the literature for being of better quality than reported exports, as imports are often reported in detail in order to allow customs to apply duties, taxes or regulatory controls.

In the case of the Stockholm Convention, ratification began in 2002 and the convention entered into force in 2004, as with the Rotterdam Convention (see Table B.1 in the Appendix for ratification dates by country). Since this convention only published the Chemical Abstracts Service Registry Number (CASRN), these CASRN codes were converted into the 2012-HS codes (6 digits), and then re-converted into 1992-HS codes <sup>11</sup>.

Import flows, as well as other gravity variables (distance, common border, common language and colonial links), are extracted from the BACI dataset compiled by CEPII for 88 exporters and 88 importers between 1995 and 2012. GDP and population data are from the World Development Indicators, while the RTA and common currency dummies are from De Sousa (2012).

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<sup>10</sup>BACI is the World trade database developed by CEPII (Center for International Prospective Studies referred to by its French acronym CEPII) at a high level of product disaggregation. <http://www.cepii.fr/cepii/>.

<sup>11</sup>On the European Commission website there is a tax and customs union section that contains a customs inventory of chemical substances ECICS. It also contains a guide to the classification of chemicals in the combined nomenclature with the Harmonised system code at the 6-digit level of disaggregation corresponding to the Chemical Abstracts Service Registry Number (CASRN) presented by the Stockholm Convention. More information about the procedure is available from the authors. For the conversion from CAS codes to HS-6 codes, please refer to: [http://ec.europa.eu/taxation\\_customs](http://ec.europa.eu/taxation_customs) and for the conversion from 2012-HS6 codes to 1992-HS6, the information is available in: <http://unstats.un.org/unsd/trade/conversions/HS>

The dummy variables representing ratification of the Stockholm and the Rotterdam conventions have been constructed using the information available on their respective websites as shown in Table B.1 in the Appendix. The year of ratification has been used in the empirical analysis irrespective of the specific month in which the ratification was completed. Table 4.1 presents summary statistics of the main variables.

The dependent variable deserves further explanation. It has been constructed using the volume imported for the specific products (at the 6-digit disaggregation level) that are subject to each convention using the 1992-HS6 codes definitions provided in Table B.2 for the Rotterdam Convention and the definition of the products for the Stockholm Convention (listed in Table B.3). It is worth mentioning that there are many countries that do not trade certain products for the entire period under study and hence those countries are excluded from the main analysis. Some of the countries that trade certain products targeted by the two conventions only report trade for a few years.

#### 4.3.2 Stylised facts

To better illustrate our data, we plotted total annual shipments of HCs and POPs in Figure 1. In this figure, imports of both HCs products and POPs show a positive trend over time and indicate that a large part of non-OECD countries' imports come from OECD countries. It also indicates a more pronounced increase in the total amount imported after 2004 in comparison to the evolution of imports before this date. However, when looking at the flow from OECD countries to non-OECD countries, the evolution of imports is rather flat after 2004 in the left part of the figure (HCs) and increases only slightly in the right part (POPs). Since the main question at hand is whether developed countries have indeed reduced the amount of these products exported to developing countries as a consequence of ratification and subsequent adoption of the conventions, we now present the evolution of imports in Figure 2 for the different



Variable	Obs.*	Mean	Std. Dev.	Min	Max
<b>Rotterdam Convention</b>					
ln(imports)	209 951	2,718	2,843	-6,911	12,497
Importer ratifies	209 951	0,469	0,499	0	1
Exporter Ratifies	209 951	0,510	0,500	0	1
Both Ratify	209 951	0,369	0,482	0	1
<b>Stockholm Convention</b>					
ln(imports)	91 673	1,793	3,073	-6,908	1,308
Importer ratifies	91 673	0,426	0,495	0	1
Exporter Ratifies	91 673	0,426	0,495	0	1
Both Ratify	91 673	0,337	0,473	0	1
Ln(gdp) importer	137 808	11,319	1,899	7,242	1,660
Ln(gdp) exporter	137 808	11,319	1,899	7,242	1,660
Ln(distance)	137 808	8,690	0,869	4,742	9,886
Contiguity	137 808	0,027	0,163	0	1
Common language	137 808	0,123	0,328	0	1
Colony ties	137 808	0,045	0,208	0	1
RTA	137 808	0,180	0,384	0	1
WTO	137 808	1,744	0,473	0	2
Common currency	137 808	0,011	0,106	0	1

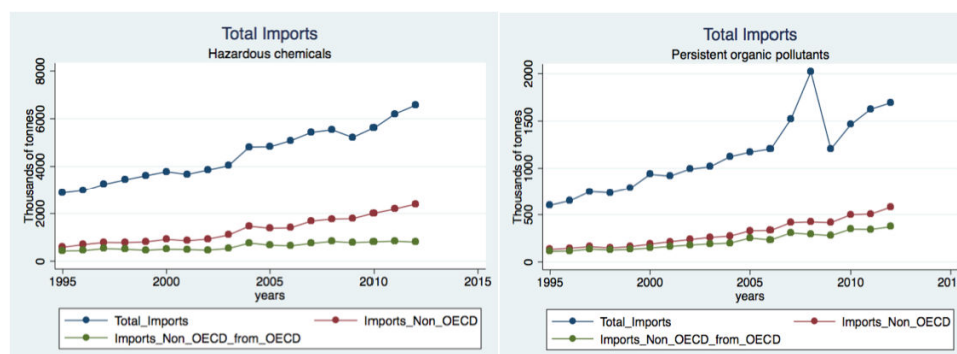
\* Number of observations differ because of disaggregation level when aggregating completely we obtain 137.808 observations (88\*87\*18)

Table 4.1: Summary statistics

groups of countries, before and after ratification and compare the figures for the group of countries that ratify with those that do not.

Figure 2 shows the average annual shipments of HCs and POPs, when the importer ratifies, the exporter ratifies, or neither does, separately. We define year zero as the point in time in which the convention was ratified. In the case of HCs, for countries that do not ratify the Rotterdam Convention, a dramatic increase in their imports is observed at year zero, followed by a sharp decrease. For cases in which at least one of the countries ratifies, there is a slight increase until the convention enters into force and then a sharp decrease followed by a stabilisation period and then a slight increase. For the POPs (right-hand side of Figure 2), there is a similar pattern for cases where at least one country ratified. However, in the case of the non-ratifiers, there is a sharp increase in year zero, followed by a period of stabilisation.

In the case of the Rotterdam Convention, the non-ratifiers show a big peak



**Figure 4.1:** Trade in time of HCs and POPs (BACI)

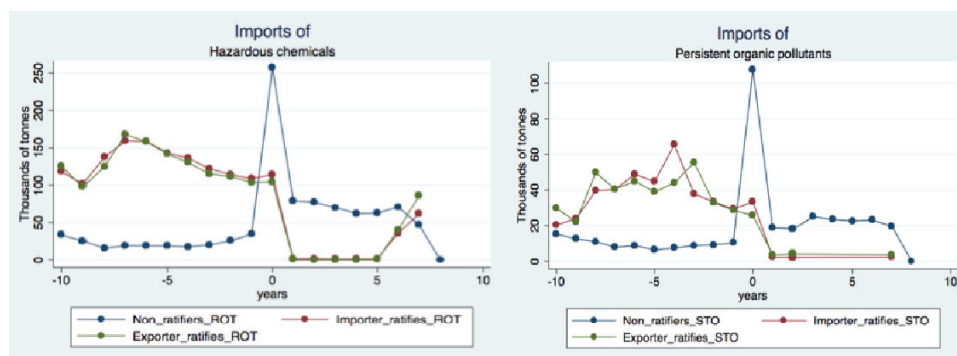
when the convention enters into force, followed by a decrease and then, six years later, a drop in HCs imports. When it is only the importer or only the exporter that ratifies, a big drop is shown when the convention enters into force and five years later a small increase, suggesting that countries may have started to relax their behaviour with respect to HCs imports.

Concerning POPs, the results are similar but there is no increase in imports after five years since the ratification of the Stockholm Convention. This could be explained by the fact that the convention uses a clear ban or import prohibition instead of only controlling the flows.

In Figure 2 we notice that a sudden increase in imports is shown for non-ratifiers in the year in which other countries ratify (year zero). Since countries know that they will not be able to trade HCs and POPs (at least not with ratifiers) in the next periods, countries that produce HCs and POPs could behave strategically by shipping those substances to the countries that have not yet ratified, once the ratification date is known. Moreover, given that we have yearly data and ratification is done in a specific month of the year, the pick in imports, could be the result of the last importation before ratification in year zero<sup>12</sup>.

The analysis of the total annual shipments of HCs and POPs made 10 years before and after countries ratified the conventions reveal an interesting

<sup>12</sup>The date of ratification used to draw the graphs is according to the years indicated in Table B.1



**Figure 4.2:** Trade in HCs and POPs before and after ratification, by ratification-status of the Rotterdam Convention (ROT) or Stockholm Convention (STO)

picture for both conventions (Figure 2), and we hope the econometric model will capture this more accurately. Since figures 1 and 2 show only trends in the data, we aim to employ our modelling strategy to investigate whether the conventions have been effective in reducing imports of the corresponding products that they target.

### 4.3.3 Model specification

The gravity model of trade has long been considered the workhorse in estimating the effect of policy-based bilateral agreements on bilateral trade flows (Feenstra (2003)). In particular, it has been widely used since the 1960s to estimate the effects of free trade agreements (FTAs), economic integration agreements (EIAs) and monetary unions (MUs). More recently, it has also been used to estimate the effects of MEAs on trade (Kellenberg and Levinson (2014)) and in most cases the methodology has been borrowed from the literature on trade agreements. We base our main state-of-the-art specification of the gravity model on Baier and Bergstrand (2007), but due to the shorter time span for which MEAs have been enforced, we will only be able to capture short-term MEA effects. As explained by Baier and Bergstrand (2007), EIAs can take more than ten years for their full impact on bilateral trade to materialise, hence we will not be able to estimate the long-run effects in our application since the

MEAs under analysis have been in force only since 2004 and because the data is only available until 2012.

An important issue in the estimation of the effects of MEAs on trade is the fact that self-selection of country pairs into MEAs possibly creates an endogeneity bias in the estimates. For instance, trade partners that ratify the conventions might be those for which trade in HCs or in POPs is not growing. As suggested by Baier and Bergstrand (2007), panel data techniques can be used to avoid endogeneity bias by incorporating bilateral effects in a log-levels specification. A second issue that is well known in the trade literature is that it is necessary to include the so-called MRF (Anderson and van Wincoop (2004)) in the model, which represents the relative price differences across countries with respect to all of their trading partners. Since these factors vary over time in a panel-data framework, they could be proxied using time-varying exporter and importer fixed effects and will capture not only price effects, but also all the unobservable heterogeneity that varies over time for each origin and for each destination. In what follows, we specify a theoretically founded gravity model of trade that will be estimated in the next section.

According to the underlying theory that has been reformulated and extended by Anderson and van Wincoop (2004), our model assumes a constant elasticity of substitution and product differentiation by place of origin. In addition, prices differ among locations due to symmetric bilateral trade costs. The reduced form of the model is specified as:

$$M_{ijt} = \frac{Y_{it}Y_{jt}}{Y_t^W} \left( \frac{t_{ijt}}{P_{it}P_{jt}} \right)^{1-\sigma} \quad (4.1)$$

where  $M_{ijt}$  are the bilateral imports from country  $i$  to country  $j$  in year  $t$ , and  $Y_{it}$ ,  $Y_{jt}$  and  $Y_t^W$  is the respective GDP of the exporting country, the importing country and the world in year  $t$ .  $t_{ijt}$  denotes trade costs between the exporter and the importer in year  $t$ , and  $P_{it}$  and  $P_{jt}$  are the so-called

MRF.  $\sigma$  is the elasticity of substitution between all goods.

The empirical specification in log-linear form is given by:

$$\ln M_{ijt} = \ln Y_{it} + \ln Y_{jt} - \ln Y_t^W + (1 - \sigma) \ln t_{ijt} - (1 - \sigma) \ln P_{it} - (1 - \sigma) \ln P_{jt} \quad (4.2)$$

The estimation of equation 4.2 is not straightforward due to the presence of trade costs and MRF. In the gravity literature the trade cost function,  $t_{ijt}$  is assumed to be a linear function of a number of trade barriers, namely, the time-invariant determinants of trade flows, including distance, common border, common colonial past and common language dummies and the time-varying policy variables (membership in multilateral agreements such as RTAs, MEAs, WTO, etc.). It takes the form:

$$t_{ijt} = d_{ij}^{\alpha_3} \exp(\alpha_4 \text{Contig}_{ij} + \alpha_5 \text{Comlang}_{ij} + \alpha_6 \text{Comcol}_{ij} + \alpha_7 \text{RTA}_{ij} + \alpha_8 \text{Comcur}_{ij} + \alpha_9 \text{WTO}_{ij} + \alpha_{10} \text{MEA}_{ij}) \quad (4.3)$$

Substitution of the trade cost function 4.3 into equation 4.2 and adding group, product and time dummy variables and an idiosyncratic error term gives the following estimation:

$$\begin{aligned} \ln M_{ijkt} = & \alpha_0 + \alpha_1 \ln Y_{it} + \alpha_2 \ln Y_{jt} - \alpha_3 \ln \text{Dist}_{ij} + \alpha_4 \text{Contig}_{ij} + \alpha_5 \text{Comlang}_{ij} \\ & + \alpha_6 \text{Comcol}_{ij} + \alpha_7 \text{Comcur}_{ij} + \alpha_8 \text{RTA}_{ijt} + \alpha_9 \text{WTO}_{ijt} + \alpha_{10} \text{MEA}_{ijt} \\ & + \alpha_{11} \sum \text{Group}_{ij} + \alpha_{12} \sum d_{iy} I_{iy} + \alpha_{13} \sum d_{jy} I_{jy} + \gamma_t + \theta_k + \mu_{ijkt} \end{aligned} \quad (4.4)$$

Where  $\ln M_{ijkt}$  are the log of quantity imported (in tonnes) of the products subject to each convention shipped from country  $i$  to country  $j$  in year  $t$ ;  $\ln Dist_{ij}$  denotes geographical distance between country  $i$  and country  $j$  in logs;  $Comlang_{ij}$  and  $Comcol_{ij}$  take the value of one when countries  $i$  and  $j$  share an official language or have ever had a colonial relationship, respectively, and zero otherwise;  $Contig_{ij}$  takes the value of one when the trading countries share a border, zero otherwise;  $RTA_{ijt}$  takes the value of one when the trading countries are members of an RTA, zero otherwise;  $WTO_{ijt}$  takes the value of one if country  $i$  or country  $j$  are WTO members and two if both are members; and  $Comcur_{ij}$  takes the value of one when countries  $i$  and  $j$  belong to the same currency union.  $MEA_{ijt}$  takes the value of one when the trading countries have ratified the corresponding convention (Sto for the Stockholm Convention and Rot for the Rotterdam Convention)<sup>13</sup>,  $\gamma_t$  denotes a set of year dummies that proxy for business cycle and other time-variant common factors (globalization) that affect all trade flows in the same manner.  $\sum Group_{ij}$  are  $g = 3$  dummy variables that represent trade from OECD to non-OECD countries, from non-OECD to OECD countries and from OECD to OECD countries, respectively, in order to partially control for group-specific bilateral unobservable heterogeneity. Since the model is estimated using product-level trade data, we add a  $k$  subscript that denotes a given product at the 6-digit HS disaggregation level and also add dummy variables that are product specific to control for any unobserved product-characteristics that are constant across bilateral flows and over time. In line with recent gravity literature, the price terms ( $\ln P_{it}$ ,  $\ln P_{jt}$ ) MRF are modelled as time-varying country-specific dummies. Hence, in equation (4) we also introduce two sets of dummies,  $d_{iy}$  and  $d_{jy}$ , for exporters and importers. We construct country-and-time dummies that vary every five years ( $y$ ) instead of yearly ( $t$ ) in an attempt to account for factors that vary slowly over time and are country specific such as domestic environmental regulations, political stability and industrial

<sup>13</sup>(In the estimations without price effects that are presented in the next section three membership dummies are included: The “importer (or exporter) ratifies” variable is encoded as a dummy variable equal to one if the importer (or exporter) ratifies independently of what the exporter does) and zero otherwise. The “both ratify” dummy takes the value of one when the two trade partners are ratifier countries in a given year.

policies (Gylfason et al. (2015))).

Finally, in an additional specification, rather than adding the usual time-invariant gravity variables to control for differences in trade costs (distance, etc.), we use country-pair-product fixed effects  $\theta_{ijk}$  to control for bilateral unobserved characteristics. The equation is given by:

$$\begin{aligned} \ln M_{ijkt} = & \alpha_0 + \alpha_1 RTA_{ijt} + \alpha_2 WTO_{ijt} + \alpha_3 MEA_{ijt} + \alpha_4 \sum Group_{ij} \\ & + \alpha_5 \sum d_{iy} I_{iy} + \alpha_6 \sum d_{jy} I_{jy} + \gamma_t + \theta_{ijk} + \mu_{ijkt} \end{aligned} \quad (4.5)$$

Our estimation strategy follows Baier and Bergstrand (2007), Gylfason et al. (2015) and Head and Mayer (2014) by using country-pair-product fixed effects to mitigate the possible endogeneity of the agreement effects (introduced in equation 4.5), as well as exporter-and-time and importer-and-time dummy variables to control for MRF (already introduced in equation 4.4 and kept in 4.5). In this way the gravity models that we estimate in this paper control for the possibility of endogeneity present in the ratification variables, which could result if countries self-select themselves into both the ratification process and the time of ratification, depending on their volume of trade in the corresponding pollutant. In summary, in the most comprehensive specification, given by equation 4.5, we exploit the panel nature of the data and include three sets of fixed effects (dummy variables) that account for unobserved factors that vary over time for the exporter and the importer separately and across the country-pair-product dimension (country-pair- or “dyadic”-product fixed effects). For comparison, we present the traditional gravity model estimations with economic and bilateral variables and product fixed effects (instead of dyadic-product fixed effects) and with common time effects instead of MRF.

## 4.4 Main Results

In this section the estimation results are presented separately for each convention. Table 4.2 presents the results obtained for the Rotterdam Convention and Table 4.3 the results for the Stockholm Convention.

Table 4.2 presents the results obtained by estimating equation 4.4 above with the inclusion of dummy variables for three groups of trading partners (OECD to non-OECD, OECD to OECD and Non-OECD to OECD), and origin and destination effects for our target variable (Rotterdam Convention ratification) and its interaction with the group of OECD and non-OECD trading partners (North-South dummy). This latter term is added to analyse if the amount of trade between OECD and non-OECD members that ratified, decreased following ratification. This could occur because the ratification process between trade partners may exert a greater impact on the countries that have to adapt to considerable differences in environmental regulations related to standards of use of these hazardous chemicals.

More specifically, for comparative purposes columns 1 and 2 present estimates of the traditional gravity model (specification (4) of the gravity model but without country-and-time dummies (MRF)). In column (1) group dummies are included, whereas in column (2) the interaction between the North-South dummy and ratification status are added. Columns 3 and 4 incorporate MRF with and without interaction terms, respectively. Column 5 presents estimations of equation 4.5, which includes “dyadic” or bilateral-product time-invariant fixed effects and group dummies and finally, column (6) adds additional interaction terms (between the North-South dummy and ratification status, as in columns (2) and (4)).

According to the results, in the model that includes interactions, shipments are lower when the exporter ratifies the Rotterdam Convention (row 8, columns 2, 4 and 6). That is, the interaction between the ratification dummy and the group dummy OECD to non-OECD countries is negative and statistically significant. The magnitude of the effect is a cumulative



decrease in imports of HCs of about 7 percent (column 6), which given the time span since ratification is not very long, the effect should as such be considered a short-run effect. These results highlight the importance of the exporter ratifying the convention. The additional gravity controls have the expected signs and indicate that countries with higher GDPs, as well as those with shared border, an official language or a colonial history, trade more<sup>14</sup>.

The results shown in columns 1 and 2, which only include group dummies but not bilateral-product (ijk) fixed effects, are biased due to the fact that we only partially control for endogeneity issues and do not control for MRF. Similarly, the results shown in columns 3 and 4 include the MRF but still do not incorporate the bilateral-product fixed effects. For these reasons, we focus on the interpretation of the results in columns 5 and 6. The results show that whereas in column 5 the dummy “both ratify” is negative and statistically significant, in column 6 it is indeed the interaction dummy that captures this effect, meaning that only trade from OECD countries to non-OECD countries is lower when the exporter ratifies. Interestingly, the estimated effects are similar to those found in columns 2 and 4, but lower in magnitude, confirming our suspicion of a possible endogeneity bias, which in this case magnifies the effect.

Table 4.3 shows the results for the Stockholm Convention regression obtained for the gravity model estimated using the imported products that are affected by this convention. The structure of the table is similar to Table 4.2. Columns 1 and 2 are for specification 4 of the gravity model but without country-and-time dummies (MRF), 3 and 4 include MRF and columns 5 and 6 also incorporate bilateral-product time-invariant fixed effects as in equation 4. As in Table 4.2, interactions between the North-South dummy and ratification dummies are also added in columns 2, 4 and 6.

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<sup>14</sup>Full results tables can be found in Table B.4 in the Appendix.

Main results Rotterdam Convention						
VARIABLES	Gravity variables		Country-time5 dummies		Country-time5 dummies & ijk FE	
	(1)	(2)	(3)	(4)	(5)	(6)
	Ln(Imports)	Ln(Imports)	Ln(Imports)	Ln(Imports)	Ln(Imports)	Ln(Imports)
OECD to non-OECD	<b>-1.104***</b> (0.0436)	<b>-1.115***</b> (0.0487)	<b>3.674***</b> (0.506)	<b>3.682***</b> (0.508)		
OECD to OECD	<b>-1.648***</b> (0.0560)	<b>-1.642***</b> (0.0561)	<b>7.030***</b> (0.595)	<b>6.962***</b> (0.597)		
Non-OECD to OECD	<b>-1.272***</b> (0.0599)	<b>-1.265***</b> (0.0599)	<b>2.755***</b> (0.318)	<b>2.728***</b> (0.318)		
Importer ratifies ROT	<b>0.106**</b> (0.0432)	0.0109 (0.0511)				
Exporter ratifies ROT	<b>0.0655*</b> (0.0396)	<b>0.148***</b> (0.0470)				
Both ratify ROT	<b>-0.142***</b> (0.0474)	<b>-0.134**</b> (0.0599)	-0.0548 (0.0363)	-0.0447 (0.0424)	<b>-0.0542**</b> (0.0218)	-0.0310 (0.0268)
Imp ratifies ROT x OECD to non-OECD		<b>0.295***</b> (0.0738)		0.0426 (0.0681)		-0.00195 (0.0477)
Exp ratifies ROT x OECD to non-OECD		<b>-0.184***</b> (0.0550)		<b>-0.111**</b> (0.0522)		<b>-0.0730**</b> (0.0359)
Both ratify ROT x OECD to non-OECD		-0.0740 (0.0895)		-0.0440 (0.0825)		-0.0513 (0.0584)
Observations	209,951	209,951	209,951	209,951	209,951	209,951
R-squared	0.255	0.255	0.349	0.349	0.067	0.067
<i>Time dummies</i>	YES	YES	YES	YES	YES	YES
<i>Product dummies</i>	YES	YES	YES	YES	YES	YES
<i>Country-and-time dummies</i>	NO	NO	YES	YES	YES	YES
<i>Dyadic-sector fixed effects</i>	NO	NO	NO	NO	YES	YES
<i>Rat.-country group int. terms</i>	NO	YES	NO	YES	NO	YES
Number of ijk					25,9	25,9

Note: Robust standard errors are in brackets, \*\*\*, \*\*, \* denotes statistical significance at the 1, 5 and 10 percent level, respectively. In column (1)-(4) other gravity controls, namely distance, common border, common language and colonial ties, are also included, but the coefficients are not shown to save space. Full results can be found in Table A.4 in the Appendix. The "importer (or exporter) ratifies" variable is encoded as a dummy variable equal to one if the importer (or exporter) ratifies (independently of what the exporter does) and zero otherwise. The "both ratify" dummy takes the value of one when the two trade partners are ratifier countries in a given year. i denotes importer, j denotes exporter and k denotes sector.

Table 4.2: Main Results of the Rotterdam Convention

The main results differ from those found for the Rotterdam Convention. This is not surprising due to the different aims of the conventions and the products affected. In particular, contrary to what we found in Table 4.2, significant effects are found in Table 4.3 (row 7, columns 4 and 6) when the importer ratifies the Stockholm Convention and the flow is from OECD to non-OECD countries. It shows a decrease in POPs shipped from OECD to non-OECD countries after the non-OECD importer has ratified the convention. Comparing the results in columns 4 and 6—with and without bilateral-product fixed effects—it can be observed that the magnitude of the effect decreased from 0.253 to 0.157, indicating the importance of controlling for endogeneity in the model to avoid biased results. Similar to Table 4.2, the rest of the gravity controls have the expected signs and a reasonable magnitude<sup>15</sup>. It is not surprising that the effect of the Stockholm Convention is bigger in magnitude, especially since this research focuses on the products that are to be eliminated and so are subject to stronger provisions.

To assess whether there is an aggregation bias when the estimations are carried out for data that is more aggregated, we performed similar estimations summing all flows at the four-digit level for the Rotterdam Convention, at the two-digit level for the Stockholm Convention<sup>16</sup> and finally with completely aggregated data.

The main results are shown in Table 4.4 and in the Appendix (Table B.6 and B.7 for two- and four-digit aggregation, respectively, and B.8 and B.9 for full aggregation). When aggregating the data we sum of all type of HCs in case of Rotterdam Convention and all type of POPs for Stockholm Convention, and not being able to distinguish among products we implicitly induce a bias due to some under or over-representation of a specific product in the sample. To our knowledge, previous research has mainly analyzed waste in an aggregated manner. Our study results show

<sup>15</sup>Full results tables are in the B.5.

<sup>16</sup>For the Stockholm Convention, it is not straightforward to estimate at the four-digit disaggregation level. Performing the estimation at the two-digit level keeps the product disaggregation but somewhat mitigates the zero problem.

that the use of disaggregated data allows us to better isolate and identify the magnitude of the effect. Otherwise, we would have claimed that the ratification of the Rotterdam Convention was effective and the effects bigger in magnitude than in our disaggregated analysis. In particular, the results from aggregating all products (column (2) of Table 4.4) indicate that when the exporter ratifies Rotterdam Convention and trade flows from OECD to non-OECD, imports of HCs are around 15.7 percent lower (compared with 7 percent obtained using product-level data at 6-digits HC).

Concerning the Stockholm Convention, there is no significant effect at the aggregated level, indicating that the average effect is not statistically different from zero. However, the effect using two-digits is similar to the one found at the six-digit level and also statistically significant, but slightly higher. Hence highlighting the importance of using disaggregated trade data when estimating the effects of the conventions in order to be able to properly isolate the effects, taking into account the possible unobserved factors that affect specific products differently.

Our main model seeks to infer whether ratification influences imports by taking into account the ratification date of each country (countries ratify at different points in time), ratifying countries are included in the treatment group and the control group includes those that do not ratify at that moment of time or at any time (Countries that do not ratify Rotterdam Convention are: Algeria, Bangladesh, Egypt, Iceland, Malta, Tunisia, Turkey, US; and Stockholm Convention: Israel, Italy, Malaysia, Malta, US). Nevertheless, the convention(s) was not implemented until 2004, the period of study being from 1995 until 2012. See Table B.1 for a list of countries, its ratification status and the date of ratification. Hence, in the next section we will analyse the timing of the impacts from ratifying the conventions, to infer when the effects could be seen in terms of lower imports.

Main results Stockholm Convention						
VARIABLES	Gravity variables		Country-time5 dummies		Country-time5 dummies & ijk FE	
	(1) Ln(Imports)	(2) Ln(Imports)	(3) Ln(Imports)	(4) Ln(Imports)	(5) Ln(Imports)	(6) Ln(Imports)
OECD to non-OECD	-1.188*** (0.0784)	-1.221*** (0.0838)	4.913*** (0.832)	5.051*** (0.837)		
OECD to OECD	-1.427*** (0.0961)	-1.428*** (0.0961)	9.344*** (0.989)	9.469*** (0.992)		
Non-OECD to OECD	-0.405*** (0.109)	-0.407*** (0.109)	4.545*** (0.552)	4.553*** (0.551)		
Importer ratifies STO	-0.147* (0.0801)	-0.163* (0.0931)				
Exporter ratifies STO	0.237*** (0.0765)	0.254*** (0.0916)				
Both ratify STO	-0.0208 (0.0871)	-0.0413 (0.109)	0.00223 (0.0650)	-0.0436 (0.0732)	0.0143 (0.0381)	0.0209 (0.0439)
Imp ratifies STO x OECD to non-OECD		0.0613 (0.113)		-0.253** (0.103)		-0.157** (0.0798)
Exp ratifies STO x OECD to non-OECD		-0.0509 (0.103)		0.0286 (0.0877)		-0.0820 (0.0601)
Both ratify STO x OECD to non-OECD		0.0721 (0.149)		0.267** (0.133)		0.0887 (0.0988)
Observations	91,673	91,673	91,673	91,673	91,673	91,673
R-squared	0.219	0.219	0.318	0.318	0.069	0.069
Time dummies	YES	YES	YES	YES	YES	YES
Product dummies	YES	YES	YES	YES	YES	YES
Country-and-time dummies	NO	NO	YES	YES	YES	YES
Dyadic-sector fixed effects	NO	NO	NO	NO	YES	YES
Ratification-country group interaction terms	NO	YES	NO	YES	NO	YES
Number of ijk					11,675	11,675

Note: Robust standard errors are in brackets, \*\*\*, \*\*, \* denotes statistical significance at the 1, 5 and 10 percent level, respectively. In column (1)-(4) other gravity controls, namely distance, common border, common language and colonial ties, are also included, but the coefficients are not shown to save space. Full results can be found in Table A.5 in the Appendix. The “importer (or exporter) ratifies” variable is encoded as a dummy variable equal to one if the importer (or exporter) ratifies (independently of what the exporter does) and zero otherwise. The “both ratify” dummy takes the value of one when the two trade partners are ratifier countries in a given year. i denotes importer, j denotes exporter and k denotes sector.

Table 4.3: Main Results of the Stockholm Convention

With respect to Kellenberg and Levinson (2014), there are three main differences in our analysis. First, our database contains fewer countries (88 versus 117) and highly disaggregated data, meaning that we have very detailed information concerning the type of product and that we can control for unobserved factors that are time invariant and product-specific. Instead, Kellenberg and Levinson (2014) aggregated all imports and applied the gravity model to the aggregated shipments. We claim that the use of data at the product level allows us to identify the effectiveness of the conventions without incurring in an aggregation bias. We are also able to identify an “aggregation effect” as described above that indicates that results substantially differ depending on the degree of aggregation used in the estimations.

Second, the time period is also likely to matter in explaining the different results obtained. Whereas Kellenberg and Levinson (2014)) use trade data over the period from 1988 to 2008, our time periods spans from 1995 to 2012. The starting year is 1995 because positive trade flows are found for more countries beginning in the mid 1990s, and because using highly disaggregated data we were facing a trade-off between extending the time period to past years or including more countries. In the end, we decided in favour of more countries.

Finally, the treaties differ clearly in their scope and implementation strategy. We believe that an important factor is the instrument defined in each convention. We suspect that imposing a Ban (as in the Stockholm Convention for Annex A products) or a PIC system (as in the Rotterdam Convention), or both at different times (as in the Basel Convention or for products subject to both, the Rotterdam and the Stockholm conventions) is likely to matter, bans could possibly be more effective in reducing trade of hazardous products. When comparing the results in Kellenberg and Levinson (2014) with those we find for aggregated data and the Stockholm Convention, we find that there is neither fundamental difference nor a statistically significant effect on imports.

	Rotterdam Convention		Stockholm Convention	
	(1)	(2)	(3)	(4)
Disaggregation level:	Both Ratify	Exp. Rat x OECD-Non-OECD	Both Ratify	Imp. Rat x OECD-Non-OECD
6-digits	-0.0542**	-0.0730**	0.0143	-0.157**
2/4 digits	-0.0134***	-0.102*	-0.0033	-0.195**
Aggregated	-0.119***	-0.171***	-0.0294	-0.172

Note: The coefficient shown are from columns (5) and (6) of Tables 2 and 3 for the first row, Tables A6 and A7 for the second row and Tables A8 and A9 for the last column. The "importer (or exporter) ratifies" variable is encoded as a dummy variable equal to one if the importer (or exporter) ratifies (independently of what the exporter does) and zero otherwise. The "both ratify" dummy takes the value of one when the two trade partners are ratifier countries in a given year.

Table 4.4: Summary table of main results at different aggregation levels

## 4.5 Robustness

As a first robustness test, we estimate the model including interactions between the years and the ratification dummies. Results are shown in Tables 4.5 and 4.6 for the Rotterdam and Stockholm conventions, respectively. Next, we estimate regressions separating the sample into three groups of developing countries, see results in Table 4.7. In these three tables (4.5 4.6 4.7), we focus on the preferred model specification that uses the three sets of fixed-effects and only the coefficients of the target variables are shown.

The results obtained with time-varying treatment effects, before and after the ratification date for the Rotterdam Convention, are shown in Table 4.5. These results could show some possible anticipation strategy of the countries importing more the years before the enforcement of the convention was implemented.

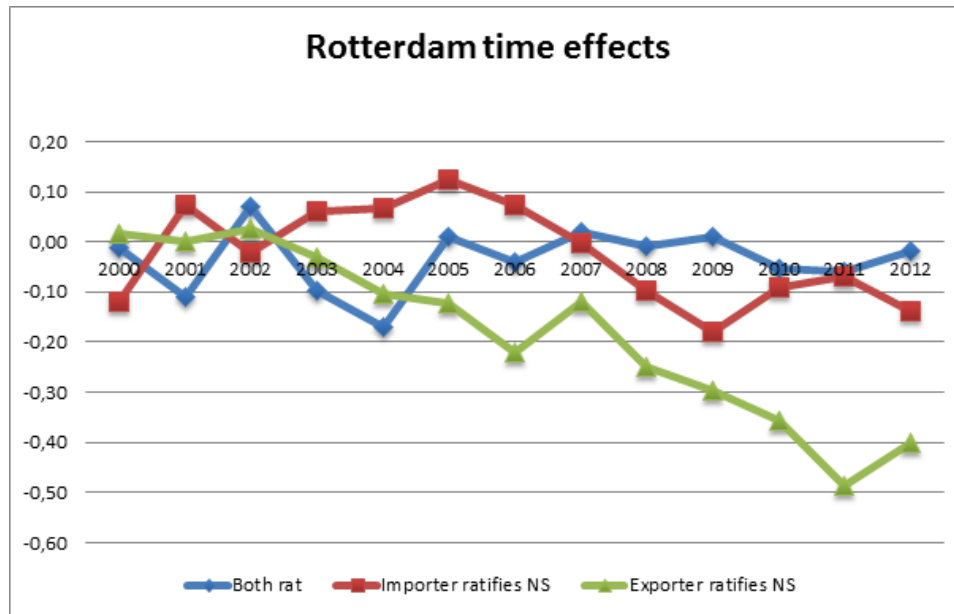
The results indicate that the coefficients are mostly non-significant before 2004, and we observe only a single coefficient that is positive and significant at the ten percent level in 2001 if there is an interaction between when exporter ratifies and the north-south dummy (column (3), second row in Table 4.5). However, there are negative and significant effects in 2003 and 2004 when both countries ratify the convention (column (1), rows 4 and 5 in Table 4.5) and when the exporter ratifies and exports flow from OECD to non-OECD countries from 2004 onwards and for most years. It is shown that the magnitude of the effects increased over the

Country-time5 dummies & ijk FE				
	Both Rat. (1)	Imp. Rat. NS (2)	Exp. Rat. NS (3)	Both Rat. NS (4)
Year	Ln(Imports)	Ln(Imports)	Ln(Imports)	Ln(Imports)
2000	-0.0131 (0.193)	-0.121 (0.116)	0.0176 (0.0896)	0.543 (0.385)
2001	-0.111 (0.113)	0.0741 (0.107)	0.105* (0.0620)	-0.0611 (0.258)
2002	0.0693 (0.0554)	-0.0225 (0.0640)	0.0262 (0.0498)	-0.133 (0.122)
2003	-0.0962* (0.0499)	0.0606 (0.0600)	-0.0272 (0.0520)	0.000720 (0.110)
2004	-0.170*** (0.0396)	0.0673 (0.0764)	-0.104** (0.0473)	0.0633 (0.103)
2005	0.0101 (0.0521)	0.124 (0.0923)	-0.123 (0.0797)	-0.0946 (0.117)
2006	-0.0403 (0.0527)	0.0717 (0.0947)	-0.218*** (0.0824)	0.0284 (0.122)
2007	0.0234 (0.0543)	-0.00190 (0.0986)	-0.121 (0.0859)	0.000283 (0.130)
2008	-0.0123 (0.0571)	-0.0966 (0.0973)	-0.245*** (0.0933)	0.167 (0.135)
2009	0.00772 (0.0579)	-0.179* (0.0987)	-0.298*** (0.0974)	0.220 (0.140)
2010	-0.0540 (0.0698)	-0.0911 (0.115)	-0.357*** (0.116)	0.144 (0.158)
2011	-0.0616 (0.0820)	-0.0736 (0.126)	-0.486*** (0.138)	0.269 (0.183)
2012	-0.0164 (0.0853)	-0.137 (0.132)	-0.400*** (0.145)	0.196 (0.194)

Note: Robust standard errors are in brackets, \*\*\*, \*\*, \* denotes statistical significance at the 1, 5 and 10 percent level, respectively. Only the coefficients for the ratification dummies and interactions with the group dummy are shown. Both Rat. denotes interactions between time dummies and a dummy variable that takes the value of 1 when both countries ratify the convention, zero otherwise. Imp. Rat. denotes interactions between time dummies and a dummy variable that takes the value of 1 when importer country ratifies the convention zero otherwise. Exp. Rat. denotes interactions between time dummies and a dummy variable that takes the value of 1 when exporter country ratifies the convention, zero otherwise. Both Rat. NS denotes interactions between time dummies and a dummy variable that takes the value of 1 when both countries ratify the convention, zero otherwise. NS stand for North and South meaning imports of Non-OECD countries from OECD countries. i denotes importer, j denotes exporter and k denotes sector.

**Table 4.5:** Time-varying ratification effects. Rotterdam Convention





Note: Importer ratifies denotes interactions between time dummies and a dummy variable that takes the value of 1 when importer country ratifies the convention zero otherwise. Exporter ratifies denotes interactions between time dummies and a dummy variable that takes the value of 1 when exporter country ratifies the convention, zero otherwise. Both rat. denotes interactions between time dummies and a dummy variable that takes the value of 1 when both countries ratify the convention, zero otherwise. NS stand for North and South meaning imports of Non-OECD countries from OECD countries. Only the effects that were jointly significant are shown.

**Figure 4.3:** Evolution over time of the coefficients in Table 4.5

years, with the highest coefficient in 2011 (-0.486) showing a lower level of imports in hazardous Chemicals for this trade flow (See also Figure 3). Our interpretation for the positive effect in 2001 is that firms anticipated ratification of their respective country and also of other countries, and tried to trade more of those substances as much as possible before ratification.

Table 4.6 shows that in the case of the Stockholm Convention, imports were higher in 2002 when both countries ratify the convention (column (1)), whereas for the years after ratification, we only find significant and negative coefficients for the year 2011 when the importer ratifies and exports go from OECD to non-OECD countries and for the year 2012 for the same exporters and importers in the case of the exporter having ratified the convention. For this convention, there are also some negative and significant results for the year 2002 (Column (4)). These could be interpreted as anticipation effects.

Additionally, Table 4.7 shows estimations for specific groups of countries. We observe that in the case of the Rotterdam Convention, there are negative and significant effects for African and American developing countries, but no effect for Asian developing countries. Regarding the Stockholm Convention, there is no significant effect observed by individual groups of developing countries but rather as a unified group. One explanation could be that the characteristics of developing countries that may affect the average results, are due to other reasons different to the geographical location.

As a final robustness test, we estimate the gravity model using the Helpman et al. (2008) method, which also considers the existence of zero trade flows. Methodologically, this is done by estimating a probit model for each year in a first step to infer whether the ratification of the agreements influences the probability deciding whether or not to import a given product (HCs and POPs, respectively) and in a second step, some elements of the first estimation (the inverse Mills ratio and the yearly predictions of the probit) are incorporated to the gravity model as specified in equation (5). The results indicate that the effect of the ratification of the Rotterdam Convention is slightly higher for imports of OECD from non-OECD countries when the extensive margin of imports is considered (coefficient equals 0.09), whereas the effect of the Stockholm Convention is not statistically significant in the second step, but the coefficient still maintains the direction of the change<sup>17</sup>. More research is needed to be able to properly identify separate effects for the extensive and intensive margins of trade.

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<sup>17</sup>Available upon request from the authors.

Country-time5 dummies & ijk FE				
	Both Rat. (6)	Imp. Rat. NS (6)	Exp. Rat. NS (6)	Both Rat. NS (6)
Year	Ln(Imports)	Ln(Imports)	Ln(Imports)	Ln(Imports)
2002	0.188* (0.108)	0.0117 (0.198)	0.119 (0.364)	-0.158* (0.0811)
2003	-0.0381 (0.0810)	-0.105 (0.175)	0.112 (0.262)	-0.104 (0.0744)
2004	-0.0718 (0.0654)	-0.166 (0.114)	0.0474 (0.174)	-0.0648 (0.0905)
2005	0.0239 (0.0746)	0.0381 (0.132)	0.0588 (0.200)	-0.107 (0.151)
2006	0.0765 (0.0757)	-0.0512 (0.140)	-0.0535 (0.199)	0.140 (0.143)
2007	0.0838 (0.0803)	-0.0710 (0.135)	-0.228 (0.226)	0.222 (0.178)
2008	0.0201 (0.0832)	-0.229 (0.142)	0.0875 (0.259)	0.110 (0.213)
2009	0.190** (0.0893)	-0.0955 (0.145)	-0.0367 (0.329)	-0.000255 (0.288)
2010	0.0274 (0.191)	-0.212 (0.177)	0.194 (0.358)	-0.109 (0.311)
2011	0.0976 (0.198)	-0.459** (0.188)	-0.429 (0.493)	0.642 (0.461)
2012	0.205 (0.202)	-0.143 (0.191)	-1.202** (0.591)	0.987* (0.561)

Note: Robust standard errors are in brackets, \*\*\*, \*\*, \* denotes statistical significance at the 1, 5 and 10 percent level, respectively. Only the coefficients for the ratification dummies and interactions with the group dummy are shown. Both Rat. denotes interactions between time dummies and a dummy variable that takes the value of 1 when both countries ratify the convention, zero otherwise. Imp. Rat. denotes interactions between time dummies and a dummy variable that takes the value of 1 when importer country ratifies the convention zero otherwise. Exp. Rat. denotes interactions between time dummies and a dummy variable that takes the value of 1 when exporter country ratifies the convention, zero otherwise Both Rat. NS denotes interactions between time dummies and a dummy variable that takes the value of 1 when both countries ratify the convention, zero otherwise. NS stand for North and South meaning imports of Non-OECD countries from OECD countries. i denotes importer, j denotes exporter and k denotes sector.

**Table 4.6:** Time-varying ratification effects. Stockholm Convention

	(5)	(6)	(5)	(6)	(5)	(6)
	Country-time5 dummies & ijk FE					
	Africa		Asia		America	
Rotterdam Convention (Regions)	Ln(Imports)	Ln(Imports)	Ln(Imports)	Ln(Imports)	Ln(Imports)	Ln(Imports)
Both ratify ROT	-0.0392 (0.0280)	-0.0189 (0.0300)	-0.0392 (0.0280)	-0.0389 (0.0302)	-0.0392 (0.0280)	0.0119 (0.0313)
Imp. ratifies ROT x OECD to non-OECD		<b>-0.192**</b> (0.0915)		0.0796 (0.102)		0.00473 (0.0887)
Exp. ratifies ROT x OECD to non-OECD		<b>-0.131**</b> (0.0637)		-0.0914 (0.0613)		-0.0642 (0.0588)
Both ratify ROT x OECD to non-OECD		-0.000189 (0.104)		-0.0468 (0.113)		<b>-0.194**</b> (0.0984)
Observations	111,849	111,849	111,849	111,849	111,849	111,849
R-squared	0.088	0.088	0.088	0.088	0.088	0.088
Number of ijk	14,370	14,370	14,37	14,37	14,370	14,370
Stockholm Convention (Regions)	Ln(Imports)	Ln(Imports)	Ln(Imports)	Ln(Imports)	Ln(Imports)	Ln(Imports)
Both ratify STO	-0.0456 (0.0544)	-0.0428 (0.0583)	-0.0456 (0.0544)	-0.0332 (0.0592)	-0.0456 (0.0544)	-0.0475 (0.0587)
Imp. ratifies STO x OECD to non-OECD		-0.0292 (0.135)		-0.0679 (0.154)		0.234 (0.180)
Exp. ratifies STO x OECD to non-OECD		-0.206 (0.180)		-0.128 (0.104)		0.0639 (0.0991)
Both ratify STO x OECD to non-OECD		0.161 (0.220)		4.50e-06 (0.174)		-0.193 (0.197)
Observations	42,011	42,011	42,011	42,011	42,011	42,011
R-squared	0.087	0.087	0.087	0.088	0.087	0.088
Time dummies	YES	YES	YES	YES	YES	YES
Product dummies	YES	YES	YES	YES	NO	NO
Country-and-time dummies	YES	YES	YES	YES	YES	YES
Dyadic-sector fixed effects	YES	YES	YES	YES	YES	YES
Rat.-country group int. terms	NO	YES	NO	YES	NO	YES
Number of ijk	6,113	6,113	6,113	6,113	6,113	6,113

Note: Robust standard errors are in brackets, \*\*\*, \*\*, \* denotes statistical significance at the 1, 5 and 10 percent level, respectively. The "importer (or exporter) ratifies" variable is encoded as a dummy variable equal to one if the importer (or exporter) ratifies (independently of what the exporter does) and zero otherwise. The "both ratify" dummy takes the value of one when the two trade partners are ratifier countries in a given year. i denotes importer, j denotes exporter and k denotes sector.

Table 4.7: Estimations by region of developing countries

## 4.6 Conclusions

The main findings of this paper indicate that both the Stockholm and Rotterdam conventions have been effective in reducing trade in HCs and POPs. This result is in contrast to the outcomes reported in the previous literature concerning other MEAs.

More specifically, we find that when the exporter ratifies the Rotterdam Convention and the flow is from OECD to non-OECD countries, a significant reduction of imports in hazardous chemicals is observed after ratification. The magnitude of the effect is a cumulative decrease in imports of about 7 percent, which is not particularly high but may increase further as long as the convention remains enforced. This effect is found after controlling for different sources of unobservable heterogeneity and is robust to changes in the specification.

In the case of the Stockholm Convention, the results show significant reductions in trade in POPs for importers that ratify the convention and for POPs shipped from OECD to non-OECD countries, with trade decreasing after the non-OECD-importer has ratified the convention. We observe a reduction of around 17 percent, which is nearly double the effect found for the Rotterdam Convention, which was expected due to the different obligations set by the respective conventions. However, while the import reducing effect of the Rotterdam Convention is robust to the inclusion of zero trade flows and to changes in the aggregation level of import flows, the one of the Stockholm Convention fades away when using aggregated imports and when including zero trade in the model. Since there are products that are subject to both conventions and others that are only affected by one of them, ideally each product-case should be investigated separately. We leave for further research a detailed analysis with product-specific ratification effects for each convention, in which the registry of final decisions taken for individual PICs for specific trading countries is also considered.

## 5

# Environmental laws: the effect on environmental outcomes in an open economy<sup>1</sup>

## 5.1 Introduction

The aim of this paper is to study the effect of environmental laws on environmental outcomes, in order to determine if environmental regulations, in this case represented by laws, act as efficient tools to improve the environment. We consider determinants of pollution as income and trade openness effects. Due to reverse causality from income and openness with the environmental outcomes, we use an instrumented variable procedure. There is also reverse causality between the environmental outcomes and the environmental regulation, we also address this issue.

There is a vivid ongoing debate among environmental economists concerning the instruments aiming to get a wholesome environment. Solid environmental regulations in a country could suggest improvements in environmental quality.

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<sup>1</sup>Joint work with Inmaculada Martínez-Zarzoso (University of Gottingen: imartin@gwdg.de)

Since the beginning of the past century, countries have been constructing them-selves with on an institutional basis. One of the main pillars of this basis is a legal frame. Laws have been shaped by the national institutionalism of countries and they also shed light on what Nations promote in terms of social priorities, cultural values, economic strategies and also their environmental priorities.

Countries can express their priorities in their laws. Intensifying environmental regulations shows an increase in environmental concern, and hence, could be measured as an increase in environmental laws. The more a country devotes itself improving its environmental outcomes, the more environmental laws it will pass. Conscious that the enforcement, or the quality of a law are also important, we also use a proxy variable to take this into account.

The pressure on the development of laws could also be initiated by agents' demands. Anecdotal evidence suggests that when the population feels that the quality of the environment is deteriorating they start changing behaviour in order to take care of their living environment and health.<sup>2</sup> This could also lead to put pressure on governments in order to increase laws protecting the environment.

The study of environmental Legislation explores more in detail the effect of environmental regulation on the environmental performance of countries. But in addition, this allows for policy recommendation in terms of a trade off between institutional efforts towards environmental Legislation development or the enforcement of the Legislation. This is of crucial importance in the context of environmental protection, all the more so when choosing between different costly policy decisions, especially in

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<sup>2</sup>For more information about anecdotal evidence about China's individual change in behaviour for environmental threats to health please see: <http://www.foodsafetynews.com/2014/07/chinas-food-safety-issues-are-worse-than-you-thought/.WAooDEeIBkQ> (China's Food Safety Issues Worse Than You Thought and <https://www.theguardian.com/sustainable-business/2015/may/14/china-middle-class-organics-food-safety-scares> (China's middle class turns to organics after food safety scares)

developing countries.

This work clear up about the fact of devoting efforts in protecting the environment through the construction and development of a legal framework. More specifically, we assess the impact of environmental laws on environmental outcomes, taking into account the determinants of pollution, as income and openness, and also the reverse causality involved with the explanatory variables and the outcomes. The environmental outcomes in study are local air emissions, water pollution and forest area. This local pollutants are going to be felt by the population and hence could induce an increase into legal demands. Specially when trade effects are taken into account and also developed and developing countries differences (Olivier (2016)). Results show, that even if enforcement and environmental laws are important to improve environmental outcomes, only the effect of environmental laws persists in all specifications. In addition, we challenge previous works proving trade being good for the environment (Frankel and Rose (2005)) showing an effect of openness increasing water pollution and decreasing forest area, the latter being particular to Non-OECD countries, and controlling by Forest transition.<sup>3</sup>

One branch of the literature studies the effect pollution determinants on the environment and other examines the effect of environmental-regulation stringency on environmental outcomes, some few works are in between in the next subsections we study them.

### 5.1.1 Determinants of pollution

Trade impact on the environment is an issue extensively discussed. The theoretical research has identified three main channels to study them: the scale, technique and composition effects ((Taylor and Copeland (2004))). But additional to these two, there is the composition effect that is less

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<sup>3</sup>Forest transition is assessed by the income effect with the log of GDP per capita and the squared of the log of GDP per capita ( $\ln(GDP_{percapita})$  and  $\ln(GDP^2_{percapita})$ )



straightforward to assess because it depends on the type of economy (cite). In order to study this composition effect, it is possible to break it down into its two driving forces: factor of endowments and/or environmental-regulation differences (Copeland (2003)).

For a country having less strict environmental-regulation vis-à-vis his trading partners, trade could have a negative effect on the environment. Not only because countries could go towards dirty production (race to the bottom hypothesis), but because they can receive pollution of trade partners, either as a pollution haven effect (Baghdadi et al. (2013), Cole (2004) and Ben Kheder and Zugravu (2012)) or as a waste haven effect (Kellenberg (2012) and Kellenberg and Levinson (2014)). In contrast to this, countries reinforcing environmental-regulation stringency could have positive effects on trade by attracting clean industries (gains from trade hypothesis) (Vogel (2009), Porter and Van der Linde (1995), de Sousa et al. (2015) and Braithwaite and Drahos (2000)). Assessing the global effect of an open economy on the environment, apart from Frankel and Rose (2005) cross-section study, more extended research is still in short supply.

### **5.1.2 Environmental regulation effects**

The effect of the environmental regulation has been studied in economics by adopting different perspectives as explained above. Their common denominator is to study the effect that these regulations can have on different economic indicators such as consumption (Vogel (2009)), competitiveness (Ambec et al. (2013)), innovation (Hemmelskamp et al. (2013), Cole and Elliott (2003)), foreign direct investment (Fredriksson et al. (2003), Cole et al. (2006)), industry development (Ryan (2012), List et al. (2003)) among others. In addition there are also some policy related issues ranging from pollution havens (Grether et al. (2012), Fredriksson and Millimet (2002)), industrial flight, environmental dumping, race-to-the-bottom and to leakage effect (Brunel and Levinson (2016)). However, the intuition

behind a continuous increase in strictness in environmental regulation is to improve environment (and health) outcomes. This is, however of extreme importance in order to efficiently allocate efforts to improve the environment.

Some efforts have been made to study environmental regulations, in an open economy, at a country level. Those studies use proxies of comparable measures such as managers' perception of environmental strictness (Kellenberg (2012)), institutional indexes (Ben Kheder and Zugravu (2012) and Nuñez-Rocha (2016)), treaties ratification (Kellenberg and Levinson (2014) and Nuñez-Rocha (2016)) or regional trade agreements with environmental provisions (Baghdadi et al. (2013)). For OECD countries there is the work by Van Beers and Van Den Bergh (1997) that uses environmental pressure, environmental conditions or indicators of societal responses, among others.

Nevertheless, it is really hard to find in the literature a measure that reflects all aspects of an environmental regulation in a country. This paper is an attempt to construct a comparable measure of environmental regulation at a country level, quantifying the number of environmental laws. However, this approach has also some drawbacks. The first one is the fact that we cannot distinguish whether the laws are outdated or modified. The second one is the fact of countries concentrating on having better laws instead of having more laws. And the third one is that in our variable, the Treaties' date displayed is its date of creation and not its date of enforcement. We mention these drawbacks in our paper as well as the way to deal with these drawbacks.

The reason for including the environmental regulation, additionally, is also important from an Environmental Kuznets Curve (EKC) perspective. There is still no clear evidence of the empirical illustration of EKC (Dinda (2004), Grossman and Krueger (1995), Lin and Liscow (2013), Stern (2004) and Copeland and Taylor (2004)).

Stern et al. (1996) criticise the existence of an EKC, and they underlined

that the estimation procedure is not straightforward due to a lack of production possibilities being modified due to quality of the environment, and also the effect of international trade on environmental degradation, and, last but not least, countries have different types of economies, which translates on income effects being different from one to another. In the model we address this effect of increasing awareness about environmental issues with an increase in income, with the forms of the GDP used as determinant of pollution.

### 5.1.3 Environmental regulation as a legal framework

Preserving a clean environment is one of the biggest challenges that governments and environmental international community face; evidence in other disciplines suggests the effect of a legal framework on different outcomes.<sup>4</sup> The economic activities of countries (production and trade) affect the quality of the environment and a poor environment can threaten the health of a country's inhabitants and also harm its wildlife. Passing environmental laws could be a way for decision makers to send a signal of the importance they give to nature, hence, being an effective way to protect the environment and fight against climate change Ruhl (2010).

Countries' willingness to enjoy a clean environment could push decision-makers to foster laws towards this objective. Environmental treaties are also seen as promoters of this legal frame, since they establish principles and then these principles are integrated in countries' Legislation. Proving an environmental legal framework being effective, would bring to light how to target efforts towards enhancing a good environment. Although a

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<sup>4</sup>Donohue and Levitt (2004) in *Further Evidence that Legalised Abortion Lowered Crime* show evidence about a causal link between legalised abortion and reductions in crime almost two decades later, when the cohorts exposed to legalised abortion reach their peak crime years. Also Acemoglu and Angrist (1999) in *How Large are Human-Capital Externalities? Evidence from Compulsory-Schooling Laws* study the effect of human capital on aggregate income, overcoming problems of identification with the use of instrumental variables. They estimate the effect of the average schooling level in an individual's state, using as an instrument for average schooling the different compulsory attendance laws and child labor laws in U.S. states

policy recommendation that suggests an increase in the number of laws passed to protect the environment oversimplifies the complexity of the institutional structure to have an unpolluted and burgeoning nature. It nonetheless sheds light on the efficiency of these laws to maintain a sound environment.

Specifically, when studying environmental-regulation stringency the literature concentrates on specific cases, either in some regions, or on some pollutants, and not always including the effect of trade (Botta and Koźluk (2014), Brunel and Levinson (2016), Sauvage (2014), Copeland (2003), Misra and Pandey (2005) Kellenberg (2009) and Pratt and Mauri (2005).)

Homogeneous variables, that could serve to compare policies at a global level, are in short supply. The usefulness of such measures is that they would give the opportunity to raise conclusions that can be suitable in a general way to any country. Nevertheless, in general the literature is forced to accept proxy variables that tackle one subject at a time, or that focus on one region or period. Hence, the difficulty of coming to more general conclusions.

In a scenario of globalisation when countries are trading with each other, ultimately what would be interesting to know, is if the environmental outcomes of countries, as a whole, are getting better when the number of number of environmental laws increases. This is of especial interest when confronted to trade with trade partners having different (stricter) environmental-regulations (Dasgupta et al. (2002) and Grossman and Krueger (1994)). However, this is a defying task due to the arduousness to find a comparable measure of environmental regulations among countries. The study of the impact of environmental regulation on environmental outcomes should take into account the three effects mentioned and deal with simultaneity between environmental laws and environmental outcomes, hence, this raises some challenges to tackle.

In order to study the impact of environmental regulations on environmental outcomes, the departure point is to follow Baghdadi et al. (2013)

and Martínez-Zarzoso and Maruotti (2011) to consider the main factors affecting emissions and Frankel and Rose (2005) to address the effect of openness on the environment, assessing simultaneity issues.

In a model à la Frankel and Rose (2005), using panel data-set, we add an environmental regulation variable to specific to each country. This environmental-regulation variable is composed of all countries' Legislation that could have an impact on the environment.

This is the first research to tackle the effect of environmental regulation on environmental outcomes. We create, at a country-level setting, a comparable measure of environmental regulation as an index of environmental laws intensity, by environmental subject. This in a context in which regulations are the expressions of governments' priorities and agents' demands for the protection of the environment in contrast to lobby pressure (Fredriksson et al. (2005)).

Additionally, this paper contributes methodologically speaking to overcoming the absence of appropriate metrics across countries for an empirical approach (Dasgupta et al. (2002)). The variable of environmental-regulation stringency that we construct adds an innovative approach about environmental-regulation *de jure* (Brunel and Levinson (2013)). What is more, this work extends the environmental outcome scope, which was before limited to air outcomes. We additionally include the time dimension in the analysis, challenging previous results in the literature.

Our approach differs from Frankel and Rose (2005) in three respects. We use panel data, we include an environmental regulation variable and we separate countries between OECD and Non-OECD. With our results we believe the positive effect of trade on the environment, is not straightforward.

The remainder of this paper is organised as follows. Section 2 introduces the construction of the environmental-regulation variable. Section 3 discusses the empirical strategy. The results are presented in section 4.

Section 5 concludes.

## 5.2 Defining environmental regulation

Environmental laws are the expression of different social, economic and global interests to tackle a certain objective. But objectives are numerous, that is why these regulations are characterised by the fact that they work at different levels and with different scopes. The literature refers to this as multidimensional (Brunel and Levinson (2016)).

In order to study these laws in their different spheres, we take into account a variable that contains each law that a country has passed, which has an environmental positive impact and we divide them into different subjects. Since the aim of studying these laws has aroused interest of more than one actor they promote environmental management, particularly in economies which are in transition. We think this sheds light on the efficiency of this legal instrument, by subject.

As a joint effort of worldwide organisations such as Food and Agriculture organisation (FAO), International Union for Conservation of Nature and Natural Resources (IUCN) and United Nations Environment Program (UNEP) a data-base is available in the form of a compilation of environmental laws that countries passed in the last century<sup>5</sup>.

Environmental law is a discipline that was formally recognised thirty years ago, and has become a major tool for sustainable development managing natural resources and the environment. Up to 2015 168,401 environmental-laws have been passed in 137 countries. On one hand, the most popular subjects of the treaties are Fisheries, Sea and Environmental General issues, which is understandable because they are linked to the economic activity of fisheries and sea space management which is one of the most important ancient economic activity, and this is also due to the

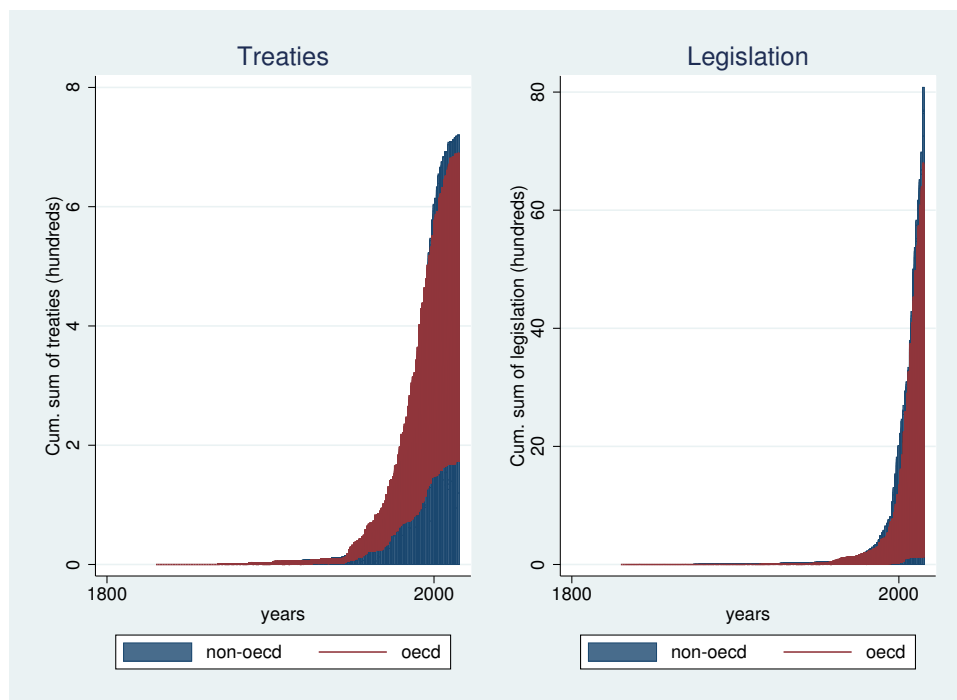
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<sup>5</sup>For more information about the source of this variable please refer to: IUCN (IUCN)

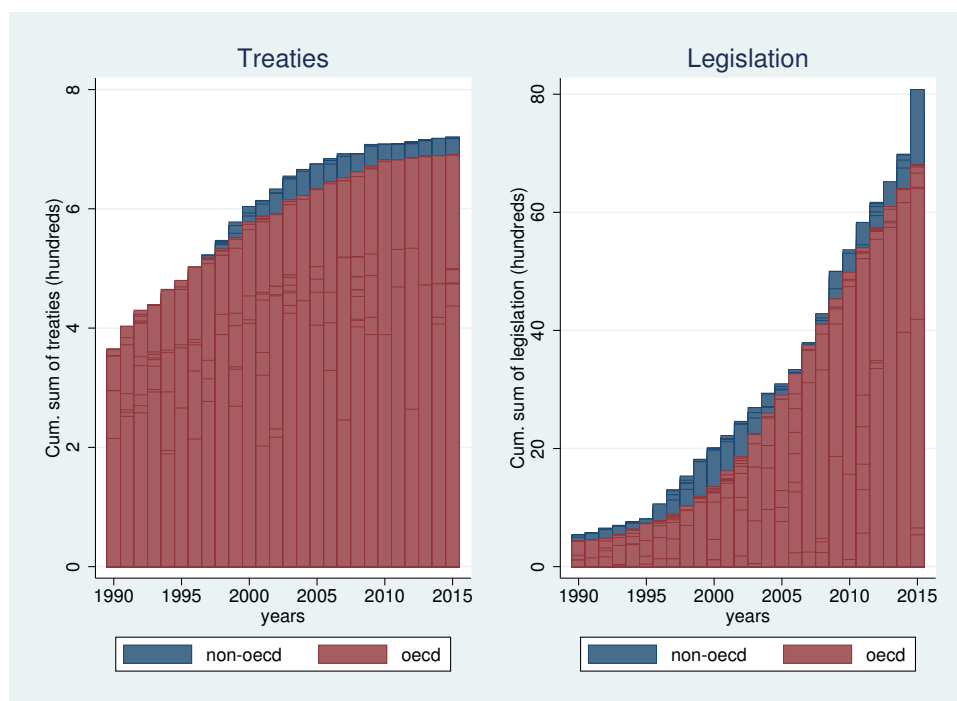
raising importance that environmental issues have had in the passed years. Conversely, the most ancient (environmental) laws that we have here, are laws that are about maritime regulations. E.g. a law that only allows a certain number of boats in a port. The main target of such a law is to ensure the good and efficient functioning of the port. Nevertheless, since fewer (or limited number) of boats will be docking on at a given port, as a positive externality there will be a decrease in see-water pollution.

The environmental regulation variable is composed of all environmental Legislation passed in a country divided into subjects. As mentioned before, national laws are derived from treaties and some of the laws that this variable contains could also be formalisations of treaties. Conscious of that, but nevertheless constrained to solve this issue, we assume that some of the laws are coming from international environmental negotiations, but since the local law creation is still part of the national effort, we assume this should not distort our results. Especially when we see in Figure 5.1 and 5.2 that there is a certain effect on the national legislation following the treaties with a certain lag in time. However, a drawback of our treaties variable is that the date displayed in our data is the creation date of the treaty, not its date of enforcement. Not being able to disentangle this for the moment we focus on the study of the Legislation. Even if this implies loosing a bit of what could be captured with the treaties' type of curve (Figure 5.2 right).

This variable considers all types of laws passed in a country, along with the target or not of having an environmental impact. The most targeted subject is Land and Soil with 288 laws as the maximum number that a country could possibly have passed in a year. Then we have Food and Nutrition, Cultivated Plants and Environmental General Issues. Non-OECD countries are those having the biggest number of laws passed in one year in those issues and also in Forestry, Energy and Agricultural and rural development. The most common subjects for OECD countries are in order of importance: Fisheries, Livestock, Mineral resources, Water, Waste and hazardous substances, Air and atmosphere and Sea.



**Figure 5.1:** Legislation intensity by topic period 1830-2012



**Figure 5.2:** Legislation intensity by topic period 1990-2012



The way the variable is created is by adding the country-specific environmental laws by year and by subject from 1830 to 2015<sup>6</sup>. The laws taken into account are environmental laws. But also, some laws that impact the environment positively even if it was not their original objective. This variable is constructed as the cumulative sum of laws that a country passed from 1830 up to 2015. The data of environmental outcomes are shorter in time span, when doing the matching process, since this variable considers all the laws of a country on an specific subject as the cumulative sum of all the periods before, the information about environmental laws previous to the year of study is considered as the initial stock of laws, as environmental legal legacy.<sup>7</sup>

The matching process between the laws that are available and the respective outcomes deserves further explanation. Table 5.1 we show the matching process of the specific laws to their correspondent environmental outcome. We use three outcomes of local air pollution: NO<sub>2</sub>, SO<sub>2</sub> and PM 2.5. and also, an outcome of water pollution and forestry area index.

Table C.1 shows the results for NO<sub>2</sub> emissions. Since these emissions are mainly the result of road traffic and energy production, we can expect energy and air pollution laws to have a more important impact on these emissions.

For SO<sub>2</sub> emissions, since they result from industrial processes, mainly coal and petroleum combustion, we can expect mainly Air and atmosphere and Environmental general laws to have an impact.

In the case of PM 2.5, emissions are linked to the burning of fossil fuels in vehicles, power plants and various industrial processes. We expect all three laws to have an impact, especially Environmental general issues.

Even though Forest area is not an index of pollution, we think that it

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<sup>6</sup>The availability of the laws begins in 1830, nevertheless, the data of the environmental outcomes is only available since 1990 for most countries.

<sup>7</sup>For more references about Indexes Based on Counts of Regulation see: Javorcik and Wei (2004) and Johnstone et al. (2010)

<b>Air &amp; atmosphere, Energy and Environment gen.</b>		
<b>Outcome</b>	<b>Unit</b>	<b>Period</b>
NO2	CO2 equiv.	1991-2008
SO2		1991-2008
PM 2,5		1995,2000,2005,2011
<b>Environment gen., Water, Waste and hazardous substances</b>		
<b>Outcome</b>	<b>Unit</b>	<b>Period</b>
Water	Water poll. kg per day	1991-2007
<b>Environment gen., Forestry and Land &amp; soil</b>		
<b>Outcome</b>	<b>Unit</b>	<b>Period</b>
Forest area	sq. km	2000-2012

**Table 5.1:** Matching of the laws with the environmental outcomes

is interesting to see the effect of this outcome for two reasons. Firstly, because it allows to globally compare our results with the work of Frankel and Rose (2005). Secondly, according to Walker (1993) forest transitions are associated with social and economic transformations, due to industrialisation and urbanisation, but also, the decrease of agricultural land use due to environmental legislation. The environmental laws that show significance in the estimations are those related to Land and Soil and Environmental in general. There are also laws concerning Forestry, but actually these laws mostly concentrate on forest management and timber harvesting. In this work Forestry is a variable accounting for the Forest area in square kilometres of a country. In this case, it is logical that a law targeting subjects as Land and Soil and general environmental issues should have significant effects. For these reasons we also think of using Forest area, as part of our environmental outcomes.

Figure 5.3 illustrates the intensity of the laws in these subjects around the world.

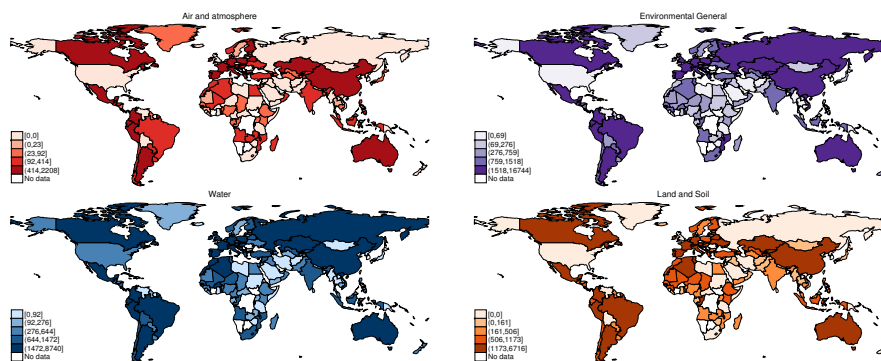


Figure 5.3: Legislation intensity by topic 2012

## 5.3 Empirical Strategy

### 5.3.1 Data and Variables

The explained variables are the environmental outcomes. These outcomes are in line with the subjects of the laws, nevertheless the matching process is not straightforward. As local Air pollutants we use NO<sub>2</sub>, SO<sub>2</sub> and PM<sub>2.5</sub> emissions, the units are kton (Gg) CO<sub>2</sub> (equivalent) per year.<sup>8</sup> For water quality we use organic water pollutant emissions and for forests we use forest area in sq km.<sup>9</sup>

The explanatory variables are the same as in Frankel and Rose (2005). Nevertheless, in order to include the environmental-regulation stringency, we constructed as explained in the last section, an index that reflects the environmental-regulation intensity by country, as the sum of all environmental Legislation (national laws), by environmental subject that 137 countries have from 2002-2012<sup>10</sup>. This could change depending on the

<sup>8</sup>Emissions are excluding short-cycle biomass burning (such as agricultural waste burning) and excluding large-scale biomass burning (forest fires, etc.)

<sup>9</sup>We take the FAO definition of Forest area. Forest Area is land under natural or planted stands of trees of at least 5 meters in situ, whether productive or not, and excludes tree stands in agricultural production systems (for example, in fruit plantations and agroforestry systems) and trees in urban parks and gardens.

<sup>10</sup>The period is restricted to the availability of all the other variables. Since we need a variable to represent the enforcement. The best candidate that we find is from 2002-2012 period.

Variable	Obs	Mean	Std. Dev.	Min	Max
Ln(NO2pc)	15611	-11.30173	1.058559	-14.8518	-6.54254
Ln(SO2pc)	15638	-11.71123	1.360985	-14.91846	-7.986481
Ln(PM2.5pc)	8903	-13.45328	1.529412	-17.26465	-9.285982
Ln(Water pollution pc)	5092	-5.234484	.9439496	-11.49111	-4.174766
Ln(Forest area pc)	15113	-5.922778	2.002903	-12.41062	-1.200452
<b>Laws by subject</b>					
Environmental general	953	44.52991	68.73646	1	753
Air and atmosphere	947	13.44245	21.4775	0	186
Energy	951	22.03365	45.09311	0	458
Energy	951	22.03365	45.09311	0	458
Forestry	953	34.35572	56.67444	0	706
Land and soil	950	52.50105	77.8284	0	809
Waste and haz. sub.	955	28.06911	44.37764	0	331
Water	954	50.00314	60.90099	1	397
All	15611	29.6701	58.96692	0	977
Ln(pred.GDP)	10842	-5.676528	1.204951	-9.866512	-3.590374
Ln(pred.GDP) <sup>2</sup>	10842	33.67475	15.58148	12.89079	97.34807
Ln(pred.OPENNESS)	15611	4.109351	.3738489	3.345485	5.492424
Ln(POP)	15611	16.2122	1.535514	13.00883	21.00939
Ln(LANCAP)	15611	-4.017046	1.358202	-8.951666	-.4554439
Gov. Effectiveness	15611	47.36686	28.73219	0	100

Table 5.2: Summary statistics

environmental outcome, although we have constructed the regulation variable from 1830-2015 (due to the initial stock of laws from countries). In the empirical analysis the period is determined by the availability of data for the dependent variable.

For more details about the period, refer to Table 5.1. A list with summary statistics of the variables is found in 5.2. For a list of the sources of the variables, refer to Table C.8

### 5.3.2 Model specification

#### Determinants of environmental outcomes

According to Frankel and Rose (2005) we regress the  $\ln(Env.Outcome_{pc})_{it}$  environmental outcome (e.g. emissions, water pollution or forest area) explained by openness, income, population and the environmental-regulation

stringency as explanatory variables. We expect income to have an effect on increasing emissions but decreasing in time, expressed with  $\ln(\hat{GDP}_{pc})_{it}$ , only showing the second part of the inverted-U shape curve. Population effect will vary depending on the group of countries and openness, we expect also it to depend on the group of countries. Enforcement and Environmental regulations expressed by laws are expected to decrease pollution and emissions.

$$\begin{aligned} \ln(Env.Outcome_{pc})_{it} = & \beta_0 + \beta_1 \ln(\hat{GDP}_{pc})_{it} + \beta_2 \ln(\hat{GDP}_{pc}^2)_{it} + \\ & \beta_3 \ln(\hat{OPEN})_{it} + \beta_4 \ln(POP)_{it} + \beta_5 \ln(Gov.effec.)_{it} + \\ & \beta_6 (Env.Regulation)_{it} + \beta_7 [(Gov.effec.)_{it} * (Env.Regulation)_{it}] \\ & + \theta_i + \theta_t + \mu_{it} \end{aligned} \quad (5.1)$$

$\ln(\hat{GDP}_{pc})_{it}$  and  $\ln(\hat{OPEN})_{it}$  are the predicted values of income and openness respectively, we discuss them further in the next subsection.  $\ln(Gov.effec.)_{it}$  Government Effectiveness is a variable that takes into account the level of institutional quality that a country can have, understood as quality of institutions.

This variable comes from World Governance Index (WGI). Its definition according to the WGI is Government effectiveness: *"It reflects perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies."* We think this variable is a good candidate to show the enforcement of the policies, due to its capacity of explaining the quality of institutions.

In Frankel and Rose (2005) specification, we also find the land capacity variable, but since this variable is time invariant, its effect will be accounted for with the country dummies.  $\theta_i, \theta_t$  are the country-time fixed effects and an idiosyncratic error term  $\mu_{it}$ . We also add the population

$\ln(POP)_{it}$  variable because we consider it to be an important factor of pollution, especially for emerging countries.<sup>11</sup>

$(EnvironmentalRegulation)_{it}$  is our variable of interest. To construct this variable we create a cumulative sum of laws from 1830-2015. This way we also take into account the initial stock of laws. Then we separate our sample into three groups, namely all the countries, OECD and non-OECD countries. The environmental law is used as one type of law in each estimation. This in order to avoid the artificial multiplication of data.

Firstly, we estimate the instrumental variable (IV) procedure for openness and income effects as equations 5.4 and 5.2 state. These results are then put on Equation 5.1 which is then estimated with a fixed effect model, with bootstrapped standard errors.

Our identification strategy is to use an interaction term between the enforcement and the environmental regulation variables (  $[Ln(Gov.effectiveness.)_{it}*$

$(Env.Regulation)_{it}]$  ) in order to capture how many laws a country has passed and how well they are being enforced. We expect the quality of institutions to be exogenous due to the country-time fixed effects. However, there could be reverse causality between the environmental regulation variable and the environmental outcomes, therefore additionally to our benchmark estimation, we also test the model using an instrumented variable procedure in order to assess this simultaneity. Further explanation about this, and also the endogeneity of the income and openness effect appear in the next subsection.

### Assessing simultaneity issues

In Equation 5.1 we illustrate the determinants of pollution, that can help to explain the environmental outcomes. Nevertheless, it is also necessary

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<sup>11</sup>In some specifications of the model this variable might, however, be collinear for this reason it does not appear on all tables

to take into account that there exist a reverse causality issue. All other things remaining equal, when a country is polluting more due to increased production in polluting activities, this increase in production is going to have an impact on increasing income (technique and factor of endowment effect). Also, if a country produces more in order to grow and trade, the effect of an increase in income and in openness leads to an increase in pollution (scale effect).

This generates a simultaneous causal effect that should be corrected in order to give conclusions about the effect that laws could have on the environmental outcomes, and further insights about the role of income and openness effects.

To overcome the simultaneity problems of the environmental outcomes with the degree of openness (international trade) and income (GDP), in a first stage we used an instrumentation of these two variables. Using the geographic variables in the case of the former and using human capital formation, investment and population in the later.

The geographic variables are good instrumental variables as noted by Frankel and Romer (1999). And the instruments for GDP are taken from the growth literature (Grossman and Krueger (1994)). We do this in a first stage, because our data vary according to countries, subjects and time. Since Openness varies according to importer countries, exporter countries and time, we need to do this in a previous stage and then we add this variable in a country-time dimension.

From growth empirics we use Equation 5.2 to obtain the predicted value of income percapita ( $\ln(\hat{GDP}_{pc})$ ), this variable is obtained after the regression using as explanatory variables population ( $\ln(POP)_{it}$ ), lag of GDP ( $\ln(GDP_{pc})_{i,t-1}$ ), share of investment ( $\ln(I/GDP)_{it}$ ), growth rate of population ( $n_{it}$ ), rate of primary school enrolment ( $\ln(school1)_{it}$ ), rate of secondary school enrolment ( $(school2)_{it}$ ) and an error term ( $\mu_{it}$ ) as in Equation 5.2 above.

$$\begin{aligned} \ln(GDP/POP)_{it} = & \beta_0 + \beta_1 \ln(POP)_{it} + \beta_2 \ln(GDPpc)_{i,t-1} + \\ & \beta_3 \ln(I/GDP)_{it} + \beta_4 n_{it} + \beta_5 \ln(school1)_{it} + \beta_6 (school2)_{it} + \mu_{it} \end{aligned} \quad (5.2)$$

The predicted multilateral openness and the bilateral trade variables used in Equation 5.1 are obtained from a gravity model of trade, which is estimated using a large panel-dataset on pair-wise trade flows. The standard gravity model states that trade between countries is positively determined by their size (GDP, population and land area) and negatively determined by geographical and cultural distance.

The geographical variables are exogenously determined and hence are suitable instruments for trade (Frankel and Romer (1999)). We follow Badinger and Breuss (2008) specification of the gravity model, in which bilateral openness is regressed on countries' populations ( $\ln(POP)_{it}$ ,  $\ln(POP)_{jt}$ ), land capacity (area) ( $\ln(Landcap_i / Landcap_j)_{ij}$ ), distance ( $\ln(Dist)_{ij}$ ), a common border dummy ( $\ln(Adj)_{ij}$ ), a common language dummy ( $(Lang)_{ij}$ ) and a landlocked variable ( $(Landlok)_{ij}$  = sum of a landlocked dummy of countries i and j). Two other variables are included in order to be consistent with the theoretical model: a measure of similarity of country size ( $\ln(Landcap_i / Landcap_j)_{ij}$ ) and remoteness from the rest of the world ( $\ln(Remoteness)_{ij}$ ).<sup>12</sup>

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$$Remote_{ij} = 0.5 D_{ij}^{CC} \left[ \ln \left( \sum_{k=1, k \neq j}^N (Dist_{ik}) / (N-1) \right) \right] + \left[ \ln \left( \sum_{k=1, k \neq i}^N (Dist_{kj}) / (N-1) \right) \right] \quad (5.3)$$

Where  $D^{(CC)}$  is a common continent dummy. This variable will then be equal to zero if countries are on the same continent. Remote is then the log of the average value of the average distances of countries i and j from all other countries.



$$\begin{aligned}
\ln(\text{trade}_{ijt}/GDP_{it}) = & \gamma_i + \chi_j + \varphi_t + \beta_1 \ln(POP)_{it} + \beta_2 \ln(POP)_{jt} + \\
& \beta_3 \ln(Dist)_{ij} + \beta_4 \ln(Adj)_{ij} + \beta_5 \ln(Area)_{ij} + \beta_6 \ln(Lang)_{ij} + \beta_7 \ln(Landborder)_{ij} + \\
& \beta_8 \ln(Landlok)_{ij} + \beta_9 \ln(Landcap_i/Landcap_j)_{ij} + \beta_{10} \ln(Remoteness)_{ij} + \\
& \mu_{ijt}
\end{aligned}
\tag{5.4}$$

Finally, from Equation 5.4 the exponent of the fitted values across bilateral trading partners ( $\hat{T}_{ijt}$ ) is aggregated to obtain a prediction of total trade for each country and year.

$$T_{ijt} = \sum \exp(\hat{T}_{ijt}) \tag{5.5}$$

Both, the bilateral prediction ( $\hat{T}_{ijt}$ ) and the aggregated bilateral prediction ( $T_{ijt}$ ) are used as regressors in the model with  $ijt$  dimension. Equation 5.4 and ( $\hat{T}_{ijt}$ ) is also used in model of Equation 5.1. By using these predicted values we are able to isolate the part of trade that is explained exclusively by geographical, cultural and country-specific factors. Other policy changes that could also explain trade variations are relegated to the unexplained part of the model (error term).

This instrument procedure helps to disentangle the endogeneity problem and also allows to control for the scale and technique effect, and, the factor of endowments (part of the composition effect). The predicted values are growth ( $\ln(\hat{GDP}_{it})$ ) and openness ( $\ln(\hat{OPEN}_{it})$ ) used in equation one.<sup>13</sup>

Nevertheless, there could also exist endogeneity of the environmental laws with the environmental outcomes. In order to tackle this, we also per-

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<sup>13</sup>For results of first stage please refer to Appendix section C.1 and C.2

formed estimations with an instrument to assess the simultaneity between environmental outcomes and environmental laws.

$$(Env.Regulation)_{it} = \beta_0 + \beta_1(Rule.law)_{it} + \mu_{it} \quad (5.6)$$

Finding a variable that can be related with the intensity of environmental laws and independent from the environmental outcomes it is not straightforward. Nevertheless, we search for a variable that could show the ease with which a country can pass laws. The candidates are institutional variables, we study some indexes from WGI<sup>14</sup> and also the Polity variable that shows the level of democracy of a country as in Frankel and Rose (2005). In order to find the most suitable one we study their performance in the first stage regressions but also the main concept that each of them are representing. Rule of law from the WGI seems to perform the best conceptually speaking. And we also observe that the results in regressions are correct.<sup>15</sup>

We consider this variable to be the most suitable, because according to its definition from WGI "It reflects perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence". Also this variable might be correlated with law intensity. The intuition behind this is that the more laws a country has, the better a society perceives its rules. In addition, the better a contract is enforced or the better courts and police function, is

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<sup>14</sup>**Regulatory Quality:** Reflects perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. **Voice and Accountability:** Reflects perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media. **Rule of Law:** Reflects perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.

<sup>15</sup>Results on all the test available from the authors upon request.

not necessarily correlated with the environmental outcomes.<sup>16</sup>

$$\begin{aligned} \ln(Env.Outcome_{pc})_{it} = & \beta_0 + \beta_1 \ln(\hat{GDP}_{pc})_{it} + \beta_2 \ln(\hat{GDP}_{pc}^2)_{it} + \\ & \beta_3 \ln(\hat{OPEN})_{it} + \beta_4 \ln(Gov.effec.)_{it} + \beta_5 (Env.Regulation)_{it} + \\ & \theta_i + \theta_t + \mu_{it} \end{aligned} \quad (5.7)$$

We first determine the instrumented variable procedure for income and openness. Then we focus on the interaction term of enforcement and environmental regulation. Later also we assess the endogeneity of environmental regulation within the environmental outcomes, these results are however less robust in general. For this reason we assume the hardness of the challenge to find the ideal instrument, and we use the interaction between the laws and their enforcement as our benchmark model and with it we do some robustness test, but additionally we present the results of an instrumented variable estimation using two different instruments.

In robustness tests, we first estimate the effect of excluding the countries considered federalists (Millimet (2003)),<sup>17</sup> because those countries are passing laws at a federal level rather than a national level, this could bias results downwards. We also performed the IV procedure using Rule of Law as an instrument model excluding the federalists, results are not so different from the IV procedure with all countries and Rule of law as an instrument. We also test a specification to see if there is a particular effect influencing the results of emerging countries such as India and China. To do this we use the first model only with these two countries, results appear to be non significant.<sup>18</sup>

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<sup>16</sup>It is worth noting that this variable also includes property rights assessment, there is research about the impact of property rights and technology change. We point out that this is part of the technique effect that is taken into account in the model by the GDP variables and also by the country-subject fixed-effects.

<sup>17</sup>Federalist countries: Argentina, Australia, Austria, Bhutan, Brazil, Canada, Ethiopia, Germany, India, Iraq, Lithuania, Malaysia, Mexico, Nigeria, Pakistan, Russian Federation, Sudan, United States of America, Venezuela Boliv. Rep. of

<sup>18</sup>Results available from the authors upon request.

Secondly, since the laws passed in one year could required time to be enforced, we test this with a lagged form of the environmental laws and enforcement variables.

Last, to assess the endogeneity of the intensity of laws with the outcomes, we follow the reasoning that environmental outcomes will possibly be affected by laws concerned directly or indirectly by their scope. Also, the intensity of laws should not be different from one subject to another. We use food and nutrition laws as reasonable instrument variable, because their nature will be in fact correlated with the number of laws in our subject but not necessarily correlated with air and water pollution and forest area.<sup>19</sup> Significant results of all the above-mentioned estimations are commented in the next sections.

## 5.4 Results

### 5.4.1 NO2 emissions

A summary of the main results are in Table 5.3. For NO2 emissions significant results are found only in estimations of the model with the interaction term between the laws and their enforcement (Table 5.8). Laws and their enforcement as a lag variable specification of the model is in Table C.9 and Instrumented Variable (IV) estimation, using food and nutrition as an instrument, is also estimated.<sup>20</sup>

Since these emissions are mainly a result of road traffic and energy production, we expect energy and air pollution laws to have a more important impact on these emissions. From Table 5.8 we infer that a change in one unit the Environmental general issues laws decreases NO2 emissions in 1.2% (column (3)) and a change in one unit in Air and atmosphere laws

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<sup>19</sup>Only summary results for these estimations are presented, full results tables are available from the authors upon request

<sup>20</sup>Results are available from the authors upon request

reduces NO<sub>2</sub> pollution by 4.27% (column (9)). However, Energy related laws have no significant effect. These effects are exclusive to Non-OECD countries, and since the enforcement variable is non significant, neither is the effect of the interaction. The same reasoning holds for all regressions for which enforcement variable is non significant.

### 5.4.2 SO<sub>2</sub> emissions

Table 5.4 shows the summary results for SO<sub>2</sub> emissions. For SO<sub>2</sub> emissions there are significant results in all specifications of the model Tables 5.9, 5.14, C.5 and C.10.

Since these emissions result from industrial processes, mainly coal and petroleum combustion, we expect Air and atmosphere laws to have the biggest impact. In Table 5.9 the interaction of the Environmental laws joined with the enforcement results confirm this, showing that a change in one unit of Environmental general issues laws decrease SO<sub>2</sub> emissions by 2.1% (Column (2)) but only in OECD countries. I also shows that, for a change in one unit of Energy laws, there is a decrease of SO<sub>2</sub> emissions by 3.1% (Column (5)) for OECD countries and less for Non-OECD countries 0.67% (Column (6)). As suspected for Air and atmosphere laws, a change in one unit decreases SO<sub>2</sub> emissions for OECD and Non-OECD countries by 3.25% (Column (8)) and 3.96% (Column (9)) respectively. Using an as an instrument the Rule of law in the IV estimation, we assess the simultaneity between the Environmental laws and outcomes. Table 5.14 shows that enforcement variable increases SO<sub>2</sub> emissions; the environmental laws have no significant effect, even with Rule of Law as a performing instrument.

### 5.4.3 PM2.5 emissions

For PM 2.5 emissions, Table 5.5 shows a summary of main results. These emissions are linked to the burning of fossil fuels in vehicles, power plants and various industrial processes, so we expect all three laws to have an impact. For PM2.5 emissions there are significant results in all specifications of the model Tables 5.10, 5.15, C.6 and C.11.

Table 5.10 shows the interaction term of Laws and their enforcement. For a change in one unit of Energy laws there is a decrease in PM2.5 emissions by 0.6% (Column (5)) for OECD countries. There are also significant results concerning the interaction variable of the enforcement and the three subjects of the laws used for Air pollution. Nevertheless, its effects is of smaller size (From 0,0242% and 0,0635%). There is also evidence of decreasing effects on income, but this effect is not robust to the division in OECD and Non-OECD countries.  $\ln(POP)$  has an effect decreasing pollution, for Non-OECD countries.

In the IV estimation, with Rule of Law as an instrument, Table 5.15 shows effects only on the determinants of pollution. Openness has an effect decreasing pollution only for OECD countries. The effect of the  $\ln(POP)$  contrarily to what the first specification of the model shows, has an effect decreasing PM2.5 emissions, the effect is in two of the laws: Environmental general issues for OECD countries and Energy for Non-OECD.

### 5.4.4 Water pollution

For Water estimations Table 5.6 has a summary of main results. For water pollution, we use Organic water pollutants that are measured by biochemical oxygen demand (BOD), which refers to the amount of oxygen that bacteria in water will consume in breaking down waste. Water can be polluted for different reasons, we use laws in Environmental general issues, Water and Waste and hazardous substances, expecting Water laws

to have the most important effect. Full results are in Tables 5.11, 5.16, C.7 and C.12.

From Table 5.11, we observe that laws concerning Waste and hazardous substances have an effect increasing water pollution. Nevertheless, these effects do not hold when separating OECD and Non-OECD countries. This might be explained because of the reverse causality between the laws on Waste and hazardous substances and the pollution of Waste and hazardous substances. However, these effects do not hold for the IV specifications. And for the determinants of pollution, there is a decreasing Water pollution income effect, only for OECD countries and an effect of openness increasing Water pollution.

In the instrumented model with Rule of law Table 5.16. There are effects decreasing Water pollution from the Laws and their enforcement. Only enforcement has significant effects, nevertheless, the instrument has only performed well. The instrument of the laws performs well for Water laws, yet the laws appear to decrease water pollution, but the effect is not significant. Income decreasing effect is confirmed only for OECD countries and openness appears to have a an increasing effect on Water pollution for Non-OECD countries. There is a population effect decreasing pollution but it does not hold for the separation between OECD and Non-OECD countries.

#### **5.4.5 Forest area**

Table 5.3 shows the summary results for Forest area, this outcome reads contrarily then the others. We expect laws on Forestry to have an effect, but also laws related to Land and soil could have an effect. All models show some significant results and they are in Tables 5.12, 5.17, C.8 and C.13

In the first specification of the model Table 5.12, we observe population

having an effect increasing Forest area, which makes sense for OECD countries because of Forest transition (Walker (1993)).

Using Rule of law as an instrument we find that our instrument of Rule of laws performs well, nevertheless, the laws' variables are not significant. Table 5.17.

Legislation on NO2 emissions						
LAWS	(1)	(3)	(9)			
Countries	Environment gen.	NON-OECD	Air and atmos.			
VARIABLES	all	NON-OECD	NON-OECD			
	ln(NO2pc)	ln(NO2pc)	ln(NO2pc)			
Env. Laws	-0.00610*	-0.0120**	-0.0427**			
	(0.00348)	(0.00577)	(0.0210)			
Enforcement x Laws		0.000161*	0.000747**			
		(8.35e-05)	(0.000378)			
Legislation on NO2 emissions lags						
LAWS	(2)	(3)	(5)	(7)	(8)	(9)
Countries	Environment gen.	NON-OECD	Energy		Air and atmos.	
VARIABLES	OECD	NON-OECD	OECD	all	OECD	NON-OECD
	ln(NO2pc)	ln(NO2pc)	ln(NO2pc)	ln(NO2pc)	ln(NO2pc)	ln(NO2pc)
Enforcement (Gov. Eff.) t-1	0.00687*		0.00752**		0.00696*	
	(0.00407)		(0.00365)		(0.00379)	
Env. Laws t-1		-0.00844*		-0.0156*		-0.0406**
		(0.00494)		(0.00864)		(0.0201)
Enforcement x Laws t-1						0.000601*
						(0.000338)
Legislation on NO2 emissions food and nutrition as an instrument						
LAWS	(1)	(5)	(7)	(11)		
Countries	Environment general	NON-OECD	Energy	NON-OECD		
VARIABLES	all	NON-OECD	all	NON-OECD		
	ln(NO2pc)	ln(NO2pc)	ln(NO2pc)	ln(NO2pc)		
Openness	1.427**	1.170*	1.470**	1.269*		
	(0.656)	(0.655)	(0.666)	(0.694)		
Ln(POP)	1.516**	1.360*	1.437**	1.334*		
	(0.661)	(0.733)	(0.634)	(0.725)		

**Table 5.3:** NO2 summary results



Legislation on SO2 emissions						
	(2)	(5)	(6)	(7)	(8)	(9)
LAWS	Environment gen.	Energy	Energy	Air and atmos.	Air and atmos.	Air and atmos.
Countries	OECD	OECD	NON-OECD	all	OECD	NON-OECD
VARIABLES	ln(SO2pc)	ln(SO2pc)	ln(SO2pc)	ln(SO2pc)	ln(SO2pc)	ln(SO2pc)
Environmental Laws	-0.0210*** (0.00745)	-0.0308* (0.0159)	-0.00668** (0.00326)	-0.0233*** (0.00875)	-0.0352** (0.0158)	-0.0396* (0.0205)
Enforcement x Laws	0.000238*** (8.17e-05)	0.000356** (0.000171)	0.000117* (6.64e-05)	0.000245** (9.74e-05)	0.000403** (0.000169)	0.000680* (0.000383)
Legislation on SO2 emissions rule of law as an instrument						
	(3)	(4)				
LAWS	Environment general	Environment general				
Countries	OECD					
VARIABLES	ln(SO2pc)	1st stage				
Enforcement (Gover. Effect.)	0.0102** (0.00438)					
Environmental Laws	-0.00238 (0.00370)					
Rule of Law		-0.929** (0.410)				
Legislation on SO2 emissions without federalist countries						
	(1)	(2)	(7)	(8)	(9)	
LAWS	Environment gen.	Environment gen.	Air and atmos.	Air and atmos.	Air and atmos.	
Countries	all	OECD	all	OECD	NON-OECD	
VARIABLES	ln(SO2pc)	ln(SO2pc)	ln(SO2pc)	ln(SO2pc)	ln(SO2pc)	
Environmental Laws	-0.00891* (0.00486)	-0.0202** (0.00978)	-0.0256** (0.0103)	-0.0315* (0.0174)	-0.0430* (0.0256)	
Enforcement x Laws		0.000227** (0.000109)	0.000260** (0.000119)	0.000355* (0.000193)		
Legislation on SO2 emissions lagged environmental laws						
LAWS	Environment gen.		Energy		Air and atmos.	
Countries	all	OECD	OECD	all	OECD	NON-OECD
VARIABLES	ln(SO2pc)	ln(SO2pc)	ln(SO2pc)	ln(SO2pc)	ln(SO2pc)	ln(SO2pc)
Ln(GDPpc) <sup>2</sup>	-0.0192* (0.0106)	-0.0645** (0.0285)	-0.0572* (0.0306)	-0.0182* (0.0108)	-0.0544* (0.0299)	
Environmental Laws t-1		-0.0275*** (0.00857)	-0.0402* (0.0209)	-0.0268*** (0.00879)	-0.0399* (0.0209)	-0.0432** (0.0193)
Enforcement x Laws t-1		0.000305*** (9.40e-05)	0.000446** (0.000223)	0.000267*** (9.61e-05)	0.000441* (0.000226)	0.000702** (0.000338)
Legislation on SO2 emissions food and nutrition as an instrument						
	(1)	(2)	(5)	(7)	(8)	(11)
LAWS	Environment general		Environment general		Energy	Energy
Countries	all		NON-OECD		all	NON-OECD
VARIABLES	ln(SO2pc)	1st stage	ln(SO2pc)	ln(SO2pc)	1st stage	ln(SO2pc)
Ln(POP)	1.608** (0.727)		1.299* (0.716)	1.239** (0.601)		1.284* (0.685)
Environmental Laws	0.00617 (0.00468)		0.00119 (0.00279)	0.0107 (0.00870)		0.00255 (0.00560)
Environmental Laws (Food)		0.113* (0.0617)			0.0619* (0.0316)	

Table 5.4: SO2 summary results

Legislation on PM2.5 emissions interaction of enforcement and laws							
	(1)	(3)	(4)	(5)	(6)	(7)	(9)
LAWS	Environment gen.	Environment gen.	Energy	Energy	Energy	Air and atmos.	Air and atmos.
Countries	all	NON-OECD	all	OECD	NON-OECD	all	NON-OECD
VARIABLES	ln(PM2.5pc)	ln(PM2.5pc)	ln(PM2.5pc)	ln(PM2.5pc)	ln(PM2.5pc)	ln(PM2.5pc)	ln(PM2.5pc)
Ln(GDPpc) <sup>2</sup>	-0.00532*** (0.00191)		-0.00577*** (0.00188)			-0.00553*** (0.00187)	
Ln(POP)	0.683*** (0.127)	0.803*** (0.193)	0.647*** (0.120)		0.756*** (0.196)	0.645***	0.775*** (0.182)
Environmental Laws			<b>0.00210*</b> (0.00118)	<b>-0.00596**</b> (0.00296)		(0.00299)	
Enforcement x Laws	<b>-2.42e-05**</b> (1.11e-05)		<b>-3.13e-05*</b> (1.66e-05)	<b>6.35e-05*</b> (3.44e-05)		<b>-6.11e-05*</b> (3.34e-05)	
Legislation on PM2.5 emissions Rule of Law as an instrument							
	(3)	(7)	(11)	(15)			
LAWS	Environment general	Energy	Energy	Air and atmosphere			
Countries	OECD	all	NON-OECD	OECD			
VARIABLES	ln(PM2.5pc)	ln(PM2.5pc)	ln(PM2.5pc)	ln(PM2.5pc)			
Openness	-1.841** (0.786)						
Ln(POP)	-0.824*** (0.225)	-0.978* (0.581)	-1.184* (0.658)	-0.693* (0.356)			
Legislation on PM2.5 emissions Federalists countries							
	(1)	(3)	(4)	(7)	(8)	(9)	
LAWS	Environment gen.	Environment gen.	Energy	Energy	Air and atmos.	Air and atmos.	
Countries	all	NON-OECD	all	all	OECD	NON-OECD	
VARIABLES	ln(PMpc)	ln(PMpc)	ln(PMpc)	ln(PMpc)	ln(PMpc)	ln(PMpc)	
Ln(GDPpc) <sup>2</sup>	-0.00291** (0.00139)		-0.00367*** (0.00139)	-0.00418*** (0.00132)			
Ln(POP)	0.639*** (0.123)	0.766*** (0.175)	0.610*** (0.129)	0.585*** (0.126)		0.768*** (0.151)	
Enforcement (Gover. Effect.)	<b>0.00264**</b> (0.00103)	<b>0.00228**</b> (0.00114)	<b>0.00223**</b> (0.00106)	<b>0.00211**</b> (0.000992)	<b>0.00621*</b> (0.00326)	<b>0.00184*</b> (0.00104)	
Environmental Laws	<b>0.00336***</b> (0.00112)	<b>0.00378**</b> (0.00149)	<b>0.00290***</b> (0.00111)	<b>0.00788**</b> (0.00380)		<b>0.0193***</b> (0.00605)	
Enforcement x Laws	<b>-4.85e-05***</b> (1.44e-05)	<b>-5.70e-05**</b> (2.70e-05)	<b>-4.52e-05***</b> (1.58e-05)	<b>-0.000104**</b> (4.80e-05)		<b>-0.000301***</b> (0.000103)	
Legislation on PM2.5 emissions lagged environmental laws							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
LAWS	Environment gen.	Environment gen.	NON-OECD	all	Energy	NON-OECD	all
Countries	all	OECD	NON-OECD	all	OECD	NON-OECD	all
VARIABLES	ln(PM2.5pc)	ln(PM2.5pc)	ln(PM2.5pc)	ln(PM2.5pc)	ln(PM2.5pc)	ln(PM2.5pc)	ln(PM2.5pc)
Ln(GDPpc) <sup>2</sup>	-0.0105*** (0.00275)		-0.00639* (0.00375)	-0.0106*** (0.00256)		-0.00779** (0.00351)	-0.0110*** (0.00265)
Ln(POP)	-0.838*** (0.144)	-1.045***		-0.775*** (0.132)	-0.964*** (0.308)		-0.783*** (0.135)
Enforcement (Gover. Effect.) t-1	<b>0.00277**</b> (0.00123)		<b>0.00287**</b> (0.00146)	<b>0.00263**</b> (0.00117)		<b>0.00255*</b> (0.00142)	<b>0.00253**</b> (0.00122)
Environmental Laws t-1				<b>0.00153*</b> (0.000854)			<b>0.00602*</b> (0.00336)
Enforcement x Laws t-1				<b>-2.38e-05*</b> (1.33e-05)			<b>0.00267**</b> (0.00132)
Legislation on PM2.5 emissions Food and nutrition laws as as instrument							
	(3)	(7)	(9)	(11)			
LAWS	Environment general	Energy	Energy	Energy			
Countries	OECD	all	OECD	NON-OECD			
VARIABLES	ln(PM2.5pc)	ln(PM2.5pc)	ln(PM2.5pc)	ln(PM2.5pc)			
Openness	-1.841** (0.786)		-1.652* (0.948)				
Ln(POP)	-0.824*** (0.225)	-0.989* (0.597)		-1.194* (0.665)			

Table 5.5: PM summary results

Legislation on water pollution interaction of enforcement and environmental laws							
LAWS	(1)	(4)	(5)	(7)			
Countries	Environment general	Water	Water	Waste and hazardous substances			
VARIABLES	all	all	OECD	all			
	ln(Water poll.pc)	ln(Water poll.pc)	ln(Water poll.pc)	ln(Water poll.pc)			
Ln(GDPpc) <sup>2</sup>			-0.0253*				
			(0.0137)				
Openness	2.458**	2.885***		2.532**			
	(1.001)	(1.099)		(0.996)			
Environmental Laws				0.00609**			
				(0.00307)			
Enforcement x Laws				-6.23e-05*			
				(3.70e-05)			
Legislation on water pollution rule of law as an instrument							
LAWS	(3)	(5)	(7)	(8)	(13)	(15)	
Countries	Environment general	Environment general	Water	Water	Waste and hazardous substances	Waste and hazardous substances	
VARIABLES	OECD	NON-OECD	all	1st stage	all	OECD	
	ln(Wat.poll.pc)	ln(Wat.poll.pc)	ln(Wat.poll.pc)		ln(Wat.poll.pc)	ln(Wat.poll.pc)	
Ln(GDPpc) <sup>2</sup>	-0.0211*					-0.0202*	
	(0.0115)					(0.0108)	
Openness		2.482**					
		(1.039)					
Ln(POP)			-0.994*		-1.079*		
			(0.579)		(0.646)		
Environmental Laws			-0.00683				
			(0.00744)				
Rule of Law				-0.318*			
				(0.187)			
Legislation on water pollution without Federalist countries							
LAWS	(1)	(4)	(7)				
Countries	Environment general	Water	Waste and hazardous substances				
VARIABLES	all	all	all				
	ln(Wat.poll.pc)	ln(Wat.poll.pc)	ln(Wat.poll.pc)				
Openness	2.941**	3.036**	2.703***				
	(1.153)	(1.201)	(0.984)				
Environmental Laws			0.00715**				
			(0.00306)				
Enforcement x Laws			-7.68e-05*				
			(3.84e-05)				
Legislation on water pollution lagged environmental regulation							
LAWS	(5)	(7)					
Countries	Water	Waste and hazardous substances					
VARIABLES	OECD	all					
	ln(NO2pc)	ln(NO2pc)					
Ln(GDPpc) <sup>2</sup>	-0.0324*						
	(0.0169)						
Environmental Laws t-1		0.00929*					
		(0.00479)					
Enforcement x Laws t-1		-9.97e-05*					
		(5.60e-05)					
Legislation on water pollution Food and nutrition laws as an instrument							
LAWS	(1)	(5)	(7)	(11)	(13)	(15)	(17)
Countries	Environment general	Environment general	Water	Water	Waste and hazardous substances	Waste and hazardous substances	Waste and hazardous substances
VARIABLES	all	NON-OECD	all	NON-OECD	all	OECD	NON-OECD
	ln(Water poll.pc)	ln(Water poll.pc)	ln(Water poll.pc)	ln(Water poll.pc)	ln(Water poll.pc)	ln(Water poll.pc)	ln(Water poll.pc)
Ln(GDPpc) <sup>2</sup>						-0.0218***	
						(0.00835)	
Openness	3.044***	2.031**	2.566***	1.708**	2.551***		1.630**
	(0.923)	(0.813)	(0.934)	(0.705)	(0.828)		(0.733)
Ln(POP)							-0.828*
							(0.499)

**Table 5.6: Water pollution summary results**

Legislation on Forest area interaction of enforcement with laws										
LAWS	(1)	(2)	(4)	(5)	(7)	(8)				
Countries	Environment general	Environment general	Forestry	Forestry	Land and soil	Land and soil				
VARIABLES	all	OECD	all	OECD	all	OECD				
	ln(Forestpc)	ln(Forestpc)	ln(Forestpc)	ln(Forestpc)	ln(Forestpc)	ln(Forestpc)				
Ln(POP)	1.252*** (0.128)	1.102*** (0.139)	1.254*** (0.134)	1.093*** (0.113)	1.248*** (0.135)	1.094*** (0.124)				
Legislation on Forest area rule of law as an instrument										
	(1)	(2)	(5)	(6)	(7)	(8)	(11)	(12)	(17)	(18)
	all	Environment general			all	Forestry				
VARIABLES	ln(Forestpc)	ln(Forestpc)	NON-OECD ln(Forestpc)	ln(Forestpc)	ln(Forestpc)	ln(Forestpc)	NON-OECD ln(Forestpc)	NON-OECD ln(Forestpc)	NON-OECD ln(Forestpc)	ln(Forestpc)
Openness	-0.225* (0.123)		-0.188* (0.100)		-0.219* (0.115)		-0.186* (0.0994)		-0.173* (0.0898)	
Ln(POP)	-1.286*** (0.155)		-1.308*** (0.182)		-1.285*** (0.161)		-1.305*** (0.185)		-1.297*** (0.171)	
Environmental Laws	-0.000188 (0.000680)		-0.000379 (0.000705)		-0.000205 (0.000790)		-0.000386 (0.000753)		-0.000409 (0.000796)	
Rule of law		0.850** (0.347)		0.973** (0.406)		0.728* (0.435)		0.912* (0.510)		0.888* (0.455)
Legislation on Forest area without Federalist countries										
LAWS	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)		
Countries	all	Environment gen.	NON-OECD	all	Forestry	NON-OECD	all	Land and Soil		
VARIABLES	ln(Forestpc)	ln(Forestpc)	ln(Forestpc)	ln(Forestpc)	ln(Forestpc)	ln(Forestpc)	ln(Forestpc)	ln(Forestpc)		
Ln(GDPpc) <sup>2</sup>			-0.00516* (0.00294)			-0.00571** (0.00263)				
Ln(POP)	1.226*** (0.126)	0.920*** (0.131)		1.226*** (0.135)	0.959*** (0.141)		1.235*** (0.138)	0.980*** (0.140)		
Enforcement (Gover. Effect.)	-0.000845* (0.000497)	-0.000126 (0.00105)	-0.00164** (0.000721)	-0.00135** (0.000538)		-0.00206*** (0.000691)				
Environmental Laws	-0.00151* (0.000780)		-0.00285** (0.00113)	-0.00437*** (0.00147)		-0.00622*** (0.00176)				
Enforcement x Laws	2.10e-05** (9.97e-06)		4.59e-05** (1.80e-05)	5.95e-05*** (1.99e-05)		9.28e-05*** (2.57e-05)				
Legislation on Forest area lagged of environmental regulation										
LAWS	(3)	(6)	(9)							
Countries	Environment general	Forestry	Land and soil							
VARIABLES	NON-OECD ln(Forestpc)	NON-OECD ln(Forestpc)	NON-OECD ln(Forestpc)							
Ln(POP)	-1.251*** (0.176)	-1.251*** (0.180)	-1.237*** (0.173)							
Legislation on Forest area Food and nutrition as an instrument										
LAWS	(1)	(3)	(5)	(7)	(9)	(11)	(13)	(15)	(16)	(17)
Countries	Environment general	Environment general	Environment general	Environment general	Forestry	Forestry	Land and soil	Land and soil	Land and soil	Land and soil
VARIABLES	all ln(Forestpc)	OECD ln(Forestpc)	NON-OECD ln(Forestpc)	all ln(Forestpc)	OECD ln(Forestpc)	NON-OECD ln(Forestpc)	all ln(Forestpc)	OECD ln(Forestpc)	OECD ln(Forestpc)	NON-OECD ln(Forestpc)
Openness	-0.216* (0.111)	-0.266* (0.155)	-0.181** (0.0909)	-0.220* (0.113)	-0.371* (0.208)	-0.182** (0.0909)	-0.220* (0.112)	-0.312* (0.160)		-0.184** (0.0915)
Ln(POP)	-1.242*** (0.109)	-1.220*** (0.249)	-1.226*** (0.136)	-1.253*** (0.110)	-1.179*** (0.183)	-1.223*** (0.149)	-1.252*** (0.0915)	-1.178*** (0.149)		-1.228*** (0.125)
Environmental Laws								0.000118 (0.000173)		
Environmental Laws (Food)									0.539** (0.236)	

Table 5.7: Forest area summary results

NO2 EMISSIONS			Legislation						
LAWS Countries VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Environment general			all	Energy		all	Air and atmos.	
	all	OECD	NON-OECD		OECD	NON-OECD		OECD	NON-OECD
	ln(NO2pc)	ln(NO2pc)	ln(NO2pc)	ln(NO2pc)	ln(NO2pc)	ln(NO2pc)	ln(NO2pc)	ln(NO2pc)	ln(NO2pc)
Ln(GDPpc)*	0.598 (0.750)	1.498 (1.642)	0.768 (0.992)	0.547 (0.727)	1.372 (1.493)	0.711 (0.984)	0.589 (0.739)	1.374 (1.697)	0.819 (1.025)
Ln(GDPpc) <sup>2</sup> *	0.0445 (0.0678)	0.169 (0.187)	0.0559 (0.0793)	0.0424 (0.0659)	0.155 (0.169)	0.0534 (0.0788)	0.0430 (0.0664)	0.156 (0.188)	0.0573 (0.0823)
Openness	1.374 (1.189)	0.00668 (1.676)	1.122 (1.601)	1.459 (1.099)	-0.0735 (1.798)	1.375 (1.790)	1.102 (1.250)	0.0809 (1.425)	0.849 (1.369)
Ln(POP)	1.184 (0.868)	0.990 (1.313)	0.952 (1.022)	1.317 (0.848)	0.931 (1.469)	1.163 (0.992)	1.160 (0.885)	0.924 (1.361)	1.096 (1.056)
Enforcement (Gover. Effect.)	-0.00790 (0.00637)	-0.00487 (0.00892)	-0.00948 (0.00779)	-0.00673 (0.00605)	-0.00606 (0.00836)	-0.00832 (0.00767)	-0.00786 (0.00583)	-0.00427 (0.00833)	-0.00990 (0.00764)
Environmental Laws	<b>-0.00610*</b> (0.00348)	-0.000265 (0.00813)	<b>-0.0120**</b> (0.00577)	0.000310 (0.00322)	-0.00297 (0.0145)	-0.00550 (0.00558)	-0.0101 (0.00821)	0.000333 (0.0132)	<b>-0.0427**</b> (0.0210)
Enforcement x Laws	6.20e-05 (4.28e-05)	9.89e-06 (8.89e-05)	<b>0.000161*</b> (8.35e-05)	-6.74e-06 (5.00e-05)	3.10e-05 (0.000155)	0.000108 (0.000109)	0.000106 (9.09e-05)	1.12e-05 (0.000143)	<b>0.000747**</b> (0.000378)
Observations	679	208	471	680	208	472	677	208	469
R-squared	0.073	0.218	0.089	0.067	0.217	0.077	0.070	0.219	0.088
Number of is	126	31	95	126	31	95	126	31	95
Country sector and time dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES
Bootstrapped standard errors	YES	YES	YES	YES	YES	YES	YES	YES	YES

Table 5.8: Legislation on NO2

Note: Robust standard errors are in between brackets. \*\*\*, \*\*, \* denote statistical significance at a 1, 5 and 10 percent level, respectively. In the *is* dimension, *i* refers to country, *s* refers to the subject of the law (Air and Atmosphere, Env. Gen., Forestry, Water, etc.) \*Openness and Income are predicted values from the instrumental-variable first stage.

SO2 EMISSIONS	Legislation								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
LAWS	Environment general			Energy			Air and atmos.		
Countries	all	OECD	NON-OECD	all	OECD	NON-OECD	all	OECD	NON-OECD
VARIABLES	ln(SO2pc)	ln(SO2pc)	ln(SO2pc)	ln(SO2pc)	ln(SO2pc)	ln(SO2pc)	ln(SO2pc)	ln(SO2pc)	ln(SO2pc)
Ln(GDPpc)*	0.0964 (0.152)	0.0251 (0.0981)	0.0728 (0.197)	0.0833 (0.162)	0.00436 (0.0929)	0.0605 (0.196)	0.106 (0.162)	0.00867 (0.0960)	0.0901 (0.206)
Ln(GDPpc) <sup>2</sup> *	-0.0124 (0.00935)	-0.0396 (0.0275)	0.000273 (0.0125)	-0.0108 (0.00965)	-0.0361 (0.0267)	0.000902 (0.0120)	-0.00961 (0.00975)	-0.0357 (0.0266)	0.00198 (0.0123)
Openness	0.771 (0.997)	0.477 (1.622)	0.483 (1.266)	0.810 (1.203)	0.461 (1.728)	0.617 (0.588)	0.855 (1.344)	0.560 (1.596)	0.557 (1.402)
Ln(POP)	1.137 (0.707)	-0.177 (1.355)	1.163 (0.895)	1.234* (0.734)	0.371 (1.545)	1.200 (0.838)	0.892 (0.720)	-0.159 (1.366)	1.036 (0.943)
Enforcement (Gover. Effect.)	-0.00565 (0.00597)	-0.00410 (0.00814)	-0.00814 (0.00685)	-0.00463 (0.00601)	0.00117 (0.00773)	-0.00751 (0.00671)	-0.00625 (0.00608)	-0.00241 (0.00829)	-0.00880 (0.00708)
Environmental Laws	-0.00544 (0.00414)	<b>-0.0210***</b> (0.00745)	-0.00769 (0.00533)	-0.00162 (0.00264)	<b>-0.0308*</b> (0.0159)	<b>-0.00668**</b> (0.00326)	<b>-0.0233***</b> (0.00875)	<b>-0.0352**</b> (0.0158)	<b>-0.0396*</b> (0.0205)
Enforcement x Laws	5.84e-05 (4.79e-05)	<b>0.000238***</b> (8.17e-05)	0.000115 (8.00e-05)	1.25e-05 (4.33e-05)	<b>0.000356**</b> (0.000171)	<b>0.000117*</b> (6.64e-05)	<b>0.000245**</b> (9.74e-05)	<b>0.000403**</b> (0.000169)	<b>0.000680*</b> (0.000383)
Observations	679	208	471	676	208	468	680	208	472
R-squared	0.085	0.535	0.081	0.079	0.506	0.079	0.092	0.531	0.086
Number of is	125	31	94	125	31	94	126	31	95
Country sector and time dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES
Bootstrapped standard errors	YES	YES	YES	YES	YES	YES	YES	YES	YES

Table 5.9: Legislation on SO2

Note: Robust standard errors are in between brackets. \*\*\*, \*\*, \* denote statistical significance at a 1, 5 and 10 percent level, respectively. In the *is* dimension, *i* refers to country, *s* refers to the subject of the law (Air and Atmosphere, Env. Gen., Forestry, Water, etc.) \*Openness and Income are predicted values from the instrumental-variable first stage.

PM2.5 EMISSIONS	Legislation								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
LAWS	Environment general			Energy			Air and atmos.		
Countries	all	OECD	NON-OECD	all	OECD	NON-OECD	all	OECD	NON-OECD
VARIABLES	ln(PM2.5pc)	ln(PM2.5pc)	ln(PM2.5pc)	ln(PM2.5pc)	ln(PM2.5pc)	ln(PM2.5pc)	ln(PM2.5pc)	ln(PM2.5pc)	ln(PM2.5pc)
Ln(GDPpc)*	-0.00317 (0.0269)	0.0282 (0.0497)	-0.0147 (0.0307)	0.00164 (0.0254)	0.0322 (0.0541)	-0.0124 (0.0290)	0.00162 (0.0272)	0.0141 (0.0511)	-0.0138 (0.0288)
Ln(GDPpc) <sup>2</sup> *	-0.00532*** (0.00191)	-0.00643 (0.00583)	-0.00159 (0.00202)	-0.00577*** (0.00188)	-0.00744 (0.00537)	-0.00210 (0.00203)	-0.00553*** (0.00187)	-0.00554 (0.00573)	-0.00204 (0.00221)
Openness	-0.0746 (0.248)	-1.175 (0.749)	-0.0820 (0.508)	-0.126 (0.246)	-0.902 (0.703)	-0.151 (0.587)	-0.105 (0.251)	-1.134 (0.758)	-0.0950 (0.565)
Ln(POP)	0.683*** (0.127)		0.803*** (0.193)	0.647*** (0.120)		0.756*** (0.196)	0.645*** (0.121)		0.775*** (0.182)
Enforcement (Gover. Effect.)	0.00164 (0.00106)	0.00436 (0.00292)	0.00133 (0.00122)	0.00143 (0.00112)	0.00335 (0.00252)	0.00113 (0.00120)	0.00115 (0.00105)	0.00453 (0.00339)	0.000942 (0.00109)
Environmental Laws	0.00134 (0.000891)	-0.00268 (0.00196)	0.00128 (0.00158)	<b>0.00210*</b> (0.00118)	<b>-0.00596**</b> (0.00296)	0.00197 (0.00191)	0.00430 (0.00299)	-0.00335 (0.00391)	0.00903 (0.00657)
Enforcement x Laws	<b>-2.42e-05**</b> (1.11e-05)	2.51e-05 (2.18e-05)	-2.52e-05 (3.09e-05)	<b>-3.13e-05*</b> (1.66e-05)	<b>6.35e-05*</b> (3.44e-05)	-3.02e-05 (3.55e-05)	<b>-6.11e-05*</b> (3.34e-05)	3.10e-05 (4.24e-05)	-0.000147 (0.000123)
Observations	378	120	258	376	120	256	377	120	257
R-squared	0.639	0.860	0.585	0.647	0.864	0.599	0.634	0.854	0.589
Number of is	122	31	91	121	31	90	121	31	90
Country sector and time dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES
Bootstrapped standard errors	YES	YES	YES	YES	YES	YES	YES	YES	YES

Table 5.10: Legislation on PM2.5

Note: Robust standard errors are in between brackets. \*\*\*, \*\*, \* denote statistical significance at a 1, 5 and 10 percent level, respectively. In the *is* dimension, *i* refers to country, *s* refers to the subject of the law (Air and Atmosphere, Env. Gen., Forestry, Water, etc.) \*Openness and Income are predicted values from the instrumental-variable first stage.

WATER POLLUTION				Legislation					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
LAWS	Environment general			Water			Waste and hazardous substances		
Countries	all	OECD	NON-OECD	all	OECD	NON-OECD	all	OECD	NON-OECD
VARIABLES	ln(Water poll.pc)	ln(Water poll.pc)	ln(Water poll.pc)	ln(Water poll.pc)	ln(Water poll.pc)	ln(Water poll.pc)	ln(Water poll.pc)	ln(Water poll.pc)	ln(Water poll.pc)
Ln(GDPpc)*	0.00919 (0.0678)	-0.0116 (0.0912)	-0.0584 (0.113)	0.00718 (0.0646)	-0.0157 (0.0856)	-0.0632 (0.113)	0.00542 (0.0648)	-0.0188 (0.0862)	-0.0589 (0.121)
Ln(GDPpc) <sup>2</sup> *	-0.00123 (0.00889)	-0.0209 (0.0137)	0.00964 (0.0141)	-0.00353 (0.00838)	-0.0253* (0.0137)	0.00686 (0.0132)	-0.00201 (0.00829)	-0.0186 (0.0144)	0.00860 (0.0121)
Openness	2.458** (1.001)	1.894 (3.266)	1.728 (1.071)	2.885*** (1.099)	1.797 (2.946)	2.101 (1.590)	2.532** (0.996)	2.152 (2.975)	1.733 (1.267)
Ln(POP)	-0.825 (0.660)	-1.103 (1.567)	-0.601 (0.846)	-0.895 (0.671)	-1.010 (1.682)	-0.600 (0.874)	-0.796 (0.668)	-1.175 (1.664)	-0.533 (0.853)
Enforcement (Gover. Effect.)	-0.000328 (0.00229)	-0.00122 (0.00672)	-0.000133 (0.00314)	-0.00100 (0.00230)	-0.00155 (0.00689)	-0.00145 (0.00356)	0.000819 (0.00233)	0.000252 (0.00595)	-0.000484 (0.00308)
Environmental Laws	0.000610 (0.00187)	0.00390 (0.00946)	0.000650 (0.00254)	0.000402 (0.00290)	0.00279 (0.00640)	-0.00104 (0.00489)	<b>0.00609**</b> (0.00307)	0.00521 (0.00533)	0.00425 (0.0101)
Enforcement x Laws	-5.24e-06 (2.27e-05)	-3.16e-05 (0.000103)	-1.13e-05 (4.91e-05)	6.10e-06 (3.30e-05)	-1.14e-05 (7.29e-05)	2.60e-05 (8.92e-05)	<b>-6.23e-05*</b> (3.70e-05)	-4.63e-05 (6.01e-05)	-5.35e-05 (0.000144)
Observations	248	119	129	247	119	128	249	119	130
R-squared	0.240	0.462	0.182	0.263	0.489	0.202	0.271	0.484	0.184
Number of is	63	26	37	63	26	37	63	26	37
Country sector and time dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES
Bootstrapped standard errors	YES	YES	YES	YES	YES	YES	YES	YES	YES

**Table 5.11:** Legislation on Water pollution

Note: Robust standard errors are in between brackets. \*\*\*, \*\*, \* denote statistical significance at a 1, 5 and 10 percent level, respectively. In the *is* dimension, *i* refers to country, *s* refers to the subject of the law (Air and Atmosphere, Env. Gen., Forestry, Water, etc.) \*Openness and Income are predicted values from the instrumental-variable first stage.



FOREST AREA	Legislation								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
LAWS	Environment gen.			Forestry			Land and soil		
Countries	all	OECD	NON-OECD	all	OECD	NON-OECD	all	OECD	NON-OECD
VARIABLES	ln(Forestpc)	ln(Forestpc)	ln(Forestpc)	ln(Forestpc)	ln(Forestpc)	ln(Forestpc)	ln(Forestpc)	ln(Forestpc)	ln(Forestpc)
Ln(GDPpc)★	0.0259 (0.0286)	-0.0308 (0.0229)	0.0365 (0.0311)	0.0240 (0.0274)	-0.0212 (0.0214)	0.0357 (0.0320)	0.0231 (0.0279)	-0.0223 (0.0241)	0.0338 (0.0312)
Ln(GDPpc) <sup>2</sup> ★	-0.000328 (0.00197)	0.000725 (0.00282)	-0.00242 (0.00268)	3.26e-05 (0.00191)	0.000544 (0.00287)	-0.00242 (0.00277)	0.000371 (0.00203)	0.000690 (0.00288)	-0.00216 (0.00273)
Openness	-0.214 (0.276)	-0.264 (0.222)	-0.193 (0.624)	-0.220 (0.309)	-0.203 (0.236)	-0.189 (0.689)	-0.220 (0.313)	-0.250 (0.234)	-0.184 (0.578)
Ln(POP)	1.252*** (0.128)	1.102*** (0.139)		1.254*** (0.134)	1.093*** (0.113)		1.248*** (0.135)	1.094*** (0.124)	
Enforcement (Gover. Effect.)	0.000266 (0.000603)	-2.83e-05 (0.000881)	-1.42e-05 (0.000732)	0.000335 (0.000576)	0.000450 (0.000978)	-4.86e-05 (0.000753)	0.000497 (0.000613)	0.000214 (0.000952)	0.000290 (0.000774)
Environmental Laws	-0.000398 (0.000458)	0.00111 (0.00105)	-0.000639 (0.000771)	-0.000369 (0.00121)	0.00208 (0.00182)	-0.000791 (0.00175)	7.11e-05 (0.000554)	0.00126 (0.00126)	3.68e-05 (0.000698)
Enforcement x Laws	7.12e-06 (5.63e-06)	-1.13e-05 (1.19e-05)	1.37e-05 (1.24e-05)	7.01e-06 (1.41e-05)	-2.45e-05 (2.00e-05)	1.82e-05 (2.49e-05)	1.62e-07 (5.93e-06)	-1.38e-05 (1.34e-05)	2.20e-06 (1.13e-05)
Observations	657	210	447	654	210	444	658	210	448
R-squared	0.668	0.728	0.677	0.664	0.731	0.675	0.665	0.726	0.675
Number of is	121	31	90	122	31	91	122	31	91
Country sector and time dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES
Bootstrapped standard errors	YES	YES	YES	YES	YES	YES	YES	YES	YES

**Table 5.12:** Legislation on Forest area

Note: Robust standard errors are in between brackets. \*\*\*, \*\*, \* denote statistical significance at a 1, 5 and 10 percent level, respectively. In the *is* dimension, *i* refers to country, *s* refers to the subject of the law (Air and Atmosphere, Env. Gen., Forestry, Water, etc.) ★Openness and Income are predicted values from the instrumental-variable first stage.

NO2 EMISSIONS												
	(1)	(2)	(3)	(4)	(5)	(6)	(13)	(14)	(15)	(16)	(17)	(18)
Laws			Environment general						Air and atmosphere			
Countries	all		OECD		NON-OECD		all		OECD		NON-OECD	
VARIABLES	ln(NO2pc)	1st stage	ln(NO2pc)	1st stage	ln(NO2pc)	1st stage	ln(NO2pc)	1st stage	ln(NO2pc)	1st stage	ln(NO2pc)	1st stage
Ln(GDPpc)*	0.508 (0.483)		4.050 (2.901)		3.648 (12.63)		1.031 (1.328)		-0.773 (4.157)		-0.640 (2.562)	
Ln(GDPpc) <sup>2</sup> *	0.0398 (0.0370)		0.440 (0.316)		0.225 (0.751)		0.0516 (0.0583)		-0.0955 (0.478)		-0.0382 (0.174)	
Openness	0.320 (3.019)		4.699 (3.951)		-2.698 (18.13)		5.102 (8.831)		9.630 (14.43)		2.492 (2.654)	
Ln(POP)	-0.222 (4.060)		1.051 (1.369)		-8.056 (42.05)		4.063 (6.295)		-2.021 (4.119)		4.379 (5.843)	
Enforcement (Gov. Effect.)	-0.00625 (0.00797)		0.0116 (0.0130)		0.0143 (0.103)		-0.00410 (0.00895)		0.0362 (0.0646)		-0.0175 (0.0184)	
Environmental Laws*	-0.0188 (0.0496)		0.0159 (0.0121)		-0.115 (0.525)		0.0929 (0.209)		0.0564 (0.0810)		0.164 (0.297)	
Rule of Law		-0.103 (0.133)		-0.579 (0.390)		-0.0316 (0.134)		0.0296 (0.0608)		-0.164 (0.258)		0.0282 (0.0479)
Observations	666		208		458		668		208		460	
R-squared	-0.443		-1.931		-14.475		-3.388		-11.082		-2.239	
Number of is	116		31		85		116		31		85	
Country sector and time dummies	YES		YES		YES		YES		YES		YES	
Variable	F(1, 540)	P-val	F(1, 167)	P-val	F( 1, 363)	P-val	F( 1, 542)	P-val	F( 1, 167)	P-val	F( 1, 365)	P-val
Environmental Laws	0.60	0.4384	2.20	0.1398	0.06	0.8140	0.24	0.6270	0.40	0.5260	0.35	0.5566
Endogeneity test of endogenous regressors:		0.187		3.328		0.558		0.458		3.172		0.957
Chi-sq(1) P-val =		0.6655		0.0681		0.4551		0.4985		0.0749		0.3278

**Table 5.13:** Legislation on NO2 IV Environmental laws

Note: Robust standard errors are in between brackets. \*\*\*, \*\*, \* denote statistical significance at a 1, 5 and 10 percent level, respectively. In the *is* dimension, *i* refers to country, *s* refers to the subject of the law (Air and Atmosphere, Env. Gen., Forestry, Water, etc.) \*Openness and Income are predicted values from the instrumental-variable first stage for Environmental Laws

SO2 EMISSIONS																		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Laws	Environment general				Energy				Air and atmosphere									
Countries	all		OECD		NON-OECD		all		OECD		NON-OECD		NON-OECD		all		OECD	
VARIABLES	ln(SO2pm)	1st stage	ln(SO2pm)	1st stage	ln(SO2pm)	1st stage	ln(SO2pm)	1st stage	ln(SO2pm)	1st stage	ln(SO2pm)	1st stage	ln(SO2pm)	1st stage	ln(SO2pm)	1st stage	ln(SO2pm)	1st stage
Ln(GDPpc)*	0.101		-0.0634		0.0476		0.0875		-0.145		0.0373		0.0299		-0.0702		0.0628	
	(0.148)		(0.0826)		(0.225)		(0.125)		(0.448)		(0.195)		(0.292)		(0.132)		(0.141)	
Ln(GDPpc) <sup>2</sup> *	-0.00521		-0.0113		0.00398		-0.00363		-0.0285		0.00296		-0.00308		-0.0127		-0.00560	
	(0.0164)		(0.0137)		(0.0451)		(0.0209)		(0.0892)		(0.0210)		(0.0237)		(0.0172)		(0.0427)	
Openness	1.316		0.545		0.780		1.352		-2.433		0.707		0.275		-1.080		0.392	
	(2.390)		(1.418)		(1.952)		(1.877)		(14.68)		(0.766)		(3.558)		(5.595)		(2.031)	
Ln(POP)	1.603		-0.733		1.848		1.327		1.824		1.546		0.699		-0.136		0.245	
	(3.211)		(0.828)		(6.285)		(1.319)		(11.27)		(2.097)		(1.766)		(1.509)		(7.881)	
Enforcement (Gover. Effect.)	-0.00453		0.0102**		-0.00701		-0.00455		-0.0120		-0.00723		-0.00455		0.00190		-0.00371	
	(0.00636)		(0.00438)		(0.0141)		(0.00593)		(0.107)		(0.0102)		(0.00635)		(0.0253)		(0.0158)	
Environmental Laws*	0.00578		-0.00238		0.00691		0.0160		-0.0302		0.0110		-0.0169		-0.0143		-0.0454	
	(0.0357)		(0.00370)		(0.0672)		(0.0786)		(0.123)		(0.0597)		(0.0808)		(0.0335)		(0.383)	
Rule of Law		-0.106		-0.929**		-0.0630		-0.0660		-0.0733		-0.0845		0.0489		-0.155		0.0130
		(0.140)		(0.410)		(0.141)		(0.221)		(0.294)		(0.249)		(0.0608)		(0.258)		(0.0477)
Observations	669		208		461		668		208		460		669		208		461	
R-squared	-0.044		0.423		-0.025		-0.563		-1.377		-0.218		-0.003		-0.085		-0.143	
Number of is	116		31		85		116		31		85		116		31		85	
Country sector and time dummies	YES		YES		YES		YES		YES		YES		YES		YES		YES	
Variable	F( 1, 543)	P-val	F( 1, 167)	P-val	F( 1, 366)	P-val	F( 1, 542)	P-val	F( 1, 167)	P-val	F( 1, 365)	P-val	F( 1, 543)	P-val	F( 1, 167)	P-val	F( 1, 366)	P-val
Environmental Laws	0.58	0.4482	5.13	0.0248	0.20	0.6556	0.09	0.7654	0.06	0.8031	0.12	0.7340	0.65	0.4223	0.36	0.5484	0.07	0.7858
Endogeneity test of endogenous regressors:		0.045		0.068		0.013		0.089		0.323		0.053		0.028		0.343		0.017
Chi-sq(1) P-val =		0.8329		0.7949		0.9076		0.7658		0.5699		0.8183		0.8662		0.5582		0.8957

**Table 5.14:** Legislation on SO2 IV Environmental laws

Note: Robust standard errors are in between brackets. \*\*\*, \*\*, \* denote statistical significance at a 1, 5 and 10 percent level, respectively. In the *is* dimension, *i* refers to country, *s* refers to the subject of the law (Air and Atmosphere, Env. Gen., Forestry, Water, etc.) \*Openness and Income are predicted values from the instrumental-variable first stage for Environmental Laws

PM2.5 EMISSIONS																		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Laws	Environment general								Energy				Air and atmosphere					
Countries	all		OECD		NON-OECD		all		OECD		NON-OECD	NON-OECD	all		OECD		NON-OECD	
VARIABLES	ln(PMpc)	1st stage	ln(PMpc)	1st stage	ln(PMpc)	1st stage	ln(PMpc)	1st stage	ln(PMpc)	1st stage	ln(PMpc)	1st stage	ln(PMpc)	1st stage	ln(PMpc)	1st stage	ln(PMpc)	1st stage
Ln(GDPpc)*	0.297		-0.0105		0.157		0.0290		-0.0237		0.00776		-0.0753		-0.0478		0.0122	
	(5.772)		(0.0404)		(0.924)		(0.0323)		(0.0806)		(0.0361)		(0.143)		(0.123)		(0.0498)	
Ln(GDPpc) <sup>2</sup> *	0.170		-0.00284		0.0352		-0.00243		-0.00183		0.00228		0.0196		-0.000894		0.00911	
	(3.603)		(0.00462)		(0.209)		(0.00810)		(0.00697)		(0.00659)		(0.0404)		(0.00840)		(0.0207)	
Openness	-4.364		-1.841**		0.178		0.0964		-1.717		0.0805		-0.732		-1.718		-0.161	
	(87.78)		(0.786)		(1.993)		(0.469)		(1.108)		(0.520)		(1.309)		(1.107)		(0.445)	
Ln(POP)	-13.52		-0.824***		-4.313		-0.978*		-0.256		-1.184*		-1.495		-0.693*		-1.501	
	(260.0)		(0.225)		(19.09)		(0.581)		(1.143)		(0.658)		(1.234)		(0.356)		(1.251)	
Enforcement (Gover. Effect.)	0.0278		0.00358		0.0111		0.00258		-0.00387		0.00284		0.00110		-0.000794		0.00331	
	(0.544)		(0.00355)		(0.0582)		(0.00326)		(0.0181)		(0.00384)		(0.00221)		(0.0109)		(0.00479)	
Environmental Laws*	-0.144		-0.00178		-0.0370		-0.00567		-0.00426		-0.00512		-0.0252		-0.00473		-0.0323	
	(2.917)		(0.00172)		(0.205)		(0.0101)		(0.00686)		(0.00845)		(0.0365)		(0.00658)		(0.0565)	
Rule of Law		0.0159		-1.381		0.0658		0.392		-0.576		0.466		0.0924		-0.519		0.0758
		(0.327)		(0.930)		(0.364)		(0.576)		(0.949)		(0.638)		(0.120)		(0.634)		(0.114)
Observations	362		120		242		360		120		240		366		120		246	
R-squared	-1,023.552		0.793		-75.856		-1.642		0.440		-2.005		-5.865		0.517		-2.757	
Number of is	107		31		76		106		31		75		109		31		78	
Country sector and time dummies	YES		YES		YES		YES		YES		YES		YES		YES		YES	
Variable	F( 1, 247)	P-val	F( 1, 81)	P-val	F( 1, 158)	P-val	F( 1, 246)	P-val	F( 1, 81)	P-val	F( 1, 157)	P-val	F( 1, 249)	P-val	F( 1, 81)	P-val	F( 1, 160)	P-val
Environmental Laws	0.00	0.9612	2.20	0.1415	0.03	0.8568	0.46	0.4960	0.37	0.5458	0.53	0.4668	0.59	0.4420	0.67	0.4154	0.44	0.5073
Endogeneity test of endogenous regressors:		1.952		0.715		2.356		2.196		1.127		2.833		1.995		0.978		2.911
Chi-sq(1) P-val =		0.1624		0.3978		0.1248		0.1384		0.2884		0.0923		0.1579		0.3227		0.0880

**Table 5.15:** Legislation on PM2.5 IV Environmental laws

Note: Robust standard errors are in between brackets. \*\*\*, \*\*, \* denote statistical significance at a 1, 5 and 10 percent level, respectively. In the *is* dimension, *i* refers to country, *s* refers to the subject of the law (Air and Atmosphere, Env. Gen., Forestry, Water, etc.) \*Openness and Income are predicted values from the instrumental-variable first stage for Environmental Laws

WATER POLLUTION						
	(7)	(8)	(9)	(10)	(11)	(12)
Laws			<b>Water</b>			
Countries	all		OECD		NON-OECD	
VARIABLES	ln(Wat.poll.pc)	1st stage	ln(Wat.poll.pc)	1st stage	ln(Wat.poll.pc)	1st stage
Ln(GDPpc)*	0.0288 (0.0733)		-0.0515 (0.146)		0.356 (0.458)	
Ln(GDPpc) <sup>2</sup> *	0.00699 (0.0113)		-0.0475 (0.0635)		0.00628 (0.0211)	
Openness	1.326 (1.224)		4.886 (8.356)		0.815 (1.531)	
Ln(POP)	-0.994* (0.579)		0.259 (4.035)		-2.532 (2.372)	
Enforcement (Gover. Effect.)	0.000250 (0.00266)		0.00593 (0.0224)		0.0178 (0.0230)	
Environmental Laws*	-0.00683 (0.00744)		0.0148 (0.0345)		-0.0305 (0.0374)	
Rule of Law		-0.318* (0.187)		-0.201 (0.499)		-0.114 (0.129)
Observations	242		119		123	
R-squared	-0.401		-1.683		-6.342	
Number of is	55		26		29	
Country sector and time dummies	YES		YES		YES	
Variable	F( 1, 176)	<b>P-val</b>	F( 1, 82)	<b>P-val</b>	F( 1, 83)	<b>P-val</b>
Environmental Laws	2.90	0.0904	0.16	0.6888	0.78	0.3782
Endogeneity test of endogenous regressors:		1.715		0.309		2.248
Chi-sq(1) P-val =		0.1903		0.309		0.1337

Table 5.16: Legislation on Water IV Environmental laws

Note: Robust standard errors are in between brackets. \*\*\*, \*\*, \* denote statistical significance at a 1, 5 and 10 percent level, respectively. In the *is* dimension, *i* refers to country, *s* refers to the subject of the law (Air and Atmosphere, Env. Gen., Forestry, Water, etc.) \*Openness and Income are predicted values from the instrumental-variable first stage for Environmental Laws

FOREST AREA																		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Laws	Environment general				Forestry				Land and soil									
Countries	all		OECD		NON-OECD		all		OECD		NON-OECD		NON-OECD		all		OECD	
VARIABLES	ln(Forestpc)	1st stage	ln(Forestpc)	1st stage	ln(Forestpc)	1st stage	ln(Forestpc)	1st stage	ln(Forestpc)	1st stage	ln(Forestpc)	1st stage	ln(Forestpc)	1st stage	ln(Forestpc)	1st stage	ln(Forestpc)	1st stage
Ln(GDPpc)*	0.0245 (0.0224)		0.409 (5.247)		0.0382 (0.0260)		0.0240 (0.0230)		0.0207 (0.0598)		0.0370 (0.0256)		0.0228 (0.0213)		-0.0155 (0.0277)		0.0376 (0.0260)	
Ln(GDPpc) <sup>2</sup> *	0.000674 (0.00172)		0.0344 (0.404)		-0.00209 (0.00216)		0.000279 (0.00150)		0.000938 (0.00243)		-0.00231 (0.00211)		0.000821 (0.00218)		0.00221 (0.00260)		-0.00222 (0.00218)	
Openness	-0.225* (0.123)		-0.316 (1.933)		-0.188* (0.100)		-0.219* (0.115)		-0.124 (0.259)		-0.186* (0.0994)		-0.174* (0.113)		-0.174 (0.208)		-0.173* (0.0898)	
Ln(POP)	-1.286*** (0.155)		0.898 (24.38)		-1.308*** (0.182)		-1.285*** (0.161)		-1.005*** (0.155)		-1.305*** (0.185)		-1.282*** (0.148)		-0.940*** (0.200)		-1.297*** (0.171)	
Enforcement (Gover. Effect.)	0.000624 (0.000562)		0.00299 (0.0425)		0.000587 (0.000563)		0.000589 (0.000496)		-0.000153 (0.000626)		0.000539 (0.000523)		0.000624 (0.000579)		-0.000718 (0.000728)		0.000552 (0.000548)	
Environmental Laws*	-0.000188 (0.000680)		-0.0108 (0.131)		-0.000379 (0.000705)		-0.000205 (0.000790)		-0.00117 (0.00142)		-0.000386 (0.000753)		-0.000268 (0.000996)		-0.000278 (0.000361)		-0.000409 (0.000796)	
Rule of Law		0.850** (0.347)		-0.0389 (0.507)		0.973** (0.406)		0.728* (0.435)		-0.359 (0.262)		0.912* (0.510)		0.596 (0.395)		-1.510 (0.945)		0.888* (0.455)
Observations	651		210		441		647		210		437		644		210		434	
R-squared	0.661		-54.324		0.666		0.660		0.600		0.659		0.645		0.621		0.649	
Number of is	113		31		82		112		31		81		112		31		81	
Country sector and time dummies	YES		YES		YES		YES		YES		YES		YES		YES		YES	
Variable	F( 1, 526)	P-val	F( 1, 167)	P-val	F( 1, 347)	P-val	F( 1, 523)	P-val	F( 1, 167)	P-val	F( 1, 344)	P-val	F( 1, 520)	P-val	F( 1, 167)	P-val	F( 1, 341)	P-val
Environmental Laws	6.00	0.0146	0.01	0.9391	5.73	0.0172	2.80	0.0951	1.89	0.1714	3.20	0.0747	2.28	0.1317	2.55	0.1121	3.82	0.0515
Endogeneity test of endogenous regressors:		0.069		0.576		0.237		0.031		0.462		0.225		0.131		0.465		0.507
Chi-sq(1) P-val =		0.7926		0.4479		0.6266		0.8594		0.4967		0.6350		0.7178		0.4951		0.4763

**Table 5.17:** Legislation on Forest IV Environmental laws

Note: Robust standard errors are in between brackets. \*\*\*, \*\*, \* denote statistical significance at a 1, 5 and 10 percent level, respectively. In the *is* dimension, *i* refers to country, *s* refers to the subject of the law (Air and Atmosphere, Env. Gen., Forestry, Water, etc.) \*Openness and Income are predicted values from the instrumental-variable first stage for Environmental Laws

## 5.5 Robustness

### 5.5.1 NO<sub>2</sub> emissions

As a robustness test we performed regressions excluding the Federalist countries due to their government setting passing law at a state level.

In addition, we performed estimations with a lagged form of the enforcement and environmental regulation variables. Finally we use Food and nutrition laws as an instrument.<sup>21</sup>

For NO<sub>2</sub> emission in Table C.9, we can notice that laws on Environmental general issues, Energy and Air and Atmosphere have an effect decreasing pollution. For a change in one unit, there is a decrease respectively of 0.8% (column (3)), 0.16% (column (7)) and 0.41% (column (9)).

In estimations using Food and nutrition laws as an instrument to correct the environmental laws endogeneity, we find significant effects only for determinants of pollution. Openness and  $Ln(POP)$  both increase NO<sub>2</sub> emissions. These effects are limited to Non-OECD countries.

### 5.5.2 SO<sub>2</sub> emissions

When studying the effect of excluding Federalist countries, Table C.5 shows Environmental laws having an effect decreasing SO<sub>2</sub> emissions. This holds for OECD countries, in which, for a change in one unit of Environmental general issues law, there is a reduction of SO<sub>2</sub> emissions by 2.02% (Column (2)). Air and atmosphere also has the biggest impact reducing emissions of SO<sub>2</sub> by 3.15% (Column (8)) and by 4.3% (Column (9)) for OECD and Non-OECD countries respectively.

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<sup>21</sup>Only summary results of these estimations are in the paper, full results tables are available from the authors upon request

Table C.10 presents the effect of lags in the interest variables. We observe that for OECD countries a change in one unit of Environmental general issues and Energy laws, there is a decrease in SO<sub>2</sub> emissions by 2,75% and by 4,02% respectively. Air and atmosphere have the biggest effect. For a change in one unit of these laws there is a decrease in SO<sub>2</sub> of 3,99% for OECD and of 4,32% for Non-OECD countries. We also observe here the decreasing effect of income with  $\ln(GDP)^2$ , but only for OECD countries. Using Food and nutrition laws as an instrument, we find an effect of population increasing SO<sub>2</sub> emissions, but for Non-OECD countries only. In this specification, we also find that instrument of the Laws on Food and nutrition performs well. Nevertheless, the laws have non significant effects.

### 5.5.3 PM<sub>2.5</sub> emissions

In Table C.6, when doing the estimation without the Federalists countries, we find that for Non-OECD countries there are significant effects of the Enforcement and the environmental laws, however, this effect is not as expected because it appears to increase PM emissions, yet the interaction between enforcement and the laws decreases pollution, this effect persists only for Non-OECD countries (in about 0,0570% to 3,01% Column (3) and Column (7) respectively). This specifically for Non-OECD countries and in Environmental general issues and Air and atmosphere laws. For the determinants of pollution, there is a global effect decreasing pollution of the  $\ln(GDP)^2$  income, but this effect disappears when separating OECD from Non-OECD countries. As for estimations in Table 5.10 the effect of  $\ln(POP)$  increases pollution.

Analysing the lagged variable of environmental regulation in Table C.11, there is an effect of the enforcement variable. But it does not reduce PM<sub>2.5</sub> emissions as expected, but it increases it instead. This is particularly true for Non-OECD countries. However, the interaction of the two decreases PM<sub>2.5</sub> emissions by 0,0238% (see Column (4)) but this is only confirmed



for all countries with Energy laws. There is a decreasing effect on emissions due to income  $\ln(GDP)^2$  confirmed only for Non-OECD countries. For OECD countries on the other hand, there is a decreasing effect, but it is due to population.

When using Food and nutrition as an instrument for the environmental laws, we find openness to decrease PM2.5 emissions for OECD countries and also population to have a decreasing effect in both groups of countries.

#### 5.5.4 Water emissions

Table C.7 shows the effect of the lagged variables of enforcement and environmental laws excluding the Federalist countries. There is an increasing effect on pollution of the Waste and hazardous substances laws. This effect is suspected to be due to the same reason as in Table 5.11. Openness in Water pollution appears to have an effect increasing pollution, yet this effect does not hold when separating OECD and Non-OECD countries.

Using the lagged form of enforcement and the environmental laws Table C.12, we find the same results as in previous specifications of the model.

When using the Food and nutrition laws as an instrument we find a persistent effect of openness increasing Water pollution that holds for Non-OECD countries. There is an effect for OECD of income decreasing water pollution and for Non-OECD an effect of population decreasing Water pollution.

#### 5.5.5 Forest emissions

Studying the effect of excluding Federalist countries on Forest area Table C.8, we find significant results for the environmental Laws and their enforcement. However, the effect is not as expected, since it appears to have a decreasing effect on forest area. Yet, the interaction term is

valid, due to the significance of the two variables, environmental Laws and their enforcement. The interaction shows that the combined effect of the laws and their enforcement increases Forest area, but this holds only for Non-OECD countries. Environmental general issues and Forestry laws, increase Forest area by 0,0459% (Column (3)) and 0,0928% (Column (6)) respectively. There is an effect of population increasing Forest area only valid for OECD countries and an effect of  $\ln(GDP)^2$  valid for Non-OECD countries, decreasing forest area.

In specification of the model with the lagged form of the environmental laws and their enforcement (Table C.13), we find a persistent effect of population decreasing Forest area in Non-OECD countries.

Finally using Food and nutrition Laws as an instrument, the instrument performs well for OECD countries for Land and Soil laws, that appear to increase Forest area, yet the effect of the laws is not significant. There is an effect concerning population for OECD and Non-OECD decreasing Forest area and also openness appears to decrease Forest area consistently.

## 5.6 Conclusions

Environmental laws intensity appear to have an effect improving environmental outcomes. This effect is particular to the environmental outcome and the law.

The enforcement proxy variable used in this work appears to reduce pollution only in certain outcomes, yet it is less important to decrease pollution than the laws in our model. Nevertheless, it works particularly efficiently for Forest area, this result is particularly interesting for policy recommendations. There is also an effect on the Laws and their enforcement on decreasing PM 2.5 emissions.

The sign of the variables concerning the environmental laws, their enforce-

ment, and the interaction between both is not always what is expected. Nevertheless, analysing results that are significant and robust to the group of countries, we notice that they follow the logic intuition of the model. Yet, we think our model could fail to capture more institutional nuances. We think there is a fertile ground for research to overcome this drawback in our model.

The expected effects of the corresponding laws with outcomes are confirmed, validating the intuition behind our underlying model.

Air and Atmosphere seem to have the biggest effect on local air pollutants. Also Environmental general issues improve Air pollution and increase Forest area.

The effect of the environmental regulation proxied with environmental laws is reinforced when excluding the Federalist countries. This is specially true for PM2.5 and Forest area.

Additionally, the lagged form of the Environmental Laws has a slightly better explanatory effect on the outcomes, particularly concerning the local air pollutants.

The effects of the laws is more frequent for Non-OECD countries. This suggests a policy recommendation towards investing in reinforcing institutions. More specifically, stressing the specific law creation in developing countries might be a crucial effort in order to protect the environment and to fight against climate change.

The effect of trade improving environmental outcomes, openness effect, is only partially confirmed. It has a decreasing effect only for OECD countries in PM2.5 emissions and an increasing effect for Non-OECD countries in NO2 emissions. In addition, openness increases water pollution for Non-OECD. Forest area in particular challenges the results of Frankel and Rose (2005), openness consistently showing a decrease in forest area. With our results, we believe the effect of trade on the environment is not

straightforward.

Only the squared form of income presents significant effects, this effect being mostly negative confirming the concave form of the income effect that increases pollution but with decreasing effects. Yet, these effects are more common globally than for specific developing or developed countries.

The effect of population increases PM2.5 emissions for Non-OECD countries. This effect is not driven for emerging countries. For OECD countries there is an increasing effect with population, which can be part of the forest transition and the EKC.

# 6

## Conclusion

The relationship between trade and environment is complex. It is only possible to give some answers to specific cases and contexts. In order to assess the effect of a given environmental outcome, a careful analysis about other determinants at play should be carried out.

It is important to be really careful about strong and straightforward statements about these effects, because the relationship between these two is not only difficult to assess but it requires taking into account for other determinants at play. It is also really sensitive to changes in time and/or in countries' characteristics.

Since the effect of trade on the environment is not easy to assess, it should be addressed taking into account specific characteristics of the countries or regions, such as level of development, how they are producing (factor of endowments) and what they are producing (sector of production intensity), among others.

Keeping these characteristics constant, due to the fact that they are harder (or slower) to change. Environmental regulations could play an important role protecting the environment of countries, specially developing countries.

The detrimental effect to developing countries' environment due to differences in environmental regulations, is a well documented fact. However, making solid environmental regulations can have an important impact to protect developing countries' environment.

Differences in environmental regulations are incentives to displace pollution. These environmental regulations depend on the level of development of countries. Developed countries have stricter environmental regulations than developing countries.

Measuring environmental regulations is not easy for empirical research at country level analysis. Different proxies are available and should be used in a creative way according to the subject tackled. The more related this environmental regulation proxy is to the phenomenon under study, the better the effect of these differences is going to be captured and the more accurate the answer to the question addressed is.

When studying environmental regulations at country level, it is important to take into account environmental related indexes, but also institutional quality indexes and International Environmental Agreements. The latter are of great relevance, especially when addressing the effects of trade.

Countries are heterogeneous, in the sense that they have different characteristics, these different characteristics play a role on how this environmental regulation is in terms of strictness and also in the consequent environmental outcome. This is particularly true in the case of developing countries.

The more developing countries stress efforts in consolidating an institutional framework in order to reinforce environmental regulations, the better they will protect their environment.

The effect of increased environmental strictness in developed countries can lead to displacing pollution to developing countries. Nevertheless, the fact that developed countries engage seriously in International Environmental

Agreements, in order not to send pollution to developing countries, is also of crucial relevance to developing countries.

This thesis shows that there are differences in environmental regulations between countries and these differences go along with their level of development. Also these differences play an important role when analysing the effect of a country open to trade with countries having stricter environmental regulations.

# **Appendix A**

## **Waste haven effect**



<i>EU-10 WASTE IMPORTS</i>								
THE NEW EUROPEAN COUNTRIES AS TREATMENT GROUP BASEL CONVENTION FORMALISATION								
CONTROL GROUP THE WORLD								
Number of observations in the DIFF-IN-DIFF: 8624								
	Baseline	Follow-up						
Control:	3808	3808	7616					
Treated:	504	504	1008					
	4312	4312	8624					
R-square: 0.0013								
DIFFERENCE IN DIFFERENCES ESTIMATION								
	Outcome Variable	Control	Treated	Diff(BL)	Control	Treated	Diff(FU)	DIFF-IN-DIFF
Imports		5 700 000	240 000	-5 500 000	6 000 000	850 000	-5 100 000	390 000
P>t		0.000	0.908	0.013**	0.000	0.683	0.021**	0.901
CONTROL GROUP OECD NON-EU								
Number of observations in the DIFF-IN-DIFF: 18200								
	Baseline	Follow-up						
Control:	8596	8596	17192					
Treated:	504	504	1008					
	9100	9100	18200					
R-square: 0.0003								
DIFFERENCE IN DIFFERENCES ESTIMATION								
	Outcome Variable	Control	Treated	Diff(BL)	Control	Treated	Diff(FU)	DIFF-IN-DIFF
Imports		3 000 000	240 000	-2 700 000	3 300 000	850 000	-2 400 000	300 000
P>t		0.000	0.871	0.073*	0.000	0.565	0.111	0.888
CONTROL GROUP NON OECD								
Number of observations in the DIFF-IN-DIFF: 37856								
	Baseline	Follow-up						
Control:	18424	18424	36848					
Treated:	504	504	1008					
	18928	18928	37856					
R-square: 0.0001								
DIFFERENCE IN DIFFERENCES ESTIMATION								
	Outcome Variable	Control	Treated	Diff(BL)	Control	Treated	Diff(FU)	DIFF-IN-DIFF
Imports		2 200 000	240 000	-1 900 000	23 000 000	850 000	-1 500 000	470 000
P>t		0.000	0.880	0.231	0.000	0.592	0.366	0.836
*** p<0.01, ** p<0.05, * p<0.1								

Table A.1: Imports of *EU-10* Difference-in-difference estimation.

DEVELOPING COUNTRIES REGIONAL EFFECTS								
TREATMENT GROUP AFRICA								
BASEL CONVENTION FORMALISATION								
CONTROL GROUP AFRICAN IMPORTS FROM NON EUROPEAN OECD COUNTRIES								
Number of observations in the DIFF-IN-DIFF: 23848								
	Baseline	Follow-up						
	Control:	10964	10964	21928				
	Treated:	960	960	1920				
		11924	11924	23848				
R-square: 0.0005								
DIFFERENCE IN DIFFERENCES ESTIMATION								
	Outcome Variable	Control	BASE LINE Treated	Diff(BL)	Control	FOLLOW UP Treated	Diff(FU)	DIFF-IN-DIFF
Imports		3 600 000	59 000	-3 500 000	3 900 000	120 000	-3 700 000	-230 000
P>t		0.000	0.967	0.019**	0.000	0.935	0.013**	0.915
TREATMENT GROUP ASIA								
BASEL CONVENTION FORMALISATION								
CONTROL GROUP AFRICAN IMPORTS FROM NON EUROPEAN OECD COUNTRIES								
Number of observations in the DIFF-IN-DIFF: 25640								
	Baseline	Follow-up						
	Control:	11380	11380	22760				
	Treated:	1440	1440	2880				
		12820	12820	25640				
R-square: 0.0001								
DIFFERENCE IN DIFFERENCES ESTIMATION								
	Outcome Variable	Control	BASE LINE Treated	Diff(BL)	Control	FOLLOW UP Treated	Diff(FU)	DIFF-IN-DIFF
Imports		3 200 000	3 000 000	-290 000	3 400 000	5 300 000	1 900 000	2 200 000
P>t		0.000	0.010	0.813	0.000	0.000	0.123	0.209
TREATMENT GROUP AMERICA								
BASEL CONVENTION FORMALISATION								
CONTROL GROUP AFRICAN IMPORTS FROM NON EUROPEAN OECD COUNTRIES								
Number of observations in the DIFF-IN-DIFF: 28104								
	Baseline	Follow-up						
	Control:	11940	11940	23880				
	Treated:	2112	2112	4224				
		14052	14052	28104				
R-square: 0.0001								
DIFFERENCE IN DIFFERENCES ESTIMATION								
	Outcome Variable	Control	BASE LINE Treated	Diff(BL)	Control	FOLLOW UP Treated	Diff(FU)	DIFF-IN-DIFF
Imports		3 300 000	61 000	-3 200 000	3 500 000	39 000	-3 500 000	-270 000
P>t		0.000	0.880	0.001***	0.000	0.965	0.000***	0.846
*** p<0.01, ** p<0.05, * p<0.1								

Table A.2: Imports of developing countries by region Difference-in-difference estimation.

Codes HS6 of products considered as waste	
251720	Macadam of slag/dross/similar industrial waste.
262110	Ash & residues from the incineration of municipal waste
271091	Waste oils containing polychlorinated biphenyls, terphenyls, biphenyls.
271099	Waste oils other than those containing polychlorinated biphenyls, terphenyls, biphenyls.
300680	Waste pharmaceuticals
300692	Waste pharmaceuticals
382510	Municipal waste
382530	Clinical waste
382541	Halogenated waste organic solvents
382549	Waste organic solvents other than halogenated waste organic solvents
382550	Waste of metal pickling liquors, hydraulic fluids, brake fluids & anti-freeze fluids
382561	Miscellaneous chemical products, mainly containing organic constituents
382569	Miscellaneous chemical products, allied industries, n.e.s. In Ch 38
382590	Residual products of the chem/allied industries, n.e.s. In Ch 38
391530	Waste, parings and scrap, of polymers of vinyl chloride
711230	Waste and scrap of precious metal or of metal clad with precious metal
740400	Copper waste and scrap
780200	Lead waste and scrap
790200	Zinc waste and scrap
810730	Cadmium waste and scrap
811020	Antimony waste and scrap
811213	Beryllium waste and scrap
811222	Chromium waste and scrap
854810	Waste and scrap of primary cells, primary batteries and electric art.

Table A.3: Hazardous waste products with HS6 codes.

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### Environmental Regulation Gradient

***Treaty ratification:***

Source: InforMEA: United Nations

Dummy of ratification of:

Basel : Waste including hazardous waste

Rotterdam : Hazardous chemicals

Stockholm : Persistent Organic Pollutants

***Institution Efficiency:***

Source: The Worldwide Governance Indicators project

Government Effectiveness

Regulatory Quality

Rule of Law

Control of Corruption

***Environmental Quality:***

Source: Environmental Performance Index: Yale University

Environmental burden of disease, Air pollution and Water

Biodiversity, Habitat, Agriculture, Forestry, Fisheries, Climate Change

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**Table A.4:** Sources of the environmental regulation proxies

### Environmental regulation gradient

The environmental regulation gradient was constructed inspired by Ben Kheder and Zugravu (2012). Taking three variables that are related to environmental regulation assembled together in order to try to capture in a country level the sound environmental regulations. In this case were chosen other complementary proxies of environmental regulation, because those are more suitable to study trade on waste. The proxies are: Treaty ratification, institution efficiency and environmental quality. These proxies are more linked with waste trade, because they take into account Treaty ratification of those treaties related to hazardous substances, also because they take into account the corruption level by countries, with a corruption perception index. Also here I use a Environmental Performance Index instead of the Efficiency as in Ben Kheder and Zugravu (2012), because since hazardous waste has a serious polluting power, it could be felt really fast on the environmental outcomes used in this index.

#### *Treaty ratification*

Treaty ratification proxy variable are treaties ratified by countries. This variable captures the ease of a country to trade dangerous substances. In this case not all ratification of treaties are used, in order to be more specific, only ratification of treaties that could affect trade in waste are taken into account.

The treaties are Basel Convention, on waste and hazardous waste, Stockholm Convention on persistent organic pollutants and Rotterdam Convention on hazardous chemicals.

There are three variables called Basel, Rotterdam and Stockholm that are time-variant dummy variables that take the value of one from the year that a country ratifies the convention on and the value of zero otherwise. These variables are for importer and exporter countries.

The information about the members, by convention, can be found in the United Nations platform InforMEA.<sup>1</sup>

### *Institution efficiency*

Institution efficiency proxy is a variable that captures the institutional solidity of a country, using corruption perception index. Four variables about institutional efficiency are chosen from The World Governance Index (WGI). These variables represent the institution efficiency of a country, the variables are related with institutional quality that could be affected by corruption. Below the description from WGI.

**Government effectiveness:** Reflects perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.

**Regulatory quality:** Reflects perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.

**Rule of law:** Reflects perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.

**Control of corruption:** Reflects perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests.

These variables range from approximately -2.5 when weak institutions to 2.5 when strong.

For methodological and analytical issues about these variables please

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<sup>1</sup><http://www.informea.org/fr>

refer to Kaufmann et al. (2011).<sup>2</sup>

### *Environmental quality*

Environmental quality proxy is the variable that measures the actual outcomes of the environment, at a country-level.

This variable ranks countries' performance on environmental issues having two scopes: Environmental Health and Ecosystem Vitality.<sup>3 4</sup>

Figure A.1 show the sub subjects of the scopes.

According to Saisana and Saltelli (2012) the main advantage of this index is that it is an aggregated index with a set of environmental indicators measuring different aspects of sustainability, which is more reliable than looking at each indicator separately. According to the technical Appendix the EPI scores are computed as weighted averages within and across ten policy categories from the two scopes in the 22 indicators of Figure A.1. Each of those indicators, which can offer a partial picture of a nations sustainability level, nevertheless, it provides a more reliable overall picture of sustainability levels around the world than any single indicator would provide taken independently. The data delivered represent the normalised values together with the country scores on ten policy categories.

The time dimension is also taken into account in the three variables. First step, is the aggregation of the components of each variable, this is done as Ben Kheder and Zugravu (2012), doing an average of the variables see Table 3.1. Second step, is the normalisation of these three variables. Once they are normalised, it is possible to construct the gradient according to Kellenberg (2012).

For the aggregated index, a regression of the log of waste imports is estimated. Using as explanatory variables, all the components of the three

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<sup>2</sup>The Worldwide Governance Indicators project are available <http://info.worldbank.org/governance/wgi/index.aspxhome>

<sup>3</sup><http://epi.yale.edu/>

<sup>4</sup>[http://archive.epi.yale.edu/files/2012\\_eppi\\_appendix1-indicator\\_profiles.pdf](http://archive.epi.yale.edu/files/2012_eppi_appendix1-indicator_profiles.pdf)

Objective	Policy Category	Indicator
<b>Environmental Health</b>	Air pollution (effects on human health)	Indoor air pollution
		Particulate matter
	Water (effects on human health)	Access to drinking water
		Access to sanitation
	Environmental burden of disease	Child mortality
<b>Ecosystem Vitality</b>	Air pollution (effects on ecosystem)	Sulfur dioxide emissions per capita
		Sulfur dioxide emissions per GDP
	Water (effects on ecosystem)	Change in water quantity
	Biodiversity and habitat	Biome protection
		Marine protection
		Critical habitat protection
	Forests	Forest loss
		Forest cover change
		Growing stock change
	Fisheries	Coastal shelf fishing pressure
		Fish stocks overexploited
	Agriculture	Agricultural subsidies
		Pesticide regulation
	Climate change	CO2 emissions per capita
		CO2 emissions per GDP
		CO2 emissions per electricity generation
		Renewable electricity

Source: Environmental Performance Index. EPI Appendix 1: Indicator Profiles

**Figure A.1:** Environmental performance components

proxies. First, for country  $i$  and then for country  $j$ . Table A.5 show the regressions results.

Then the predicted values  $\hat{E}_{it}$  and  $\hat{E}_{jt}$  are taken from Table A.5, this procedure allows to have the part of waste trade that could have been explained by environmental regulation reasons (To see more details about the orthogonal projection please refer to Wooldridge (2010)). Then these values are used to construct the gradient (Kellenberg (2012)).

$$ERG_{ijt} = (\hat{E}_{jt} - \hat{E}_{it}) / [(\hat{E}_{jt} + \hat{E}_{it}) / 2]$$



Waste trade explained by environmental regulation variables		
VARIABLES	(1) ln(Imports)	(2) ln(Imports)
Gov_eff.i	1.992*** (0.155)	
Reg_quality.i	-0.642*** (0.138)	
Rule_law.i	2.409*** (0.165)	
Control_corr.i	-2.724*** (0.130)	
Env_perf.i	-0.0296*** (0.00489)	
Basel_rat.i	-0.893*** (0.152)	
Rotterdam_rat.i	0.824*** (0.101)	
Stockholm_rat.i	0.0409 (0.0925)	
Gov_eff.j		-1.384*** (0.168)
Reg_quality.j		1.318*** (0.145)
Rule_law.j		0.111 (0.177)
Control_corr.j		-0.0576 (0.139)
Env_perf.j		-0.00375 (0.00505)
Basel_rat.j		0.451*** (0.164)
Rotterdam_rat.j		-0.174 (0.106)
Stockholm_rat.j		-0.0786 (0.0985)
Constant	11.64*** (0.285)	10.76*** (0.292)
Observations	13,469	13,469
R-squared	0.079	0.013
Controls	NO	NO
df_m	8	8
Standard errors in parentheses		
*** p<0.01, ** p<0.05, * p<0.1		

Table A.5: Environmental regulation predicted value

DEVELOPING COUNTRIES		
Africa	America	Asia
Egypt	Argentina	Bangladesh
Kenya	Bolivia	China
Morocco	Brazil	India
Mozambique	Colombia	Indonesia
Nigeria	Costa Rica	Jordan
Senegal	Dominican Republic	Malaysia
South Africa	Ecuador	Pakistan
Tunisia	El Salvador	Philippines
Zambia	Guatemala	Singapore
Zimbabwe	Honduras	Sri Lanka
	Jamaica	Thailand
	Nicaragua	
	Panama	
	Paraguay	
	Peru	
	Trinidad and Tobago	
	Uruguay	
	Venezuela	

Table A.6: Countries by region

OLS EU 10-15 BACI				OLS EU 10-15 BACI			
AGGREGATED ENVIRONMENTAL REGULATION PROXY				DISAGGREGATED ENVIRONMENTAL REGULATION PROXY			
VARIABLES	(1) CG: WORLD	(2) OECD NON-EU	(3) Developing NON OECD	VARIABLES	(1) CG: THE WORLD	(2) OECD NON-EU	(3) Developing NON OECD
Post	1.212** (0.588)	0.576 (0.860)	1.149* (0.671)	Post	0.928* (0.498)	1.089 (0.877)	0.937 (0.671)
Environmental reg. gradient	-0.949 (1.124)	-0.388 (4.248)	-2.205 (1.556)	Post x 10-15	2.387*** (0.780)	2.835*** (0.761)	-1.158 (2.001)
Post x 10-15	1.131*** (0.374)	1.626*** (0.567)	-1.951 (1.573)	Env. performance gradient	0.116 (1.108)	-1.961 (4.221)	1.543 (1.445)
Environmental reg. gradient x post	1.079 (0.924)	0.551 (3.060)	1.788 (1.191)	Env. performance gradient x 10-15	4.179 (4.683)	2.961 (6.183)	6.075 (9.896)
Environmental reg. gradient x 10-15	-6.697 (6.898)	-3.822 (7.940)	3.695 (21.65)	Env. performance gradient x post	0.0854 (0.270)	-1.069 (0.854)	0.102 (0.303)
Env. reg. grdt. x post x 10-15	-0.714 (4.746)	-3.483 (5.735)	-16.25 (20.74)	Env. perf. grdt. x post x 10-15	-2.238 (1.645)	-4.107** (2.077)	9.520** (4.100)
Ln(GDP).i	-0.660* (0.386)	0.375 (0.918)	-0.696 (0.580)	Institution efficiency gradient	-2.364* (1.331)	-3.844 (3.244)	-3.867** (1.526)
Ln(GDP).j	-1.553 (1.204)	-1.275 (1.807)	-1.947 (1.652)	Institution efficiency gradient x 10-15	2.623 (5.029)	3.196 (5.929)	1.765 (7.946)
RTA	-0.909 (0.798)	0.317 (1.986)	-1.270 (0.960)	Institution efficiency gradient x post	0.187 (0.363)	1.082 (1.366)	0.443 (0.423)
Partial effect Environmental reg. Gradient x Post	0	0	0	Institution efficiency grdt. x post x 10-15	-1.528 (2.526)	-1.598 (2.874)	3.538 (5.577)
Partial effect post x 10-15	1.131***	1.626***	-1.951	Env. trade barriers gradient	0.374 (0.263)	0.619 (0.673)	0.321 (0.364)
Total effect	0	0	0	Env. trade barriers gradient x 10-15	0.299 (1.091)	0.212 (1.283)	0.283 (3.092)
Observations	4,045	1,255	2,451	Env. trade barriers gradient x post	-0.321 (0.307)	-0.0790 (0.492)	-0.306 (0.347)
R-squared	0.018	0.059	0.012	Env. trade barriers grdt. x post x 10-15	-2.720** (1.343)	-3.107** (1.374)	-14.72*** (5.550)
Number of ij	787	230	543	Ln(GDP).i	-0.778 (0.480)	0.401 (0.895)	-0.969* (0.565)
Time dummy	YES	YES	YES	Ln(GDP).j	-1.867 (1.146)	-2.179 (1.760)	-2.285 (1.428)
Country and time dummies	YES	YES	YES	RTA	-0.418 (0.888)	2.608 (1.797)	-1.402 (0.913)
Bilateral FE	YES	YES	YES	Total effect env. performance grdt. x post x 10-15	-2.238	-4.107**	9.520**
Dependent variable	ln Imports	ln Imports	ln Imports	Total effect institution efficiency grdt. x post x 10-15	0	0	0
Bootstrap	YES	YES	YES	Total effect treaty ratification grdt. x post x 10-15	-2.720**	-3.107**	-14.72***
Robust standard errors in parentheses				Observations	4,045	1,255	2,451
*** p<0.01, ** p<0.05, * p<0.1				R-squared	0.024	0.082	0.021
				Number of ij	787	230	543
				Time dummy	YES	YES	YES
				Country and time dummies	YES	YES	YES
				Bilateral FE	YES	YES	YES
				Dependent variable	ln Imports	ln Imports	ln Imports
				Bootstrap	YES	YES	YES
				Robust standard errors in parentheses			
				*** p<0.01, ** p<0.05, * p<0.1			

Table A.7: EU-10 15 BACI

OLS Developing-EU BACI				OLS Developing-EU BACI			
AGGREGATED ENVIRONMENTAL REGULATION PROXY				DISAGGREGATED ENVIRONMENTAL REGULATION PROXY			
VARIABLES	Africa-EU	Asia-EU	America-EU	VARIABLES	Africa-EU	Asia-EU	America-EU
post	-0.245 (2.134)	-0.682 (0.718)	-1.065 (0.863)	post	-2.825 (2.521)	0.0761 (0.476)	0.324 (0.594)
Environmental reg. gradient	-11.73 (10.47)	<b>5.708***</b> (1.861)	-2.243 (2.546)	post x Af/As/Am	1.456 (2.649)	-0.693 (0.483)	-0.0983 (0.850)
post x Af/As/Am - EU	1.419 (1.844)	-0.0451 (0.326)	-0.237 (0.619)	Env. performance gradient	0.547 (4.427)	-1.311 (2.772)	<b>-7.508***</b> (2.780)
Environmental reg. gradient x post	12.21 (10.27)	<b>-3.801*</b> (2.281)	2.520 (1.741)	Env. performance gradient x Af/As/Am	5.844 (5.110)	-1.950 (3.326)	<b>9.895**</b> (4.300)
Environmental reg. gradient x Af/As/Am - EU	15.09 (9.859)	<b>-6.485***</b> (2.483)	-7.040 (4.844)	Env. performance gradient x post	-0.0388 (0.874)	0.230 (0.394)	-0.506 (0.708)
Env. reg. grdt. x post x Af/As/Am - EU	-6.998 (10.90)	<b>7.175**</b> (2.920)	-0.118 (3.045)	Env. perf. grdt. x post x Af/As/Am	0.405 (1.229)	<b>1.229**</b> (0.487)	-1.818 (1.467)
Ln(GDP).i	<b>-2.724**</b> (1.198)	0.986 (0.717)	-0.231 (1.131)	Institution efficiency gradient	2.044 (5.367)	-0.163 (2.437)	-2.573 (2.457)
Ln(GDP).j	0.815 (2.606)	0.0430 (0.708)	<b>2.508*</b> (1.467)	Institution efficiency gradient x Af/As/Am	-2.583 (6.349)	-2.685 (2.901)	3.048 (4.941)
RTA	2.019 (1.387)	0.0448 (0.428)	0.539 (0.650)	Institution efficiency gradient x post	<b>4.104*</b> (2.371)	-0.231 (0.639)	<b>-1.218**</b> (0.575)
Partial effect env. reg. gradient x post	12.21	<b>-3.801*</b>	2.520	Institution efficiency grdt. x post x Af/As/Am	-0.820 (2.572)	-0.584 (0.852)	1.173 (1.247)
Partial effect env. reg. gradient x Af/As/Am - EU	15.09	<b>-6.485***</b>	-7.040	Env. trade barriers gradient	<b>3.011*</b> (1.770)	-0.249 (0.687)	<b>-2.271***</b> (0.746)
Total effect	-6.998	<b>7.175**</b>	-0.118	Env. trade barriers gradient x Af/As/Am	<b>-3.192*</b> (1.855)	1.097 (0.768)	<b>2.494**</b> (1.246)
Observations	593	1,499	980	Env. trade barriers gradient x post	-1.281 (0.793)	<b>0.502*</b> (0.298)	0.523 (0.428)
Number of ij	164	290	286	Env. trade barriers grdt. x post x Af/As/Am	0.202 (1.810)	-0.997 (0.691)	-0.846 (1.263)
R-squared	0.044	0.034	0.044	Ln(GDP).i	<b>-2.500**</b> (1.109)	0.124 (0.764)	0.573 (1.006)
Time dummy	YES	YES	YES	Ln(GDP).j	0.820 (2.420)	-0.0716 (0.669)	2.391 (1.603)
Country and time dummies	YES	YES	YES	RTA	2.697* (1.386)	0.0628 (0.506)	0.736 (0.593)
Bilateral FE	YES	YES	YES	Partial effect institution efficiency gradient x post	<b>4.104*</b>	-0.231	<b>-1.218**</b>
Dependent variable	ln Imports	ln Imports	ln Imports	Total effect env. perf. grdt. x post x Af/As/Am	0.405	<b>1.229**</b>	-1.818
Bootstrap	YES	YES	YES	Observations	593	1,499	980
Robust standard errors in parentheses				Number of ij	164	290	286
*** p<0.01, ** p<0.05, * p<0.1				R-squared	0.066	0.052	0.060
				Time dummy	YES	YES	YES
				Country and time dummies	YES	YES	YES
				Bilateral FE	YES	YES	YES
				Dependent variable	ln Imports	ln Imports	ln Imports
				Bootstrap	YES	YES	YES
				Robust standard errors in parentheses			
				*** p<0.01, ** p<0.05, * p<0.1			

Table A.8: Developing-EU BACI

## **Appendix B**

### **IEAs Hazardous Substances**

Convention ratification					
Country	Rotterdam Convention	Stockholm Convention	Country	Rotterdam Convention	Stockholm Convention
Algeria	NR	2006	Madagascar	2004	2005
Argentina	2004	2005	Malawi	2009	2009
Australia	2004	2004	Malaysia	2002	NR
Austria	2002	2002	Malta	NR	NR
Bangladesh	NR	2007	Mauritius	2005	2004
Belgium	2002	2006	Mexico	2005	2003
Bolivia	2003	2003	Morocco	2011	2004
Brazil	2004	2004	Mozambique	2010	2005
Bulgaria	2000	2004	Netherlands	2000	2002
Canada	2002	2001	New Zealand	2003	2004
Chile	2005	2005	Nicaragua	2008	2005
China	2005	2004	Nigeria	2001	2004
Colombia	2008	2008	Norway	2001	2002
Costa Rica	2006	2007	Pakistan	2005	2008
Croatia	2007	2007	Panama	2000	2003
Czech Republic	2000	2002	Paraguay	2005	2004
Denmark	2004	2003	Peru	2005	2005
Dominican Republic	2006	2007	Philippines	2006	2004
Ecuador	2004	2004	Poland	2005	2008
Egypt	NR	2003	Portugal	2005	2004
El Salvador	1999	2008	Romania	2003	2004
Estonia	2006	2013	Russian Federation	2011	2011
Ethiopia	2003	2003	Senegal	2001	2003
Finland	2004	2002	Singapore	2005	2005
France	2004	2004	Slovakia	2007	2002
Germany	2001	2002	Slovenia	1999	2004
Greece	2003	2006	South Africa	2002	2002
Guatemala	2010	2008	Spain	2004	2004
Honduras	2011	2005	Sri Lanka	2006	2005
Hungary	2000	2008	Sweden	2003	2002
Iceland	NR	2002	Switzerland	2002	2003
India	2005	2006	Thailand	2002	2005
Indonesia	2013	2009	Trinidad and Tobago	2009	2002
Ireland	2005	2010	Tunisia	NR	2004
Israel	2011	NR	Turkey	NR	2009
Italy	2002	NR	Uganda	2008	2004
Jamaica	2002	2007	Ukraine	2002	2007
Japan	2004	2002	United Kingdom	2004	2005
Jordan	2002	2004	United States of America	NR	NR
Kenya	2005	2004	Uruguay	2003	2004
Korea, Republic of	2003	2007	Venezuela (Bolivarian Republic of)	2005	2005
Latvia	2003	2004	Viet Nam	2007	2002
Lithuania	2004	2006	Zambia	2011	2006
Macedonia, Republic of	2010	2004	Zimbabwe	2012	2012

Table B.1: Status of ratification of the conventions

Note: NR= Not ratified. Source: Rotterdam Convention Website.

<http://www.pic.int/Countries/StatusofRatifications/tabid/1072/language/en-US/Default.aspx>.

Stockholm Convention Website:

<http://chm.pops.int/Countries/StatusofRatifications/PartiesandSignatoires/tabid/4500/Default.aspx>.

Harmonized System Codes assigned to chemicals in Annex III to the Rotterdam Convention			
Annex III Chemicals and Pesticides	HS Code Pure Substance	HS Code (*3) Mixtures, Preparations containing Substance	
2,4,5-T and its salts and esters	2918.91	3808.50 (*1)	
Alachlor	See below (*4)		
Aldicarb	See below (*4)		
Aldrin	2903.82	3808.50 (*1)	
Binapacryl	2916.16	3808.50 (*1)	
Captafol	2930.50	3808.50 (*1)	
Chlordane	2903.82	3808.50 (*1)	
Chlordimeform	2925.21	3808.50 (*1)	
Chlorobenzilate	2918.18	3808.50 (*1)	
DDT	2903.92	3808.50 (*1)	
Dieldrin	2910.40	3808.50 (*1)	
DNOC and its salts (such as ammonium salt, potassium salt and sodium salt)	2908.92	3808.50 (*1)	
DNOC and its salts (such as ammonium salt, potassium salt and sodium salt)			
Dinoseb and its salts	2908.91	3808.50 (*1)	
Dinoseb acetate	2915.36	3808.50 (*1)	
1,2-dibromoethane (EDB)	2903.31	3808.50 (*1)	
		3811.11, 3811.19	
Endosulfan	See below (*4)		
Ethylene dichloride	2903.15	3808.50 (*1)	
Ethylene oxide	2910.10	3808.50 (*1)	
		3824.81	
Fluoroacetamide	2924.12	3808.50 (*1)	
HCH (mixed isomers)	2903.81	3808.50 (*1)	
Heptachlor	2903.82	3808.50 (*1)	
Hexachlorobenzene	2903.92	3808.50 (*1)	
Lindane	2903.81	3808.50 (*1)	
Mercury compounds including inorganic mercury compounds, alkyl mercury compounds and alkyloxyalkyl and aryl mercury compounds (CAS numbers)	2852.10	3808.50 (*1)	
Monocrotophos	2924.12	3808.50 (*1)	
Parathion	2920.11	3808.50 (*1)	
Pentachlorophenol and its salts and esters	2908.11 – Pentachlorophenol 2908.19 – salts of Pentachlorophenol	3808.50 (*1)	
Toxaphene	–	3808.50 (*1)	
Dustable powder formulations containing a combination of : benomyl at or above 7 per cent, carbofuran at above 10 per cent, thiram at or above 15 per cent	–	3808.50 (*1)	
Methamidophos (Soluble liquid formulations of the substance that exceed 600 g active ingredient/l)	2930.50	3808.50 (*1)	
Phosphamidon (Soluble liquid formulations of the substance that exceed 1000 g active ingredient/l)	2924.12	3808.50 (*1)	
mixture, (E)&(Z) isomers)			
(Z)-isomer			
(E)-isomer			
Methyl-parathion (emulsifiable concentrates (EC) with 19.5%, 40%, 50%, 60% active ingredient and dusts containing 1.5%, 2% and 3% active ingredient)	2920.11	3808.50 (*1)	
Asbestos	11[2]*2524.10 - Crocidolite 2524.90 – Other(*2)	6811.40 – Containing asbestos.	
		6812.91 – Clothing, clothing accessories, footwear and headgear	
		6812.92 – Paper, millboard and felt	
		6812.93 – Compressed asbestos fibre jointingm in sheets or rolls	
		6812.99 - Other	
		6813.20 – Containing asbestos.	
		The same as Asbestos other than heading 68.12 (*2)	
		6812.80	
		The same as Asbestos (*2)	
		6812.91 – Clothing, clothing accessories, footwear and headgear	
Crocidolite	2524.10		
Actinolite	2524.90		
Anthophyllite	2524.90	6812.92 – Paper, millboard and felt	
Amosite	2524.90	6892.93 – Compressed asbestos fibre jointing in sheets or rolls	
		6892.99 - Other	
Tremolite	2524.90		
Polybrominated biphenyls (PBB)	–	2710.91	
(hexa-)		3824.82	
(octa-)			
(deca-)			
Polychlorinated biphenyls (PCB)	–	2710.91	
		3824.82	
Polychlorinated terphenyls (PCT)	–	2710.91	
		3824.82	
Tetraethyl lead	2931.10	e.g., 3811.11 – Anti-knock preparations based on lead compounds	
Tetramethyl lead	2931.10	e.g., 3811.11 – Anti-knock preparations based on lead compounds	
Tris (2,3-dibromopropyl) phosphate	2919.10	3824.83	
Tributyl tin compounds	2931.20	3808.50 (*1)	

Note: (\*1) Subheading 3808.50 covers only goods of heading 38.08, containing one or more of the following substances : aldrin (ISO); binapacryl (ISO); camphochlor (ISO) (toxaphene); captafol (ISO); chlordane (ISO); chlordimeform (ISO); chlorobenzilate (ISO); DDT (ISO) (clofenotane (INN), 1,1,1-trichloro-2,2-bis(p-chlorophenyl)ethane); dieldrin (ISO, INN); 4,6-dinitro-o-cresol (DNOC (ISO)) or its salts; dinoseb (ISO), its salts or its esters; ethylene dibromide (ISO) (1,2-dibromoethane); ethylene dichloride (ISO) (1,2-dichloroethane); fluoroacetamide (ISO) (1,2-dibromoethane); ethylene dichloride (ISO) (1,2-dichloroethane); fluoroacetamide (ISO); heptachlor (ISO); hexachlorobenzene (ISO); 1,2,3,4,5,6-hexachlorocyclohexane (HSH (ISO)), including lindane (ISO, INN); mercury compounds; methamidophos (ISO); monocrotophos (ISO); oxirane (ethylene oxide); parathion (ISO); ) parathion-methyl (ISO) (methyl-parathion); pentachlorophenol (ISO), its salts or its esters; phosphamidon (ISO); 2,4,5-T (ISO) (2,4,5-trichlorophenoxyacetic acid), its salts or its esters; tributyltin compounds. Subheading 3808.50 also covers dustable powder formulations containing a mixture of benomyl (ISO), carbofuran (ISO) and thiram (ISO). (\*2) Asbestos is a natural mineral substance produced by the decomposition of certain rocks. (\*3) The list of HS codes in the column for “HS Code Mixtures, Preparations containing Substance” is not exhaustive. (\*4) This substance has entered into Annex III in 2011. HS code for this substance is expected to be assigned by WCO in 2017.

**Table B.2:** Harmonized System Codes Assigned to Annex III Chemicals. Rotterdam Convention

Stockholm Convention			
Annex A			ELIMINATION
Chemical	HS code	Activity	Specific exemptions
Aldrin*		Production	None
CAS No: 309-00-2	290382	Use	Local ectoparasiticide Insecticide
Alpha hexachlorocyclohexane*		Production	None
CAS No: 319-84-6	290381	Use	None
Beta hexachlorocyclohexane*		Production	None
CAS No: 319-85-7	290381	Use	None
Chlordane*		Production	As allowed for the Parties listed in the Register
6[0]*CAS No: 57-74-9	290382	6[0]*Use	Local ectoparasiticide Insecticide
	290382		Termiticide
			Termiticide in buildings and dams
			Termiticide in roads
			Additive in plywood adhesives
Chlordecone*		Production	None
CAS No: 143-50-0	291470	Use	None
Dieldrin*		Production	None
CAS No: 60-57-1	291040	Use	In agricultural operations
Endrin*		Production	None
CAS No: 72-20-8	291090	Use	None
Heptachlor*		Production	None
5[0]*CAS No: 76-44-8		5[0]*Use	Termiticide
	290382		Termiticide in structures of houses
			Termiticide (subterranean)
			Wood treatment
			In use in underground cable boxes
Hexabromobiphenyl*		Production	None
CAS No: 36355-01-8	290399	Use	None
Hexabromodiphenyl ether*		Production	None
and		2[0]*Use	Use Articles in accordance with the
heptabromodiphenyl ether*			provisions of Part IV of this Annex
Hexachlorobenzene		Production	As allowed for the Parties listed in the Register
4[0]*CAS No: 118-74-1		4[0]*Use	Intermediate
	290392		Solvent in pesticide
			Closed system site limited
			intermediate2
			None
Lindane*		Production	Human health phar. for control of head lice and scabies as second line treatment
CAS No: 58-89-9	290381	Use	As allowed for the Parties listed in the Register
Mirex*		Production	Termiticide
CAS No: 2385-85-5	290389	Use	None
Pentachlorobenzene*		Production	None
CAS No: 608-93-5	290399	Use	None
4[0]*Polychlorinated biphenyls (PCB)*		2[0]*Production	None
		2[0]*Use	Articles in use in accordance with the provisions
			of Part II of this Annex
			None
Tetrabromodiphenyl ether* and		Production	Articles in accordance with the provisions of
2[0]*pentabromodiphenyl ether*		2[0]*Use	Part V of this Annex
			None
Toxaphene*		Production	None
CAS No: 8001-35-2	380850	Use	None

Table B.3: CAS and HS codes. Stockholm Convention



	Gravity variables		Country-time5 dummies		Country-time5 dummies & ijk FE	
VARIABLES	(1) Ln(Imports)	(2) Ln(Imports)	(3) Ln(Imports)	(4) Ln(Imports)	(5) Ln(Imports)	(6) Ln(Imports)
Ln(GDP) importer	0.450*** (0.0102)	0.449*** (0.0102)				
Ln(GDP) exporter	0.615*** (0.0114)	0.615*** (0.0115)				
<b>OECD to non-OECD</b>	<b>-1.104***</b> (0.0436)	<b>-1.115***</b> (0.0487)	<b>3.674***</b> (0.506)	<b>3.682***</b> (0.508)		
<b>OECD to OECD</b>	<b>-1.648***</b> (0.0560)	<b>-1.642***</b> (0.0561)	<b>7.030***</b> (0.595)	<b>6.962***</b> (0.597)		
<b>Non-OECD to OECD</b>	<b>-1.272***</b> (0.0599)	<b>-1.265***</b> (0.0599)	<b>2.755***</b> (0.318)	<b>2.728***</b> (0.318)		
Ln(distance)	-0.478*** (0.0214)	-0.480*** (0.0214)	-0.825*** (0.0262)	-0.822*** (0.0261)		
Contiguity	0.537*** (0.0639)	0.536*** (0.0640)	0.472*** (0.0635)	0.475*** (0.0635)		
Common language	0.238*** (0.0403)	0.236*** (0.0403)	0.0803* (0.0468)	0.0804* (0.0468)		
Colony ties	0.149* (0.0835)	0.135 (0.0832)	-0.0648 (0.0943)	-0.0661 (0.0942)		
RTA	0.290*** (0.0388)	0.290*** (0.0389)	0.171*** (0.0435)	0.171*** (0.0435)	0.134*** (0.0333)	0.135*** (0.0334)
WTO	0.119*** (0.0334)	0.114*** (0.0333)	0.156*** (0.0455)	0.153*** (0.0455)	0.174*** (0.0429)	0.174*** (0.0430)
Common currency	0.687*** (0.0742)	0.685*** (0.0744)	0.452*** (0.0813)	0.435*** (0.0817)	0.160** (0.0633)	0.138** (0.0632)
<b>Importer ratifies ROT</b>	<b>0.106**</b> (0.0432)	0.0109 (0.0511)				
<b>Exporter ratifies ROT</b>	<b>0.0655*</b> (0.0396)	<b>0.148***</b> (0.0470)				
<b>Both ratify ROT</b>	<b>-0.142***</b> (0.0474)	<b>-0.134**</b> (0.0599)	-0.0548 (0.0363)	-0.0447 (0.0424)	<b>-0.0542**</b> (0.0218)	-0.0310 (0.0268)
<b>Imp. ratifies ROT x OECD to non-OECD</b>		<b>0.295***</b> (0.0738)		0.0426 (0.0681)		-0.00195 (0.0477)
<b>Exp. ratifies ROT x OECD to non-OECD</b>		<b>-0.184***</b> (0.0550)		<b>-0.111**</b> (0.0522)		<b>-0.0730**</b> (0.0359)
<b>Both ratify ROT x OECD to non-OECD</b>		-0.0740 (0.0895)		-0.0440 (0.0825)		-0.0513 (0.0584)
Observations	209,951	209,951	209,951	209,951	209,951	209,951
R-squared	0.255	0.255	0.349	0.349	0.067	0.067
<i>Time dummies</i>	YES	YES	YES	YES	YES	YES
<i>Product dummies</i>	YES	YES	YES	YES	YES	YES
<i>Country-and-time dummies</i>	NO	NO	YES	YES	YES	YES
<i>Dyadic-sector fixed effects</i>	NO	NO	NO	NO	YES	YES
<i>Ratification-country group interaction terms</i>	NO	YES	NO	YES	NO	YES
Number of ijk					25,9	25,9

Note: Robust standard errors are in brackets. \*\*\*, \*\*, \* denotes statistical significance at the 1, 5 and 10 percent level, respectively. The “importer (or exporter) ratifies” variable is encoded as a dummy variable equal to one if the importer (or exporter) ratifies (independently of what the exporter does) and zero otherwise. The “both ratify” dummy takes the value of one when the two trade partners are ratifier countries in a given year.

**Table B.4:** Full results Rotterdam Convention (six-digit disaggregation)

	Gravity variables		Country-time5 dummies		Country-time5 dummies & ijk FE	
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	Ln(Imports)	Ln(Imports)	Ln(Imports)	Ln(Imports)	Ln(Imports)	Ln(Imports)
Ln(GDP) importer	0.603*** (0.0181)	0.602*** (0.0181)				
Ln(GDP) exporter	0.812*** (0.0195)	0.812*** (0.0196)				
<b>OECD to non-OECD</b>	<b>-1.188***</b> (0.0784)	<b>-1.221***</b> (0.0838)	<b>4.913***</b> (0.832)	<b>5.051***</b> (0.837)		
<b>OECD to OECD</b>	<b>-1.427***</b> (0.0961)	<b>-1.428***</b> (0.0961)	<b>9.344***</b> (0.989)	<b>9.469***</b> (0.992)		
<b>Non-OECD to OECD</b>	<b>-0.405***</b> (0.109)	<b>-0.407***</b> (0.109)	<b>4.545***</b> (0.552)	<b>4.553***</b> (0.551)		
Ln(distance)	-0.362*** (0.0368)	-0.363*** (0.0369)	-0.647*** (0.0437)	-0.651*** (0.0438)		
Contiguity	0.399*** (0.0933)	0.399*** (0.0933)	0.599*** (0.0918)	0.598*** (0.0918)		
Common language	0.166** (0.0686)	0.166** (0.0686)	0.0167 (0.0814)	0.0155 (0.0813)		
Colony ties	0.376*** (0.141)	0.372*** (0.141)	-0.0762 (0.173)	-0.0644 (0.173)		
RTA	0.0237 (0.0703)	0.0187 (0.0705)	-0.0542 (0.0799)	-0.0517 (0.0799)	0.00556 (0.0567)	0.00658 (0.0567)
WTO	0.0701 (0.0595)	0.0688 (0.0594)	0.359*** (0.0852)	0.361*** (0.0852)	0.457*** (0.0754)	0.458*** (0.0754)
Common currency	0.795*** (0.0969)	0.799*** (0.0973)	0.163 (0.114)	0.167 (0.114)	0.226** (0.0960)	0.215** (0.0960)
<b>Importer ratifies STO</b>	<b>-0.147*</b> (0.0801)	<b>-0.163*</b> (0.0931)				
<b>Exporter ratifies STO</b>	0.237*** (0.0765)	0.254*** (0.0916)				
<b>Both ratify STO</b>	-0.0208 (0.0871)	-0.0413 (0.109)	0.00223 (0.0650)	-0.0436 (0.0732)	0.0143 (0.0381)	0.0209 (0.0439)
<b>Imp ratifies STO x OECD to non-OECD</b>		0.0613 (0.113)		<b>-0.253**</b> (0.103)		<b>-0.157**</b> (0.0798)
<b>Exp ratifies STO x OECD to non-OECD</b>		-0.0509 (0.103)		0.0286 (0.0877)		-0.0820 (0.0601)
<b>Both ratify STO x OECD to non-OECD</b>		0.0721 (0.149)		<b>0.267**</b> (0.133)		0.0887 (0.0988)
Observations	91,673	91,673	91,673	91,673	91,673	91,673
R-squared	0.219	0.219	0.318	0.318	0.069	0.069
<i>Time dummies</i>	YES	YES	YES	YES	YES	YES
<i>Product dummies</i>	YES	YES	YES	YES	NO	NO
<i>Country-and-time dummies</i>	NO	NO	YES	YES	YES	YES
<i>Dyadic-sector fixed effects</i>	NO	NO	NO	NO	YES	YES
<i>Ratification-country group interaction terms</i>	NO	YES	NO	YES	NO	YES
Number of ijk					11,675	11,675

Note: Robust standard errors are in brackets. \*\*\*, \*\*, \* denotes statistical significance at the 1, 5 and 10 percent level, respectively. The “importer (or exporter) ratifies” variable is encoded as a dummy variable equal to one if the importer (or exporter) ratifies (independently of what the exporter does) and zero otherwise. The “both ratify” dummy takes the value of one when the two trade partners are ratifier countries in a given year.

**Table B.5: Full results Stockholm Convention (six-digit disaggregation)**

	Gravity variables		Country-time5 dummies		Country-time5 dummies & ijk FE	
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	Ln(Imports)	Ln(Imports)	Ln(Imports)	Ln(Imports)	Ln(Imports)	Ln(Imports)
Ln(GDP) importer	0.610*** (0.0189)	0.609*** (0.0189)				
Ln(GDP) exporter	0.921*** (0.0200)	0.921*** (0.0200)				
<b>OECD to non-OECD</b>	<b>-1.247***</b> (0.0811)	<b>-1.209***</b> (0.0880)	<b>5.159***</b> (0.869)	<b>5.223***</b> (0.874)		
<b>OECD to OECD</b>	<b>-1.935***</b> (0.108)	<b>-1.932***</b> (0.108)	<b>10.48***</b> (1.015)	<b>10.38***</b> (1.018)		
<b>Non-OECD to OECD</b>	<b>-1.699***</b> (0.105)	<b>-1.689***</b> (0.106)	<b>4.510***</b> (0.527)	<b>4.459***</b> (0.526)		
Ln(distance)	-0.732*** (0.0405)	-0.734*** (0.0405)	-1.234*** (0.0473)	-1.230*** (0.0472)		
Contiguity	0.769*** (0.132)	0.768*** (0.132)	0.510*** (0.128)	0.513*** (0.128)		
Common language	0.476*** (0.0762)	0.474*** (0.0762)	0.179** (0.0794)	0.179** (0.0795)		
Colony ties	0.328** (0.154)	0.311** (0.153)	0.0220 (0.171)	0.0181 (0.171)		
RTA	0.314*** (0.0745)	0.319*** (0.0746)	0.184** (0.0784)	0.185** (0.0786)	0.0816 (0.0524)	0.0825 (0.0525)
WTO	0.146** (0.0613)	0.140** (0.0612)	0.230*** (0.0737)	0.225*** (0.0738)	0.245*** (0.0675)	0.244*** (0.0676)
Common currency	0.869*** (0.158)	0.863*** (0.158)	0.573*** (0.146)	0.542*** (0.146)	0.180 (0.111)	0.132 (0.111)
<b>Importer ratifies ROT</b>	<b>0.199***</b> (0.0770)	0.126 (0.0874)				
<b>Exporter ratifies ROT</b>	<b>0.233***</b> (0.0716)	<b>0.384***</b> (0.0839)				
<b>Both ratify ROT</b>	<b>-0.238***</b> (0.0844)	<b>-0.303***</b> (0.104)	<b>-0.143**</b> (0.0611)	<b>-0.129*</b> (0.0698)	<b>-0.134***</b> (0.0364)	<b>-0.0778*</b> (0.0449)
<b>Imp ratifies ROT x OECD to non-OECD</b>		<b>0.256*</b> (0.138)		-0.00420 (0.118)		-0.0300 (0.0759)
<b>Exp ratifies ROT x OECD to non-OECD</b>		<b>-0.346***</b> (0.0972)		<b>-0.216**</b> (0.0856)		<b>-0.102*</b> (0.0591)
<b>Both ratify ROT x OECD to non-OECD</b>		0.0740 (0.166)		-0.0212 (0.142)		-0.117 (0.0943)
Observations	72,176	72,176	72,176	72,176	72,176	72,176
R-squared	0.311	0.312	0.480	0.480	0.101	0.102
<i>Time dummies</i>	YES	YES	YES	YES	YES	YES
<i>Product dummies</i>	YES	YES	YES	YES	YES	YES
<i>Country-and-time dummies</i>	NO	NO	YES	YES	YES	YES
<i>Dyadic-sector fixed effects</i>	NO	NO	NO	NO	YES	YES
<i>Ratification-country group interaction terms</i>	NO	YES	NO	YES	NO	YES
Number of ijhs6					7,254	7,254

Note: Robust standard errors are in brackets. \*\*\*, \*\*, \* denotes statistical significance at the 1, 5 and 10 percent level, respectively. The “importer (or exporter) ratifies” variable is encoded as a dummy variable equal to one if the importer (or exporter) ratifies (independently of what the exporter does) and zero otherwise. The “both ratify” dummy takes the value of one when the two trade partners are ratifier countries in a given year.

**Table B.6:** Rotterdam Convention two digits aggregation

	Gravity variables		Country-time5 dummies		Country-time5 dummies & ijk FE	
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	Ln(Imports)	Ln(Imports)	Ln(Imports)	Ln(Imports)	Ln(Imports)	Ln(Imports)
Ln(GDP) importer	0.591*** (0.0203)	0.590*** (0.0202)				
Ln(GDP) exporter	0.766*** (0.0225)	0.766*** (0.0226)				
<b>OECD to non-OECD</b>	<b>-1.099***</b> (0.0887)	<b>-1.115***</b> (0.0946)	<b>5.295***</b> (0.776)	<b>5.470***</b> (0.784)		
<b>OECD to OECD</b>	<b>-1.364***</b> (0.108)	<b>-1.363***</b> (0.108)	<b>9.727***</b> (1.032)	<b>9.858***</b> (1.038)		
<b>Non-OECD to OECD</b>	<b>-0.486***</b> (0.122)	<b>-0.488***</b> (0.122)	<b>4.521***</b> (0.683)	<b>4.523***</b> (0.683)		
Ln(distance)	-0.309*** (0.0412)	-0.310*** (0.0412)	-0.604*** (0.0507)	-0.607*** (0.0507)		
Contiguity	0.374*** (0.111)	0.374*** (0.111)	0.548*** (0.111)	0.548*** (0.111)		
Common language	0.123 (0.0801)	0.122 (0.0801)	-0.000910 (0.0967)	-0.00224 (0.0966)		
Colony ties	0.421*** (0.143)	0.416*** (0.143)	-0.0679 (0.180)	-0.0559 (0.180)		
RTA	0.0350 (0.0784)	0.0309 (0.0787)	-0.0401 (0.0895)	-0.0370 (0.0896)	-0.0160 (0.0595)	-0.0147 (0.0596)
WTO	0.134** (0.0670)	0.131** (0.0668)	0.409*** (0.0876)	0.413*** (0.0876)	0.493*** (0.0787)	0.497*** (0.0787)
Common currency	0.821*** (0.112)	0.823*** (0.112)	0.155 (0.134)	0.158 (0.134)	0.206** (0.102)	0.192* (0.102)
<b>Importer ratifies STO</b>	-0.138 (0.0903)	-0.156 (0.105)				
<b>Exporter ratifies STO</b>	<b>0.265***</b> (0.0853)	<b>0.302***</b> (0.102)				
<b>Both ratify STO</b>	-0.0148 (0.0975)	-0.0382 (0.122)	-0.00893 (0.0713)	-0.0451 (0.0809)	-0.00331 (0.0398)	0.0223 (0.0458)
<b>Imp ratifies STO x OECD to non-OECD</b>		0.0731 (0.129)		<b>-0.280**</b> (0.115)		<b>-0.195**</b> (0.0828)
<b>Exp ratifies STO x OECD to non-OECD</b>		-0.103 (0.113)		0.0142 (0.0963)		-0.0412 (0.0624)
<b>Both ratify STO x OECD to non-OECD</b>		0.0804 (0.167)		0.253* (0.150)		0.0420 (0.102)
Observations	80,720	80,720	80,720	80,720	80,720	80,720
R-squared	0.181	0.181	0.284	0.284	0.075	0.075
<i>Time dummies</i>	YES	YES	YES	YES	YES	YES
<i>Product dummies</i>	YES	YES	YES	YES	NO	NO
<i>Country-and-time dummies</i>	NO	NO	YES	YES	YES	YES
<i>Dyadic-sector fixed effects</i>	NO	NO	NO	NO	YES	YES
<i>Ratification-country group interaction terms</i>	NO	YES	NO	YES	NO	YES
<b>Number of ijhs6</b>					9,862	9,862

Note: Robust standard errors are in brackets. \*\*\*, \*\*, \* denotes statistical significance at the 1, 5 and 10 percent level, respectively. The “importer (or exporter) ratifies” variable is encoded as a dummy variable equal to one if the importer (or exporter) ratifies (independently of what the exporter does) and zero otherwise. The “both ratify” dummy takes the value of one when the two trade partners are ratifier countries in a given year.

**Table B.7: Stockholm Convention fourth digits aggregation**

	Gravity variables		Country-time5 dummies		Country-time5 dummies & ijk FE	
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Ln(Imports)	Ln(Imports)	Ln(Imports)	Ln(Imports)	Ln(Imports)	Ln(Imports)
Ln(GDP) importer	0.586*** (0.0204)	0.585*** (0.0204)				
Ln(GDP) exporter	0.980*** (0.0215)	0.980*** (0.0215)				
<b>OECD to non-OECD</b>	<b>-1.230***</b> (0.0879)	<b>-1.243***</b> (0.0967)	<b>5.721***</b> (0.878)	<b>5.773***</b> (0.884)		
<b>OECD to OECD</b>	<b>-2.047***</b> (0.117)	<b>-2.045***</b> (0.117)	<b>11.04***</b> (1.015)	<b>10.93***</b> (1.019)		
<b>Non-OECD to OECD</b>	<b>-1.916***</b> (0.113)	<b>-1.906***</b> (0.114)	<b>4.412***</b> (0.511)	<b>4.374***</b> (0.512)		
Ln(distance)	-0.832*** (0.0421)	-0.835*** (0.0421)	-1.366*** (0.0473)	-1.362*** (0.0473)		
Contiguity	0.883*** (0.134)	0.880*** (0.134)	0.520*** (0.131)	0.522*** (0.131)		
Common language	0.616*** (0.0815)	0.613*** (0.0815)	0.216*** (0.0782)	0.217*** (0.0782)		
Colony ties	0.298* (0.176)	0.276 (0.175)	0.106 (0.190)	0.0996 (0.191)		
RTA	0.413*** (0.0775)	0.417*** (0.0777)	0.300*** (0.0779)	0.301*** (0.0782)	0.102* (0.0542)	0.105* (0.0542)
WTO	0.231*** (0.0662)	0.225*** (0.0662)	0.284*** (0.0824)	0.281*** (0.0825)	0.272*** (0.0768)	0.273*** (0.0769)
Common currency	0.564*** (0.167)	0.563*** (0.166)	0.283** (0.133)	0.243* (0.134)	0.212* (0.110)	0.142 (0.110)
<b>Importer ratifies ROT</b>	<b>0.177**</b> (0.0820)	0.0575 (0.0930)				
<b>Exporter ratifies ROT</b>	<b>0.205***</b> (0.0777)	<b>0.323***</b> (0.0896)				
<b>Both ratify ROT</b>	-0.133 (0.0890)	-0.144 (0.109)	<b>-0.137**</b> (0.0572)	-0.0869 (0.0653)	<b>-0.119***</b> (0.0362)	-0.0602 (0.0451)
<b>Imp. ratifies ROT x OECD to non-OECD</b>		<b>0.412***</b> (0.148)		0.0545 (0.116)		-0.102 (0.0752)
<b>Exp. ratifies ROT x OECD to non-OECD</b>		<b>-0.261**</b> (0.105)		<b>-0.218***</b> (0.0823)		<b>-0.171***</b> (0.0601)
<b>Both ratify ROT x OECD to non-OECD</b>		-0.101 (0.176)		-0.150 (0.136)		-0.0646 (0.0923)
Observations	53,268	53,268	53,268	53,268	53,268	53,268
R-squared	0.353	0.354	0.582	0.582	0.139	0.140
<i>Time dummies</i>	YES	YES	YES	YES	YES	YES
<i>Country-and-time dummies</i>	NO	NO	YES	YES	YES	YES
<i>Dyadic-sector fixed effects</i>	NO	NO	NO	NO	YES	YES
<i>Ratification-country group interaction terms</i>	NO	YES	NO	YES	NO	YES
Number of ij					4,888	4,888

Note: Robust standard errors are in brackets. \*\*\*, \*\*, \* denotes statistical significance at the 1, 5 and 10 percent level, respectively. The “importer (or exporter) ratifies” variable is encoded as a dummy variable equal to one if the importer (or exporter) ratifies (independently of what the exporter does) and zero otherwise. The “both ratify” dummy takes the value of one when the two trade partners are ratifier countries in a given year.

**Table B.8:** Rotterdam Convention. Aggregated imports

	Gravity variables		Country-time5 dummies		Country-time5 dummies & ijk FE	
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Ln(Imports)	Ln(Imports)	Ln(Imports)	Ln(Imports)	Ln(Imports)	Ln(Imports)
Ln(GDP) importer	0.801*** (0.0284)	0.801*** (0.0284)				
Ln(GDP) exporter	1.174*** (0.0300)	1.174*** (0.0300)				
<b>OECD to non-OECD</b>	<b>-0.995***</b> (0.133)	<b>-1.003***</b> (0.141)	<b>8.622***</b> (1.255)	<b>8.943***</b> (1.265)		
<b>OECD to OECD</b>	<b>-1.165***</b> (0.159)	<b>-1.166***</b> (0.159)	<b>15.53***</b> (1.733)	<b>15.72***</b> (1.743)		
<b>Non-OECD to OECD</b>	<b>-1.062***</b> (0.183)	<b>-1.063***</b> (0.182)	<b>6.458***</b> (1.194)	<b>6.451***</b> (1.199)		
Ln(distance)	-0.477*** (0.0562)	-0.478*** (0.0561)	-0.908*** (0.0611)	-0.910*** (0.0611)		
Contiguity	0.597*** (0.155)	0.597*** (0.155)	0.696*** (0.141)	0.699*** (0.140)		
Common language	0.393*** (0.113)	0.392*** (0.113)	0.253** (0.109)	0.252** (0.109)		
Colony ties	0.788*** (0.213)	0.785*** (0.213)	0.0663 (0.271)	0.0817 (0.270)		
RTA	0.215** (0.106)	0.213** (0.106)	0.0648 (0.107)	0.0706 (0.107)	-0.0573 (0.0830)	-0.0537 (0.0832)
WTO	0.0602 (0.0983)	0.0590 (0.0980)	0.393*** (0.130)	0.398*** (0.130)	0.370*** (0.117)	0.377*** (0.117)
Common currency	0.602*** (0.181)	0.603*** (0.181)	0.0750 (0.161)	0.0712 (0.161)	0.162 (0.161)	0.125 (0.161)
<b>Importer ratifies STO</b>	<b>-0.260**</b> (0.126)	<b>-0.268*</b> (0.144)				
<b>Exporter ratifies STO</b>	0.0893 (0.117)	0.126 (0.140)				
<b>Both ratify STO</b>	0.171 (0.136)	0.141 (0.168)	0.0108 (0.0852)	-0.00547 (0.0961)	-0.0294 (0.0573)	0.0740 (0.0661)
<b>Imp. ratifies STO x OECD to non-OECD</b>		0.0404 (0.184)		<b>-0.407***</b> (0.150)		-0.172 (0.108)
<b>Exp. ratifies STO x OECD to non-OECD</b>		-0.0935 (0.159)		-0.0708 (0.119)		-0.0912 (0.0844)
<b>Both ratify STO x OECD to non-OECD</b>		0.0859 (0.234)		0.275 (0.188)		-0.159 (0.134)
Observations	32,562	32,562	32,562	32,562	32,562	32,562
R-squared	0.349	0.349	0.537	0.537	0.111	0.112
<i>Time dummies</i>	YES	YES	YES	YES	YES	YES
<i>Country-and-time dummies</i>	NO	NO	YES	YES	YES	YES
<i>Dyadic-sector fixed effects</i>	NO	NO	NO	NO	YES	YES
<i>Ratification-country group interaction terms</i>	NO	YES	NO	YES	NO	YES
Number of ij					3,346	3,346

Table B.9: Stockholm Convention. Aggregated imports

## **Appendix C**

### **Environmental laws and outcomes**

Trade first stage	
VARIABLES	(1) ln(NOX emissions)
Ln(POP)_importer	-0.0229*** (0.00708)
Ln(POP)_exporter	0.748*** (0.00673)
Ln(distance)	-1.269*** (0.0213)
AREA	0*** (0)
COMLANG	0.617*** (0.0410)
CONTIG	0.984*** (0.0883)
LANDLOK	-0.994*** (0.0291)
Ln(landcap)	0.0701*** (0.00697)
REMOTE	0.00478 (0.00323)
Constant	-3.045*** (0.236)
Observations	410,306
R-squared	0.355
Country dummies	NO
Time dummies	NO
Country-time dummies	NO
Bilateral dummies	NO

**Table C.1:** First stage IV trade and geographic variables



Income first stage	
VARIABLES	(1) ln(GDPpc)
Ln(POP)	-0.0307*** (0.0103)
Ln(GDPpc)t-1	2.679* (1.621)
Ln(I/GDP)	0.0287 (0.0544)
Growth pop.	6.988*** (2.199)
Ln(school1)	-1.763*** (0.0976)
Ln(school2)	2.215*** (0.0500)
Constant	-6.387*** (0.388)
Observations	2,579
R-squared	0.582
Country-time dummies	NO

**Table C.2:** First stage IV income and growth variables

List of variables by source	
NO2	Emission database for global atmospheric research (EDGAR)
SO2	Emission database for global atmospheric research (EDGAR)
PM2.5	Emission database for global atmospheric research (EDGAR)
Water pollution	World Bank Development Index (WDI)
Forest area	World Bank Development Index (WDI)
Population	World Bank Development Index (WDI)
Investment	World Bank Development Index (WDI)
Schooling	World Bank Development Index (WDI)
Population	World Bank Development Index (WDI)
Population growth rate	World Bank Development Index (WDI)
GDP	World Bank Development Index (WDI)
Trade (Imports and exports)	Centre d'Etudes Prospectives et d'informations Internationales (CEPII)
Geographical variables (gravity variables)	Centre d'Etudes Prospectives et d'informations Internationales (CEPII)
Environmental Laws	ECOLEX The gateway to environmental law
Government Effectiveness	The Worldwide Governance Indicators (WGI) project
Rule of Law	The Worldwide Governance Indicators (WGI) project

**Table C.3:** Sources of the data

NO2 EMISSIONS WITHOUT FEDERALIST COUNTRIES									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
<b>LAWS</b>	<b>Environment gen.</b>				<b>Energy</b>			<b>Air and atmos.</b>	
<b>Countries</b>	<b>all</b>	<b>OECD</b>	<b>NON-OECD</b>	<b>all</b>	<b>OECD</b>	<b>NON-OECD</b>	<b>all</b>	<b>OECD</b>	<b>NON-OECD</b>
<b>VARIABLES</b>	ln(NO2pc)	ln(NO2pc)	ln(NO2pc)	ln(NO2pc)	ln(NO2pc)	ln(NO2pc)	ln(NO2pc)	ln(NO2pc)	ln(NO2pc)
Ln(GDPpc)*	0.780 (0.872)	2.271 (3.072)	1.002 (1.018)	0.731 (0.899)	2.351 (2.988)	0.975 (1.089)	0.771 (0.889)	2.156 (3.246)	1.030 (1.099)
Ln(GDPpc) <sup>2</sup> *	0.0514 (0.0746)	0.261 (0.328)	0.0647 (0.0828)	0.0476 (0.0781)	0.268 (0.321)	0.0618 (0.0873)	0.0513 (0.0764)	0.249 (0.347)	0.0662 (0.0879)
Openness	1.303 (1.003)	0.563 (2.052)	1.021 (1.358)	1.239 (1.224)	0.537 (1.965)	1.095 (2.279)	0.848 (1.029)	0.558 (1.930)	0.550 (1.665)
Ln(POP)	0.805 (0.924)	1.332 (1.422)	0.521 (1.042)	0.832 (0.861)	1.313 (1.740)	0.627 (1.089)	0.950 (0.866)	1.336 (1.482)	0.900 (1.093)
<b>Enforcement (Gover. Effect.)</b>	-0.00982 (0.00662)	-0.00288 (0.00991)	-0.0113 (0.00792)	-0.00896 (0.00647)	-0.00433 (0.00875)	-0.0106 (0.00764)	-0.00851 (0.00654)	-0.00159 (0.00877)	-0.0106 (0.00746)
<b>Environmental Laws</b>	-0.00783 (0.00572)	-0.000199 (0.0112)	-0.0133 (0.00860)	0.000329 (0.00316)	-0.00403 (0.0179)	-0.00404 (0.00609)	-0.00674 (0.00967)	0.00230 (0.0167)	-0.0378 (0.0286)
<b>Enforcement x Laws</b>	7.79e-05 (6.42e-05)	5.71e-06 (0.000120)	0.000166 (0.000120)	3.25e-06 (5.38e-05)	4.31e-05 (0.000187)	9.16e-05 (0.000118)	6.82e-05 (0.000110)	-1.80e-05 (0.000183)	0.000693 (0.000491)
Observations	574	162	412	576	162	414	575	162	413
R-squared	0.082	0.234	0.097	0.067	0.235	0.073	0.068	0.235	0.083
Number of is	107	24	83	108	24	84	108	24	84
<b>Country sector and time dummies</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>
<b>Bootstrapped standard errors</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>

**Table C.4:** NO2 emissions without federalist countries

Note: Robust standard errors are in between brackets. \*\*\*, \*\*, \* denote statistical significance at a 1, 5 and 10 percent level, respectively. In the *is* dimension, *i* refers to country, *s* refers to the subject of the law (Air and Atmosphere, Env. Gen., Forestry, Water, etc.) \*Openness and Income are predicted values from the instrumental-variable first stage.

SO2 EMISSIONS WITHOUT FEDERALIST COUNTRIES									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
LAWS		Environment gen.			Energy			Air and atmos.	
Countries	all	OECD	NON-OECD	all	OECD	NON-OECD	all	OECD	NON-OECD
VARIABLES	ln(SO2pc)	ln(SO2pc)	ln(SO2pc)	ln(SO2pc)	ln(SO2pc)	ln(SO2pc)	ln(SO2pc)	ln(SO2pc)	ln(SO2pc)
Ln(GDPpc)*	0.167 (0.174)	-0.0410 (0.174)	0.150 (0.202)	0.152 (0.181)	-0.0636 (0.164)	0.141 (0.205)	0.179 (0.171)	-0.0208 (0.164)	0.172 (0.203)
Ln(GDPpc) <sup>2</sup> *	-0.00406 (0.0105)	-0.0448 (0.0340)	0.00794 (0.0130)	-0.00241 (0.0110)	-0.0414 (0.0329)	0.00754 (0.0133)	-0.000239 (0.0103)	-0.0381 (0.0309)	0.00931 (0.0142)
Openness	0.853 (1.208)	0.659 (1.881)	0.573 (1.303)	0.770 (1.165)	0.876 (1.855)	0.567 (1.295)	0.779 (1.106)	0.805 (2.058)	0.468 (1.223)
Ln(POP)	0.816 (0.778)	0.191 (1.695)	0.688 (1.001)	1.001 (0.795)	0.991 (1.995)	0.915 (0.999)	0.684 (0.792)	0.277 (1.650)	0.774 (1.035)
Enforcement (Gover. Effect.)	-0.00724 (0.00640)	-0.00278 (0.00951)	-0.00932 (0.00708)	-0.00540 (0.00625)	0.00250 (0.00838)	-0.00849 (0.00710)	-0.00720 (0.00592)	-0.000304 (0.00830)	-0.00961 (0.00637)
Environmental Laws	<b>-0.00891*</b> (0.00486)	<b>-0.0202**</b> (0.00978)	-0.0107 (0.00835)	-0.000269 (0.00307)	-0.0288 (0.0205)	-0.00534 (0.00527)	<b>-0.0256**</b> (0.0103)	<b>-0.0315*</b> (0.0174)	<b>-0.0430*</b> (0.0256)
Enforcement x Laws	8.05e-05 (5.98e-05)	<b>0.000227**</b> (0.000109)	0.000123 (0.000127)	-1.28e-05 (5.21e-05)	0.000328 (0.000226)	9.29e-05 (0.000115)	<b>0.000260**</b> (0.000119)	<b>0.000355*</b> (0.000193)	0.000692 (0.000475)
Observations	572	162	410	574	162	412	575	162	413
R-squared	0.098	0.525	0.094	0.081	0.505	0.080	0.098	0.518	0.090
Number of is	107	24	83	107	24	83	108	24	84
Country sector and time dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES
Bootstrapped standard errors	YES	YES	YES	YES	YES	YES	YES	YES	YES

Table C.5: SO2 emissions without federalist countries

Note: Robust standard errors are in between brackets. \*\*\*, \*\*, \* denote statistical significance at a 1, 5 and 10 percent level, respectively. In the *is* dimension, *i* refers to country, *s* refers to the subject of the law (Air and Atmosphere, Env. Gen., Forestry, Water, etc.) \*Openness and Income are predicted values from the instrumental-variable first stage.

PM2.5 EMISSIONS WITHOUT FEDERALIST COUNTRIES									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
LAWS	Environment gen.			Energy			Air and atmos.		
Countries	all	OECD	NON-OECD	all	OECD	NON-OECD	all	OECD	NON-OECD
VARIABLES	ln(PMpc)	ln(PMpc)	ln(PMpc)	ln(PMpc)	ln(PMpc)	ln(PMpc)	ln(PMpc)	ln(PMpc)	ln(PMpc)
Ln(GDPpc)	-0.0363 (0.0253)	-0.0166 (0.0656)	-0.0445 (0.0294)	-0.0204 (0.0285)	-0.0287 (0.0655)	-0.0272 (0.0316)	-0.0268 (0.0286)	-0.0312 (0.0677)	-0.0421 (0.0343)
Ln(GDPpc) <sup>2</sup>	-0.00291** (0.00139)	-0.00448 (0.00578)	-0.000737 (0.00175)	-0.00367*** (0.00139)	-0.00700 (0.00561)	-0.00133 (0.00177)	-0.00418*** (0.00132)	-0.00497 (0.00578)	-0.00187 (0.00173)
Openness	0.0977 (0.200)	-0.640 (0.917)	0.106 (0.416)	0.00448 (0.191)	-0.488 (0.941)	-0.0337 (0.419)	0.0952 (0.201)	-0.322 (0.940)	0.132 (0.309)
Ln(POP)	0.639*** (0.123)		0.766*** (0.175)	0.610*** (0.129)		0.730*** (0.171)	0.585*** (0.126)		0.768*** (0.151)
Enforcement (Gover. Effect.)	<b>0.00264**</b> (0.00103)	0.00629* (0.00350)	<b>0.00228**</b> (0.00114)	<b>0.00223**</b> (0.00106)	0.00419 (0.00304)	0.00186 (0.00116)	<b>0.00211**</b> (0.000992)	<b>0.00621*</b> (0.00326)	<b>0.00184*</b> (0.00104)
Environmental Laws	<b>0.00336***</b> (0.00112)	-0.000437 (0.00237)	<b>0.00378**</b> (0.00149)	<b>0.00290***</b> (0.00111)	-0.00276 (0.00372)	0.00267 (0.00186)	<b>0.00788**</b> (0.00380)	-0.000120 (0.00355)	<b>0.0193***</b> (0.00605)
Enforcement x Laws	<b>-4.85e-05***</b> (1.44e-05)	-1.73e-06 (2.66e-05)	<b>-5.70e-05**</b> (2.70e-05)	<b>-4.52e-05***</b> (1.58e-05)	2.32e-05 (4.40e-05)	-4.21e-05 (3.28e-05)	<b>-0.000104**</b> (4.80e-05)	-6.70e-06 (3.97e-05)	<b>-0.000301***</b> (0.000103)
Observations	317	92	225	314	92	222	317	92	225
R-squared	0.711	0.877	0.681	0.711	0.878	0.677	0.705	0.877	0.706
Number of is	105	24	81	102	24	78	105	24	81
Country sector and time dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES
Bootstrapped standard errors	YES	YES	YES	YES	YES	YES	YES	YES	YES

Table C.6: PM2.5 emissions without federalist countries

Note: Robust standard errors are in between brackets. \*\*\*, \*\*, \* denote statistical significance at a 1, 5 and 10 percent level, respectively. In the *is* dimension, *i* refers to country, *s* refers to the subject of the law (Air and Atmosphere, Env. Gen., Forestry, Water, etc.) \*Openness and Income are predicted values from the instrumental-variable first stage.

WATER POLLUTION WITHOUT FEDERALIST COUNTRIES									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
<b>LAWS</b>	<b>Environment gen.</b>				<b>Water</b>		<b>Waste and hazardous substances</b>		
<b>Countries</b>	<b>all</b>	<b>OECD</b>	<b>NON-OECD</b>	<b>all</b>	<b>OECD</b>	<b>NON-OECD</b>	<b>all</b>	<b>OECD</b>	<b>NON-OECD</b>
<b>VARIABLES</b>	ln(Wat.poll.pc)	ln(Wat.poll.pc)	ln(Wat.poll.pc)	ln(Wat.poll.pc)	ln(Wat.poll.pc)	ln(Wat.poll.pc)	ln(Wat.poll.pc)	ln(Wat.poll.pc)	ln(Wat.poll.pc)
Ln(GDPpc)	0.0380 (0.0773)	0.0104 (0.109)	-0.0308 (0.131)	0.0315 (0.0762)	0.00126 (0.118)	-0.0546 (0.116)	0.0366 (0.0777)	0.00630 (0.110)	-0.0238 (0.136)
Ln(GDPpc) <sup>2</sup>	-0.000377 (0.00907)	-0.0175 (0.0155)	0.00672 (0.0143)	-0.00318 (0.00881)	-0.0225 (0.0153)	0.00362 (0.0126)	-0.00127 (0.00860)	-0.0156 (0.0160)	0.00632 (0.0124)
Openness	2.941** (1.153)	2.317 (3.499)	2.294 (1.735)	3.036** (1.201)	2.151 (3.324)	2.433 (1.691)	2.703*** (0.984)	2.731 (3.169)	2.067 (1.275)
Ln(POP)	-0.997 (0.740)	-0.959 (1.806)	-0.677 (0.974)	-1.037 (0.728)	-1.038 (1.941)	-0.556 (0.889)	-0.914 (0.709)	-0.978 (2.023)	-0.617 (0.903)
<b>Enforcement (Gover. Effect.)</b>	-0.000251 (0.00244)	0.00132 (0.00789)	-0.00103 (0.00364)	-0.000443 (0.00249)	-0.000838 (0.00762)	-0.00339 (0.00392)	0.000943 (0.00234)	0.00206 (0.00687)	-0.000647 (0.00320)
<b>Environmental Laws</b>	0.00256 (0.00202)	0.00746 (0.00965)	0.00139 (0.00336)	0.00250 (0.00327)	0.00312 (0.00783)	0.000827 (0.00597)	<b>0.00715**</b> (0.00306)	0.00744 (0.00645)	0.00681 (0.00918)
<b>Enforcement x Laws</b>	-2.55e-05 (2.64e-05)	-8.30e-05 (0.000112)	-1.11e-05 (7.35e-05)	-1.29e-05 (4.14e-05)	-2.07e-05 (9.60e-05)	4.19e-05 (0.000102)	<b>-7.68e-05**</b> (3.84e-05)	-7.64e-05 (7.28e-05)	-7.94e-05 (0.000132)
Observations	214	101	113	214	101	113	216	101	115
R-squared	0.282	0.458	0.220	0.285	0.456	0.240	0.296	0.481	0.213
Number of is	53	22	31	53	22	31	53	22	31
<b>Country sector and time dummies</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>
<b>Bootstrapped standard errors</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>

**Table C.7:** Water pollution without federalist countries

Note: Robust standard errors are in between brackets. \*\*\*, \*\*, \* denote statistical significance at a 1, 5 and 10 percent level, respectively. In the *is* dimension, i refers to country, s refers to the subject of the law (Air and Atmosphere, Env. Gen., Forestry, Water, etc.) \*Openness and Income are predicted values from the instrumental-variable first stage.

FOREST AREA WITHOUT FEDERALIST COUNTRIES									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
LAWS	Environment gen.			Forestry			Land and Soil		
Countries	all	OECD	NON-OECD	all	OECD	NON-OECD	all	OECD	NON-OECD
VARIABLES	ln(Forestpc)	ln(Forestpc)	ln(Forestpc)	ln(Forestpc)	ln(Forestpc)	ln(Forestpc)	ln(Forestpc)	ln(Forestpc)	ln(Forestpc)
Ln(GDPpc)	0.0227 (0.0274)	-0.0190 (0.0299)	0.0349 (0.0305)	0.0284 (0.0271)	-0.0138 (0.0288)	0.0424 (0.0267)	0.0144 (0.0254)	-0.00824 (0.0277)	0.0232 (0.0281)
Ln(GDPpc) <sup>2</sup>	-0.00257 (0.00223)	-0.000231 (0.00288)	-0.00516* (0.00294)	-0.00309 (0.00208)	0.000490 (0.00276)	-0.00571** (0.00263)	-0.00109 (0.00235)	-1.00e-05 (0.00289)	-0.00393 (0.00319)
Openness	-0.152 (0.320)	-0.0856 (0.204)	-0.133 (0.521)	-0.139 (0.290)	-0.0904 (0.258)	-0.104 (0.533)	-0.171 (0.336)	-0.135 (0.246)	-0.135 (0.557)
Ln(POP)	1.226*** (0.126)	0.920*** (0.131)		1.226*** (0.135)	0.959*** (0.141)		1.235*** (0.138)	0.980*** (0.140)	
Enforcement (Gover. Effect.)	-0.000845* (0.000497)	-0.000126 (0.00105)	-0.00164** (0.000721)	-0.00135** (0.000538)	0.000309 (0.00115)	-0.00206*** (0.000691)	-0.000286 (0.000591)	0.000143 (0.00112)	-0.000855 (0.000783)
Environmental Laws	-0.00151* (0.000780)	0.00177 (0.00135)	-0.00285** (0.00113)	-0.00437*** (0.00147)	0.00259 (0.00222)	-0.00622*** (0.00176)	0.000394 (0.000687)	0.00151 (0.00213)	0.000222 (0.000935)
Enforcement x Laws	2.10e-05** (9.97e-06)	-1.71e-05 (1.56e-05)	4.59e-05** (1.80e-05)	5.95e-05*** (1.99e-05)	-2.81e-05 (2.49e-05)	9.28e-05*** (2.57e-05)	-2.20e-06 (8.39e-06)	-1.62e-05 (2.14e-05)	5.41e-06 (1.55e-05)
Observations	546	161	385	547	161	386	549	161	388
R-squared	0.691	0.633	0.712	0.703	0.595	0.728	0.683	0.595	0.701
Number of is	104	24	80	105	24	81	105	24	81
Country sector and time dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES
Bootstrapped standard errors	YES	YES	YES	YES	YES	YES	YES	YES	YES

**Table C.8:** Forest area without federalist countries

Note: Robust standard errors are in between brackets. \*\*\*, \*\*, \* denote statistical significance at a 1, 5 and 10 percent level, respectively. In the *is* dimension, *i* refers to country, *s* refers to the subject of the law (Air and Atmosphere, Env. Gen., Forestry, Water, etc.) \*Openness and Income are predicted values from the instrumental-variable first stage.

NO2 EMISSIONS LAGGED ENVIRONMENTAL LAWS									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
LAWS	Environment gen.				Energy			Air and atmos.	
Countries	all	OECD	NON-OECD	all	OECD	NON-OECD	all	OECD	NON-OECD
VARIABLES	ln(NO2pc)	ln(NO2pc)	ln(NO2pc)	ln(NO2pc)	ln(NO2pc)	ln(NO2pc)	ln(NO2pc)	ln(NO2pc)	ln(NO2pc)
Ln(GDPpc)*	0.732 (0.814)	0.581 (0.981)	0.789 (1.153)	0.699 (0.830)	0.432 (1.030)	0.771 (1.164)	0.729 (0.767)	0.535 (1.042)	0.840 (1.184)
Ln(GDPpc) <sup>2</sup> *	0.0558 (0.0731)	0.0566 (0.109)	0.0616 (0.0913)	0.0544 (0.0749)	0.0405 (0.114)	0.0609 (0.0916)	0.0564 (0.0681)	0.0510 (0.115)	0.0650 (0.0934)
Openness	1.234 (1.216)	0.252 (1.166)	1.053 (2.363)	1.221 (1.403)	0.312 (1.134)	1.084 (2.694)	1.224 (1.384)	0.280 (1.286)	1.075 (2.350)
Ln(POP)	1.134 (0.982)	-0.275 (0.569)	0.851 (1.098)	1.421 (0.970)	-0.426 (0.618)	1.273 (1.141)	1.232 (0.929)	-0.291 (0.613)	1.128 (1.104)
Enforcement (Gover. Effect.)t-1	-0.00280 (0.00447)	<b>0.00687*</b> (0.00407)	-0.00446 (0.00535)	-0.00158 (0.00427)	<b>0.00752**</b> (0.00365)	-0.00345 (0.00513)	-0.00311 (0.00459)	<b>0.00696*</b> (0.00379)	-0.00494 (0.00592)
Environmental Laws t-1	-0.00504 (0.00330)	0.00443 (0.00463)	<b>-0.00844*</b> (0.00494)	0.000397 (0.00488)	0.0123 (0.00851)	-0.00419 (0.00710)	<b>-0.0156*</b> (0.00864)	0.00822 (0.00776)	<b>-0.0406**</b> (0.0201)
Enforcement x Laws t-1	2.29e-05 (3.66e-05)	-4.82e-05 (4.84e-05)	7.36e-05 (6.98e-05)	-4.61e-05 (6.12e-05)	-0.000137 (8.70e-05)	4.71e-05 (0.000138)	0.000124 (9.35e-05)	-8.56e-05 (8.10e-05)	<b>0.000601*</b> (0.000338)
Observations	572	178	394	576	178	398	572	178	394
R-squared	0.077	0.330	0.100	0.065	0.343	0.081	0.073	0.331	0.094
Number of is	122	31	91	122	31	91	122	31	91
Country sector and time dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES
Bootstrapped standard errors	YES	YES	YES	YES	YES	YES	YES	YES	YES

**Table C.9:** NO2 emissions lagged environmental laws

Note: Robust standard errors are in between brackets. \*\*\*, \*\*, \* denote statistical significance at a 1, 5 and 10 percent level, respectively. In the *is* dimension, *i* refers to country, *s* refers to the subject of the law (Air and Atmosphere, Env. Gen., Forestry, Water, etc.) \*Openness and Income are predicted values from the instrumental-variable first stage.

SO2 EMISSIONS LAGGED ENVIRONMENTAL LAWS									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
LAWS	Environment gen.			Energy			Air and atmos.		
Countries	all	OECD	NON-OECD	all	OECD	NON-OECD	all	OECD	NON-OECD
VARIABLES	ln(SO2pc)	ln(SO2pc)	ln(SO2pc)	ln(SO2pc)	ln(SO2pc)	ln(SO2pc)	ln(SO2pc)	ln(SO2pc)	ln(SO2pc)
Ln(GDPpc)*	0.0891 (0.159)	0.113 (0.0797)	0.0385 (0.182)	0.0798 (0.164)	0.0867 (0.0813)	0.0341 (0.198)	0.0868 (0.163)	0.0894 (0.0819)	0.0399 (0.189)
Ln(GDPpc) <sup>2</sup> *	-0.0192* (0.0106)	-0.0645** (0.0285)	-0.00341 (0.0147)	-0.0171 (0.0112)	-0.0572* (0.0306)	-0.00225 (0.0151)	-0.0182* (0.0108)	-0.0544* (0.0299)	-0.00309 (0.0147)
Openness	0.872 (1.329)	1.402 (2.021)	0.617 (1.928)	0.885 (1.324)	1.118 (1.922)	0.651 (1.724)	0.934 (1.367)	1.176 (1.701)	0.623 (1.168)
Ln(POP)	1.071 (0.731)	-1.228 (0.912)	1.087 (0.856)	1.268* (0.711)	-0.464 (1.109)	1.299 (0.878)	0.972 (0.702)	-1.057 (0.983)	1.180 (0.899)
Enforcement (Gover. Effect.)t-1	-0.00150 (0.00348)	-0.00995 (0.00727)	-0.00311 (0.00401)	-0.000399 (0.00349)	-0.00232 (0.00709)	-0.00271 (0.00425)	-0.00248 (0.00358)	-0.00516 (0.00689)	-0.00500 (0.00414)
Environmental Laws t-1	-0.00535 (0.00372)	<b>-0.0275***</b> (0.00857)	-0.00639 (0.00477)	-0.00215 (0.00379)	<b>-0.0402*</b> (0.0209)	-0.00666 (0.00599)	<b>-0.0268***</b> (0.00879)	<b>-0.0399*</b> (0.0209)	<b>-0.0432**</b> (0.0193)
Enforcement x Laws t-1	4.03e-05 (4.31e-05)	<b>0.000305***</b> (9.40e-05)	7.52e-05 (7.74e-05)	-7.50e-06 (5.73e-05)	<b>0.000446**</b> (0.000223)	0.000104 (0.000122)	<b>0.000267***</b> (9.61e-05)	<b>0.000441*</b> (0.000226)	<b>0.000702**</b> (0.000338)
Observations	571	178	393	573	178	395	575	178	397
R-squared	0.101	0.575	0.095	0.092	0.528	0.088	0.115	0.547	0.107
Number of is	121	31	90	123	31	92	123	31	92
Country sector and time dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES
Bootstrapped standard errors	YES	YES	YES	YES	YES	YES	YES	YES	YES

Table C.10: SO2 emissions lagged environmental laws

Note: Robust standard errors are in between brackets. \*\*\*, \*\*, \* denote statistical significance at a 1, 5 and 10 percent level, respectively. In the *is* dimension, *i* refers to country, *s* refers to the subject of the law (Air and Atmosphere, Env. Gen., Forestry, Water, etc.) \*Openness and Income are predicted values from the instrumental-variable first stage.



PM2.5 EMISSIONS LAGGED ENVIRONMENTAL LAWS									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
LAWS	Environment gen.				Energy			Air and atmos.	
Countries	all	OECD	NON-OECD	all	OECD	NON-OECD	all	OECD	NON-OECD
VARIABLES	ln(PM2.5pc)	ln(PM2.5pc)	ln(PM2.5pc)	ln(NO2pc)	ln(PM2.5pc)	ln(PM2.5pc)	ln(NO2pc)	ln(PM2.5pc)	ln(PM2.5pc)
Ln(GDPpc)*	0.0162 (0.0269)	0.00283 (0.0916)	0.00581 (0.0268)	0.00871 (0.0249)	-0.00881 (0.103)	0.000200 (0.0270)	0.0154 (0.0278)	-0.0223 (0.0998)	0.00198 (0.0264)
Ln(GDPpc) <sup>2</sup> *	-0.0105*** (0.00275)	-0.00960 (0.00889)	-0.00639* (0.00375)	-0.0106*** (0.00256)	-0.0108 (0.00798)	-0.00779** (0.00351)	-0.0110*** (0.00265)	-0.00793 (0.00949)	-0.00676* (0.00375)
Openness	-0.149 (0.215)	-1.079 (0.910)	-0.0874 (0.637)	-0.181 (0.211)	-1.016 (0.983)	-0.124 (0.617)	-0.152 (0.232)	-1.071 (0.945)	-0.0827 (0.708)
Ln(POP)	-0.838*** (0.144)	-1.045*** (0.294)		-0.775*** (0.132)	-0.964*** (0.308)		-0.783*** (0.135)	-1.032*** (0.314)	
Enforcement (Gover. Effect.) t-1	<b>0.00277**</b> (0.00123)	0.00446 (0.00321)	<b>0.00287**</b> (0.00146)	<b>0.00263**</b> (0.00117)	0.00330 (0.00324)	<b>0.00255*</b> (0.00142)	<b>0.00253**</b> (0.00122)	<b>0.00602*</b> (0.00336)	<b>0.00267**</b> (0.00132)
Environmental Laws t-1	0.000384 (0.000803)	-0.00224 (0.00171)	0.000595 (0.00146)	<b>0.00153*</b> (0.000854)	-0.00378 (0.00304)	0.00192 (0.00146)	0.00149 (0.00239)	-0.000871 (0.00342)	0.00469 (0.00582)
Enforcement x Laws t-1	-1.11e-05 (1.02e-05)	2.03e-05 (1.92e-05)	-1.81e-05 (2.63e-05)	<b>-2.38e-05*</b> (1.33e-05)	3.86e-05 (3.50e-05)	-3.26e-05 (2.98e-05)	-2.28e-05 (2.73e-05)	6.85e-06 (3.83e-05)	-8.88e-05 (0.000108)
Observations	278	90	188	277	90	187	278	90	188
R-squared	0.742	0.888	0.682	0.753	0.886	0.700	0.738	0.878	0.685
Number of is	114	31	83	113	31	82	114	31	83
Country sector and time dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES
Bootstrapped standard errors	YES	YES	YES	YES	YES	YES	YES	YES	YES

**Table C.11:** PM2.5 emissions lagged environmental laws

Note: Robust standard errors are in between brackets. \*\*\*, \*\*, \* denote statistical significance at a 1, 5 and 10 percent level, respectively. In the *is* dimension, *i* refers to country, *s* refers to the subject of the law (Air and Atmosphere, Env. Gen., Forestry, Water, etc.) \*Openness and Income are predicted values from the instrumental-variable first stage.

WATER POLLUTION LAGGED ENVIRONMENTAL LAWS									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
LAWS		Environment gen.			Water		Waste and hazardous substances		
Countries	all	OECD	NON-OECD	all	OECD	NON-OECD	all	OECD	NON-OECD
VARIABLES	ln(Wat.poll.pc)	ln(Wat.poll.pc)	ln(Wat.poll.pc)	ln(Wat.poll.pc)	ln(Wat.poll.pc)	ln(Wat.poll.pc)	ln(Wat.poll.pc)	ln(Wat.poll.pc)	ln(Wat.poll.pc)
Ln(GDPpc)*	0.0319 (0.0853)	0.00122 (0.105)	-0.0417 (0.143)	0.0328 (0.0832)	0.000816 (0.106)	-0.0699 (0.148)	0.0256 (0.0838)	-0.00226 (0.106)	-0.0414 (0.144)
Ln(GDPpc) <sup>2</sup> *	-0.00413 (0.0101)	-0.0330 (0.0203)	0.00532 (0.0146)	-0.00440 (0.00969)	-0.0324* (0.0169)	0.00453 (0.0141)	-0.00105 (0.00906)	-0.0287 (0.0185)	0.00383 (0.0133)
Openness	1.701 (1.150)	1.408 (4.928)	0.879 (1.693)	1.768 (1.149)	1.786 (4.178)	0.931 (1.825)	1.756 (1.137)	1.642 (4.330)	1.105 (1.596)
Ln(POP)	-0.446 (0.889)	11,616 (13,688)	0.206 (0.972)	-0.485 (0.844)	11,913 (11,912)	0.203 (1.019)	-0.373 (0.754)	11,736 (12,431)	0.225 (0.955)
Enforcement (Gover. Effect.) t-1	-0.00229 (0.00306)	-0.00652 (0.00767)	-0.00337 (0.00368)	-0.00191 (0.00297)	-0.00464 (0.00954)	-0.00401 (0.00437)	0.000434 (0.00266)	-0.00368 (0.00801)	-0.00183 (0.00338)
Environmental Laws t-1	-0.000199 (0.00316)	-0.00365 (0.0109)	1.22e-05 (0.00408)	0.000416 (0.00370)	0.000170 (0.00983)	3.42e-05 (0.00516)	<b>0.00929*</b> (0.00479)	0.00169 (0.00849)	0.00819 (0.00888)
Enforcement x Laws t-1	1.06e-05 (3.90e-05)	4.29e-05 (0.000125)	1.82e-05 (7.14e-05)	7.25e-06 (4.09e-05)	1.35e-05 (0.000108)	5.01e-05 (9.52e-05)	-9.97e-05* (5.60e-05)	-1.41e-05 (9.31e-05)	-5.92e-05 (0.000126)
Observations	198	95	103	198	95	103	199	95	104
R-squared	0.149	0.405	0.117	0.154	0.424	0.127	0.188	0.407	0.150
Number of is	58	26	32	58	26	32	59	26	33
Country sector and time dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES
Bootstrapped standard errors	YES	YES	YES	YES	YES	YES	YES	YES	YES

**Table C.12:** Water pollution lagged environmental laws

Note: Robust standard errors are in between brackets. \*\*\*, \*\*, \* denote statistical significance at a 1, 5 and 10 percent level, respectively. In the *is* dimension, *i* refers to country, *s* refers to the subject of the law (Air and Atmosphere, Env. Gen., Forestry, Water, etc.) \*Openness and Income are predicted values from the instrumental-variable first stage.

FOREST AREA LAGGED ENVIRONMENTAL LAWS									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
<b>LAWS</b>	<b>Environment gen.</b>				<b>Forestry</b>			<b>Land and soil</b>	
<b>Countries</b>	<b>all</b>	<b>OECD</b>	<b>NON-OECD</b>	<b>all</b>	<b>OECD</b>	<b>NON-OECD</b>	<b>all</b>	<b>OECD</b>	<b>NON-OECD</b>
<b>VARIABLES</b>	ln(Forestpc)	ln(Forestpc)	ln(Forestpc)	ln(Forestpc)	ln(Forestpc)	ln(Forestpc)	ln(Forestpc)	ln(Forestpc)	ln(Forestpc)
Ln(GDPpc)*	0.0356 (0.0301)	-0.00765 (0.0221)	0.0481 (0.0345)	0.0339 (0.0320)	0.00530 (0.0207)	0.0479 (0.0351)	0.0329 (0.0305)	-0.00236 (0.0220)	0.0456 (0.0368)
Ln(GDPpc) <sup>2</sup> *	0.000130 (0.00185)	0.000703 (0.00304)	-0.00152 (0.00245)	0.000467 (0.00184)	0.000206 (0.00301)	-0.00146 (0.00252)	0.000602 (0.00175)	0.000336 (0.00278)	-0.00140 (0.00242)
Openness	-0.202 (0.288)	-0.207 (0.170)	-0.176 (0.520)	-0.211 (0.303)	-0.164 (0.170)	-0.175 (0.547)	-0.205 (0.275)	-0.193 (0.196)	-0.166 (0.524)
Ln(POP)			-1.251*** (0.176)			-1.251*** (0.180)			-1.237*** (0.173)
<b>Enforcement (Gover. Effect.) t-1</b>	0.000628 (0.000577)	-7.10e-05 (0.000869)	0.000522 (0.000725)	0.000688 (0.000637)	0.000212 (0.00105)	0.000494 (0.000792)	0.000795 (0.000634)	0.000202 (0.00107)	0.000646 (0.000824)
<b>Environmental Laws t-1</b>	-0.000348 (0.000464)	0.000875 (0.00102)	-0.000405 (0.000722)	-0.000320 (0.00137)	0.00102 (0.00175)	-0.000512 (0.00195)	1.21e-05 (0.000669)	0.00114 (0.00126)	-9.22e-06 (0.000795)
<b>Enforcement x Laws t-1</b>	6.30e-06 (5.55e-06)	-9.46e-06 (1.17e-05)	8.58e-06 (1.13e-05)	5.89e-06 (1.55e-05)	-1.46e-05 (1.90e-05)	1.15e-05 (2.80e-05)	9.94e-07 (7.05e-06)	-1.29e-05 (1.34e-05)	2.76e-06 (1.12e-05)
Observations	552	179	373	546	179	367	551	179	372
R-squared	0.675	0.703	0.685	0.673	0.712	0.684	0.674	0.711	0.685
Number of is	119	31	88	117	31	86	118	31	87
<b>Country sector and time dummies</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>
<b>Bootstrapped standard errors</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>	<b>YES</b>

**Table C.13:** Forest area lagged environmental laws

Note: Robust standard errors are in between brackets. \*\*\*, \*\*, \* denote statistical significance at a 1, 5 and 10 percent level, respectively. In the *is* dimension, *i* refers to country, *s* refers to the subject of the law (Air and Atmosphere, Env. Gen., Forestry, Water, etc.) \*Openness and Income are predicted values from the instrumental-variable first stage.

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# **Commerce International et environnement : le rôle des réglementations environnementales**

## **Résumé**

Cette thèse contribue à la compréhension de la relation entre le commerce et l'environnement, en mettant l'accent sur le rôle de la réglementation environnementale entre pays. Trois essais abordent ce lien selon différentes perspectives.

Le premier chapitre analyse l'efficacité de la formalisation de la Convention de Bâle sur le commerce des déchets dangereux dans l'Union européenne (UE-WSR) puis sur les pays en développement, divisés en régions. Je construis un indice de réglementation environnementale, qui comprend notamment la qualité des institutions. Les résultats montrent peu de preuves d'un effet de havre de déchets dans les pays de l'UE les moins développés. Dans l'analyse régionale, il n'y a aucune preuve de l'efficacité de l'UE-WSR.

Le second chapitre étudie l'efficacité des accords internationaux sur l'environnement. Ce chapitre évalue les effets de la ratification et de l'adoption de ces accords sur les importations de produits chimiques dangereux et de polluants organiques persistants. Les résultats soulignent l'effet partiel de ces deux conventions. Plus précisément, lorsqu'on évalue un accord moins restrictif, les importations ne sont réduites que lorsque l'exportateur ratifie la convention. Lors de l'évaluation de l'interdiction des polluants organiques persistants, les importations sont réduites.

Le troisième examine l'effet de la réglementation environnementale sur les résultats environnementaux. Ce chapitre a pris en compte les déterminants de la pollution et une variable de réglementation environnementale composée de lois environnementales adoptées par les pays. Les résultats montrent que les lois environnementales ont un effet améliorant les résultats environnementaux. Cet effet est particulier aux résultats environnementaux et à la loi. Ainsi on met en question certaines conclusions antérieures tirées de la littérature sur l'effet bénéfique du commerce sur l'environnement.

**Mots-clefs:** Commerce international et environnement, traités internationaux et commerce, commerce de substances dangereuses, résultats environnementaux et réglementation environnemental.

# **Essays on International Trade, Capital Flows and Financial Frictions**

## **Abstract**

This thesis contributes to an understanding of the relationship between trade and the environment, with an emphasis on the role of environmental regulation among countries. Three essays deal with this link from different perspectives.

The first chapter analyses the effectiveness of the formalisation of the Basel Convention on trade in hazardous wastes in the European Union (EU-WSR), followed by developing countries, divided into regions. I build an environmental regulation index, which includes the quality of the institutions. The results show little evidence of a waste haven effect in the least developed EU countries. In the regional analysis, there is no evidence of the effectiveness of the EU-WSR.

The second chapter examines the effectiveness of international environmental agreements. This chapter assesses the effects of the ratification and adoption of these agreements on imports of hazardous chemicals and persistent organic pollutants. The results underline the partial effect of these two conventions. More specifically, when assessing a less restrictive arrangement, imports are reduced only when the exporter ratifies the agreement. In assessing the ban on persistent organic pollutants, imports are reduced.

The third examines the effect of environmental regulation on environmental outcomes. This chapter has taken into account the determinants of pollution and an environmental regulatory variable composed of environmental laws adopted by countries. The results show that environmental laws have an effect improving environmental outcomes. This effect is unique to environmental outcomes and to the law. Thus, some previous conclusions drawn from the literature on the beneficial effect of trade on the environment are questioned.



**Keywords:** International trade and environment, international treaties and trade, trade in dangerous substances, environmental outcomes and environmental regulations.