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THESE

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Environmental Regulation, Foreign Direct Investment and Pollution

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À mes chers parents

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Résumé en français

"[...] Les pays les moins développés qui choisiraient de ne pas imposer de contraintes sur leur pollution locale, et ce dans le but d'améliorer leur compétitivité internationale, deviendraient volontairement les entrepôts des industries polluantes du monde entier ". Baumol et Oates, 1988, p 265.

Cette affirmation correspond à l'une des conclusions essentielles du travail majeur de Baumol et Oates relatif à l'examen des implications internationales de la protection environnementale. Toutefois, après plus de vingt années d'études, les choses se sont révélées être plus complexes.

L'un des principaux sujets de discorde entre partisans et adversaires de la mondialisation porte sur les questions environnementales. Ainsi, les implications internationales de la protection environnementale et l'impact environnemental de la libéralisation accrue des échanges ont suscité et continuent de soulever des protestations de la part des divers acteurs concernés. Selon l'intérêt des parties impliquées, les protestations sont respectivement d'ordre commercial ou bien environnemental, et dans ce travail nous étudions les deux aspects du problème.

Récemment, de nombreux exemples ont contribué à alimenter le débat houleux entre les parties prenantes. En France, dix organisations non gouvernementales, dont Greenpeace, le WWF et Les amis de la Terre, ont adressé une lettre de protestation au président Nicolas Sarkozy quand il décida en mars 2010 d'abandonner la

taxe carbone. La Secrétaire d'État chargée de l'écologie, ainsi que le parti écologiste des Verts initialement opposé à la réforme car la jugeant écologiquement inefficace et socialement injuste, ont également été très critiques envers le président français. Cependant, pour justifier sa décision, Nicolas Sarkozy déclara: "Nous n'imposerons pas à nos industriels des contraintes si, dans le même temps, on autorise les importations venant de pays qui ne respectent aucune des règles environnementales à inonder nos marchés"[1]. Cet argument illustre parfaitement un aspect stratégique du débat, à savoir l'interdépendance entre les politiques environnementale et commerciale. Ceci n'est pas sans nous rappeler des discussions antérieures tenues à un moment où la pollution était en forte hausse et où le débat entre commerce et environnement était attisé par les négociations relatives à l'Accord de Libre-Échange Nord-Américain (ALENA) et par une série de différends commerciaux liés à l'environnement et portés devant le General Agreement on Tariffs and Trade (GATT)[2]. Cet argument nous remémore également la réaction des écologistes protestant contre les effets environnementaux d'un accroissement du commerce mondial lors de la création de l'Organisation Mondiale du Commerce (OMC).

L'exemple de l'ALENA est très significatif ; en effet, la principale crainte du moment était que les normes environnementales moins strictes du Mexique lui confèrent un avantage comparatif dans les biens à forte intensité polluante et engendrent une catastrophe environnementale dans le pays suite à l'arrivée massive d'industries polluantes. Ainsi, la préoccupation était triple et concernait :

- la disparité entre les régulations environnementales

- l'impact de ces dernières sur la spécialisation internationale et la localisation

[1] Le Figaro Magazine, 12 mars 2010.

[2] Un exemple bien connu est celui de l'embargo décidé par les États-Unis en 1988 sur l'importation du thon pêché par les pays de la zone orientale de l'océan Pacifique oriental qui ne respectaient pas les normes imposées aux pêcheurs des États-Unis en vue de protéger les dauphins.

des industries polluantes

- l'impact environnemental de la migration des industries polluantes

Cet exemple résume les principales questions relatives à la relation entre la libéralisation du commerce et des investissements et l'environnement dans les économies ouvertes. Dans ce travail, nous examinons ces trois questions. Cependant, pour le troisième aspect de la relation entre commerce et environnement, à savoir l'impact environnemental des mécanismes en jeu, nous focaliserons notre analyse sur le problème de la pollution. D'autres graves problèmes environnementaux tels que la déforestation au Brésil ou encore l'épuisement des ressources naturelles ne sont pas étudiés ici car ils nécessiteraient de faire l'objet d'une analyse séparée.

La régulation environnementale a évolué différemment selon les pays, et ces différences sont particulièrement prononcées entre les pays développés et les pays en voie de développement. Tandis que les États-Unis et l'Europe ont adopté leurs principales lois au début des années soixante-dix, le reste du monde n'a commencé à se préoccuper des questions environnementales qu'à partir des années quatre-vingt-dix. Ainsi, au milieu des années soixante-dix, Pethig (1976), Siebert (1977) et McGuire (1982) ont été parmi les premiers chercheurs à étudier les conséquences de telles différences de rigueur de la régulation environnementale, en se concentrant sur la théorie de l'avantage comparatif. Ces auteurs ont démontré à l'aide de modèles standards de commerce international (modèle de Ricardo ou Heckscher-Ohlin), que les pays dont la régulation environnementale était relativement faible tendaient à exporter les biens dont la production était intensive en ressources environnementales, tandis que les pays les plus stricts tendaient à exporter les biens dont la production était relativement moins intensive en ressources environnementales. Cependant, malgré ces résultats quelque peu déconcertants, l'intérêt porté par l'opinion publique

et les chercheurs à ces questions a décliné dans les années quatre-vingt. Il ne s'est ravivé que dix ans plus tard, lorsque le véritable débat entre commerce et environnement s'est relancé avec la signature de l'ALENA et la création de l'OMC. Tel que suggéré précédemment, un des aspects les plus importants de ce débat concerne l'impact de la régulation environnementale sur la compétitivité internationale et sur la localisation des industries polluantes. La crainte est que les régulations environnementales affectent la localisation des industries, et que les différences de régulation entre les pays du Nord plus stricts, et les pays du Sud moins sévères, impliquent non seulement une spécialisation du Sud dans les productions polluantes, mais très probablement le déplacement des industries les plus polluantes des pays du Nord vers le Sud. Ce raisonnement correspond dans la littérature économique à l'*Hypothèse de Pollution Haven*, qui est au cœur de notre travail.

Régulations environnementales inégales

Ainsi, la phrase de Nicolas Sarkozy citée plus haut, et prononcée quinze ans après la reprise du débat, laisse à penser que les choses n'ont pas changé et que ce débat est toujours d'actualité, voire même s'est intensifié. Malgré les progrès réalisés à travers le monde ces dix dernières années, les écarts entre les pays demeurent encore bien larges et entretiennent le débat. Dans certains pays en voie de développement par exemple, les industries très polluantes bénéficient souvent de conditions spéciales et ne sont de ce fait pas affectées par les régulations (exemple de l'industrie minière en Indonésie et au Zimbabwe). Dans d'autres pays, les lois sont adoptées mais ne sont pas appliquées. L'existence de différents niveaux de régulations à travers le monde est donc une réalité commune aux années mille neuf cent quatre-vingt dix et à celles d'aujourd'hui. Cette thèse montre que de nos jours, les régulations environnementales revêtent plusieurs formes, et qu'une distinction trop schématique

entre les pays du Nord et les pays du Sud n'est plus appropriée pour différencier les pays les plus régulés des pays les plus laxistes. De plus, nous démontrerons qu'au sein même d'un seul pays, la rigueur des régulations diffère en fonction du risque environnemental envisagé.

Firmes multinationales et investissement direct à l'étranger

En réalité, un phénomène nouveau est tout de même apparu et ne cesse de s'intensifier depuis les premières protestations et la mise en place de l'ALENA: la mobilité internationale des firmes. Ce phénomène grandissant se mesure à travers la croissance des activités des firmes multinationales (FMNs). Par définition, les firmes multinationales opèrent dans plusieurs pays à travers leurs filiales étrangères[3]. La meilleure façon d'appréhender leur activité serait d'utiliser des données individuelles d'entreprises indiquant le nombre d'employés des filiales ou encore le montant de leurs ventes. Cependant, ces données d'entreprises n'étant pas diffusées à grande échelle, les chercheurs ont souvent recours aux données de flux d'investissements directs à l'étranger (IDE) pour mesurer l'internationalisation des activités des firmes multinationales. Selon les définitions du Fonds Monétaire International (FMI) et de l'Organisation de Coopération et de Développement Économiques (OCDE), l'investissement direct à l'étranger est l'investissement d'une compagnie dans une entreprise résidente dans un autre pays que le sien, à travers lequel l'investisseur étranger détiendrait au moins 10% du capital ou des droits de vote de l'entreprise investie, de manière à établir un intérêt durable et exercer une influence significative dans la gestion de l'entreprise. Ainsi, les flux d'IDE se distinguent des investissements de portefeuille, ces derniers n'impliquant ni la notion

[3] Selon les recommandations du Fonds Monétaire International et de l'Organisation de Coopération et de Développement Économiques, une firme étrangère peut être considérée comme une filiale étrangère si l'investisseur étranger détient plus de la moitié des droits de vote.

de propriété ni celle du pouvoir de décision de l'investisseur étranger.

Depuis les années quatre-vingt, les pays ont cherché à attirer les IDE en rendant leurs politiques plus favorables aux investisseurs étrangers. Cette tendance s'est accentuée dans les années mille neuf cent quatre-vingt dix. La Conférence des Nations Unies sur le Commerce et le Développement (CNUCED) a reporté, pour la période 1991-1999, mille trente cinq modifications de lois à travers le monde, dont 94% étaient en faveur des investisseurs étrangers. En 1999, les pays en voie de développement et les pays en transition ont libéralisé les opérations d'industries jusque là inaccessibles ou du moins restreintes pour les IDE. Parmi ces industries figuraient l'industrie pétrolière, l'industrie minière, l'industrie énergétique et l'industrie pharmaceutique. De nos jours, l'investissement direct à l'étranger joue un rôle croissant dans l'économie mondiale[4]. En 2007, le montant global des IDE entrants a dépassé le dernier record enregistré en 2000, et a été estimé à 1,5 milliard de dollars[5]. De même, le nombre de filiales étrangères dans le monde a considérablement augmenté. Les ventes de ces filiales sont passées de 3 milliards de dollars en 1980 à 14 milliards de dollars en 1999, représentant environ le double du montant des exportations totales en 1999. En 2004, les ventes totales des filiales ont presque atteint les 19 milliards de dollars[6].

Les deux situations que nous venons d'exposer, à savoir d'une part des régulations environnementales inégales entre les pays, d'autre part une augmentation des activités des firmes multinationales mesurée à travers la croissance du nombre de filiales et des IDE, sont propices à l'étude de l'hypothèse de *pollution haven*. Dans ce travail, nous examinons ainsi l'hypothèse de *pollution haven* en nous intéressant

[4]Source : UNCTAD, 2001.
[5]Source : UNCTAD, 2008.
[6]Source : UNCTAD, 2005.

tour à tour à la localisation des filiales à l'étranger et au montant des IDE[7].

Régulation environnementale et localisation des firmes

Une des principales justifications de l'hypothèse de *pollution haven* réside dans le fait qu'en imposant des équipements spécifiques, en limitant l'usage de certaines ressources, ou encore en appliquant des sanctions en cas de non-conformité, des régulations environnementales rigoureuses augmentent les coûts de production des entreprises, réduisant ainsi leur compétitivité. La littérature sur les IDE et sur la localisation des firmes multinationales considère la recherche du moindre coût comme un des premiers déterminants des IDE et de la multinationalisation des firmes. Dans le cadre de l'hypothèse de *pollution haven* et dans une logique d'avantage comparatif, il paraît ainsi évident qu'une entreprise qui a la possibilité de se déplacer choisira de se localiser dans les pays dont les régulations environnementales sont les moins strictes afin de réduire ses coûts de production et d'être plus compétitive. Cette hypothèse a été démontrée théoriquement dans des analyses en équilibre général menées par Pethig (1976), Siebert (1977), McGuire (1982) et Baumol et Oates (1988), dans lesquelles la différence de coûts environnementaux était l'unique déterminant des IDE et suffisait donc à inciter les firmes à se délocaliser. Toutefois, certaines études stipulent que les coûts environnementaux ne représentent qu'un faible pourcentage des coûts de production totaux, et ne suffisent donc pas à entraîner le déplacement des firmes. De plus, cette hypothèse est contredite par une hypothèse alternative énoncée par Porter (1991) et Porter et van der Linde (1995) : l'hypothèse de Porter. Celle-ci stipule au contraire que des régulations environnementales plus strictes sont bénéfiques à l'environnement et favorables à la compétitivité des firmes car elles

[7] Une seconde approche de l'hypothèse de pollution haven, non abordée dans ce travail, consiste à observer les données du commerce international. Néanmoins, nous passerons en revue certains exemples de cette approche dans le Chapitre 2 (Tobey, 1990 ; Levinson et Taylor, 2008).

sont une incitation à l'innovation, contribuant ainsi à l'amélioration de la qualité des produits ou à la réduction des coûts de production d'une firme. Il découle de l'hypothèse de Porter que les firmes ne seraient pas incitées à migrer suite à un renforcement des régulations environnementales. Une autre alternative théorique qui s'oppose à l'hypothèse de *pollution haven* est l'hypothèse des dotations factorielles (*Factor Endowment Hypothesis*). Cette hypothèse suppose que la structure des échanges et la spécialisation des pays sont plus susceptibles de résulter des avantages comparatifs traditionnels. L'hypothèse stipule que les industries polluantes étant également les industries les plus intensives en capital, elles sont plus à même de se localiser dans les pays relativement plus abondants en capital, à savoir les pays développés et régulés, tandis que les industries les moins polluantes et donc les moins intensives en capital ont tendance à se localiser dans les pays relativement moins abondants en capital, c'est à dire les pays en voie de développement dont les régulations environnementales sont les plus faibles. Par conséquent, les prédictions de l'hypothèse des dotations factorielles contrastent avec celles de l'hypothèse de *pollution haven* en suggérant que la régulation environnementale ne pourrait avoir tout au plus qu'une faible influence sur les structures des IDE ou du commerce. Ces différentes hypothèses théoriques aboutissant à des prédictions opposées, il apparaît clairement qu'une étude minutieuse de l'hypothèse de *pollution haven* requière d'une part une analyse théorique rigoureuse, d'autre part une évaluation empirique robuste. Dans cette thèse, afin de répondre à ces deux exigences, nous développons tout d'abord un modèle théorique adéquat de l'hypothèse de *pollution haven*, puis nous le testons empiriquement.

Le cadre théorique de l'hypothèse de *pollution haven* est celui de l'analyse des déterminants de la localisation des firmes et des déterminants des investissements

directs à l'étranger. Plusieurs explications de l'internationalisation et des investissements directs à l'étranger ont été analysées dans la théorie des IDE. Les premiers travaux ayant introduit les mouvements de capitaux en économie internationale ne différenciaient pas les IDE des autres formes de mobilité internationale des capitaux. Les mouvements internationaux de capitaux étaient justifiés par des différences de taux d'intérêts entre les pays qui résultaient des différences de dotations factorielles (Mundell, 1957). Cette approche fondée sur la théorie des avantages comparatifs a réussi à expliquer les investissements directs des pays développés dans les pays en voie de développement jusque dans les années soixante-dix. Cependant, depuis les années quatre-vingt, la part des IDE entre pays développés s'est considérablement accrue, et cette nouvelle structure des IDE ne peut plus s'expliquer par la seule théorie classique du commerce international et des IDE. Une des raisons est que de nos jours, le capital étant largement disponible au niveau international, l'exploitation d'un différentiel de coût des facteurs ne peut plus constituer l'explication centrale de la multinationalisation des firmes et de la structure des IDE. D'ailleurs, les statistiques d'investissements directs provenant des balances de paiement des pays recensent l'ensemble des opérations financières transfrontières au sein des groupes multinationaux (financement de nouveaux investissements, prêts inter-firmes, bénéfices réinvestis, fusions-acquisitions)[8]. L'apport de capital associé à ces investissements n'est donc pas très important. En conséquence, il est plus juste de considérer que l'IDE est davantage un vecteur de transfert de connaissances et de savoir-faire qu'un simple mouvement international de capital. C'est plutôt la détention d'un avantage spécifique qui incite les entreprises multinationales à s'internationaliser. Ce facteur a été mis en évidence par l'approche éclectique développée par John

[8] L'investissement direct en balance des paiements est, pour cette raison, de plus en plus considéré comme un mauvais indicateur de l'activité des firmes multinationales. Cf. Chapitre 4.

Dunning (1977). Cette analyse globale des conditions d'existence des firmes multinationales, également appelée paradigme OLI, fait référence à trois facteurs explicatifs de l'investissement direct d'une entreprise : l'avantage spécifique de la firme (Ownership advantage), son avantage à la localisation à l'étranger (Localisation advantage), son avantage à l'internalisation (Internalization advantage). L'avantage spécifique correspond ainsi aux actifs spécifiques à la firme tels que la possession d'une technologie ou de compétences qui lui sont propres et qui lui permettent de compenser son désavantage lié au maintien de son activité à l'étranger[9]. Les explications théoriques de l'IDE renvoient souvent au paradigme OLI (Krugman, 1983; Helpman, 1984; Markusen, 1984) qui est resté central dans la théorie de l'investissement direct moderne. Par ailleurs, un arbitrage fondamental entre proximité géographique des clients et concentration des activités (et donc réalisation d'économies d'échelle) intervient dans l'explication des différentes stratégies d'expansion des firmes à l'étranger (exporter ou bien produire à l'étranger). Selon Brainard (1993), le résultat de cet arbitrage dépend du niveau des coûts de transport, et plus généralement des barrières à l'échange.

D'un point de vue empirique, une vision d'ensemble de la production internationale indique une concentration de la production dans les pays développés et dans certains pays en voie de développement, et une forte proportion d'IDE intra-industriel. Les approches en concurrence pure et parfaite ne parvenant pas à expliquer de telles structures, une analyse en concurrence imparfaite s'avère nécessaire.

[9] Selon le paradigme OLI, entreprendre un investissement direct ne peut profiter à une entreprise que si elle dispose d'un certain avantage spécifique (tel que le savoir-faire) qui lui conférerait un avantage par rapport aux entreprises locales, et qui compenserait les inconvénients de produire à l'étranger. De plus, la localisation choisie doit présenter un avantage de localisation non seulement par rapport au pays d'origine de l'entreprise désirant investir, mais aussi par rapport à toutes les autres localisations possibles. Enfin, il doit être plus profitable à l'entreprise d'internaliser son avantage spécifique plutôt que d'octroyer des licences pour l'exploitation d'une technologie par exemple.

De plus, on observe que ces mouvements internationaux concernent en grande partie les industries de biens différenciés. Enfin, tel que mentionné ci-dessus et confirmé par des tests menés par Brainard (1997), l'arbitrage proximité-concentration est une explication adaptée à la structure observée du commerce et des IDE. Tous ces éléments, ainsi que la distance qui joue un rôle majeur dans l'explication de la distribution spatiale des firmes, sont pris en compte par la Nouvelle Économie Géographique. Dans cette thèse, nous recourons donc à la Nouvelle Économie Géographique afin de fournir une modélisation théorique de l'hypothèse de *pollution haven*.

Impact des IDE sur les niveaux de pollution

L'exemple de l'ALENA mentionné plus haut dépeint les inquiétudes que cet accord a suscitées quant à ses effets potentiels sur la qualité de l'environnement au Mexique, inquiétudes dues à l'appréhension de voir migrer les industries polluantes des États-Unis vers le Mexique en réponse à la différence de rigueur environnementale entre les deux pays. Cette crainte relative aux dommages environnementaux constitue le troisième aspect fondamental de l'hypothèse de *pollution haven*. Pour autant, ce volet n'a été que peu étudié dans la littérature relative à l'hypothèse de *pollution haven*. Exception faite de He (2006) qui examine les impacts environnementaux des IDE dans les provinces chinoises, la plupart des travaux se sont plutôt évertués à tenter de trouver une solide preuve empirique de l'hypothèse. Plus récemment, les études se sont plutôt tournées vers la mise en évidence de l'*Effet de Pollution Haven* (*Pollution Haven Effect*). Contrairement à l'hypothèse de *pollution haven* qui stipule qu'une élévation des coûts environnementaux résultant d'un renforcement des régulations est l'unique motif du commerce et des IDE, et l'emporte sur tous les autres déterminants, l'effet de *pollution haven* prédit plus modestement un effet de dissuasion exercé par le durcissement des régulations environnementales

sur le commerce et les IDE. En d'autres termes, l'hypothèse de *pollution haven* suppose un impact plus important des régulations environnementales sur les flux internationaux que l'effet de *pollution haven*. Les implications économiques et politiques de l'hypothèse de *pollution haven* sont donc plus fortes que celles énoncées par l'effet de *pollution haven*. C'est pour cette raison que dans ce travail de recherche, nous nous sommes surtout attachés à tester l'hypothèse de *pollution haven* plutôt que l'effet de *pollution haven*. Nous utiliserons de ce fait plus fréquemment le terme d'hypothèse de *pollution haven* que nous envisageons comme un cadre d'analyse général englobant l'effet de *pollution haven*.

L'IDE répondant à des motivations de *pollution haven* peut avoir une incidence sur la qualité de l'environnement, et plus précisément sur les niveaux de pollution, à travers différents modes de transmission. Trois principaux déterminants de la pollution résultant de la libéralisation du commerce et des IDE ont été identifiés dans la littérature et sont désignés par l'effet d'échelle, l'effet de composition et l'effet technique. L'effet d'échelle fait référence à l'augmentation du niveau de production qui à son tour accroît la pollution. L'effet de composition désigne les changements de la structure de production d'une économie suite à sa spécialisation, et son impact sur les niveaux de pollution dépend donc de l'avantage comparatif du pays concerné. L'effet technique se rapporte à l'usage de technologies de production plus propres qui résultent de l'augmentation du revenu. L'effet global de la libéralisation du commerce et des IDE sur le niveau de pollution dépend finalement de l'interaction entre ces trois effets.

L'investissement direct à l'étranger peut être un vecteur de nouvelles technologies plus propres à même de réduire la pollution. Lorsqu'elles font face à des régulations strictes dans leur pays d'origine, les entreprises multinationales ont des incitations

fortes à innover afin d'améliorer leur efficacité ou de réduire leurs émissions polluantes. Il est rentable pour ces entreprises d'utiliser les mêmes technologies dans différents pays, y compris les pays où les lois sont plus faibles, afin d'augmenter leurs économies d'échelle. Si nous considérons la pollution globale, celle-ci n'est pas affectée par ces IDE puisque quelque soit l'endroit où l'investissement a lieu, l'impact est le même sur la pollution globale. En revanche, si nous considérons une pollution locale, les émissions polluantes, suite à l'accroissement d'activité induit par l'IDE, sont supposées augmenter à l'endroit où l'investissement se produit. Toutefois, si l'IDE dans le pays d'accueil se substitue à des installations de production locales plus polluantes et moins compétitives, la pollution globale tout comme la pollution locale dans le pays d'accueil s'en verront réduites.

De plus, par le biais de l'IDE, de nouvelles idées, technologies et pratiques de travail peuvent être transférées à des entreprises nationales, améliorant ainsi leur efficacité. Cette meilleure efficacité des entreprises locales provenant de *spillover* effects se traduirait ainsi par une réduction de la pollution locale et globale.

En revanche, si l'IDE est motivé par la recherche de normes environnementales moins contraignantes tel que suggéré par l'hypothèse de *pollution haven*, le comportement des multinationales dans les pays étrangers pourrait s'avérer moins vertueux et annihiler les impacts positifs décrits ci-dessus. Les exemples de dommages environnementaux provoqués par des firmes multinationales ne manquent pas. À titre d'illustration, les résultats préliminaires d'un rapport des Nations Unies à paraître (été 2010) relatif aux activités des 3000 plus grandes compagnies en 2008 prévoit que leurs profits diminueraient d'un tiers si ces firmes devaient payer pour les pertes et les dommages environnementaux qu'elles engendraient. L'étude estime ainsi que le dommage global s'était élevé à 2,2 milliards de dollars en 2008[10].

[10] *The Guardian*, 18 février 2010.

Finalement, afin d'être exhaustifs dans notre analyse des mécanismes de transmission de la pollution à travers l'IDE, et bien que cette question dépasse le cadre de ce travail, nous devons rappeler l'impact des activités de transport liées aux IDE sur les niveaux de pollution. Si l'IDE est réalisé pour des motifs d'accès au marché, cela peut entraîner une réduction des émissions de pollution résultant de la diminution des activités de transport. En revanche, dans le cas d'IDE verticaux où la production serait réexportée vers le pays d'origine, la pollution augmenterait en raison de ces transports supplémentaires de biens.

En résumé, les effets de l'IDE sur les niveaux de pollution sont complexes et l'impact global est incertain. La détermination de cet impact est en définitive une question empirique. Dans ce travail, nous examinons donc empiriquement l'impact des IDE sur les émissions de pollution dans les pays d'accueil. La pollution globale, qui contribue au changement climatique, est un problème environnemental et économique majeur auquel l'hypothèse de *pollution haven* est intimement liée. En effet, la crainte majeure inhérente à l'hypothèse de *pollution haven* est que les progrès accomplis dans les pays les plus stricts soient plus que compensés par l'augmentation de la pollution dans les pays les moins régulés. Cependant, l'examen empirique de la pollution globale est difficilement réalisable dans le cadre de cette thèse et nécessiterait des données dont nous ne disposons pas actuellement. La pollution locale est, quant à elle, une autre préoccupation majeure en raison des problèmes d'ordre environnemental, sanitaire et économique qu'elle pose dans les pays qui en souffrent. L'hypothèse de *pollution haven* a donc également suscité des craintes en matière de pollution locale, et c'est ce dernier aspect que nous approfondissons dans notre travail.

L'objectif de cette thèse est de participer au débat entre commerce et environnement en étudiant en profondeur les questions relatives à l'hypothèse de *pollution haven*. Nous examinons l'effet des régulations environnementales sur le choix de localisation des firmes d'un point de vue théorique et empirique. Nous explorons également l'impact des investissements directs à l'étranger sur les émissions de pollution.

Structure de la thèse

Avant de procéder à l'examen proprement dit de l'hypothèse de *pollution haven* dans les chapitres qui le suivent, dans le Chapitre 1 nous considérons l'évolution des politiques environnementales des pays. En effet, dans le cadre d'analyse de l'hypothèse de *pollution haven*, l'hétérogénéité des politiques environnementales est une condition nécessaire à la délocalisation des firmes et à l'émergence de l'hypothèse. Par conséquent, nous séparons les pays en quatre groupes en fonction de leur niveau de développement, et au sein de chaque groupe nous menons une analyse plus détaillée en examinant les politiques environnementales par type de pollution et en insistant sur certaines caractéristiques individuelles. Notre objectif est d'ajuster et affiner l'idée communément admise selon laquelle les pays développés du Nord ont les régulations environnementales les plus strictes, tandis que les pays en voie de développement du Sud sont beaucoup plus permissifs. Cet exercice confirme globalement la pertinence de la distinction habituelle faite entre pays développés et pays en voie de développement en l'établissant de manière plus concrète. De plus, il révèle que les pays émergents et les Pays d'Europe Centrale et Orientale (PECO) se trouvent dans une position intermédiaire. En effet, ces pays ont en général entrepris la réforme de leurs institutions et de leurs politiques environnementales depuis les années quatre-vingt-dix, mais les mesures décidées restent insuffisamment appliquées.

Ces résultats précis vont ainsi nous guider dans la suite de notre analyse et nous aider pour nos interprétations.

Le Chapitre 2 permet au lecteur de se familiariser avec le débat sur le commerce et l'environnement, puis propose une modélisation théorique de l'hypothèse de *pollution haven*. Nous présentons dans un premier temps les arguments théoriques en faveur de l'hypothèse de *pollution haven* puis nous exposons les questions et les craintes qu'elle suscite. Nous dressons ensuite une revue des analyses théoriques qui ont étudié cette hypothèse. Cet exercice met en évidence le manque de fondements théoriques dans la littérature afférente. En effet, bien que la littérature existante soit riche d'enseignements et ait apporté des éléments utiles à l'analyse, elle s'est essentiellement concentrée sur les différences de régulations environnementales entre les pays. Parmi les principales études de cette catégorie, nous avions cité précédemment les contributions majeures de Pethig (1976), McGuire (1982), Baumol et Oates (1988) qui ont utilisé des modèles standard de commerce international. Ce chapitre montre que ces modèles étaient trop restrictifs pour pouvoir appréhender toutes les questions liées à l'hypothèse de *pollution haven*, et qu'ils n'aboutissaient pas à une relation structurelle estimable entre la régulation environnementale et les structures de spécialisation. La revue des études empiriques menées à ce sujet souligne les progrès majeurs réalisés dans l'analyse empirique de l'hypothèse de *pollution haven*, mais révèle également des lacunes importantes. Ainsi, le Chapitre 2 met en exergue les raisons pour lesquelles après plus de trente années d'investigations et malgré les progrès réalisés tant au niveau théorique qu'empirique, les chercheurs ne sont toujours pas parvenus à apporter une preuve empirique claire de l'effet des régulations environnementales sur la décision de localisation des firmes.

Le manque de fondement théorique étant l'un des principaux problèmes rencon-

trés, nous proposons dans la suite du Chapitre 2 une modélisation théorique formelle de l'hypothèse de *pollution haven*. Nous utilisons à cet effet un modèle de Nouvelle Économie Géographique tel que développé par Krugman (1980), dans lequel nous introduisons l'aspect environnemental. En effet, le principal intérêt de l'économie géographique est d'étudier l'attractivité relative de différentes localisations sur les entreprises, en voulant établir les principes auxquels la répartition spatiale des firmes obéit. L'économie géographique cherche ainsi à déterminer les caractéristiques des localisations qui sont les plus attrayantes pour les firmes, et elle repose aussi sur des hypothèses bien adaptées à notre travail (concurrence monopolistique avec rendements d'échelle croissants). Par ailleurs, nous nous inspirons de Head et Mayer (2004) afin de dériver de notre modèle d'économie géographique une spécification du choix de localisation des firmes. Nous prolongeons le travail de Head et Mayer (2004) en considérant la pollution comme un facteur de production et en dérivant un coût marginal qui est affecté par des distorsions du marché reflétant des défaillances institutionnelles. Cette méthodologie nous permet ainsi de considérer l'ensemble des déterminants du choix de localisation indispensables à une analyse exhaustive de l'hypothèse de *pollution haven*. Le modèle obtenu conduit finalement à une équation estimable qui prédit que la profitabilité pour une firme de se localiser dans un pays est une fonction croissante du marché potentiel et de la productivité globale des facteurs dans ce pays, et une relation décroissante des défaillances du marché et des coûts de production, parmi lesquels figure le coût environnemental.

L'objectif du Chapitre 3 est de fournir un test empirique de l'hypothèse de *pollution haven*. Ce chapitre établit une relation étroite entre les prédictions théoriques du modèle de choix de localisation dérivé dans le Chapitre 2 et la validation empirique de l'hypothèse. L'estimation de l'hypothèse de *pollution haven*, fondée sur

une spécification directement tirée d'un modèle théorique approprié, est une contribution majeure à la littérature existante. En effet, très peu d'analyses empiriques de l'hypothèse de *pollution haven* se sont appuyées sur un modèle théorique, et ce manque de fondements théoriques a souvent donné lieu à des erreurs de spécification.

Alors que la majeure partie de la littérature empirique a examiné l'hypothèse de *pollution haven* en observant l'effet dissuasif exercé par des régulations environnementales strictes sur la répartition des firmes au sein d'un même pays, le véritable débat consiste à déterminer si des différences internationales entre les régulations environnementales provoquent la délocalisation des industries polluantes des pays les plus stricts vers les pays les moins régulés, qui sont également souvent les plus pauvres. En effet, la première approche correspondrait davantage à la recherche de l'effet de *pollution haven*, tandis que la recherche d'une preuve empirique de l'hypothèse de *pollution haven* devrait s'appuyer sur des données internationales. Par conséquent, dans ce troisième chapitre, nous étudions les choix de localisation des firmes françaises du secteur manufacturier dans tous les pays d'accueil et analysons les déterminants de ces choix.

En particulier, nous insistons dans notre analyse sur l'impact que peuvent avoir des régulations environnementales renforcées sur la probabilité qu'une firme française de l'industrie manufacturière investisse dans un pays. A cet effet, nous construisons pour chaque pays d'accueil un indice traduisant le niveau de rigueur et le degré d'application de la politique environnementale locale. L'objectif est d'obtenir un indice qui capte les différents aspects d'une politique environnementale afin d'être en mesure de classer les pays selon la sévérité de leur politique environnementale globale. Les valeurs de l'indice environnemental ainsi construit sont en adéquation avec les conclusions de l'analyse des politiques environnementales menée dans le

Chapitre 1. De plus, en introduisant dans notre travail des variables-clés qui ont été fréquemment négligées dans les analyses empiriques de l'hypothèse de *pollution haven*, nous limitons le problème de biais de variable omise souvent rencontré dans la littérature. Nous considérons tout particulièrement les facteurs de gouvernance, en suivant les recommandations d'auteurs tels que Smarzynska et Wei (2004) qui ont souligné l'importance de leur prise en compte. En effet, les pays les plus laxistes en matière d'environnement étant souvent ceux qui souffrent d'un taux de corruption relativement élevé, l'effet positif que pourraient avoir des régulations faibles sur les IDE risque d'être occulté par l'effet négatif d'une corruption exacerbée, entraînant ainsi des interprétations erronées. De même, tel que cela a été mentionné par Keller et Levinson (2002) et Levinson et Taylor (2008), l'omission de caractéristiques inobservables des industries ou des localisations a été à l'origine de la faiblesse des résultats empiriques trouvés dans la littérature. Nous tentons de remédier à ce problème d'hétérogénéité inobservable en ayant recours à des données désagrégées sectorielles, en contrôlant pour différents groupes de pays, et en utilisant des méthodes d'estimation qui contrôlent aussi pour les effets spécifiques des firmes et des industries. Dans le modèle de base, nous utilisons un logit conditionnel qui est un modèle empirique particulièrement bien adapté à l'analyse des choix discrets, tandis que dans nos analyses complémentaires et nos tests de robustesse nous utilisons différentes méthodes d'estimation.

Les résultats font ressortir un impact négatif des régulations environnementales sur la probabilité du choix de localisation des firmes manufacturières françaises, indépendamment de l'intensité polluante du secteur manufacturier auquel elles appartiennent. Une analyse par groupes de pays révèle une relation non-linéaire indiquant que dans les pays les moins stricts, la corrélation entre la rigueur environnementale

et le choix de localisation est positive. Par ailleurs, les résultats d'une estimation contrôlant pour le mode d'entrée des firmes suggèrent qu'une régulation plus stricte décourage aussi bien les investissements *greenfield* que les fusions-acquisitions.

Les déterminants des choix de localisation ayant été étudiés dans le Chapitre 3, l'objet du Chapitre 4 est d'évaluer les conséquences de telles décisions sur le pays d'accueil. Plus précisément, après avoir prouvé empiriquement l'hypothèse de *pollution haven* dans le Chapitre 3 en démontrant que les industries fuient les pays aux régulations environnementales rigoureuses et préfèrent se localiser dans les pays moins stricts, dans le Chapitre 4 nous franchissons une étape supplémentaire dans l'analyse de cette problématique par l'examen de ses implications en termes de pollution. En effet, une fois l'hypothèse de *pollution haven* confirmée, la question est de savoir quelles sont ses implications environnementales. Notamment, de quelle façon un tel comportement des firmes affecte-t-il les émissions de pollution dans les pays d'accueil ? Malgré la pertinence de cette question, celle-ci a été largement négligée dans la littérature sur l'hypothèse de *pollution haven.* En effet, la plupart des études dans ce domaine se sont essentiellement focalisées sur la recherche d'une preuve empirique de l'hypothèse, et lorsqu'elles y parvenaient, ces études en déduisaient simplement que l'environnement était altéré. Pourtant, si nous nous référons à la littérature sur les firmes multinationales, celle-ci suggère une conclusion inverse puisqu'elle suppose que les IDE contribuent à l'amélioration des techniques utilisées dans les pays d'accueil. Dans ce cas, l'IDE répondant à des motivations de *pollution haven* nuit-il nécessairement à l'environnement ? Ou encore, lorsque les IDE sont principalement attirés par de faibles régulations environnementales, demeurent-ils bénéfiques aux pays d'accueil ? À supposer que les filiales étrangères des multinationales utilisent des techniques moins polluantes que les entreprises locales, cela

signifie-t-il nécessairement que les IDE réduisent les émissions de pollution dans les pays d'accueil ?

Le Chapitre 4 tente de répondre à ces questions en explorant la relation entre les IDE français et les niveaux de pollution dans les pays d'accueil. Cela consiste en l'estimation d'un système d'équations qui capte simultanément l'attractivité des pays moins régulés sur les IDE et l'impact des IDE sur les émissions de pollution des pays d'accueil.

En plus des problèmes de variables omises et d'hétérogénéité inobservable traités dans le Chapitre 3, les travaux récents ont relevé un autre problème majeur compliquant l'analyse de l'hypothèse de *pollution haven*, à savoir l'endogénéité de la régulation environnementale (Cole et al., 2006; Levinson et Taylor, 2008). L'existence d'un lien de causalité fonctionnant dans les deux sens peut avoir empêché la détection d'un impact significatif de la régulation environnementale sur les IDE. Cette question, abordée dans le Chapitre 3 à travers l'usage de la méthode des variables instrumentales, est traitée dans le Chapitre 4 de manière plus spécifique à travers l'estimation d'équations simultanées.

Cela nous amène à considérer un système de trois équations où l'IDE, la régulation environnementale et les émissions de pollution sont déterminées simultanément. Le modèle de base est estimé en utilisant des données d'IDE français manufacturiers et d'émissions de CO_2 émises par le secteur manufacturier. L'estimation du système d'équations est supposée capturer l'effet direct des IDE motivés par la recherche de *pollution haven* sur les émissions de pollution, tout en tenant compte du caractère endogène de la régulation environnementale. Ainsi, nous aspirons à répondre aux principales préoccupations exprimées au sujet de l'hypothèse de *pollution haven.* Les résultats obtenus mettent en évidence un impact négatif significatif des régulations

environnementales sur les IDE, confirmant ainsi les résultats du Chapitre 3. Ils font également ressortir une corrélation négative entre l'élaboration de la régulation environnementale dans les pays d'accueil et les IDE. En ce qui concerne la détermination de la pollution, les résultats montrent un impact positif significatif, bien que de faible amplitude, des IDE sur les émissions de pollution. Cependant, dans une analyse complémentaire, il apparait que les IDE réduisent l'intensité polluante dans les pays d'accueil.

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[11] This chapter has been in part written with Natalia Zugravu.

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General Introduction

"[...] Less-developed countries that choose uncontrolled domestic pollution as a means to improve their economic position will voluntarily become the repository of the world's dirty industries". Baumol and Oates, 1988, p 265.

This assertion was one of the conclusions of the seminal work of Baumol and Oates as they examined international issues of environmental protection. However, after more than twenty years of investigation, things have proven to be not quite so simple.

One of the most striking discord between advocates and critics of globalization was, and still is, over the international implications of environmental protection, or on the environmental implications of trade liberalization. The perception of the causality between environment and trade depends on the perspective of the analysis, and we can already announce that in this work, we will be interested in both issues.

Recent illustrations that have contributed to fuel the heated debate between stakeholders are not lacking. In France, ten Non Governmental Organizations, including Greenpeace, WWF and Friends of the Earth addressed a complaining letter to the president Nicolas Sarkozy when he decided in March 2010 to abandon the tax carbon. The junior ecology minister, and the ecologist party (the Green) which was initially opposed to the reform because it judged it ecologically ineffective and socially unfair, have also been very critical towards the French President. How-

ever, to justify his decision, Nicolas Sarkozy said "We will not impose constraints on our industry if, in the meantime, we allow imports from countries which do not respect environmental norms to flood our markets"[12]. This argument illustrates one strategic aspect of the debate, namely the interdependency between environmental and trade policies. It is reminiscent of former discussions, when the debate between trade and environment, at a time where pollution was rising, was prompted by a series of contentious environmentally-related trade disputes[13] and by the negotiations over the North American Free Trade Agreement (NAFTA). And it also recalls the protests of environmentalists at the creation of the World Trade Organization (WTO), as they were concerned with the environmental effects of increased world trade.

The example of NAFTA is highly descriptive: concern has focused on the idea that the less stringent environmental standards in Mexico would imply a comparative advantage in pollution-intensive goods and would result in an environmental disaster in Mexico as polluting industries migrate to the country. Therefore, the concern was threefold and referred to:

- The disparity in environmental regulations
- Their impact on the international specialization and the location of polluting industries
- The environmental impact of the polluting industries migration

This example illustrates the major issues related to the links between economic growth, liberalized trade, and the environment in open economies. Thus in this work we will investigate the interaction between these three components of the trade and

[12] The Figaro Magazine, 12 mars 2010.

[13] One well-cited example is the umbargo decided by the United States in 1988 on the tuna harvested in the Eastern Tropical Pacific Ocean that did not satisfy the standards for the protection of dolphins applied to US fishermen.

environment relationship. However, regarding the third component, i.e. the environmental impact, we will focus on the particular aspect of pollution. The deforestation in the Brazil Amazon and the depletion of natural resources are environmental disasters not investigated in our dissertation, since they probably require to be examined separately.

Environmental regulation has progressed at different paces in different countries of the world, these differences being particularly pronounced between developed and developing countries. Whereas the United-States and Europe passed their major laws in the beginning of the seventies, the rest of the world started to address environmental issues during the nineties. Therefore, in the mid-seventies, early research investigated the consequences of such different levels of stringency in environmental policies. Pethig (1976), Siebert (1977), and McGuire (1982) were important contributions to the early literature focusing on the theory of comparative advantage. They demonstrated through standard models of international trade (Ricardian or Heckscher-Ohlin), that countries with relatively lax environmental policies tend to export environmentally intensive production commodities, whereas more stringent countries tend to export less environmentally intensive production commodities. However, despite these puzzling findings, the interest of public and researchers about these questions declined in the eighties, until the effective debate between trade and environment renewed about ten years later with NAFTA and the WTO as described above. One important aspect of the debate was the impact of environmental regulation on international competitiveness and the location of polluting industries. It was pretended that environmental regulations affect industrial location, and that differential regulations between the more regulated North, (e.g., the United States), and the less regulated South, (e.g. Mexico), will induce spe-

cialization of the South in polluting production, and probably the shifting of more polluting industries from the North to the South. This assumption has been called *the Pollution Haven Hypothesis,* and is central to our work.

Different levels of environmental regulations across the world

Thereby, fifteen years after the revival of the debate, Nicolas Sarkozy's sentence that we have quoted above suggests that things have not changed and that the debate is still relevant, or even intensified. In the 2000s, despite the improvements made worldwide, the gap between countries is still important, which partly explains the persistence of the debate. For instance, in some developing countries, highly polluting industries often benefit from special conditions and are not affected by regulations (e.g., mining in Indonesia and Zimbabwe). In other countries, laws are passed but are not effective. The existence of different levels of environmental regulations across the world is therefore common to the nineties and nowadays. This dissertation emphasizes that nowadays, environmental regulations take many forms, and a too simplistic distinction between North and South countries is no longer sufficient to differentiate regulated countries from those which are less stringent. Besides, we will show that even within a country, the stringency of regulations may differ with regard to the environmental risk.

Multinational firms and foreign direct investment

But something important has actually changed and spread out since the first protests and the establishment of the NAFTA: the international mobility of firms. This increasing international mobility of firms is reflected through the growth of multinational firms (MNFs) activities. Indeed, multinational firms, by definition, operate in many countries through their foreign affiliates[14]. The activities of MNFs

[14] According to the International Monetary Fund (IMF) and the Organisation for Economic Co-

would be best measured by firm-level data, such as the number of employees and the size of the sales. Since these firm-level data are not widely available, researchers often rely on data regarding flows of foreign direct investment (FDI). According to the International Monetary Fund (IMF) and the Organisation for Economic Cooperation and Development (OECD) definitions, FDI is an investment in a foreign company where the foreign investor owns at least 10% of the ordinary shares, the objective of which is to establish a lasting interest in the country, a long-term relationship and a significant influence on the management of the firm. Thus, FDI flows are different from portfolio investments which do not result in foreign management, ownership, or legal control.

Since the eighties, countries have been seeking to attract FDI making their policies more favorable to investors. This tendency intensified in the nineties, and the United Nations Conference on Trade and Development (UNCTAD) reported, over the period 1991-1999, 1035 regulatory changes all over the world, whose 94% favoured investors. In 1999, developing and transition economies liberalized operations in industries which in the past were closed or restricted to FDI. Among them are petroleum, mining, energy, and pharmaceuticals. Nowadays, FDI is still playing an increasing role in the world economy[15]. In 2007, global FDI inflows surpassed the previous record set in the year 2000, and grew to an estimated US$1.5 trillion[16]. Similarly, the number of foreign affiliates in the world has considerably expanded. Sales of foreign affiliates worldwide increased from $3 trillion in 1980 to $14 trillion in 1999, representing nearly twice the amount of global exports in 1999. In 2004, total sales by foreign affiliates amounted to almost $19 trillion[17].

operation and Development (OECD) recommendations, a foreign firm can be defined as a foreign affiliate (subsidiary) if the foreign investor controls more than 50% of the voting stock.

[15] Source: UNCTAD, 2001.

[16] Source: UNCTAD, 2008.

[17] Source: UNCTAD, 2005.

These two conditions, i.e. a differential of environmental regulations between countries and increased MNFs activities with an increasing number of foreign affiliates and growing FDI, are promising to the study of the so-called pollution haven hypothesis. In this work, we investigate the pollution haven hypothesis by examining location as well as amounts of FDI[18].

Environmental regulation and firms location

A primary justification of the pollution haven hypothesis is that either by imposing specific equipment, limiting the use of certain resources, or applying sanctions for non-compliance, strong environmental regulations increase production costs and reduce firms competitiveness. In the literature on FDI and on location choice of MNFs, the search of cost advantage was one of the first determinants of FDI. In the context of pollution haven hypothesis and in a logic of comparative advantage, it is therefore obvious that a firm which has the possibility of moving will locate in less stringent countries to reduce its costs and be more competitive. Such a hypothesis, as it has been theoretically demonstrated through a general equilibrium framework by Pethig (1976), Siebert (1977), McGuire (1982), and Baumol and Oates (1988), considers the difference of environmental costs as the unique determinant of FDI and sufficient to incite firms relocation. However, some studies argue that environmental costs do not represent a sufficient share of production costs to cause such a displacement. Moreover, an opposite hypothesis as regards to environmental regulations and competitiveness has been developed by Porter (1991) and Porter and van der Linde (1995), and is therefore called the *Porter Hypothesis*. It stipulates that stricter environmental regulations are good for the environment and promote

[18] A second approach of the pollution haven hypothesis, not addressed here, is to consider trade data. We will nevertheless review some examples of this approach in Chapter 2 (e.g., Tobey, 1990; Levinson and Taylor, 2008).

competitiveness because they encourage innovation, improving thus the quality of the products or lowering a firm's costs of production. Therefore, firms would not be incited to migrate in response to strengthened regulations. Another theoretical alternative that plays against pollution haven hypothesis predictions is commonly called the *Factor Endowment Hypothesis.* This hypothesis assumes that specialization patterns are more likely to be driven by more conventional comparative advantages. Since highly polluting production is at the same time capital intensive, polluting industries tend to relocate to capital-abundant countries, i.e. developed and regulated ones, while less pollution-intensive and therefore less capital intensive industries locate in capital-scarce developing and under-regulated countries. Therefore, the predictions of the *Factor Endowment Hypothesis* contrast with those of the pollution haven hypothesis and suggest that environmental regulations have no or small effect on trade and FDI patterns. Given these various theoretical hypotheses that lead to different predictions, it seems clear that the study of the pollution haven hypothesis requires on one hand a comprehensive theoretical framework, and on the other hand a robust empirical assessment. This dissertation develops an adequate theoretical model of the pollution haven hypothesis, and proceeds then to empirical tests of this model.

The analytical framework of the pollution haven hypothesis is the one related to the investigation of the determinants of firms location choice and FDI. Therefore, several explanations of internalization and FDI have been analyzed in the theory of FDI. Earlier works that introduced capital movements in international economics do not distinguish FDI from other kinds of cross-border capital flows. Capital flows are seen to be motivated by differences in interest rates between countries which result from differences in relative factor endowments and time preferences between coun-

tries (Mundell, 1957). This approach managed to explain FDI of advanced countries in developing countries on the basis of comparative advantage until the seventies. However, since the eighties, new patterns of FDI from developed countries towards developed countries have become dominant, and the classical theory of trade and FDI fails to explain them. One reason is that capital is largely abundant nowadays, and therefore exploitation of factor cost differentials might not be the central explanation of FDI patterns. This is emphasized by the missing correlation between FDI flows and capital account balances of a country. Because of this same missing correlation, it is often argued that the investment from the balance of payment is not a fully relevant indicator of the international activity of MNFs. Therefore, it seems that FDI can be considered as a vehicle of knowledge more than a movement of capital. It is rather the ownership of a specific advantage that drives firms' international activities. This factor has been highlighted in the eclectic approach (Dunning, 1977), also known as OLI framework, and points to three motivations of foreign investment: Ownership advantage, Location advantage and Internationalization advantage[19]. Theoretical formulations of FDI are largely built on the OLI paradigm (Krugman, 1983; Helpman, 1984; Markusen, 1984). Moreover, a trade-off between proximity and concentration is often taken into account to explain the different strategies of overseas expansion (exports or production abroad) (Brainard, 1993). The proximity describes the advantage of being close to customers, while concentration describes the advantage of using economies of scale by producing at only one location.

[19] According to OLI paradigm, FDI can only be profitable if the investing company has some kind of ownership advantage (e.g., knowledge) which gives the company an advantage over domestic companies to make up for the disadvantages the company has by producing in a foreign country. Therefore, FDI is bound to market imperfections. Second, the chosen location must have a location advantage, not only compared to the home country of the MNF undertaking the FDI, but also to all other possible locations. Finally, it must be profitable to internalize the ownership advantage in the company; licensing to foreign companies, for example, must be less profitable than internalization.

From an empirical point of view, the overview of international production demonstrates the concentration of production in developed and some developing countries, and high intra-industry shares in FDI. Therefore, perfect competition approaches fail in explaining such patterns, and an imperfect competition framework is needed. Moreover, it has been demonstrated that proximity-concentration approach is suitable to explain the observed pattern of trade and FDI, and that overseas activities are particularly dominant in differentiated-goods industries. All these elements are taken into account in the New Economic Geography framework, as well as falling distances that play a major role in explaining the spatial distribution of firms. In this thesis, we use such a framework to provide a theoretical modelling of the pollution haven hypothesis.

FDI impact on pollution levels

The example of NAFTA previously mentioned refers to the concern raised by the agreement regarding its potential effects on the environmental quality in Mexico, given that the migration of polluting industries from the United States to Mexico was predicted due to differential environmental regulations between the two countries. This fear about the environmental damages corresponds to the third major aspect of the pollution haven hypothesis. However, this issue has been little studied in the pollution haven hypothesis literature. He (2006) is one exception and investigates the environmental impacts of FDI in Chinese provinces. Much of the related literature focused on trying to find a clear empirical evidence for the hypothesis. More recently, it concentrated rather on finding evidence for a Pollution Haven Effect. Unlike the pollution haven *hypothesis* which stipulates that higher environmental costs induced by strengthened regulations are the unique motive for trade and FDI, thus outweighing all other determinants, the pollution haven *effect*

only predicts that trade and FDI may be deterred by tighten regulations. In other words, the assumed impact of environmental regulations on international flows is much stronger in case of pollution haven *hypothesis* than in case of pollution haven *effect*. Thus, implications of the former hypothesis are larger. For this reason, in this research we mostly attempt to test the *hypothesis* rather than the *effect*, and therefore mostly use the term pollution haven hypothesis which we consider as a general framework comprising the pollution haven effect.

FDI driven by pollution haven hypothesis motivations may affect environmental quality and especially pollution levels through different channels. Three major channels resulting from trade and FDI liberalization are identified in literature as scale effect, composition effect and technique effect. The scale effect refers to the increase of overall production which in turn increases pollution. The composition effect stems from changes in production of an economy caused by specialization, and its impact on pollution levels depends on the comparative advantage of countries. The technique effect relates to the use of cleaner production technology resulting from increase in income. The global effect depends on the interplay between these three effects.

Foreign investment may be a vehicle of new and cleaner technologies that can reduce pollution. When they face strict regulations in their source country, multinational companies have strong incentives to innovate in order to improve the efficiency of resource use or reduce pollution emissions. It is cost-effective for them to use the same technologies in different countries and increase economies of scale, even where environmental laws are weaker. If we consider global pollution, it is not affected by such FDI since whether investment takes place in the source country or in a foreign country it does not modify the global pollution emissions. If we consider

local pollution, due to an increase of activity, polluting emissions are expected to increase where the investment takes place. However, if FDI replaces in host countries domestic production facilities, which are more polluting and less competitive, global pollution as well as local pollution in host country will be reduced.

FDI can also act as a vehicle through which new ideas, technologies, and working practices can be transferred to domestic firms and improve their efficiency. This would result in a reduction of both local and global pollutions.

However, if FDI is motivated by the search of less environmental standards as suggested by the pollution haven hypothesis, the behavior of MNFs in foreign countries could be less virtuous and offset the above mentioned beneficial impacts regarding global and local pollutions. Examples of pollution damages caused by multinational firms are not lacking. For illustration, preliminary findings of a forthcoming report (Summer 2010) for the United Nations into the activities of the world's 3,000 biggest companies in 2008 estimates one-third of profits would be lost if firms were forced to pay for use, loss and damage of environment. The study found the estimated combined damage was worth US$2.2 trillion in 2008[20].

Finally, with the aim of being exhaustive in the analysis of the several FDI-pollution transmission channels, we remind here the role on pollution levels of international shipping activities tied to FDI, despite the fact this issue is beyond the scope of this work. If FDI is driven by market access motivations, it will be consistent with a reduction of pollution emissions resulting from the reduction of shipping activities. In contrast, in case of vertical FDI, production is re-exported to the source country, therefore pollution will increase due to the additional shipping of goods.

To sum up, theoretical views presume that the effect of FDI on pollution lev-

[20] The Guardian, February 18th, 2010.

els operates via several channels. Therefore, the global effect of FDI on pollution is ultimately an empirical issue. In this work, we will empirically investigate the impact of FDI on host countries pollution emissions. Global pollution is a major environmental and economical issue due to the well-known climate change problem. Regarding the pollution haven hypothesis, it is intimately tied to global pollution problems since the fear is that the improvements made in strict countries are more than offset by the increase of pollution in less regulated countries. However, the empirical investigation of global pollution is hardly feasible and would require unavailable data. Local pollution is also a critical issue with environmental, health and development impacts in affected countries, and concerns about the impact of the pollution haven hypothesis on local pollutions were also expressed.

The objective of this dissertation is to contribute to the existing literature on the trade and environment debate, by investigating in depth the issues related to the pollution haven hypothesis. We examine theoretically as well as empirically the effect of strengthened environmental regulations on firms location choice. We also focus on the impact of foreign direct investment on the pollution emissions.

Structure of the dissertation

Prior to the direct investigation of the pollution haven hypothesis in the following chapters, we examine in *Chapter 1* the evolution of countries' environmental policies. Indeed, a necessary condition for firms to be incited to migrate is that there are interjurisdictional differences in regulatory stringency. Therefore, we group countries according to four levels of development, and within each group we carry on a more detailed analysis by examining the environmental policies by types of pollution, and by focusing on certain individual characteristics. The objective is to adjust and refine the common representation defining the developed North as regulated and the

developing South as lax. Firstly, this useful essay broadly confirms and concretely establishes the relevance of the common distinction between developed and developing countries. Furthermore, it brings out that emerging economies and Central and Eastern European Countries (CEEC) are in an intermediate position. They have undertaken the reform of their institutions and their environmental policies from the nineties, but the environmental measures are not sufficiently enforced. These results will guide us in our analysis of the pollution haven hypothesis and help us in our interpretations.

Chapter 2 helps the reader to become familiar with the debate on trade and environment, and then proposes a theoretical modelling of the pollution haven hypothesis. We firstly introduce and explain the theoretical foundations of the hypothesis and present the controversial issues related to its emergence. We then review the existing theoretical analyses that highlighted the pollution haven hypothesis. This exercise emphasizes the lack of theoretical foundations in literature. Indeed, while the existing literature contains many useful insights, it largely focused on one assumption, the difference of environmental regulations. Seminal works in this field are Pethig (1976), McGuire (1982), Baumol and Oates (1988) using standard international models. The chapter shows that these models were too restrictive to capture all issues related to the pollution haven hypothesis, and did not manage to yield an estimable structural relationship between environmental regulations and patterns of specialization. The review of the empirical studies conducted on the subject underlines major progresses made in the empirical investigation of the pollution haven hypothesis and also reveals drawbacks encountered in this field. Thus, Chapter 2 stresses the reasons for which, although over the last thirty years, many researchers have investigated the pollution haven hypothesis and contributed to pro-

vide theoretical as well as empirical foundations, they did not manage to bring out a clear empirical evidence of the effect of environmental regulations on firms location decision.

Since one major shortcoming is the lack of theoretical foundation, we finally propose a formal theoretical modelling of the pollution haven hypothesis. We use a New Economic Geography model as developed by Krugman (1980) in which we incorporate the environmental aspect. Indeed, the economic geography primary interest is to study the relative attractiveness of various locations for firms, and to clarify the causes behind the differences in spatial patterns of firms. It seeks to determine the characteristics of locations that are the most attractive to firms, and it relies on assumptions well-adapted to our work (i.e., monopolistic competition with increasing returns to scale). Moreover, we follow Head and Mayer (2004) to derive from this economic geography model our specification of firms location choice. We extend the methodology adopted by Head and Mayer (2004) by considering pollution as a production factor and by deriving a marginal cost that is affected by market distortions which capture institutional failures. This enables us to consider the complexity of the location choice determinants appropriate to an exhaustive investigation of the pollution haven hypothesis. The model finally leads to an estimable equation predicting a positive relationship between the profitability of a firm location and the market potential and the global productivity of factors, and a negative one between this profitability and the production factor costs including the pollution cost, as well as market failures.

The objective of *Chapter 3* is to provide an empirical test of the pollution haven hypothesis. It establishes a close link between the theoretical predictions of the location choice model derived in Chapter 2 and the empirical estimation of the

pollution haven hypothesis. The estimation of the pollution haven hypothesis based on a specification directly derived from an appropriate theoretical model represents an improvement over existing literature. Indeed, the integration of theory with empirical work is rare in related literature, and the lack of theoretical foundations of the equations tested often entails specification errors.

While a large body of the empirical literature investigates the pollution haven hypothesis by examining the deterrent effect of strengthened environmental regulations on firms location within a country, the real debate is whether international differences in environmental regulations stringency cause the relocation of polluting industries from regulated countries to the less regulated, and often poor, ones. Indeed, the first approach would better correspond to the search for a pollution haven effect, while seeking for a pollution haven hypothesis evidence must rely on international data. Therefore, in this chapter, we examine the location choices of French firms in all host countries, and we analyze their determinants.

In particular, we dwell on the effect of tightened environmental regulations in a country on the probability that a French firm invests in this country. To this end, we construct an index trying to capture the overall strictness and effectiveness of the environmental policy of each host country. The objective of such a global index is to capture the different aspects of an environmental policy, in order to rank countries. The values of the environmental index confirm the conclusions ensuing from the analysis of the environmental policies in Chapter 1. Furthermore, the introduction of key variables in a study of the pollution haven hypothesis, and yet often neglected in other empirical studies on the question, helps to limit the problems of omitted variable bias often observed in literature. In particular, governance factors are considered in this thesis, as recommended by authors such as

Smarzynska and Wei (2004) who stressed the importance of taking them into account. Indeed, the least regulated countries being often the most corrupted ones, the positive effect of weaken environmental regulations on FDI may be occulted by the likely negative effect of increased corruption, resulting in misled interpretations. Similarly, as mentioned by Keller and Levinson (2002) and Levinson and Taylor (2008), the omission of unobservable characteristics of industries and locations has been a major source of the inconsistency of results in empirical investigations of the pollution haven hypothesis. We also attempt to control for unobserved heterogeneity, by using disaggregate data on firms' sectors, by controlling for different groups of countries, and by using estimations methods that control for firms and industry specific effects. In the base model, we use a conditional logit which is an empirical model particularly well-adapted to the analysis of discrete choices, while in extended analyses and robustness checks we use different estimations methods.

The results show a negative impact of strict environmental regulations on the probability of location choice, regardless of the pollution intensity of the manufacturing sectors. The analysis by groups of countries reveals a nonlinear relationship, indicating that in least regulated countries, the correlation between environmental stringency and the location choice is positive. Moreover, an estimate controlling for the mode of entry of firms suggests that a stricter regulation deters both greenfield entry and mergers and acquisitions.

The determinants of location choices having been studied in Chapter 3, the purpose of *Chapter 4* is to assess the outcomes of such decisions on the host country. More precisely, since Chapter 3 provides an empirical evidence of the pollution haven hypothesis, establishing that industries avoid strict environmental regulations and preferably locate in less stringent countries, in Chapter 4 we move one step forward

in the analysis of this issue by examining its impacts on pollution levels. Indeed, once the pollution haven hypothesis was confirmed, the question is what impact such a behavior of firms has on environmental issues, and especially on host country pollution levels? Despite the relevance of this question, it has been neglected in the literature on the pollution haven hypothesis, which essentially focuses on looking for empirical evidence for pollution havens; and if such evidence is found, studies simply conclude that environment is harmed. However, a contradictory conclusion is more likely to emerge if we refer to the literature on multinational firms, which often argues that FDI improves the techniques used in production by host countries. Therefore, is FDI necessarily harming environment if it is driven by pollution haven motivations? Conversely, is still FDI beneficial to host countries when one of its essential determinants is a lax environmental policy? Even if multinationals' foreign affiliates do use cleaner techniques than their local counterpart, does this necessarily mean that FDI reduces pollution emissions in host countries?

Chapter 4 explores the relationship between French FDI and pollution levels in the host country. This consists in estimating a system of equations that simultaneously captures the attractiveness of less regulated countries on FDI and the impact of FDI on host countries pollution emissions.

Moreover, in addition to the problems of omitted variables and unobserved heterogeneity that have been dealt with in Chapter 3, another major issue complicating the analyses of the pollution haven hypothesis has been highlighted in recent works, i.e. the endogeneity of environmental regulation (Cole et al., 2006; Levinson and Taylor, 2008). The existence of a causal relationship running in both directions may have hampered the detection of a large impact of environmental regulation on FDI patterns. This issue has been treated in Chapter 3 through an instrumental

estimation. In Chapter 4, it is addressed more specifically through the estimation of simultaneous equations.

Considered together, the three issues lead to a system of three equations where FDI, environmental regulation and pollution emissions are simultaneously determined. The base model is estimated using data on French manufacturing FDI and CO_2 emissions. The estimation of the system of equations is expected to capture the direct effect of FDI driven by PHH motivations on pollution emissions, while taking into account the endogeneity of environmental regulation. Therefore, it is supposed to address the main concerns expressed about the pollution haven hypothesis. Results emphasize a strong negative effect of tightened regulations on FDI, thus confirming results of Chapter 3. They also bring out a negative correlation between environmental regulation design in host countries and FDI. Regarding the pollution determination, results show a significant, even weak, positive impact of FDI on the pollution emissions in host countries. However, in an extended analysis, it appears that FDI reduces pollution intensity.

Chapter 1

Comparative Analysis of Environmental Policies

Introduction

Since the seventies, the Western Europe and the United States have become increasingly concerned with environmental quality. As a result, their first major environmental laws were introduced (Table 1.1). This was not the case in the rest of the world, as the African countries were more concerned with the fight against poverty and famine, while the communist ones were pursuing a policy of heavy industrialization. Thus, the first definitions of the pollution haven hypothesis stipulated that, facing stringent environmental policies in the developed countries in the North, polluting firms should relocate from these countries to the less regulated ones in the South. This definition focuses on two points: first, the northern countries pursue stricter environmental policies than those of the South; second, this disparity causes the relocation of firms. Indeed, the idea is that if a stringent environmental policy increases the production costs of firms, they will be encouraged to set up in locations where they minimize these costs. In this chapter, we will focus on the first element, namely the different levels of stringency in environmental policies, while its impact

on the behavior of firms will be dealt with in subsequent chapters.

Table 1.1: Date of creation of first environmental laws in selected countries

Country	**Region**	**Year**	**Main legislation**	**Subject**
USA	Developed	1970	National Environmental Policy Act (NEPA)	National environmental policy
France	Developed	1976	Nature Protection Law	National environmental policy
Mexico	Emerging	1988	General Law on Ecological Balance and Environmental Protection	Management of air, water, hazardous waste, soils, protected areas, and noise.
Tunisia	Emerging	1988	Law 91, on environmental protection	Environment protection
Poland	CEEC, EU	1990	Nature Protection Law	National environmental policy
Czech Rep.	CEEC, EU	1992	Environmental Law	National environmental law
Honduras	Developing	1993	General Law for the Environment	Global environment national policy
Salvador	Developing	1998	National Environmental Law	Regulatory framework for general environmental issues

Although at the emergence of the pollution haven hypothesis, the world seemed to be bipolar, with on one hand the North whose rules are strict, and on the other hand the South, where legislation is less severe, the reality is more complex today. Some countries in Asia, Latin America or Africa have experienced rapid economic growth in the eighties and their living standards converge today towards those of developed countries. These countries are often described as "emerging". Ever since they left their long communism experience in the nineties, the countries of the former Soviet bloc have embarked on a path of transition to a market economy. The Environmental Kuznets Curve stipulates that with low levels of development, pollution levels are also low, and then they increase with income, before declining again. One explanation for this inverted U-shaped curve is that the environmental

requirements of populations and governments increase along with rising income. Different levels of income imply different environmental policies. Thus, a too sharp North/South or developed/developing countries distinction must be overcome, to avoid a biased analysis of the pollution haven hypothesis. Since the pollution haven hypothesis ensues from the heterogeneity of environmental policies, our objective in this chapter is to examine in detail the environmental policies of countries with regard to different levels of development, in order to draw an accurate and precise picture of the current state of environmental regulation in the world.

Moreover, given that the strength of environmental measures within a country may vary in function of the environmental risks and the incentives of governments, it seems more relevant to examine the policies implemented for specific problems rather than attempt a general comparison of environmental policies between countries or groups of countries. Indeed, all countries do not face the same pressures on their environment. Some witness the deterioration of their atmosphere and others observe the depletion of their marine resources. Depending on the risk involved, the strictness of the environmental policy of a country may differ as to the management of various resources. In addition, it may also be influenced by specific industries. Thus, we will compare the policies implemented to reduce local pollution and then those implemented in the case of global pollution. Regarding local pollution, we will focus on measures related to air and water pollution, since these are often regulated as a priority and are closely related to industry. In terms of global pollution, we will examine the fundamental issue of the prevention of global climate change. Moreover, we will conduct our comparative analysis on four groups of countries corresponding to four levels of development: developed, emerging, transition and developing countries, for each type of pollution. Within these groups, we will also

take a few examples of specific countries, as all countries in a group are not perfectly homogeneous. Finally, we will focus on measures affecting industry. For example, we will not detail the measures implemented to manage air pollution resulting from road traffic.

This chapter is divided into two parts. To be able to assess the effectiveness of the policies implemented and to compare them, we will first present the instruments available for governments to establish their environmental policies, highlighting the advantages and weaknesses of these instruments and their coordination. Then in the second section of this chapter, we will examine the environmental policies that are actually implemented in different countries, in order to emphasize the heterogeneity of these policies.

1 Environmental policy instruments

In the neoclassical approach of environmental economics, pollution is considered as a negative externality. In fact, there is an externality when the well-being of an agent (the utility of a consumer or the profit of a firm) is directly affected by the actions of another agent and does not result in any market transaction between the two agents.

Positive externalities affect positively the other agents, while negative externalities deteriorate their situation. Sulfur dioxide (SO_2) emissions released by industry during the production process, thus causing respiratory problems in humans, meet perfectly the concept of externality. The same thing applies to all the other known forms of pollution (emissions of carbon dioxide CO_2, particulate matter etc.)

The producer causing the pollution imposes on the other members of the society a damage cost which is not taken into account when deciding the quantities to be

produced. Thus, the private cost of the producer is lower than the total cost incurred by the society, i.e. social cost. The market equilibrium price, which does not take into account the social cost but the private one which is inferior, is too low, and therefore results in a sub-optimal production.

Externalities are one example of market failures - (public goods are another one) - since the competitive equilibrium does not achieve a Pareto optimal solution. More specifically, the presence of externalities questions the first theorem of welfare economics as agents' welfare depends on priceless commodities, while obtaining an efficient allocation requires that agents are confronted with the fair price of these commodities. To address this market failure, government intervention is often necessary[1]. The government intervention to achieve the Pareto optimum in presence of externalities is to internalize them. For this purpose the government has various means grouped into two categories: the command and control instruments and the market-based instruments.

1.1 Command and Control instruments

1.1.1 Standards

Command and control instruments, namely standards or quotas, are a simple way in theory to ensure that the optimal level of pollution is reached. Indeed, these instruments specify a maximum level of pollution to comply with, under threat of penalties. For example, to reduce car pollution emissions, the EU has set since 1998 the maximum amount of lead allowed in fuels. These standards are theoretically defined to achieve the optimum, but to reach this goal they must be properly established. This requires an accurate assessment that is possible only with perfect

[1] Other solutions such as bilateral negotiations would also be possible in some cases, according to the Coase Theorem.

information on the damage suffered by the victims and the costs incurred by the polluter. The regulator must then ensure compliance with these standards through strict and frequent controls.

If standards are not set correctly, for example being set at a very lax level, the pollution level will be too high, while agents have no economic incentive to reduce it further. This is the main drawback of standards, namely their inability to incite agents to further reduce their pollution and innovate to this end. Conversely, if standards are set at a too rigorous level, the pollution level is below the optimal one, but from a strictly economic point of view this level will be inefficient because it will impose an excessive abatement cost on polluters, implying a loss of social welfare. In general, standards are proven to be costly and less efficient than the second category of instruments: the market-based instruments.

1.2 Market-based instruments

Insofar as non-optimal production in the presence of externalities is due to a difference between the social cost and the private cost of an activity, market-based instruments have to fill this gap through the internalization of the external cost. They aim to affect the polluters' costs to encourage the voluntary adoption of less polluting behaviors. Market-based instruments affect prices (taxes, subsidies), or quantities (emissions permits).

1.2.1 Taxes and subsidies

Taxes

A.C. Pigou was the first in 1920 to propose the application of a tax to internalize negative externalities. This tax, which is called Pigovian tax since then, consists in imposing on the polluting firm an amount to pay per unit produced, i.e., to impose

on the firm a marginal cost of emissions (the tax t) equal to the marginal damage D_m ($t = \mathrm{D}_m$), so that the polluting firm has an incentive to emit exactly the optimal level of pollution by equalizing its marginal abatement cost C_m^d to its marginal cost of emission. The Pigovian tax thus makes the additional costs supported by the agent that creates the externality, in accordance with the polluter pays principle.

The implementation of the Pigovian tax requires the assessment of environmental damage, which poses many methodological problems. It also requires the collection of information on marginal abatement costs, which faces problems of asymmetric information, as the polluters have an incentive to cheat to encourage the regulator to establish a lower and therefore suboptimal tax. Therefore, the introduction of a Pigovian tax seems to be hardly feasible, and it is not in force in most countries having opted for a taxation system.

However, the adoption of a second-best tax different from the optimal one, but that aims to reach a certain emissions control objectives, has certain advantages. In comparison with standards, it contributes to the achievement of the same goals but at a lower total cost, and is therefore more economically efficient in a context without uncertainty on abatement costs. Indeed, while standards apply uniformly to all aggregate polluters regardless of their characteristics of production, taxes make more efficient agents reduce their pollution more than the least efficient ones, which results in a minimization of pollution abatement costs. Moreover, the considerable advantage of the tax resides in the incentive it exerts on firms to innovate and the improvement of environmental quality that follows: when the marginal pollution abatement cost decreases, emissions of agents also decline; they derive a double benefit by reducing their pollution abatement costs while reducing the amount of the tax to pay (see Section 1.3). But to meet these expectations, the tax rate which

is chosen must not be too low because in this case it does not provide incentives to innovate. This task is even more complicated during a period of inflation which significantly weakens the incentive power of the tax and requires the tax to be frequently raised.

In summary, as for the standards, the establishment of an efficient tax requires good information and knowledge of the marginal damage imposed by the polluter on society. However, this system does not require knowledge of marginal pollution abatement costs of firms. In addition, it encourages innovation.

Subsidies

Sometimes, governments also resort to subsidies to reduce pollution (Example: subsidies paid to industries to support them in their effort to control pollutant releases). In the short run, from a strict viewpoint of the level of pollution reached, a subsidy system for abatement activities is equivalent to that of taxation. Indeed, if the polluter receives a subsidy amount per unit of pollution below the level of pollution of reference (the one he would have chosen in the absence of constraint), he has an incentive to clean up as long as his marginal abatement cost C_m^d is inferior to the subsidy rate s. The optimal subsidy rate is then equal to the optimal tax rate. However, in the long run, these two systems will have different consequences. The introduction of the tax leads to the elimination of poorly performing firms (because the tax increases both the marginal cost and the average cost of production), while a subsidy helps to further maintain unprofitable firms (because it increases the marginal cost of production but decreases the average cost of production), challenging even the entry of new firms. Thus, with a subsidy, even if each company reduces its individual pollution volume, the aggregate level of pollution will exceed the desired level. The subsidy system is also contrary to the polluter pays principle, and its

financing increases the public deficit.

1.2.2 Emissions trading

Emissions trading, also called tradable pollution quotas, are the market instrument that acts directly on the amount of pollution emitted. An emissions trading system was proposed in Kyoto in 1997 as a market instrument to regulate emissions of greenhouse gases. Indeed, the problem with externalities may arise in the absence of markets, leading to an imperfect allocation of resources. The intervention of the government consists in creating an originally non-existent market, and then defining property rights, while leaving market forces to restore the optimum. Thus, after the maximum allowed level of pollution has been established by public authorities, each firm is allocated a certain amount of pollution rights, the total amount of permits to match the predefined maximum level. These quotas are then traded on the pollution rights market at a price determined by the balance between supplied and demanded quantities. The agents who are most likely to reduce their emissions continue to sell their quotas as long as the selling price will remain above their marginal cost of abatement, while the least effective agents will purchase these rights as long as the permit price is below their marginal cost of pollution abatement. In order for a market to exist, this requires that firms are heterogeneous in terms of pollution abatement costs so that the ones who initially have a marginal abatement cost below the market price of permits can sell to others whose abatement costs are higher than the market price of permits. At equilibrium, the price of permits will be equal to the marginal pollution abatement cost for all firms.

The great advantage of emissions trading systems comes from their flexibility. Indeed, these systems are more flexible than that of an emissions taxes because the permit price results from the balance between supply and demand. It adapts to

the economic conditions and is not affected by inflation. Moreover, as for taxes, this flexibility is a source of innovation because the agents are free to use a more efficient and less polluting production method to capitalize on the opportunity to trade unused permits (Section 1.3).

Beside, in the same way as the establishment of standards enables the regulator to achieve the maximum level of pollution set, the predetermination of the desired level of pollution and the distribution of the number of allowed pre-requisite permits for achieving this level ensure the realization of the quantified objective ex ante. Conversely, the tax system does not systematically lead to a given level of pollution since it sets the price but has a less direct impact on the quantity.

Thus, the permit system combines advantages of standards and taxes, while filling at the same time some weaknesses of these two systems. However, this system also has its limits. For example, an error on the amount of rights resulting in high prices may lead to the unjustified closure of some companies. Above all, the performance of this system assumes that the permits market structure is competitive, which, ultimately, is rarely the case. The most polluting firms are often large firms enjoying a strong market power that they can use to manipulate prices as on the goods market.

1.3 Dynamic efficiency of instruments

We have seen that, in addition to the criteria of environmental efficiency (ability of the instrument to achieve the fixed environmental objective) and economic efficiency (in accordance with Pareto efficiency: achieving the target at lower cost), another criterion of comparison of different instruments is the evaluation of their dynamic efficiency, i.e., their ability to exercise a continuous incentive to innovate in order to exceed the target set by maximizing social welfare. According to this criterion, the

economic instruments are preferable to uniform standards, but their effectiveness depends however on the market structure of the polluting sector.

In cases where the polluting sector is perfectly competitive, the imposition of a standard creates no incentives for polluters to reduce their emissions to a level below that required by the standard. On the contrary, in the presence of a tax, the polluter is continuously encouraged to innovate in order to lower its marginal abatement costs, which allows him to reduce emissions, and consequently the amount of the tax to pay. This dynamic effect benefits not only the polluter, but yields also an environmental gain. Similarly, the possibility of gains resulting from the sale of unused permits acts as a permanent stimulus to innovating and consequently exceeding the objectives. However, this incentive to innovate is influenced by the initial permit allocation method. In addition, as far as firms are able to influence, through their behavior, the permit price but not the tax rate, the adoption of a tax is more efficient.

However, in imperfect competition, the incentive to innovate may reduce welfare if the obtained cost reduction allows firms to increase production while reducing their emission rates, resulting in a higher emission level than what would have been reached in the absence of innovation. In this case, the damage may be greater than the benefit derived from increased output. Finally, with regard to emissions trading, strategic behavior of firms on the market for goods and on the permits market may reduce their incentive to innovate in order to prevent their competitors from taking advantage of lower permits prices.

1.4 Choice and coordination between the different systems

This analysis shows that standards appear to be costly environmental policy instruments and are the most difficult to use efficiently because of their rigidity. Under

certain conditions, taxes and further emission permits do constitute the advantage of being more flexible and more incentive for innovation. Thus, market instruments are recognized to be more efficient than command and control instruments (Table 1.2).

Table 1.2: Comparison of the regulatory instruments, according to the criteria of efficiency

Environmental efficiency	Economic efficiency	
	Static	Dynamic
- Standards - Permits	- Taxes, Subsidies - Permits	- Taxes - Permits

However, among these market instruments, the choice between taxes and permits is an increasingly discussed issue at the establishment of environmental policies, both internationally, regionally and nationally. Theoretically, in the absence of uncertainty, taxes and permit systems are equivalent in terms of environmental efficiency and economic efficiency, so the choice of one or the other is accompanied by the minimization of the cost for achieving the environmental objective. However, under uncertainty, these instruments are no longer equivalent. Indeed, Weitzman (1974) shows, using a model with an additive error, that the choice of the instrument depends on the relative slope of the aggregate marginal damage and marginal abatement curves: when the slope of the marginal damage curve is lower (higher) than the marginal abatement curve, the tax (permit) is preferable. Specifically, in the case of climate change for example, if concentrations of greenhouse gases increase less (more) rapidly than the emissions reduction costs, taxes (permits) are preferable to permits (taxes) because they minimize the expected loss of welfare if there is an error in the estimation of the abatement cost curve (Figure 1.1).

Roberts and Spence (1976) were the first to suggest that hybrid solutions, which consist for example in limiting the transactions volume while establishing a trigger

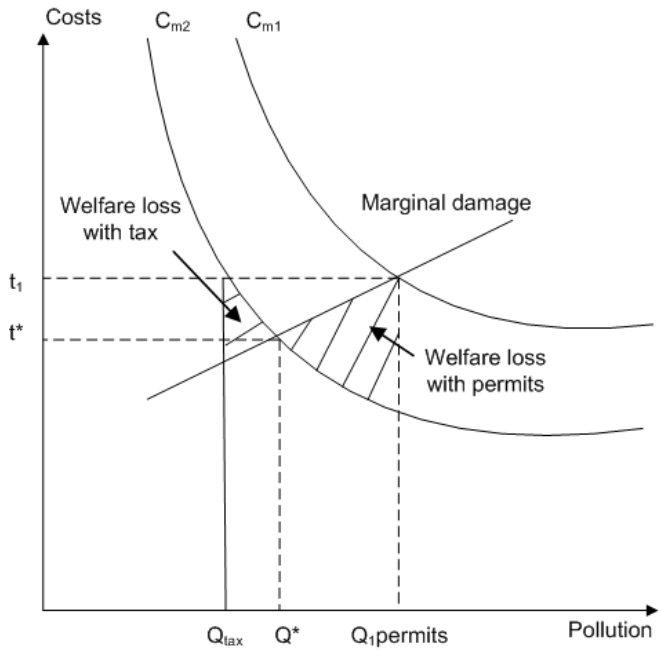

Figure 1.1: Loss of welfare with taxes and permits under uncertainty

price and a price-floor (Safety Valve), would be preferable to the use of a unique instrument. These systems, while based on a market permit, would overcome their major flaw, namely the volatility of price which is the counterpart of the assurance of achieving the target. Indeed, an over-allocation of quotas or a too lax goal drives the price of a ton of carbon down. This volatility (and a too low price) decreases the incentive provided by permits, thus depriving the system of its main advantage, and leads to uncertainty about the cost of the program. The setting of the trigger price and the floor limits this uncertainty, the trigger price serving as an insurance against an improper assessment of emissions reduction costs and the floor price guaranteeing that a minimum amount of emissions reductions will occur.

The introduction of a tax would compensate the price volatility, since it is not subject to the vagaries of market. But the fear here is the coexistence of two different carbon prices within a given economy (if the tax is not equal to the permit price),

thereby preventing emissions to be reduced at a lower cost. This particular problem arose in France in 2009 during debates on the introduction of a carbon tax and its mix with the existing European Union Emissions Trading Scheme (EU ETS), the permit price valuing a ton of carbon at about 13 Euros, and the tax rate initially considered around 32 Euros. Another question was whether a company already subject to a quota should be subject to a tax. Indeed, the current ETS covers about 40% of polluting emissions (30% of French emissions), corresponding to those emitted by major industries which are also the largest consumers of energy. Although a carbon tax was considered for complementarity with the European system, to limit the remaining 70% of French CO_2 emissions related to transport and housing, there remains a hazard for companies that would straddle the two systems. More generally, problems of distortions between the two systems are still feared. This was the case during the implementation of the ETS, whose compatibility with the IPPC directive in Europe and the classified installations for the environment protection directive in France, based on the use of the best available techniques, was also raised and led to reform these measures.

The mix between several instruments always raises problems of compatibility. Just as systems based on a single instrument, the systems known as "hybrid" raise questions about their advantages and drawbacks. Moreover, besides the three criteria of efficiency, a criterion of acceptability by polluters also comes into account in the choice of the instruments and the establishment of environmental policies. All these reasons explain why in practice, governments have imposed regulatory measures that have taken different forms in different countries and periods, which we will examine in the next section.

2 Stylized facts on the development of environmental polices and regulations

For the preparation of this part, we used different sources of documentation. We have been mainly helped by reports from various international organizations analyzing the economic and environmental conditions of countries or regions. Thus, the Environmental Performance Reviews by country, published by the Organization for Economic Cooperation and Development (OECD), outline the main achievements and remaining challenges in OECD countries (developed countries and some emerging countries) in environmental management and sustainable development. The United Nations Economic Commission for Europe has undertaken last decade similar studies on transition countries. These reports, entitled Environmental Performance Review, review for each country the evolution of the environmental policy and the management of pollution and natural resources. For developing countries, our research has mainly been developed from the Country Environmental Analyses, published by the World Bank, studying the institutional framework for countries' environmental management and their natural resource management. Besides these periodic reports, we have completed and refined our research using specific studies on certain topics or areas.

2.1 Local pollution

2.1.1 Air pollution

Air pollution results from the release of air pollutants such as dust, sulfur dioxide (SO_2), nitrogen dioxide (NOx), carbon monoxide (CO) and volatile organic compounds (VOCs). It may be anthropogenic or natural, and the main anthropogenic sources are transport, energy production and industry. Because of its impact on

ecosystems and health, air pollution has historically been one of the first areas of the environment to be regulated.

Developed countries

The United States The first law dealing with the problem of air pollution in the United States was the "Air Pollution Act", enacted in 1955 by the U.S. Congress. This law denounced the dangers of air pollution but contained no national measure of repression against potential polluters, leaving that task to the care of each state. This law was replaced in 1963 by the Clean Air Act, but the first major advances were made in 1970 with the amendment of the Clean Air Act. This amendment was required by the newly created EPA, following an increase in observed rates of nitrogen dioxide (NO_2), ozone (O_3), sulphur dioxide, suspended particles and carbon monoxide in the atmosphere, and a growing popular demand. The Clean Air Act of 1970 is thus the first federal law governing the regulation of the environment at a national level for health and environmental reasons. The NAAQS Standards (National Ambient Air Quality Standards) regulating the emission of these pollutants were then defined. Their implementation required a commitment on the part of States which set action plans for submission to EPA. As far as they were not feasible with the techniques of that period, they also had an incentive effect on innovation. For example, the standards of the Clean Air Act prompted the car industry to develop catalysts that have contributed to a significant reduction in emissions from cars. The amendment of the Clean Air Act in 1990 introduced an emission trading system of sulfur dioxide emissions to fight acid rain, by encouraging firms to reduce their pollution abatement costs, and a control program against leakage of volatile organic compounds. The United States was the first country to use tradable permit

systems for air emissions of sulfur oxides (SOx) and oxides of nitrogen (as well as for management of water resources). This system creates significant additional costs for industry. But it has allowed the reduction of emissions at a lower cost than other types of regulations. Overall, SO_2 emissions dropped by 50% between 1980 and 2007.

The United States use standards, economic instruments and voluntary measures to manage air quality, but recently the emphasis has been placed on flexible approaches, market-based programs such as Cap and Trade. Since the late nineties, emissions of air pollutants have decreased as well. Despite this progress, the intensity of air pollution (emissions per unit of GDP) is rather high compared to the rest of the OECD countries (Figure 1.2). Inspection activities of compliance rates with regulations as well as better inter-regional cooperation lack sometimes. For industry, this policy is rather restrictive and sometimes leads to high additional costs (Greenstone, 2002).

Europe Most ambitious laws were decided in the late nineties at the European Union (EU) level, especially for long-term management of air pollution, water pollution and industrial pollution. As regards air pollution, generally, the law established upper limits for various air pollutants to ensure that ambient air quality was in line with the recommendations of the World Health Organization. Thus, the Framework Directive on air quality in 1996 set out general principles, while its four Daughter Directives of 1999, 2000, 2002 and 2004 set threshold values for each concerned pollutant, by adopting an approach based on the estimated (or observed) effects of pollution on health and/or environment. However, the Large Combustion Plant Directive (LCPD) of 2001 on Large Combustion Plants which aims to reduce sulfur dioxide emissions and nitrogen oxides from existing combustion plants and

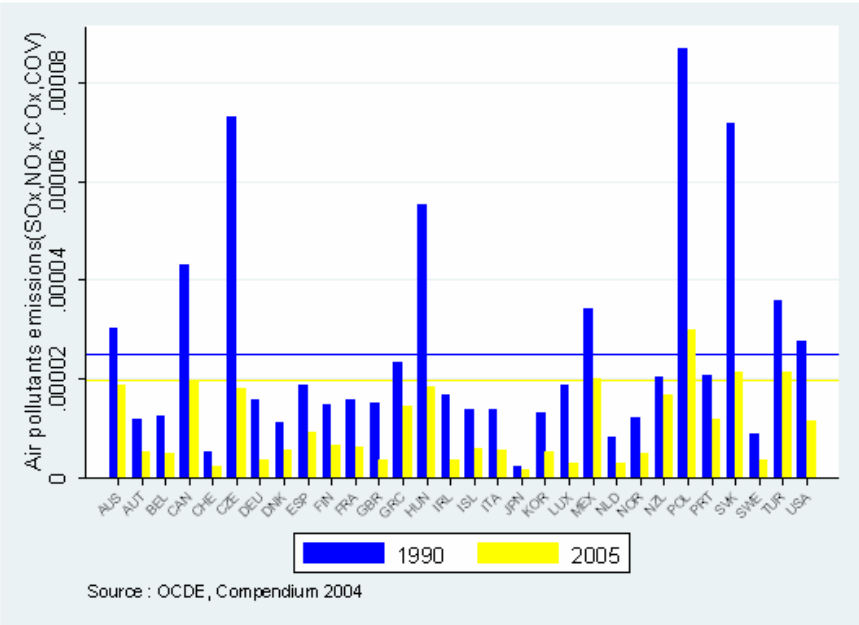

Figure 1.2: Changes in air pollutants emissions for OECD countries (kg / GDP at constant 2000 prices).

the 2001/81/EC Directive on the National Emission Ceilings (NEC), which aims to limit emissions of acidifying and eutrophic pollutants and ozone precursors (SO_2, NOx, VOC (Volatile Organic Compounds) and NH_3 (ammonia)), set emission standards taking into account their technological and economic feasibility, in order to achieve the quality standards of ambient air established by the Framework Directive and its four Daughter Directives.

From an operational point of view, since the nineties, national and European policy makers have opted for more flexible instruments such as environmental taxes or tradable permits. The particular objective is to reduce the costs imposed by regulatory instruments, and in this way fight the problems related to the implementation of EU environmental policy that lasted until the late nineties. Thus, during these years, a significant gap has subsisted between regulation in theory and

in practice, mainly because of the technical difficulties encountered in the decision making at the supranational level and the application of laws within each country. Indeed, the European environmental policy is often done in two stages. Initially, the Council and the European Parliament jointly adopt environmental laws in the form of directives, while in the second phase the governments are responsible for the formal transposition of these laws and their implementation at national levels, and the choice of methods to achieve the objectives set at the European level. Under the Daughter Directives for example, the European policy gives member countries the ability to choose the method and the possibility of setting more stringent standards or even to apply them to other pollutants apparently not concerned. Although the directives apply to all Member States, involving a long-run convergence of their environmental policies, some countries such as the Scandinavian ones for example, sometimes implement even more stringent measures, thus leading to a somewhat heterogeneity of regulations within the European Union[2].

France In France, while amending the Act of 19 December 1917 on classified installations, Law No. 61-842 of 2 August 1961 on the prevention of air pollution and odors is the starting point of the legislative framework of the air regulation in France before its repeal by Law No. 2006-686 of 13 June 2006. Law No. 61-842 establishes the reduction of pollutant emissions from stationary sources. But it was especially in 1976 that was adopted the law which would become at the core of the legal provision of prevention of risks and pollution generated by industrial activities. Thus, this law No. 76-663 of July 19 on the Classified Installations for the Protection of the Environment aims to limit damages from installations which are a major source of air pollutants (sulfur dioxide, nitrogen oxides, hydrocarbons...), through

[2]Sweden, for example, banned the use of TCE (Trichloroethylene), while the EU did not.

a system of prescription of emission limit values and a system of monitoring of the effects on ambient air quality. Later, this law also influenced the European IPPC Directive (see below). More recently, the Framework Law on Air and Rational Use of Energy from 30 December 1996 (LAURE law) sets new qualitative objectives, new monitoring requirements and implements three types of plans to reduce air pollution. In 1999, the General Tax on Polluting activities (TGAP) was created to replace former environmental taxes. Especially, it replaced the Parafiscal Tax on Air Pollution (TPPA), and aims to apply the polluter pays principle. However, the rates are low and below the environmental damages the tax aims at internalizing.

The implementation of measures now benefits from the use of a set of regulatory instruments (classified installations), economic instruments (taxes on polluting activities), planning and voluntary approaches, and is subject to enhanced inspections. Controls on classified installations are frequent and sanctions are dissuasive. Consequently, air pollutant emissions per unit of GDP in France are well below the average of OECD countries and reflect not only the country's economic structure, but also the efficiency of the environmental policy (Figure 1.2).

Emerging Countries

Among emerging countries, we focus on the management of air pollution in three countries from different regions: Mexico, China and Tunisia.

Mexico Articles 110 to 116 of the General Law on Ecological Balance and Environmental Protection constitute the legal basis for the management of air pollution in Mexico. This law defines the powers of the various economic agents in the prevention of pollution. Thus, the Ministry of Environment and Natural Resources (SEMARNAT) publishes regional or local standards and verifies the compatibility

of the measures taken by states and municipalities with federal standards. A national monitoring program of air quality has been established in the largest cities in the mid nineties. The use of economic instruments is encouraged to accompany the system of standards already established. On the whole, these measures which have been strengthened since the early 2000s resulted in a substantial reduction of air pollution. However, ambient air quality standards are still too frequently exceeded. Several industrial sectors are not subject to any regulations and inspections are focused on heavily polluting industries. As an illustration, between 1998 and 2002, 75% of inspected companies did not comply with air emission standards.

Tunisia The main sources of air pollution are energy production, industry and transportation. However, air pollution levels were not very high in the early 2000s, and key actions could be summarized by the introduction in the mid-nineties of three standards defining the limits for some pollutants, emission limits of pollutants from cement plants, and standards for pipe gas emissions from transport vehicles. But without a comprehensive monitoring network, the real impact of these measures is difficult to estimate. In 2001, air pollution from industry accounted for 23.1% of CO_2 and 42.1% of SO_2 emissions (Source: UNFCCC). A framework law on air quality was adopted in 2007, which fixes emission limits to be respected by industry.

China In China, air pollution mainly comes from the coal industry (about 70-80% of SO_2 emissions). Five main laws determine the legal framework for regulating air pollution, and since 1996 three classes of national ambient air quality and emission standards were established. More specific, national numerical objectives for reducing emissions (e.g. -20% for industrial dust) are set. But the problem is that the objectives of ambient air quality and emissions reduction do not coincide,

because the reduction targets are insufficient. The five-year plans also incorporate energy policy objectives focused on energy efficiency. The fact remains that emissions of major air pollutants remain above the average of OECD countries (2.9 times for SO_2), and that China's energy intensity per unit of GDP is 20% higher than the OECD average (but close to that of the United States). Charges, in use since 1979, have not provided incentives for industry, as they were too low, but they were modified in 2003. The establishment of an emission trading system, mainly in the case of SO_2, has been studied since the late nineties. Finally, laws are not enforced strictly enough.

Transition Countries[3]

In the Central and Eastern Europe countries (CEECs) members or candidates to the European Union, since 1995, efforts in economic policy in general and environmental policy in particular have been largely guided by the requirements of the accession process[4]. Thus, these countries had to harmonize their legislation with that of the EU at a high cost price. Regarding air pollution, the introduction of technological innovations and a more efficient management have contributed to an improvement of air quality. In the countries of the Commonwealth of Independent States, the various instruments used for the management of air pollution are not efficient[5]. Legislation is inadequate, the fees are too low to induce a change in com-

[3] According to several commonly accepted definitions, the term "transition countries" refers in our work to the countries where a planned socialist economic system prevailed until 1990, and which prompted a subsequent transition to democracy and a market economy.

[4] CEECs include the ten countries of Eastern Europe (Bulgaria, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia, Czech Republic) now members of the European Union, and six countries of South Eastern Europe candidates for entry into the EU (Albania, Bosnia-Herzegovina, Croatia, Former Yugoslav Republic of Macedonia, Montenegro, Serbia). While Croatia and Macedonia are official candidates respectively since June 2004 and December 2005, Albania, Bosnia-Herzegovina and the Former Yugoslav Republic of Macedonia are still considered as potential candidates in 2009.

[5] Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Uzbekistan, Rus-

panies' behavior, and standards are too stringent to be met. Thus, industry does not face real constraints.

Developing Countries

Finally, in African, Asian and Latin American developing countries, environmental policies have begun to soar since the nineties. In Africa, during the late nineties, laws and standards to govern the air quality are enacted, and many African countries are trying to apply the polluter pays principle. But the vision is too sectoral and source of inconsistencies. Moreover, countries face a technical, human and financial failure to enforce regulations or to implement sanctions against violators. Natural resources continue to be exploited without effective control, no penalty being set against polluters and polluting industries benefitting only from very weak financial and fiscal incentives to make them comply with defined standards. In Senegal, for example, measures to control air emissions date from 2003, and they are still not properly implemented. For other legal texts, no decrees have been issued yet to implement them.

Most developing countries in Asia also established environmental legislation in the early nineties. For some (Pakistan, Philippines), it was relatively sophisticated, while for others (Bhutan and other South Pacific countries) it remained rudimentary. The conventional environmental problems such as air quality were fairly well understood, but the laws remained theoretical and were not reflected in regulations or decrees detailing the implementation of environmental protection.

In the developing countries of Latin America, mainly countries of Central America, environment legislative and regulatory frameworks have been established in the second half of the nineties. But, like other developing countries, those of Latin

sia, Tajikistan, Turkmenistan, Ukraine.

America suffer from multiple inconsistencies and inadequacies of the laws and the difficulty of establishing measures. In Honduras, for example, there is no real regulation on air pollutants emissions. In Guatemala also, major deficiencies are observed about the air regulation.

2.1.2 Water pollution

Water pollution is mainly due to human activities, basically agricultural (fertilizers, pesticides), industrial and urban ones. According to the United Nations Program for Environment (UNEP), about two billion tons of polluted water-comprising wastewater and water contaminated by industrial wastes and pesticides are discharged every day, worldwide. They contribute to the spread of disease and destruction of ecosystems. Like the fight against air pollution, the prevention of water pollution has been a major concern of countries' environmental policies.

Developed countries

The United States The general awareness about the need to control this resource led to the enactment of the Federal Water Pollution Control Act Amendments in 1972, which, since its amendment in 1977, has been commonly called the Clean Water Act. This Act also marked a significant change in the history of environmental policy in the United States by going much further than the previously existing laws. It regulates the discharge of pollutants into the United States waters by establishing standards and control programs established by the EPA. Since then, any discharge into navigable waters coming from industrial plants, agricultural and even governmental requires prior possession of a permit granted by the EPA or by some states administrations. The Act thus imposes new standards, a tradable permit system to ensure its enforcement as well as heavy penalties. It also creates a

system of subsidies for the construction of wastewater treatment plants. Discharges from industrial point sources are regulated under the Law on Water Quality. Increasingly, the application of the polluter pays principle is reinforced. Despite these stringent measures, the intensity of water use (per unit of GDP) is higher by almost 70% above the average of OECD countries, and several cases of non-compliance with the polluter pays principle are listed.

Europe European water legislation was also set early, in the mid-seventies. For thirty years, the EU has adopted legislation to fight comprehensively the dumping of polluting substances in water, but also more precisely by defining standards for certain areas and specific uses. This profusion of texts which made the European Water Policy inconspicuous after all, finally gave rise in October 2000 to the 2000/60/EC Directive. This Framework Directive will thus complete the thirty European directives already in force in the field of water, establishing a clearer and more effective water framework for Community. Following the French law 64-1245, this directive establishes a management and a protection of water resources based on large hydraulics river basins[6]. It includes in particular the gradual phasing out of discharges of some dangerous pollutants within a period of twenty years and has the ultimate goal of restoring a good level of ecological status in 2015. Industries must comply with emission limits and are required to treat their sewage.

France The first important text on the management of water resources in France has been the Law 64-1245 of December 16, 1964. Although this law has undergone several amendments, it has been the main basis for water policy in France for nearly forty years, until its abrogation by Article 2 of Decree No. 2007-1357 of

[6]See Section 2.1.2 below.

14 September 2007. It has also organized water management in six hydrographic river basins following the natural watershed and created river basin agencies (which became water agencies by the 1992 law) whose particular mission is to fight against industrial water pollution by charging water users fees under the polluter pays principle. Moreover, it introduces an important criminal element against polluters. Thus, this law organizes a comprehensive water management in France by implementing a preventive, incentive and punitive regulation. As noted above, it inspired the European Framework Directive of 2000. Two other laws have marked the legislative framework of water policy in France and also affected industries:

- Law No. 92-3 of January 3, 1992: called "water law", this law, conceived under the 1991 EU Directive on urban waste water revives the water policy by generalizing the purification of this resource. It establishes the overall planning of water by creating new water management instruments, the Water Management and Development Top Scheme (SDAGE) and Water Management and Development Scheme (SAGE). Finally, it establishes a system of declarations and permits for all facilities and activities having impact on water, and strengthens the role of the water police.

- Law No. 2006-1772 on water and aquatic environments, enacted December 30, 2006: after a phase of consultation and debate for almost two years, the targets set by the European Framework Directive of October 2000 concerning water regulation made this act necessary[7]. Its primary mission is to provide all water stakeholders the tools to achieve the objectives of good ecological status set by the European Framework Directive. This law has introduced the fee for nonpoint source pollution perceived by Water Agencies as of 1st January 2008, replacing the TGAP on

[7] As for the rest of the European Union countries, the environmental policy of France is strongly tied to that of the European Union. Today, some 70% of French environmental legislation is of EU origin.

pesticides.

Thus, integrated river basin management in France is effective, especially for treating problems of industrial pollution. The measures implemented in application of the polluter pays principle, are strict and reinforced, and thus lead to a continuous decrease of industrial pollution in rivers, despite an occasional dubious efficacy of the water police.

Emerging countries

Mexico Since 1995, Mexico has greatly improved its water policy, and in 2000 it achieved the objectives set by the National Water Plan 1995-2000 on access to water distribution, sanitation services and treatment of wastewater. In the early 2000s, the decentralization of water management has encouraged 27 states to pass their own state water law, and the most important federal water programs have been increasingly devolved to the states. Industries must meet discharge limits and implement the treatment of their discharges. But these limits are less stringent than those applied in most other OECD countries for example, and are not always respected, while industrial discharges are largely untreated. Moreover, in case of non compliance, very high fines are not recovered. Efforts have been made to internalize environmental externalities through the use of market instruments. Mexico has established a system of water abstraction charges and water pollution charges. The industry must also deal with water rates, higher than those for households. The law, concessions and permits enforcement as well as the collection of water abstraction and pollution charges have been strengthened over the various plans; the number of inspections having increased in most sectors of the industry. Thus, for the first time in 2002, the decision was made to close down one of Mexico's largest paper

industries for not complying with pollutant limits in its wastewater discharges. But in order to make these measures fully effective and profoundly alter the behavior of industry, they should be more respected and strengthened.

Tunisia In Tunisia, the sanitation and the prevention of water pollution has long been a priority of environmental policy, because of the vulnerability of water resources of the country. Thus, the first water master plan was implemented in 1970. Since then, the standards regulating industrial water pollution are well developed, but the use of economic and financial instruments is still very brief. The polluter pays principle is not firmly established, the polluting sectors do not internalize the costs they generate and therefore do not change their production habits. Similarly, penalties are too weak to induce behavioral change. As for air pollution management, the private sector and industries show lack of involvement in the process of water resources management.

China Water management holds a major position in China's overall environmental priorities. The legal framework for water in China is therefore complete, including the 2002 law which opens the way for integrated water management and stakeholder participation and initiates the use of market instruments. The laws are implemented together with regulatory provisions and supplemented by decrees. But their implementation at the provincial level can result in regional disparities. Regarding industry, the emissions are a major cause of watercourse pollution. Since the early years of 2000, China has focused its efforts on major polluting industries, and considerable progress has been made. But as for air, compliance monitoring is not coordinated between the different environmental authorities and therefore lacks effectiveness. Furthermore, the levy system which applies only to pollution from

industrial sources is a way to implement the polluter pays principle.

Since 1993, these fees cover all discharges, but they are relatively ineffective and not binding for the industry as their rate is much lower than the abatement cost. In addition, small companies can overlook these charges because they are not pursued by Local Environmental Protection Bureaus, although they are generally more pollution intensive. The water price for industrial use is relatively high; however the efficiency of water use by industry is very low. Finally, the issuance of discharge permits on the basis of national concentration standards and a total load allowance opens the way for trading of pollution allowances.

Transition countries

In most CEE countries, water legislation has been revised in accordance with the requirements of EU directives and improvements have been observed in the early 2000s. The countries apply emissions standards and have included royalties in line with the polluter pays principle, and control systems are put in place. In the CIS countries, water policy was ineffective until the year 2003. It then improved with the introduction of better institutional and legislative framework, but it remains low, with inappropriate actions and very little reinforcement.

Developing countries

In developing countries, drawbacks in water management policies are similar to those of air pollution management policies. Water resources management suffers from legislative, financial and institutional deficiencies. In Senegal, the 2001 measures relating to effluents are not yet implemented. Industrial activity remains an important source of marine pollution. It is the same in Nigeria, where the industrial water pollution is inadequately controlled because of outdated regulation. This is

exacerbated both by the low penalties applied to polluters as well as by the lack of incentives to pollute less. In Asian developing countries, water pollution is a major problem that persists because of poor governance and weak regulation. In most countries, industrial wastewater for example is not treated. In the developing countries of Latin America too, water regulations are as inadequate as those for air. In Honduras, e.g., industrial effluents are almost untreated.

2.1.3 Other regulations

As we have just seen, air and water management policies all contain provisions that directly affect industries. In many countries, industries are moreover the subject of specific measures. In Europe, they have been regulated by 96/61/EC Directive on the integrated prevention and reduction of pollution (Integrated Pollution Prevention and Control), which was adopted in 1996 to reduce the impact of industries on the environment, as a significant portion of the pollution observed in Europe was assigned to them. This directive establishes a framework for integrated control of emissions of certain industrial activities in the air, water and soil, through a licensing system based on the use of best available techniques (BAT). The European IPPC Directive thus provides a common framework for the delivery of permits to the potentially highly polluting plants and for their control throughout the EU. It initially concerned some 50 000 plants, especially in the chemicals, energy, metallurgy, waste management and intensive farming sectors. Having undergone several changes, the IPPC Directive 96/61/EC was replaced by Directive 2008/1/EC, but due to the high pressure that it imposes on the industry sector, some Member States must redouble their efforts to enforce it. Thus, to manage the problem of industrial emissions, the EU has applied a dual approach, on the one hand adopting sectoral directives such as LCPD Directive and the Directive on the incineration of waste that set

standards and obligations for specific sectors, and on the other hand the IPPC Directive which is a transversal instrument controlling emissions from most industrial activities. In some emerging countries, voluntary approaches are encouraged in the industry and cover all types of industrial pollution. In Mexico for instance, clean industry certificates are issued on the basis of voluntary audits.

Other more recent laws also affect industries, such as measures against industrial waste. These measures appeared in the U.S. and Europe in the late seventies, while in most developing countries the issue treatment of hazardous waste is critical due to the lack of resources. Finally, it is worth noting that alongside all these local rules, countries often entered international commitments by participating in global environmental agreements or multilateral agreements consistent with their local pollution management policies. In contrast, the decisions are mainly multilateral as regards global pollution.

2.2 Global pollution and the prevention of climate change

2.2.1 Definitions

Climate change and global warming is the major phenomenon of global pollution since the end of the last century. It corresponds to the increase in worldwide average temperature of oceans and air, observed over several years, and mainly attributed to the intensification of the greenhouse effect.

The greenhouse effect is "a natural phenomenon through which the earth's atmosphere holds the heat emitted by our planet which is heated by the sun: the average temperature of the Earth results from the balance between the radiation flux that comes from the sun and the infrared radiation flux sent back in space" (Beaumais and Chiroleu-Assouline, 2002). Greenhouse gases (GHG), mainly water vapor, carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) absorb

the radiation emitted by the Earth, thus warming the atmosphere. Without these greenhouse gases, the average temperature on Earth would be about -18°C. But it is the increase in atmospheric concentrations of greenhouse gases from human activities which is incriminated in the phenomenon of global warming. The latest report of the Intergovernmental Panel on climate change (IPCC) published in 2007, shows that 49 billion tons of CO_2 are emitted annually by human activities, of which 25.9% are emitted by energy sector, 19.4% by industry, 17.4% by forestry, 13.5% by agriculture and 13.1% by transport. According to these experts, the probability that global warming is due to human activity is greater than 90%.

If not controlled, the dreaded consequences of this mechanism are the loss of some coastal areas due to the melting of ice and the warming of oceans causing the rise of seas level, or the risk of famine and the spread of disease. To fight the greenhouse effect and prevent the climate change, an international action was initiated since the nineties, which was realized in particular through the implementation of the Kyoto Protocol.

2.2.2 The Kyoto Protocol

During the Earth Summit in Rio in June 1992, the Framework Convention on Climate Change was signed by 178 States and the European Union. Its main objective, as defined in Article 2, is to stabilize greenhouse gas emissions, by putting the developed countries under the obligation to bring back individually or jointly their carbon dioxide emissions and other greenhouse gases to their 1990 level. The framework agreement also provides that its executive organ, namely the Conference of the Parties, shall consider whether the decided commitments are appropriate in view of the state of scientific knowledge, and that it shall fix new commitments through amendments or protocols. Thus, in 1995, the Conference of the Parties considered

that the Rio commitments were insufficient, and began to prepare for the adoption of a more ambitious and binding protocol. After more than two years of negotiations, the Kyoto Protocol was adopted on December 11, 1997. It entered into force on February 16, 2005, after the ratification of Russia.

Annex I Parties

The objectives of the Kyoto Protocol are quantified and legally binding for the Annex I developed and transition countries (these objectives are listed in Appendix B of the Kyoto Protocol. See Table 3). They consist in a reduction of six greenhouse gases emissions (CO_2, CH_4, N_2O, HFCs, PFCs and SF6, Appendix A of the Protocol) of at least 5% compared to 1990 levels during the 2008-2012 commitment period. Thus, the European Union and most of the countries of Central and Eastern Europe have committed to reduce their greenhouse gas emissions by 8%, U.S. by 7%, Japan 6%, while Norway, Iceland and Australia have won the right to raise them. The EU then proceeded to the sharing of the load of this target among the fifteen member countries according to their 1990 emission levels and also according to demographic and economic criteria. Finally, Germany target is for a 21% reduction, while France must stabilize its emissions (0%). However, Parties are free to implement national policies and adopt measures that will enable them to reach these thresholds.

United States In 2010, the United States are the only Annex I country which has not yet ratified the Kyoto Protocol, under the pressure of some industrial sectors invoking the impact on the competitiveness of U.S. companies. However, they remain attached to the United Nations Framework Conference on Climate Change. But since the measures taken were not stringent enough, in 2000 the target of reducing their emissions to 1990 levels was not reached. The new US target was

an 18% reduction of greenhouse gas emissions intensity by 2012, and to do so the United States implemented a series of voluntary programs and incentives, mainly focused on the search for technological innovations. Companies therefore encounter no strong incentives to reduce their emissions, and have no real obligations. However, some states such as California, the Connecticut and the Massachusetts, have taken the initiative to have a stricter policy than that imposed by Federal law, and thus introduce an intra-national heterogeneity.

European Union The European Union launched in 2000 its European program on Climate Change (CCAP), which established the European Union Emission Trading System. Entered in force in 2005, it aims to reduce emissions of greenhouse gases of specific industrial sectors (ferrous metals, mineral industry, paper and cardboard), thus covering approximately 40% of European CO_2 emissions. In principle, the system encourages concerned firms to be less polluting and to produce more efficiently (see sections 1.2.2. and 1.3), but it has been criticized for its too generous permits allocation method, which ultimately did not involve substantial behavioral changes nor emissions reductions. Indeed, these quotas being freely allocated to companies, and their level most often based on optimistic forecasts of economic growth, industry did not have to provide much effort. The European Union reinforced these measures in 2008 through the Energy-Climate Plan Package. Within the EU, other countries had already taken their own initiatives, some have adopted national systems of emissions permits (Denmark in 2001, the United Kingdom in 2002), and others put in place tax systems (Sweden in 1991, the United Kingdom in 2001).

France In order to honor its international commitments, France set up in 2000 the National Program to Combat Climate Change (PNLCC) containing measures related to the construction, industry and transport sectors. In 2004, the Climate Plan included measures affecting all sectors of the economy. Following the Grenelle Environment Forum in 2007, the introduction of a carbon tax in France in addition to the European Emission Trading System was discussed at some length, and in March 2010 this project was postponed indefinitely because of the fear that French industries become less competitive than imports from countries that do not bear a similar tax. In other countries where a tax is applied, the efficiency of this instrument is often altered by exemptions and refunds.

Transition countries The limits imposed by the Kyoto Protocol for the transition countries of Annex I, although theoretically binding, may not have much impact on the industries in these countries. Indeed, these limits were set in relation to the 1990 year baseline, after which countries such as Russia and Ukraine have experienced a sharp decline in their economic and industrial activity due to the collapse of the Soviet regime. Industrial emissions dropped considerably without having the industries being encouraged to do so, which suggests they have not changed their behavior. Moreover, these countries may not need the total amount of quotas that has been allocated to them. They will try to sell them, thereby weighing down the international price of permits. Thus, the intensity of the constraint faced by a country and its industry through an emission trading system is strongly linked to the operating conditions of the permit market.

Non-Annex I Parties

Non-Annex I countries (CEEC non-Annex I, CIS countries, emerging and devel-

oping countries) have not committed to quantified reduction targets. This is the second reason given by the United States to justify their refusal to ratify the Kyoto Protocol, especially referring to emerging countries such as India, Brazil or China. Some of these countries have nevertheless implemented measures to control their emissions. However, they remain more lenient than those of Annex I Parties. The conference in Copenhagen in December 2009, which should have been an opportunity for countries that had ratified the Convention to renegotiate a new international climate agreement replacing the Kyoto Protocol, resulted in an agreement designed to limit and reduce greenhouse gases for keeping temperature rises to no more than 2°C. This agreement was qualified as "the first global agreement," because for the first time, it involved all major polluting countries, both industrialized and emerging. Although the agreement is not legally binding and does not set deadlines or quantitative targets, countries such as Brazil and South Africa have adopted a proactive approach in providing a reduction of emissions by about 40% and 34% by 2020, respectively.

We should note that in addition to their national policies, the Parties may also use three flexibility mechanisms that have been defined under the Kyoto Protocol, to reduce emissions at a lower cost:

- Emission permits: provide opportunities for industrialized countries to buy or sell emission rights.

- Joint Implementation: this mechanism allows Annex I Parties to earn emission reduction units by investing in projects in other Annex I Parties, most of which happen to be countries of Central and Eastern Europe.

- The Clean Development Mechanism: is similar to the Joint Implementation but only concerns projects undertaken by Annex I countries in Non-Annex I countries.

Conclusion

In this chapter, we attempted to examine the heterogeneity of environmental policies around the world, since it is a necessary condition for the emergence of the pollution haven hypothesis. This analysis was conducted in the light of the previous theoretical study of environmental policy instruments. Given that the environmental policy of a country is not necessarily homogeneous and depends on the environmental risk involved, we focused on air and water policies. The management of air and water pollution was the first top priority of environmental policies and remains essential today in most countries. For some countries, our detailed analysis has indeed revealed small disparities between air and water regulations. In Tunisia, for example, priority is given to water policy which is more developed and more restricting for companies. However, in most cases, the implementation of measures, much tied to the institutional level of countries, is rather homogeneous within the same country for all types of pollutions. The results of our analysis thus show clear differences between countries at different levels of development, as well as similar but distinct characteristics in countries belonging to the same group. As a whole, the developed countries have implemented their policies since the seventies and strengthened them in the nineties, culminating today in strong policies, illustrated by the adoption of stricter but consistent laws and by the use of various and efficient instruments. Effective implementation of strict measures, especially through market-based instruments which encourage innovation, can thus provide a technological advance to firms from these countries and confer them a comparative advantage. But they must also face environmental costs that may affect their competitiveness. In contrast, emerging and transition countries have begun to address environmental issues in the nineties, and have been successfully since then have been able to develop legislative and insti-

tutional frameworks promising a satisfactory environmental management. However, in emerging countries, the use of market instruments remains insufficient, while the heavy use of subsidies tends to attract polluting industries. In transition countries, the Central and Eastern Europe countries have had an accelerated pace of reform since the early nineties, whereas the CIS countries have started reforms much later in the middle of the decade. Progress in CEEC is much higher than that in CIS countries. In emerging countries as well as in transition ones, firms are likely to encounter stricter regulations soon. But now, they benefit from some flexibility. Finally, developing countries have begun to worry about the environment in the early nineties, and most of them have undertaken reform measures in the second half of the decade. However, because of the lack of technical, human and financial means still preventing the implementation of these measures, firms in these countries are not subject to constraints and are not limited in the amount of pollution emitted.

These disparities in the management of local pollution remain valid if one considers the management of a global pollution problem such as the global warming. The developed countries and some CEE countries have quantified targets, and have, to some extent, taken measures consistent with these objectives. Having not binding targets, the emerging and developing countries have undertaken much less stringent actions.

This analysis has thus highlighted the emergence of differentiated environmental policies between groups of countries over time, in addition to the individual characteristics of each country. In developed countries, the regulation provides elements of flexibility but is relatively strict for industries. Theoretically, the increased production costs can lead to reduced exports, increased imports and a shift of industries to the less regulated countries. Emerging countries and CEE countries are not com-

pletely homogeneous regions, but in spite of their specificity, these countries face common challenges such as ambitious but insufficiently enforced regulations, therefore not excessively burdensome for industry. Developing countries, in their turn, still suffer from a real lack of environmental policies. This heterogeneous development between countries and the impact of the compliance costs of environmental reforms have provoked intense debate, and still give rise to protests during international trade negotiations, as we shall develop in the next chapter.

Appendix 1

1.A Kyoto Protocol's Annex B

Table 1.3: Annex B to the Kyoto Protocol: Emission Limitation or Reduction Commitments

Country	Pourcentage of Base Year
Australia	108
Austria	92
Belgium	92
Bulgaria	92
Canada	94
Croatia	95
Czech Republic	92
Denmark	92
Estonia	92
European Community	92
Finland	92
France	92
Germany	92
Greece	92
Hungary	94
Iceland	110
Ireland	92
Italy	92
Japan	94
Latvia	92
Liechtenstein	92
Lithuania	92
Luxemborg	92
Monaco	92
Netherlands	92
New Zealand	100
Norway	101
Poland	94
Portugal	92
Romania	92
Russian Federation	100
Slovakia	92
Slovenia	92
Spain	92

Sweden	92
Switzerland	92
Ukraine	100
United Kingdom	92
USA	92

Chapter 2

Environmental Regulation and International Issues: the Impact on Location Choices

Introduction

The environment was considered as an international issue for the first time at the United Nations Conference on Human Environment held in Stockholm in 1972. The objective of this innovative conference was to initiate international cooperation for the improvement of living conditions, by boldly trying to link development and environment. This conference thus marked the beginning of a dialogue between industrialized and developing countries, and gave birth to the United Nations Environment Programme (UNEP). After the conference, the environment was integrated as a political priority by many governments, culminating in the creation of hundreds of environmental ministries throughout the world, particularly in the most developed countries[1]. While Stockholm conference has been considered retrospectively as the first Earth Summit, the United Nations Conference on Environment and Development, held in Rio in June 1992, constitutes the real starting point of international

[1] Cf Chapitre 1.

awareness about environmental problems. Indeed, during the twenty years separating these two international events, the environment has been subjected to strong pressures, exacerbated by global catastrophes such as Bhopal chemical disaster in India (1984), the explosion of the Chernobyl Nuclear Power Plant in Ukraine (1986), and the grounding of the tanker Exxon Valdez on the coast of Alaska in 1989. The interdependence between development and environment thus became evident, and the Rio Summit helped to establish the concept of sustainable development which was defined in the Brundtland report (prepared in 1987 by the World Commission on Environment and Development) as follows: " Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs". Besides this breakthrough, the main achievements of the summit were the adoption of the Convention on Climate Change, ultimately coming out with the famous Kyoto Protocol and the adoption of the Convention on Biological Diversity.

This global awareness gave rise to environmental questions during international trade negotiations. This trend was initiated in 1992 with the ratification of the North American Free Trade Agreement (NAFTA) between the United States, Canada and Mexico. It was intensified by the creation of the World Trade Organization (WTO) in 1995 and its decision to prepare reports over trade and the environment. From that time, a close relationship was established between environment and international trade, rapidly raising the question of the environmental consequences of trade liberalization, which still remains a controversial issue.

The main participants involved in this debate are advocates of free trade, environmentalists, and industrialists, each alleging some kind of distortion caused by the trade-environment relationship. In fact, all concerns are directly linked to the as-

sumption that interjurisdictional differences in environmental regulatory stringency affect industries. This assumption, which is referred to as the pollution heaven hypothesis, has been at the heart of a large amount of theoretical as well as empirical literature. Theoretical investigations of this hypothesis have been conducted by Pethig (1976), Baumol and Oates (1988), Copeland and Taylor (1994), who all find theoretical support to a negative impact of environmental stringency on the pattern of trade. In spite of these strong theoretical foundations, early empirical analyses attempting to assess the pollution haven hypothesis concluded that environmental regulations do not really matter (Kalt, 1988; Tobey, 1990, Jaffe et al., 1995). More recently, some researchers have demonstrated that environmental policy has a more significant effect on trade and investment flows (Ederington and Minier, 2003; Cole et al., 2006). This discrepancy between theoretical results and empirical evidence may be due to a poor theoretical framework, or incorrect empirical implementation.

Our objective in this chapter is to explore the theoretical side, while empirical issues will be examined in the following chapters. Indeed, most of theoretical papers in related literature use a traditional Heckscher-Ohlin framework based on perfect competition and focusing on the heterogeneity of environmental regulations between countries. Different market structures that may be more adapted to real conditions have not been sufficiently investigated, while other determining factors like market potential or corruption have been neglected. We attempt to overcome these shortcomings by developing an economic geography model that takes into account industrial agglomeration and in which environmental aspect is introduced in addition to other conflicting factors. We wish to depict more robust theoretical predictions this way, and to derive a clear specification that would be easily testable.

The chapter is organized as follows. In Section 1 we explain the concerns related

to the growing interdependence of trade and environmental policies, and give a review of the major papers in this field. Section 2 will be devoted to a detailed presentation of the pollution haven hypothesis. Section 3 surveys and discusses theoretical foundations and empirical works in related literature. Finally, in Section 4 we derive a theoretical model highlighting the pollution haven hypothesis.

1 Trade and environmental policies

1.1 A controversial relationship

As trade agreements were signed, the effects of increasing world trade on the environment were feared and raised protests. The interdependence of trade and environment has thus given rise to diverging opinions between the various parties. While industrialists worry that stricter regulation affects their competitiveness, environmentalists fear that freer trade leads to an increase in pollution, particularly in developing countries, following from an increase in the scale of economic activity or a change in the economic structure of the country. They also fear that trade considerations prevent countries from setting adequate regulations or, worse, that they lead developed countries to voluntarily weaken their standards in order to attract foreign firms, as predicted by the *race to the bottom* hypothesis (see Box 1). Therefore, environmentalists have called for expanding international trade agreements such as WTO or NAFTA to include cooperation over domestic policies, especially to harmonize domestic environmental policies. Environmentalists' protests were shared by free trade advocates who worry that countries use environmental regulation as a barrier to trade, in order to limit imports. Indeed, the argument is that as trade agreements commit the signatory countries to their trade policy, countries that pursue protectionism objectives, to offer their local industries a competitive advantage over foreign

firms, to protect a particular sector and defend the interests of pressure groups, or to maintain and improve their terms of trade, would use a more lax environmental policy in order to circumvent these trade agreements. These objections led the United States to require, through a Presidential Executive Order, in 1999, that U.S. agencies conduct quantitative assessments of the environmental effects of free trade agreements. Coughlin (2002) notes that at the same time, an opinion survey showed that 67% of respondents thought that the absence of environmental regulatory harmonization would incite U.S. firms to relocate in less strict countries, threatening U.S. jobs as well as environmental quality in developing countries. Fontagné et al. (2005) note that up to 2004, nine environmentally-related trade disputes were recorded under the General Agreement on Tariffs and Trade (GATT) and thereafter the WTO. One of the most famous is the import ban on tuna from Mexico introduced by U.S. government, arguing that the practice of Mexican fishermen did not comply with U.S. Marine Mammal Protection Act.

Box 1: The *race to the bottom* hypothesis

The *race to the bottom* hypothesis was initially developed in federal systems like the United States where environmental responsibilities were originally decentralized to confer federal states flexibility to adapt to local conditions. The failure of this system to prevent the spread of pollution from one state to another, and the inability of governments to manage firms relocation within the country, gave rise to the hypothesis. In the late sixties, along with the *race to the bottom* hypothesis, the federal agencies and laws described in Chapter 1 were created, making the shift of environmental initiative and regulatory authority from the local level to the federal level. With the occurrence of transboundary pollution problems and the increasing international mobility of capital, the *race to the bottom* hypothesis has been applied to the supranational level.

It stipulates that, in the face of falling tariff barriers with weakly regulated countries, it is feared that industrialized countries will relax their environmental regulations or even be hampered from enacting new legislation in the name of international competitiveness. The latter case, namely preventing environmental standards from being raised to appropriate levels because of competitiveness concerns, is also called *regulatory chill*. For illustration, the refusal to ratify the Kyoto Protocol by the United States can be considered as an example of *regulatory chill*. Finally, the *race to the bottom* hypothesis warns against regulatory harmonization at a suboptimal level. It has been demonstrated by some theoretical studies, but it lacks empirical validation, and has mostly been illustrated in literature by a few examples of laws that have never been adopted.

Discussions on the European Union position on the genetically modified organisms (GMOs) issue are another illustration of this controversial debate. In 2003, the United States, Canada and Argentina have complained to the World Trade Organization about the European moratorium on GMO approvals between 1998 and 2004. These three countries, which apply a less restrictive regulation than that of the European Union, considered that the moratorium was a non-tariff protection-

ist measure, designed to protect European agricultural sectors. After reviewing, in 2006 the WTO required the EU to lift the safeguard clauses prohibiting the import of GMOs. In contrast, the EU justifies its position by invoking the risks to human health and environmental toxicity. France invoked impacts on fauna and flora when it decided in January 2008 to activate the safeguard clause with the European Commission, on behalf of the "precautionary principle". This decision is embodied in the suspension of the cultivation of MON810 maize in February 2008[2]. The hostility of public opinion to GMOs and the pressure of farmers have also played a decisive role in the position of France and the European Union.

1.2 Theoretical assessment

Copeland (1990), by dividing protecting instruments into two classes (negotiable and non-negotiable), shows through a two-stage game that trade liberalization induces, in countries motivated to maintain trade protection, substitution toward the less efficient, non-negotiable instrument (e.g., environmental policy). The use of environmental policy as a substitute for trade policy to protect local firms is considered as a second best policy, the first best consisting of the direct manipulation of tariff. The work of Copeland (1990) demonstrates that in the presence of multiple policy instruments, a free trade agreement that would only restrict trade policy would be incomplete, as it is easily circumvented by governments that substitute other instruments to trade barriers. More recently, Bagwell and Staiger (2001) and Ederington (2001, 2002) have also been interested in this mechanism. For example,

[2]The concept of precautionary principle emerged for the first time in Germany in the late sixties. This principle was introduced into Community law by the Maastricht Treaty in 1992. It is invoked for decision-making and action in case of uncertainty about the potential risks to humans and environment. Initially restricted to the environment, it is now extended to health. It allows policy makers to stop the distribution and to decide on the removal from the market of products that may be hazardous to the environment or to health.

Ederington (2001) extended the work of Copeland (1990) by considering both trade and domestic policies under symmetric limitations on cooperation, i.e. by investigating cooperation in an international trade agreement when these policies are seen both as negotiable but imperfectly substitutable instruments of protection. She argues that when limited enforcement power prevents countries from implementing an efficient set of trade and domestic policies, countries should cooperate fully over domestic policy and relax trade policy to maintain the viability of the agreement. This relationship between trade liberalization and environmental policy will be further tested and empirically confirmed for the first time by Ederington, in collaboration with Minier (Ederington and Minier, 2003).

In addition, the use of trade policy as a substitute for environmental policy has been investigated in some works. A first reason for such a manipulation is that since trade may increase pollution, restrictions on trade can reduce pollution. Harmonization of environmental regulations constitutes a second motive for using trade interventions to achieve environmental goals. Strict countries should impose restrictions on the imports of foreign goods from less restrictive countries. A good illustration of this action is, in 2010, as French President Nicolas Sarkozy planned to introduce a carbon tax in France, he suggested applying a carbon tax at the borders of the European Union on goods imported from countries with less stringent laws. A third argument is that people may want to influence the environmental policy in another country. This occurs when pollution is transboundary or global, but it can also be guided by personal beliefs or selfish reasons such as being in favor of wildlife conservation in foreign countries in anticipation of a future visit. The first best policy in these situations typically involves negotiations plus mechanisms of transfers. Alternatives to negotiation are unilateral attempts to influence foreign

environmental policy. Thus, a country that is large enough can use its trade policy to influence the world price of a dirty good. However, such a policy would be effective only if countries coordinate their trade policies to avoid leakage issues (Copeland and Taylor, 2004).

2 The pollution haven hypothesis

2.1 The underlying reasons

The various fears of industrialists, environmentalists and advocates of free trade described above all stem from the same assumption: the environmental regulation affects trade and direct investment abroad. Intuitively, this statement is easily understandable. The environmental regulation affects the production costs both directly and indirectly. Direct costs correspond, for instance, to expenses incurred for the acquisition of a new technology or new skills, as well as to additional costs of labor (Sterner, 1996). Indirect costs are more related to practical problems, for example when the waste disposal sites are reduced or when the use of raw materials is limited or prohibited. Similarly, more complex administrative procedures, such as those required by the IPPC Directive in Europe from industrial plants for obtaining permits, complicate the establishment of firms. Initial studies conducted in the nineties on U.S. data and published by the Census Bureau, showed low industry abatement costs, representing less than 2% of the value of production. These additional costs were often claimed to be too small to affect the competitiveness of U.S. firms. At the same time, a study by the Organization for Economic Cooperation and Development (OECD, 1997) estimated that they represented between 1% and 5% of the production costs of OECD countries, which was more significant and

cannot be neglected in situations of fierce competition between firms and countries. In France, a study conducted by Raspiller and Riedinger (2005) shows that sectoral costs of environmental protection represent about 0.03% to 6.54% of the value added by the sector. Furthermore, not only the strength but also the type of regulations is important (Jaffe, 1995, Nordstrom and Vaughan, 1999; Bruneau, 2004). According to Jaffe (1995), the impact of regulation depends on its shape (market-based instruments or standards). He stipulates that the regulation always raises production costs, but, in the countries where it rather takes the form of exacting standards, it tends to discourage more investment from foreign firms which fear that too ambitious standards would leave them with just a little flexibility. Finally, it appears that whatever the form taken by the regulation (tax, standard, requirement to use cleaner but more expensive processes, or pollution control equipment), it generates additional costs that may affect the competitiveness of firms and countries in a particular sector.

However, as we have seen in the previous chapter, environmental policies have evolved differently in different periods and countries, and these differences are particularly pronounced between industrialized countries and other less developed countries, mainly the developing ones. This feeds the debate on the relationship between regulation and economic growth in an open economy, where one of the most important aspects is the impact of environmental policy on international competitiveness and firms location. Indeed, under the assumption that stricter regulations raise the costs of production, it is more profitable for firms to locate and produce where regulation is the weakest, all other things being equal. In a context of regulations heterogeneity and suppression of trade barriers, it was feared that polluting firms relocate from the most developed and restrictive countries to the least developed

and least regulated ones. These arguments correspond in the economic literature to the pollution haven hypothesis, which is central to our work.

Definition 1: According to the pollution haven hypothesis, it is optimal for polluting industries to move their production capacities to countries with more lax environmental regulation, called "pollution havens". The latter will therefore tend to specialize in those industries for which they enjoy a comparative advantage.

Thus, the main distinction between the race to the bottom hypothesis and the pollution haven hypothesis is that the former predicts a generalized weakening of environmental policies worldwide, leading to a harmonization at a low level, while the second considers heterogeneous policies, with some countries adopting relatively strict measures but importing pollutant products from less rigorous countries.

2.2 A distinction between pollution haven *hypothesis* and pollution haven *effect*

It is noteworthy that in the literature on the pollution haven hypothesis, a distinction/confusion is sometimes made between the pollution haven *hypothesis* (PHH) defined above, and the pollution haven *effect* (PHE). Copeland and Taylor (2004) expose in their work what distinction they make between these two statements. They suggest that the PHH is a stricter version of the PHE. According to them, the PHE stipulates that more stringent regulations marginally affect trade flows and direct investments abroad, while PHH states that trade liberalization leads to a shift of polluting industries from the strictest countries to the least regulated ones, in other words from the developed countries to developing ones. Thus, according to them, the pollution haven hypothesis is confirmed when the pollution haven effect

is so strong that a severe regulation annihilates all other motives for trade, leading to the relocation of polluting industries. We note here that while the PHE affects both trade flows and FDI flows, the PHH is intimately linked to firms' location, and therefore to investment flows. This distinction made by Copeland and Taylor was taken by some authors from the same period, using the expression of PHE to explain that a strict environmental regulation increases the production costs of polluting firms and thus influences trade flows, but that it does not change the source of comparative advantage or the specialization of the country as it would be required by the PHH (Ederington, 2007). Recently, some works refer solely to PHE, others use only the term PHH while others use both terms interchangeably (Levinson and Taylor, 2008). In the Brunnermeier and Levinson article (2004) that provides a review of the literature on the pollution haven hypothesis, the use of both terms suggests that the PHE is the measured effect resulting from PHH. This use is also applied by Eskeland and Harrison (2003) and He (2006), who rarely use the term pollution haven effect, which they use only to point out to the supposed effect of the pollution haven hypothesis. The same use is made by Levinson and Taylor (2008) who, conversely, almost exclusively use the term PHE (except once) to denote the effect that results from testing the PHH, without mentioning the difference between the two terms. Finally, other studies deal with the problem of the impact of environmental policy on FDI without using the words "effect" or "hypothesis" (Keller and Levinson, 2002; Cole et al., 2006), but only speak of pollution havens.

We understand from this analysis that the concept of pollution haven hypothesis has evolved over time. In the nineties, at the revival of the problems generated by the signing of free trade agreements, most studies have investigated the impact of environmental regulations on industry without reference to any "hypothesis" (Jaffe

et al, 1995; Levinson, 1996; List and Co, 2000). One reason is probably that most studies at that time were conducted on the U.S. Then, as the phenomenon has gradually become internationalized, a growing number of studies have focused on the environmental impact of heterogeneous policies between countries, specifically between the North and the South. The Pollution Haven Hypothesis concept then spread (Antweiler et al., 2001; Eskeland and Harrison, 2003; Smarzynska and Wei, 2004), and after that the distinction between Pollution Haven Hypothesis and Pollution Haven Effect appeared in the literature. This distinction probably arose because and as a consequence of mixed results found when testing the pollution haven hypothesis. Furthermore, with the exception of Grether, Mathys and de Melo (2006) which, as far as we know, is the only reference defining the PHE in terms of foreign investments and relocation of industries from North to South, a consensus seems established to refer to the PHH when it comes to studying investment flows[3]. Finally, it seems that the fundamental hypothesis in the literature remains the pollution haven hypothesis. Ultimately, we consider that the PHE is a nuance of the PHH and that the PHH is the generic term to describe general issues associated with the impact of heterogeneous environmental policies on trade and FDI in the context of trade liberalization.

[3]In this case, the term *industrial flight hypothesis* is also used in the literature to describe the relocation of polluting industries from the most regulated to the least regulated countries(Jaffe et al., 1995; Dean, 2002; Brunnermeier and Levinson, 2004).

3 Theoretical foundations and empirical results

3.1 Theoretical foundations of the pollution haven hypothesis in literature

First attempts to take into account the interdependence of international trade and environmental policy by modelling the pollution haven hypothesis occurred in the seventies. They were based on traditional theories of international trade and assumed that countries were identical except for their exogenous environmental policies. Thus, Pethig (1976) demonstrated, through the use of a Ricardian model where pollution was taken into account, that if two countries were identical except for their exogenous emissions standards, the country whose standards were less stringent would export the polluting good. Later on, McGuire (1982) extended this analysis by considering two factors of production and pollution as an input, and demonstrated through a Heckscher-Ohlin international trade standard model that when the production factors are mobile between countries, regulated industries relocate to the least regulated country[4]. Chichilnisky (1994) used a model with two countries, two goods, two factors, where the environment, considered as one of the two factors of production, is a private property in the North, while its ownership is not regulated in the South. She therefore considered that countries only differed in their property rights regime over natural resources, and demonstrated that this caused international trade of pollution-intensive goods from poorest countries (the South), which are supposed to have no property rights, towards the more industrialized countries that were relatively more endowed with natural resources, but whose property rights were better defined. As for Copeland and Taylor (1994), they devel-

[4]See Box 2 for a quick overview of Ricardian and Heckscher-Ohlin models.

oped a general equilibrium model with two countries (North and South), in which only the heterogeneous environmental policies, arising from differences in income between the two countries, were the source of international trade[5]. They showed that when the pollution tax was introduced exogenously and supposed to be higher in Northern countries, the latter produced less pollution-intensive goods, while the Southern countries were producing the more pollution-intensive goods. Copeland and Taylor (1994) also made the contribution of considering the case when tax was endogenous and chosen by the government to maximize consumers' welfare. They found the same result as when income differences were sufficient for the North to establish a higher pollution tax than the South.

Box 2: Classical and neoclassical international trade theories

The Ricardian model (1817, Principles of Political Economy and Taxation):

The Ricardian model is the simplest model of international trade that shows how differences between countries give rise to international trade and gains from trade. Labor is the only primary input to production, and countries are identical except for the productivity of labor between industries and across countries.

Hypotheses:

1) Two countries
2) Two goods
3) A single input, labor, perfectly mobile among sectors but not internationally
4) Constant returns to scale
5) No barriers to trade
6) Preferences are identical and homothetic

[5] However, in the last section of their paper, Copeland and Taylor (1994) examined the potential impact of other factors such as population density, labor and physical carrying capacity of the environment on trade flows.

Box 2 *(cont.)*

7) Technological differences between countries, summarized by differences in the opportunity cost of the production of goods
8) Identical factor endowments

Ricardo developed the principle of comparative advantage: each country can benefit from free trade, provided that it specializes in the good it can produce at a lower opportunity cost than the other country.
The basic idea is that the comparative advantage results from technological differences. In these circumstances, countries will export goods that they produce relatively efficiently and will import goods that they produce relatively less efficiently.

The Hecksher-Ohlin model:
In the Ricardian model, since labor is the unique input, comparative advantage can only result from international differences in labor productivity. But in the real world, trade is not only partly explained by these differences in productivity, but it also depends on the relative factor endowments of countries. This last point is central to the Heckscher-Ohlin theory.
Hypotheses:
1) Two countries
2) Two goods
3) Two factors of production, capital K and labor L, perfectly immobile across countries
4) Constant returns to scale
5) No barriers to trade
6) Preferences are identical and homothetic
7) Identical production technology
8) Countries differ in their relative factor endowments

In the Heckscher-Ohlin model, comparative advantages and trade are determined by international differences in factor endowments. A country will export the commodity that intensively uses its relatively abundant factor.

These early theoretical models of the pollution haven hypothesis, by considering that countries were similar except for their environmental policies, showed that trade liberalization would lead the less stringent country to export the most polluting goods because of the comparative advantage it held for their production. Thus, polluting goods would be produced in the South, i.e. in the unregulated country, while less-polluting goods would be produced in the North, i.e. in the more regulated country.

Due to the increasing international mobility of capital, a few standard models of international factor mobility including environmental aspects have also been developed in the late eighties and in the nineties (Baumol and Oates, 1988; Oates and Schwab, 1988; Rauscher, 1997). The analytical framework of most of these models was the standard model of international factor mobility developed by Jasay (1960), MacDougall (1960) and Kemp (1964), where the environment was introduced as an additional variable. These models produced results that were closely related to those derived in the Hecksher-Ohlin trade framework, factor movement and international trade being substitutes under the assumptions of perfect competition and absence of market interventions. The model developed by Baumol and Oates (1988) highlights the main mechanisms behind this outcome. In this two-country model, each country produces a commodity; there are two techniques of production, one being less polluting but more expensive than the other one. The developed country uses the less polluting production process, while developing country uses the most polluting but less expensive one. With the introduction of a free trade system between the two countries, the use of the polluting production process in the developing country keeps down the world price of the commodity, and thus increases its demand. This higher world demand of the commodity, as well as the increase of

its production in the developing country because of its use of the polluting and less expensive method, generates an increase in polluting emissions. In the long run, the developing country will enhance its comparative advantage in the production of the commodity, while the developed country will specialize in the production of other outputs. These results led Baumol and Oates (1988) to write that if some countries do not adopt environmental regulations while others do adopt them, the first ones "[...] will voluntarily become the repository of the world's dirty industries".

The main interest of these models is that they provided the first theoretical answers to the various questions dealing with the relationship between trade and environment, thus constituting rigorous foundations for subsequent discussions. But their major weakness is assuming that the differences in regulations are the only motive for trade. Indeed, international trade could not only be influenced by environmental considerations, such as highlighted by the pollution haven hypothesis, but by many other conflicting factors. A major improvement in these models was the inclusion of these other determinants. The factor endowment hypothesis is the main alternative to the pollution haven hypothesis, involving another factor than environmental regulation. This hypothesis suggests that factor endowments affect production and trade patterns. Copeland and Taylor (2004) showed theoretically each of the two hypotheses. Taken separately, these assumptions lead to contradictory results: the pollution haven hypothesis, in accordance with results above, predicts the production of polluting goods in the less regulated South, and the production of clean goods in the North. Conversely, when countries only differ in their relative factor endowments, the factor endowments hypothesis predicts the production of the polluting capital-intensive goods in the capital-abundant country (the North), and the production of the clean and less capital-intensive goods in the

capital-scarce country (the South). When both assumptions are taken together, the direction of trade will ultimately depend on the prevailing assumption. The work of Copeland and Taylor (2004) is in line with previous theoretical models of pollution haven based on traditional theories of trade. Copeland and Taylor (2004) review some of these models, and also extend them. The authors come to a more general model incorporating environmental regulation and other factors such as factor endowments as the determinants of international trade.

Thus, the theoretical starting point for most of the empirical work on the pollution haven hypothesis is the Heckscher-Ohlin model of international trade, which shows that countries tend to export goods whose production intensively uses locally abundant factors of production. But, as mentioned by Brunnermeier and Levinson (2004), since these models do not yield an estimable structural equation relating environmental policy to trade, most of empirical works rely on simple reduced-form estimation of the impact of the severity of the environmental policy and other country characteristics on trade flows. These equations take the following form: $Y_i = \alpha P_i + \beta F_i + \varepsilon i$, where the dependent variable Y is a specific measure of economic activity in a country, P is the stringency of the environmental policy, F is a vector of characteristics, and ε is a random error term. Regarding the dependent variable Y, it can represent net exports or direct investment, remaining consistent with Heckscher-Ohlin intuitions. We therefore carry out below the review of the empirical works studying the pollution haven hypothesis when approached through trade flows, or through capital flows.

3.2 Reviewing the empirical studies of the pollution haven hypothesis

3.2.1 Pollution haven hypothesis and the patterns of trade

This category of studies examines the effect of environmental regulation on output measures such as production, net exports and emissions. These empirical studies started in the late eighties, with the aim of testing the above-described theoretical predictions, developed in the seventies. Kalt (1988) conducted one of the earliest studies in this field, using a cross-sectional analysis on the United States like most of the studies of the same period. Indeed, Kalt used a cross-sectional Heckscher-Ohlin model to investigate whether domestic environmental policy affects the competitiveness of U.S. industries. He thus linked cross-sectional variation in trade flows to industry characteristics, by estimating the impact of industry i specific measure of environmental stringency, such as pollution abatement costs$_i$, on trade flows of i. As in similar studies, pollution abatement costs did not appear to impact the cross-sectional pattern of trade. On the contrary, the findings were counterintuitive, with a positive coefficient on abatement costs. The main explanation for these results in this type of studies was that pollution abatement costs only represent a small fraction of total costs. However, the endogeneity of pollution abatement costs combined with unobserved industry heterogeneity are consistent explanations too.

Tobey (1990) also used a cross-sectional Heckscher-Ohlin model. He studied the impact of environmental stringency and other factor endowment variables on trade patterns of five highly polluting sectors, in 1977. In all regressions, (one for each commodity group), he found that environmental regulation was not a significant determinant of net exports. Although the study has the merit of considering not only the United States but was conducted on 23 countries, 13 of which industrialized

and 10 developing, its findings are open to criticism. For instance, they rely on a weak index representing the environmental variable, since it is based on subjective surveys and does not take into account the degree of enforcement of regulations. In addition, regressions have small degrees of freedom, which explains the insignificant impact of the environmental index as well as of the other country characteristics.

Grossman and Krueger (1993) is another widely cited example of this approach, in their attempt to assess the environmental impacts of the North American Free Trade Agreement. The authors argue that trade liberalization affects the environment by expanding the scale of economic activity and changing the technique of production and the composition of economic activity. When comparative advantage is derived from differences in environmental stringency, then the composition effect of trade would exacerbate existing environmental problems in the countries with relatively lax regulations. In a section examining the impact of American industries' pollution abatement costs on the pattern of trade and investment between the United States and Mexico, Grossman and Krueger tested whether dirtier U.S. industries relied more heavily on imports from Mexico, as it would be expected if Mexico was functioning as a pollution haven relative to the U.S. Traditional economic determinants of trade and investment, such as factor prices and tariffs, were found to be very important, while cross-industry differences in pollution abatement costs on U.S. imports from Mexico appeared to be small and statistically insignificant. The authors conclude that differences in abatement costs do not play a significant role, due to the weak weight of environmental costs compared to more considerable production costs.

Since then, articles on pollution haven hypothesis followed, without a consensus being established, while concerns abound over the effects of environmental stan-

dards on trade flows and FDI. Early scientific research did not manage to validate the assumption that environmental regulation affects trade patterns (e.g., Jaffe et al., 1995; Wheeler, 2001). In another attempt to search for the pollution haven hypothesis, Kahn (2003) tests whether the greatest dirty U.S. trade growth has taken place with poorer non-democratic countries. The author shows that poor nations and non-democratic nations are not major exporters of pollution intensive goods to the United States. In addition to the endogeneity of pollution abatement costs and the unobserved characteristics, Ederington et al. (2005) explain partially why previous studies did not confirm the pollution haven hypothesis. They recall that international trade is essentially made between developed countries, whose regulation is quite similar. Nevertheless, if one examines only the flows between industrial nations and developing countries, the environmental standards have more pronounced effects on the trade structure: with the strengthening of the environmental regulation of the United States, imports from developing countries decrease. Moreover, Ederington et al. (2005) notice that on one hand, pollution abatement costs represent a small fraction of total costs on average; on the other hand, polluting industries, whose pollution abatement costs are the largest, are generally the least geographically mobile.

3.2.2 Pollution haven hypothesis and investment

Plant location studies Another strand of the literature examines pollution haven hypothesis using data on direct investment. Studies could either consider plant locations or capital flows. As regards to earliest studies examining plant location decisions, given the lack of data, they have mostly explored the impact of differences in environmental policy across U.S states on plant locations within the United States. They have found similar results as studies on trade flows. For instance,

Bartik (1988), examining the plant location of Fortune 500 companies between 1972 and 1978, concludes that environmental variables have only small effects on location choice. McConnell and Schwab (1990) found a similar insignificant relationship between compliance of states with federal ambient ozone standards and the location of plants from the vehicle assembly sector. Though these studies use different samples of location choices and different measures of environmental stringency and other independent variables, all their results may be biased by unobserved heterogeneity and endogeneity problems. Levinson (1996) makes an attempt to distinguish his study by not focusing on particular industries nor on measures of environmental regulatory stringency. His main contribution was to use adjusted abatement costs also, in order not to overestimate abatement costs in states where polluting plants are more present, controlling thus for states' industrial composition. However, he concludes that strict environmental regulations weakly affect location choices of most manufacturing plants. List and Co (2000) also detect a weak relationship between stringent regulations and manufacturing plant locations. Employing a conditional logit model and using four measures of regulatory stringency, they find evidence that heterogeneous environmental policies across states affected foreign multinational corporations' new plant location decisions from 1986 to 1993. However, the effect is of a relatively small magnitude compared to the effect of states' other characteristics. In response to the problems raised by these cross-section analyses, Becker and Henderson (2000) examine effects of air quality regulation on U.S plant locations, using panel data for 1963-1992. They address problems of earlier plan location literature by using disaggregated state-level data and alternative measures of environmental regulation, as well as controlling for unobserved heterogeneity across locations. Their results indicate a significant negative effect of air regulation on plant births

of polluting industries. Works of Greenstone (2002) and List et al. (2003) confirm this negative effect of stringent environmental regulation on plant location. In this literature on plant location, two additional studies should be mentioned because they do not concern the United States. Smarzynska and Wei (2004) look at foreign investment decisions in 25 economies in Eastern Europe and the former Soviet Union. They find some weak evidence for pollution havens when stringency of environmental policy is measured by participation in international environmental treaties, while results were not supported by robustness checks. Recently, in a study on China, Dean et al. (2009), demonstrate, through a conditional and nested logit analysis, that only equity joint ventures in highly polluting industries and from ethnically Chinese source countries (Hong-Kong, Macao, Taiwan) are attracted by weak environmental standards, whereas projects from industrial nations are not, regardless of their pollution industry. Dean et al. suggest that these findings could be explained by technological differences since developed countries may adopt newer and cleaner technologies regardless of the local standards.

Foreign direct investment flows studies Among the studies that have considered capital flows, we can cite the seminal work of Keller and Levinson (2002). What distinguished their work was its use of, on the one hand, panel data on inward FDI flows in the United States over a long period of time and, on the other hand, an innovative measure of the relative abatement costs across states that were adjusted to take into account industrial composition effects within the state. Regressing foreign direct investment on the index of abatement costs through a pooled OLS and without including state fixed effects, they show a positive or insignificant correlation between the two variables. Inversely, when including state fixed effects, the authors find a robust result indicating that abatement costs have dissuasive effects on for-

eign investments. This result suggests biases due to unobserved state level variables that correlate with abatement costs and investments in earlier literature. However, Henderson and Millimet (2007) attempt to evaluate the sensibility of these results to changes in the parametric hypotheses. Applying to Keller and Levinson (2002) data recently developed non parametric techniques, they reveal that some of the parametric results are not robust, and that the impact of relative abatement costs is not uniform across states and is generally of a smaller magnitude than suggested in the work of Keller and Levinson (2002).

These works on capital flows focus on United States, and thus constitute specific cases of pollution haven hypothesis investigation. However, they do not allow accounting for a greater heterogeneity of environmental regulations and other factors influencing foreign direct investment between different countries. Some studies depart from this methodology and examine different countries in the early 2000's. Xing and Kolstad (2002) examine U.S. FDI from six manufacturing sectors with different pollution intensity, in 22 different countries (7 developing), for 1985-1990. Using an instrumented regulatory stringency, they conclude that U.S. FDI in sectors with high environmental control costs, namely chemicals and primary metals, has a significant negative relationship with the stringency of environmental regulations in the host country, while it is insignificant for less polluting sectors. They also stress the importance of accounting for measurement error problems due to the unobserved regulatory stringency. Eskeland and Harrison (2003) study the effect of sectoral U.S. abatement cost and pollution intensity on FDI originating from France to Morocco and Ivory Coast, and from United States to Venezuela and Mexico. They detect essentially no empirical support for the pollution haven hypothesis in either cases. However, their sample was restricted, and they did not use consistent data on host

country environmental policy.

Finally, we should mention that more recent studies account for endogeneity issues and tend to detect more robust evidence of pollution haven effect, whether they consider trade flows or direct investment (e.g., Ederington and Minier, 2003; Cole et al., 2006). However, they often use instrumental variable analyses which are sensitive to the instruments used, and the effect is of a small magnitude. We will more deeply discuss the endogenity issues and related literature in Chapter 4.

3.3 Summary

In light of the results of key existing studies, we observe that empirical evidence about pollution haven hypothesis remains unclear. While some authors use a general equilibrium and provide theoretical foundations for this hypothesis, its empirical investigations have failed in clearly supporting the theoretical claims that stringent environmental policy leads to specialization in relatively clean production and deters polluting investment. Since the various empirical attempts often led to different results, they did not contribute to mitigate questions raised by the hypothesis. One reason is that theoretical predictions are not directly estimable. Moreover, the latter often focus so far on a few determinants of international trade. The search for pollution havens focusing on data has overlooked the importance of other factors in determining trade or capital flows. By relying more heavily on theory which suggests alternative hypotheses, we should identify those factors more explicitly. We have seen above that theoretical foundations of pollution haven hypothesis often ensued from Hechsher-Ohlin model of international trade, whether their empirical investigation involved trade flows or capital flows. Inversely, we propose in the following section a theoretical model that involves capital flows and would be directly

estimable since it highlights the whole set of factors that influence location decision. Our objective is to put in evidence, through an adjusted theoretical model, the impact of environmental regulations on the location of manufacturing activities, in order to contribute to the clarification of the pollution haven hypothesis.

4 An economic geography model of the pollution haven hypothesis

4.1 Introducing economic geography models

For our theoretical framework, we depart from earlier international trade-based theoretical studies of pollution haven hypothesis and adopt a modern economic geography model. Economic geography has been neglected in economic theorizing for a long time, until Paul Krugman reintroduced it by publishing his monograph "Geography and Trade" in 1991. Economic geography models seem particularly appropriate in our period where capital is more and more mobile, to explain the international or interregional spatial distribution of economic activities. Whereas traditional models of pollution haven hypothesis mostly assume perfect competition and constant returns to scale, economic geography models enable us to introduce more appropriate market structures such as monopolistic competition with increasing returns to scale. The existence of a trade-off between increasing returns to scale due to fixed costs of production that spurs the concentration of production, and transport costs that incite industries to produce close to demand, determines in a comprehensive way the centripetal and centrifugal forces that affect the allocation of economic activity in geographical space. Indeed, in the absence of fixed costs of production, one plant would be built in each consumption place in order to avoid the

shipment of goods. Conversely, in the presence of fixed production costs, it would be more profitable to minimize the fixed costs by building one plant in a single location and ship the goods to the other locations. However, this decision depends on the variable transport costs. In the absence of transport costs, a single plant would be enough to satisfy the entire demand since the shipment of goods from that plant to all other locations is costless; conversely, with an increase of transport costs in function of distance, it is better to build a plant close to each consumption place. Thus, the optimal solution depends on the transport cost, the level of the fixed costs and the quantity of goods produced, i.e. the returns of scale. This framework seems particularly well-adapted to the study of manufacturing industries and the explanation of the industrial agglomeration observed in some regions of the European Union and in emerging countries (e.g., Bangalore in India). It is all the more well-adapted for polluting industries, which are generally characterized by imperfect competition, increasing returns to scale and large transportation costs, for instance, chemicals, steel and other metals, pulp. Moreover, the relationship between geographical space and environmental economics is undeniable, especially in the case of local pollution since environmental harm is directly linked to the location of activities.

Despite these arguments, only a few recent papers have examined the role of the environment in a framework of economic geography. VanMarrewijk (2005) investigates a core-periphery model, Rauscher (2007) examines a variety of New Economic Geography models and derives optimal environmental policies, while Rieber et al. (2008) and Rauscher (2009) look at issues of economic geography and environment through a footloose-capital model. Although these works constitute a major step in addressing environmental issues, they often suffer from a lack of tractability that hampers them from deriving clear analytical results.

4.2 The model

We adopt the standard model of economic geography developed by Krugman (1980)[6], that we extend to take into account the environmental aspect, thus connecting the economic geography literature to environmental economics. Moreover, following Head and Mayer (2004), we aim to derive a firm's location choice specification. However, we extend the model of Head and Mayer (2004) by considering pollution as a third production factor, together with labor and capital. We further depart from Head and Mayer (2004) by deriving a marginal cost that is affected by market distortions.

The theoretical frame of our model is based on the classic hypotheses of the New Economic Geography, i.e. an open economy model with increasing returns to scale, monopolistic competition and trade costs. Monopolistic competition is a common market structure in our economies nowadays, whose basic concept is the product differentiation. Monopolistic competition is characterized by an important number of sellers and consumers. Sellers provide differentiated products, which confers to them some degree of control over price, whereas consumers have clearly defined preferences. Moreover, there are few barriers to entry and exit.

In our model, the world consists of $i = 1, ...N$ open economies. In each country there are two sectors - industry and agriculture. Given the interest of this paper in the industry's location, we model the traditional sector, denoted sector T, as simply as possible. Sector T is supposed to produce a homogeneous good under Walrasian conditions (constant returns to scale and perfect competition), which is freely traded. The manufacturing sector M produces a continuum of differentiated

[6] The standard model of economic geography has been developed by Krugman (1980, 1991), who incorporates transport costs to the model of Dixit and Stiglitz in an open economy. It has been extended by Fujita et al. (1999), whose specification has become very common in international trade theory.

goods, called varieties v, under increasing returns to scale in an environment of monopolistic competition à la Dixit and Stiglitz (1977). Each firm produces a distinct variety, while the elasticity of substitution between two varieties is denoted σ, and $\sigma > 1$. The shipping of these varieties towards another country implies "iceberg" transport costs: $\tau > 1$ units must be sent so that a unity arrives at destination; the rest, $\tau - 1$, is melt in transit. Obviously, the transport of goods generates pollution. However, goods whose production is relatively polluting in a country could be imported from countries using more efficient techniques, which would be consistent with a global reduction of pollution. The mechanisms depicting the relationship between transport and pollution will be detailed to a greater degree in Chapter 4, but at this stage of our work it is sufficient to consider the private cost of transport, since firm's profit maximization is not affected by the pollution resulting from transport.

The consumers spend a part μ of their income E on the purchase of the composite good M, with $0 < \mu < 1$, and the rest is spent on the good T. They have constant elasticity of substitution (CES) sub-utility functions for the composite good. Under constraints of income and each variety's price, the maximization of this sub-utility results in the following demand function of the country j consumers for a specific variety h produced in a country i (see details in Appendix 2.A):

$$q_{ij}(h) = \frac{[p_i(h)\tau_{ij}]^{-\sigma}}{\sum_i \int_{n_i} [p_i(v)\tau_{ij}]^{1-\sigma} dv} \mu E_j \tag{2.1}$$

where p_i is the price of the variety h, $h \in [1...n_i]$, in the exporting country i; n_i is the mass of varieties in any country i, $i \in N$; and τ_{ij} is the trade cost supported by the consumer in the importing country j. The trade cost includes all transaction costs related to the shipment of goods.

Each firm aims to maximize its gross profit on every market. We can write the

gross profit realized in each destination country j by a firm h implanted in a country i:

$$\pi_{ij}(h) = [p_i(h) - c_i(h)]\,\tau_{ij} q_{ij}(h) \tag{2.2}$$

with $c_i(h)$ the marginal production cost of the firm h in country i.

In this model à la Dixit and Stiglitz (1977) and Krugman (1980), the production price is a simple mark-up on the marginal cost: $p = c\frac{\sigma}{(\sigma-1)}$. By substituting it in the Equation (2.1), we obtain the following expression for the quantity that a firm h produces in country i and would ship to any destination j:

$$q_{ij}(h) = \frac{\sigma-1}{\sigma}\frac{[c_i(h)\,\tau_{ij}]^{-\sigma}}{\sum_i \int_{n_i} [c_i(v)\,\tau_{ij}]^{1-\sigma}\,dv}\mu E_j \tag{2.3}$$

Replacing the expression (2.3) and the price expression in the Equation (2.2), summing the gross profits realized by a firm h located in country i while shipping its goods to any market j (Equation 2.2), and deducting the firm's fixed cost $F_i(h)$, we obtain the total net profit earned by a firm h:

$$\Pi_i(h) = \frac{c_i(h)^{1-\sigma}}{\sigma}\sum\nolimits_j \phi_{ij}\frac{\mu E_j}{G_j} - F_i(h) = \frac{c_i(h)^{1-\sigma}}{\sigma}MP_i - F_i(h) \tag{2.4}$$

with $\phi_{ij} = \tau_{ij}^{1-\sigma}$, $G_j = \sum_i \int_{n_i} [c_i(v)\,\tau_{ij}]^{1-\sigma}\,dv$ and $MP_i = \sum_j \phi_{ij}\frac{\mu E_j}{G_j}$.

The profit equation (2.4) shows that the profitability of a country i depends essentially on two factors, namely its real market potential (represented by MP_i, an abbreviation of Market Potential which is a measure of demand representing the accessibility to overall markets from country i. This concept is more deeply developed in the next Chapter), and the prevailing marginal production cost. This is a quite intuitive result, nevertheless these determinants should be made more explicit and expressed in a more predictable way. To this end, we follow Head and

Mayer (2004), who propose a location choice model fully consistent with theory. We suppose that a firm makes its location choice depending on its profit (Equation (2.4)) on each location, thus it proceeds to the arranging in order of those profits. We could thus transform $\Pi_i(h)$ provided that we maintain the same ordering of profits. We firstly assume for tractability that fixed production costs are the same everywhere ($F_i(h) = F \ \forall \ i$)[7], so that they do not affect the profit ordering of locations. We afterwards apply some simple monotonic transformations to Equation (2.4). Namely, by adding F, multiplying by σ, raising to the power $1/\sigma - 1$ and taking natural logs, we write the profitability U of a firm h located in country i:

$$U_i(h) \equiv \ln[(c_i(h)^{1-\sigma} MP_i)^{\frac{1}{\sigma-1}}] = \frac{1}{\sigma - 1} \ln MP_i - \ln c_i(h) \tag{2.5}$$

We need now to specify the marginal production cost $c_i(h)$. In our model, in addition to the two usual production factors, K- capital, and L- labor used by Head and Mayer (2004), we introduce the pollution, P, as a third production factor. The introduction of pollution as a third factor is a realistic assumption, because all industries have an impact on the environment, either through the use of energy or the use of environmental resources. Moreover, pollution is modeled as an input into the production process (and not as a joint output) because it is interpreted as the part of the resources used in the production process and discharged into the environment as pollution. Thus, since pollution is correlated to the use of energy and natural resources, for simplicity it could represent these factors in the production function.

Moreover, we introduce a negative effect from market distortions on productivity. These market distortions, denoted Ω, may include social norms, judicial corruption,

[7]For this reason, our model does not consider specialization of countries.

information asymmetries and other market failures that impose a negative external productivity effect. Some authors underline the necessity of taking into account market distortions resulting from corruption or weak institutions on FDI, while trying to test the pollution haven hypothesis (Smarzynska and Wei, 2004). Indeed, less regulated countries have often more severe institutional problems. Since corruption and laxity of environmental regulation may have opposite effects on location choice decision, it is essential to well specify both of them.

We then represent the production function as a common Cobb-Douglas with constant returns: $Q = AK^{\alpha}L^{\beta}P^{\theta}\Omega^{-\gamma}$, and the associated marginal cost:

$$c = \frac{1}{A} r^{\alpha} w^{\beta} t^{\theta} \Omega^{\gamma} \tag{2.6}$$

where $\theta = 1-(\alpha+\beta)$, $\gamma \succeq 0$, and r, w and t, are costs of capital K, labor L, and pollution P, respectively. The output elasticities of capital, labor and pollution are denoted α, β and θ, respectively, whereas A represents the total factor productivity.

With these last assumptions, we can rewrite Equation (2.5) in the following way:

$$\begin{aligned} U_i(h) \equiv & \frac{1}{\sigma-1} \ln MP_i + \ln A_i - \alpha(h) \ln r_i - \beta(h) \ln w_i - \\ & \theta(h) \ln t_i - \gamma \ln \Omega_i \end{aligned} \tag{2.7}$$

Equation (2.7) predicts that the profitability of a firm h settled in a country i is an increasing function with regard to the market potential and the global factor productivity in country i, and is decreasing with regard to production factor costs and market failures. Particularly, as regards the production factor costs, this equation shows that, in addition to the usual costs of capital and labor, the cost of pollution

also reduces the profitability of a firm h when it increases. Thus, unlike results following from traditional Heckscher-Ohlin models which solely highlight particular comparative advantages, this equation derived from an economic geography model captures explicitly the full scope of location choice determinants. Moreover, it is directly estimable, which is particularly valuable given that the main shortcoming in this literature is the lack of reconciliation between theory and empirical evidence. However, since Equation (2.7) expresses the profitability of a location in function of its absolute costs, one can suppose that it is not appropriate to indicate the location choice of a firm since a firm's decision to invest in a particular country is tied to relative costs across countries. In fact, as we do not observe the potential profitability of each location, we assume that firms choose the country providing the highest profit. We will see in the next chapter that Equation (2.7) is perfectly suitable to a conditional logit implementation which relies on the comparison of profits between several alternatives.

Conclusion

In this chapter, we aimed to introduce the pollution haven hypothesis debate and contribute to it by providing a theoretical model. We first exposed the historical and factual emergence of environmental issues on the international stage and especially during international trade negotiations. As we saw in the previous chapter that the first developed countries began to worry about their environment in the early seventies, in this chapter we showed that the environment held an increasing role worldwide and became a major issue of trade negotiations in the early nineties. Since then, the pollution haven hypothesis has been explicitly expressed, defined, and has become a topic of research of special interest ... still relevant in light of

doubts and challenges that it continues to inspire. After an analysis of key studies in related literature, we conclude that empirical evidence of pollution haven hypothesis still requires further investigation. Since one of the main failures of the previous studies is the lack of theoretical foundation, we developed in the last section of this chapter a theoretical model of economic geography, in which we introduced the environmental aspect. Our model of economic geography introduces several determinants of location choice, among them the market potential, the pollution cost and market failures. The model supplied us with a log-linearized specification for the determinants of firms' location choice, among which we distinguished the impact of the environmental policy. Thus, the use of such an economic geography model has enabled us to derive a rigorous econometric specification, that we will use in next chapters to conduct an extended empirical investigation of the pollution haven hypothesis.

Appendix 2

2.A Deriving the demand function for varieties in an economic geography model

The consumer's behavior described in Section 4 results from the maximization of the following utility function:

$$U_j = C_{Tj}^{1-\mu} C_{Mj}^{\mu} \tag{A. 1}$$

where $0 < \mu < 1$, C_T represents the consumption of the traditional good T, and C_M is the consumption of the manufacturing composite good M.

If p_t denotes the price of the agricultural good, and P_M the price index of the manufactured good, the budget constraint of a consumer whose income is E is written $P_M C_M + p_t C_T \preceq E$. In this case, it is well-known that the aggregate demand functions take the form $C_M = \frac{\mu E}{P_M}$ and $C_{Tj} = \frac{(1-\mu)E}{p_t} = \frac{E_t}{p_t}$, with $0 < \mu < 1$, and μE and E_t are the expenditures on the composite manufactured good and the traditional good, respectively.

Consumers have constant elasticity of substitution (CES) sub-utility functions for the manufacturing composite good M. CES preferences are at the heart of the Dixit-Stiglitz monopolistic competition model (Dixit and Stiglitz, 1977). In our case, they are expressed in terms of a continuum of varieties:

$$C_{Mj} = \left(\sum_{i}^{N} \int_{n_i} q_{ij}(v)^{1-1/\sigma} \, dv \right)^{\frac{1}{1-1/\sigma}}, \text{ with } 1 < \sigma \tag{A. 2}$$

n_i is the mass of varieties produced in a country i, $i \in N$; N is the number of countries in the world; $q_{ij}(v)$ the consumption of the $v^{\,th}$ variety in the country j,

and $\sigma > 1$ is the constant elasticity of substitution.

The consumption of each variety is obtained by maximizing (A. 2) under the budget constraint. We can write the Lagrangian function of this problem:

$$L_j = C_{Mj} - \lambda \left[\sum_i^N \int_{n_i} p_{ij}(v)\, q_{ij}(v)\, dv - \mu E_j \right] \tag{A. 3}$$

and the first order conditions:

$$\frac{\partial L_j}{\partial q_{ij}(h)} = \frac{\partial C_{Mj}}{\partial q_{ij}(h)} - \lambda \sum_i^N \int_{n_i} p_{ij}(v)\, dv = 0 \tag{A.4}$$

$$\frac{\partial L_j}{\partial \lambda} = \sum_i^N \int_{n_i} p_{ij}(v)\, q_{ij}(v)\, dv - \mu E_j = 0 \tag{A.5}$$

The first order condition resulting from the maximization of the CES sub-utility function is equivalent to:

$$[q_{ij}(h)]^{-1/\sigma} C_{Mj}^{\frac{1}{\sigma}} = \lambda p_{ij}(h) \tag{A. 6}$$

and we can rewrite it:

$$q_{ij}(h) = \lambda^{-\sigma} p_{ij}(h)^{-\sigma} C_{Mj} \tag{A.7}$$

with $q_{ij}(h)$ et and $p_{ij}(h)$ the consumption and the price of a specific alternative variety h, $h \in [1, n_i]$, respectively.

Multiplying (A.7) by $p_{ij}(h)$, taking the integral of varieties and summing across the entire mass of varieties produced in all N countries, and substituting this sum in the budget constraint $\mu E_j = \sum_i^N \int_{n_i} p_{ij}(v)\, q_{ij}(v)\, dv$, we obtain:

$$C_{Mj}\lambda^{-\sigma} = \frac{\mu E_j}{\sum\limits_{i}^{N} \int_{n_i} p_{ij}(v)^{1-\sigma}\, dv}$$

Replacing in (A.7), we obtain the indirect demand function of a consumer from a country j for a specific variety h produced in a country i:

$$q_{ij}(h) = \frac{[p_{ij}(h)]^{-\sigma}}{\sum_i \int_{n_i} [p_{ij}(v)]^{1-\sigma}\, dv} \mu E_j \tag{A. 8}$$

and the inverse demand function:

$$p_{ij}(h) = \frac{[q_{ij}(h)]^{-1/\sigma}}{\sum_i \int_{n_i} [q_{ij}(v)]^{1-1/\sigma}\, dv} \mu E_j \tag{A. 9}$$

Chapter 3

Environmental Regulation and French Firms Location Abroad: an International Comparative Study[1]

Introduction

There is, by now, quite an extensive literature on the factors that influence firms' location decisions abroad. Among these factors, the most studied are the cost of production factors such as labor and capital, and the market access. Additional determinants of foreign direct investment (FDI) such as taxation or agglomeration effects have also been studied. In the late seventies, a new factor appeared as a potential determinant of firms' location abroad: environmental regulation.

Environmental regulation has notably been put in evidence by Copeland and Taylor (2004) through a simple model of specialization and trade, according to which the rich countries that protect their environment, should abandon their polluting activities to developing countries, whose environmental legislation and enforcement are not severe. The relatively less severe environmental regulation in developing coun-

[1] This chapter has been in part written with Natalia Zugravu.

tries can create a comparative advantage in pollution-intensive production. This statement commonly illustrates the pollution haven hypothesis that we presented in previous chapter. As a reminder, the pollution haven hypothesis assumes that countries are identical except for exogenous differences in their environmental policies. Thus, it is cheaper to produce pollution-intensive goods in developing countries with a weaker environmental regulation. Trade openness and foreign direct investment could then damage the environment of developing countries. However, from another theoretical point of view, researchers proposed an alternative hypothesis to explain the relationship between trade and FDI openness and the environment: the "factor endowment hypothesis". This alternative approach is based on the classic theory of endowments and would yield an opposite conclusion: polluting activities are generally capital-intensive and should thus locate in rich countries where capital is abundant. Indeed, the factor endowment hypothesis suggests that trade is determined by countries' relative abundance of production factors (labor and capital in most models). Thus, if pollution-intensive goods are generally capital intensive, they should be produced in relatively capital-abundant countries. The underlying ambiguity is that developed countries are supposed at the same time to be abundant in capital and to have a stricter environmental policy, unlike poor countries. These opposite theoretical views can explain the lack of robust empirical proof for pollution havens reality. The stringency of the environmental standards is only one factor determining the comparative advantages between countries, while the endowments of factors such as skilled human capital and physical capital could also largely determine industrial location and the products that a country will export. As far as the strongly polluting industries tend also to be intensive in capital, the relative lack of capital in the developing countries can prevail over the advantage of low abatement

costs (e.g., Antweiler et al., 2001; Cole and Elliott, 2005). This narrow connection between both pollution haven hypothesis and factor endowment hypothesis should be taken into account while testing anyone of them.

The debate on the pollution haven hypothesis produced a political challenge by trying to find clear empirical evidence in order to answer what is really a complex and dynamic issue: how does environmental regulation interact with more and more mobile production? The increasing relocation of industries towards developing countries raises many questions in the field of employment and with regard to the environment. Nevertheless, as mentioned in previous chapter, empirical research often fails to prove this hypothesis. Generally, statistical studies prove that the pollution haven hypothesis cannot be clearly identified. Four potential problems in this literature require more empirical tests. First of all, most studies are lacking theoretical foundations for the construction of the equations to be tested, which often entails specification errors. Secondly, the studies of Zhang and Markusen (1999) and Cheng and Kwan (2000) demonstrate the importance of relative endowments of production factors in the explanation of FDI. The absence of this determinant can lead to omitted variable bias. Next, as noted by Smarzynska and Wei (2004), several studies use very aggregated data on FDI, and proxies of the severity of the environmental policy that depart from the real variable to be taken into account, which generally results in bias induced from measurement-error. Finally, Keller and Levinson (2002) and Levinson and Taylor (2008) emphasize the empirical importance of controlling for the unobservable characteristics of industries and locations. The laxness of the environmental policy, supposed to attract polluting firms, may be associated with other characteristics that, in their turn, generally discourage the establishment of foreign firms. It is notably the case of weak institutions, expressed through high

corruption level, lack of civil freedoms' and property rights' protection, etc. That is why, as Smarzynska and Wei (2004) underline, it is necessary to take into account the effect of institutions on FDI, while trying to test the pollution haven hypothesis.

Our objective in this chapter is to empirically reexamine the pollution haven hypothesis, by attempting to take into account these various limits by different means. Consequently, we rely on the classic theoretical model of New Economic Geography developed in Chapter 2, which provided us a log-linearized specification for the determinants of firms' location choice, among which we distinguish the impact of the environmental regulation. As far as we know, despite the ability of economic geography models in explaining the localization of manufacturing industries[2], at the moment there is broadly no empirical study on the pollution haven hypothesis based on a theoretical model of New Economic Geography. One exception is Jug and Mirza (2005), where authors derive a structural gravity equation and manage to show that environmental regulation is a determinant of trade flows. Otherwise, economic geography models have been used in purely theoretical studies (e.g., Conrad, 2005; Rauscher, 2007; Van Marrewijk, 2005; Rieber et al., 2008), while studies on pollution haven hypothesis are most often strictly empirical studies or based on standard international trade models. In previous chapter, we took use of such a model with the aim of deriving a rigorous econometric specification on which we can base an empirical investigation of the pollution haven hypothesis. Thus, for our empirical work we use firm-level data on French firms, and we analyze FDI determinants in heterogeneous countries. We should pay particular attention to transition and emerging economies, since these countries became very popular destinations for French firms at the beginning of the 21th century. Concerning the specific case of transition countries, between 1992 and 2002 the French multinationals multiplied

[2]Cf. Chapter 2 for more justifications about the economic geography models.

by six the number of their subsidiaries in Central and Eastern European Countries (CEEC) and countries of the Commonwealth of Independent States (CIS), this region representing thus 11% of the total of the French firms abroad in 2002 (3 % in 1992)[3]. Regarding emerging countries, while they counted about 25% of the French establishments in 1992, in 2002 they counted about 35%. This reorientation of French FDI towards countries that we have identified in Chapter 1 as relatively lenient, constitutes a strong incentive for an investigation of the pollution haven hypothesis.

Furthermore, to represent the environmental regulation's stringency in a complete way, we create a complex and dynamic index which assesses the relative severity of the environmental policy across countries, based on a diverse set of variables.

Finally, in order to take into account the specific characteristics of countries and industries, the empirical estimations are performed controlling for different country-groups (high-income Developed countries, Emerging countries[4], Transition CEEC, Transition countries of CIS, and Developing countries[5]), while the estimation methods used control for firms and industry specific effects. An additional test would be conducted to take into account the heterogeneity of FDI, controlling for the FDI

[3]Source: Subsidiaries-Survey 2002, managed by the Directorate of Treasury and Economic Policy on 2002.

[4]An emerging country is a country, up to there under developed, which undertook measures and accumulated means, in particular legal and cultural, in order to begin a phase of fast growth of the production and social welfare. According to the Morgan Stanley Emerging Markets Index published by Morgan Stanley Capital International (MSCI), in July 2006, the status of emerging country was awarded to the following countries: Argentina, Brazil, Chile, China, Colombia, Egypt, India, Indonesia, Iran, Israel, Jordan, Malaysia, Mexico, Morocco, Pakistan, Peru, the Philippines, South Africa, South Korea, Taiwan, Thailand, Tunisia, Turkey, and Vietnam. Czech Republic, Hungary, Poland, and Russia are also classified by MCSI as emerging economies, but we include these countries in their respective transition country-group.

[5]According to the World Bank classification, countries with per capita GNI superior to $11,456 are considered as high-income countries. We use this classification excluding from this list countries considered in our study as transition or emerging economies. All other countries, not included in our Transition, Emerging, or Developed (high-income) country-groups, have been included in the Developing country-group (see Appendix 3.B for the list of countries included in our sample).

mode of entry.

The novelty of this study lies on using a specification derived from an economic geography model that integrates pollution as an additional production factor, and employing appropriate econometric techniques to well-exploit a firm-level database on worldwide location of French manufacturing subsidiaries. We use the conditional logit model, which is a proven estimation method in the literature on location choice, providing high precision on estimated effects, since performed on thousands of firm-level data observations. As we have seen in the literature review in Chapter 2, most existing studies estimate the impact of cross-regional differences in environmental regulation on foreign firms' location inside a single country, a large part of them focusing on the United States. Only a few attempted to examine this hypothesis for other countries (Smarzynska and Wei, 2004; Dean et al., 2009). However, the actual debate on the reality of pollution havens mainly concerns international issues: the fear that less regulated, poorer countries become pollution havens for polluting firms from more regulated, developed countries. Hence, our study is more relevant in the actual international debate regarding pollution havens, since it assesses the impact of environmental regulation on FDI in different countries.

Our chapter is structured as following: Section 1 describes the empirical model and data used; in Section 2, we examine main empirical results and provide an extended analysis, while in the third section we present some robustness tests.

1 Empirical methodology

Our objective in this chapter is to empirically estimate the model that we developed in Chapter 2, so as to examine the determinants of firms location and the role played by the environmental regulation in the location decision. In Chapter 2, we

used an economic geography framework à la Krugman and derived a firm's location choice specification consistent with theory, following Head and Mayer (2004) but introducing an environmental aspect. We obtained the resulting equation:

$$\begin{aligned} U_i(h) \equiv & \frac{1}{\sigma - 1} \ln MP_i + \ln A_i - \alpha(h) \ln r_i - \beta(h) \ln w_i - \\ & \theta(h) \ln t_i - \gamma \ln \Omega_i \end{aligned} \tag{3.1}$$

where the profitability of a firm h settled in a country i is an increasing function of the market potential MP_i and the global factor productivity A_i in country i, and is decreasing with regard to production factor costs and market failures prevailing in country i. The location choice decision of a firm depends on the comparison of its profits in each location. We present below the econometric investigation of this decision.

1.1 A location choice model: the conditional logit

We must examine the individual location decisions of firms, which corresponds to the discrete choice of establishing a plant in one location. This type of decision involves a particular econometric modeling, i.e. the models of qualitative choice. These models calculate the probability that an individual will choose a particular alternative among a set of alternatives based on the observations available to the researcher. In our case, we seek to study the factors determining a specific firm single location choice between some unordered alternatives. An unordered choice model particularly well-adapted to our theoretical framework is the model developed by McFadden in 1974, i.e., the conditional logit (firm fixed-effects logit model).

The conditional logit is a discrete choice model based on profit maximization, assuming that firms maximize a profit function subject to some uncertainty when they choose a location. The underlying idea is that although the potential profit corresponding to each location cannot be observable, by contrast we observe the firm's actual location choice, as well as the locations' characteristics that correspond to the profit function components. We can therefore sort locations according to their potential profits and determine the effect of each component variable in U_i.

In such a model, each firm compares the profits related to the different location alternatives, and selects, among the N alternatives, the location that will maximize its profit $\pi_i(h)$. In other words, each French firm h, faced with N alternatives, will choose to locate in country i if the expected profit $\pi_i(h)$ exceeds the expected profits $\pi_j(h)$, for all $j \in N$ alternative locations. If we denote $\pi_i(h)$ the underlying profit associated to a location i, and $Y_i(h)$ the location choice observed, we have:

$$Y_i(h) = \begin{cases} 1 \text{ if } \pi_i(h) = Max(\pi_1(h), \pi_2(h), \pi_N(h)) \\ 0 \text{ otherwise} \end{cases}$$

In our example, for a French firm h facing N alternatives, the profitability of choosing i, $i \in N$, can be written:

$$\pi_i(h) = \beta' Z_i + \varepsilon_i \tag{3.2}$$

with Z_i a vector of independent variables that vary between location alternatives, β the vector of estimated parameters, and ε_i a random error term which may correspond to the random part of the maximization process, the unobserved variables related to location i and affecting the choice of firm h, or measurement errors.

The model is made operational by a particular choice of distribution for the dis-

turbances. With $Y_i(h)$ the random variable that indicates the choice made, McFadden showed that, if and only if the N disturbances are independent and identically distributed with Weibull distribution, the probability that firm h chooses location i is given by:

$$Pr(Y_i(h) = 1) = exp(\beta' Z_i) / \sum_{j=1}^{N} exp(\beta' Z_j) \tag{3.3}$$

Our purpose here is the estimation of β for each explanatory variable Z for location choice (i.e. for the underlying profitability function of each location). These coefficients will be estimated by the maximum likelihood technique, which consists in finding the values of the parameters that maximize the probability of observing a given sample. In our case, the maximum likelihood technique will provide the values of the parameters that maximize the probability of observing the particular location choices made by the firms of our sample.

This intuitive formulation of the conditional logit model presents nevertheless some limits due to the assumption concerning the disturbances, which implies the property of Independence from Irrelevant Alternatives (IIA). According to the IIA property, the likelihood of making a choice is independent of the other alternatives. In practice, this assumption could be problematic. In order to mitigate this problem, in our econometric specification we introduce in addition to the explanatory variables, dummy variables representing the five different groups of countries forming our sample. With the assumption that the error terms are correlated only within the groups of countries and not across the groups, the dummy variables (defined in Section 2) should capture this correlation and reduce the IIA problem (see Head, Ries and Swenson, 1995, for a similar technique).

1.2 Data description

1.2.1 Dependent variable: the location choice

Data concerning French firms location choice have been gathered from the Subsidiaries-Survey, conducted by the Directorate of Treasury and Economic Policy (DGTPE in French) in 2002. This Department collects from French Economic Missions abroad the census of French subsidiaries, defined as units whose capital is owned by a French parent company by at least 10%. The best records in this survey, with no missing points, concern for each subsidiary three variables used in our study: the French classification NAF93 code of the subsidiary's sector, the host country and the year the location choice was undertaken. Since we estimate our location model through a conditional logit, other characteristics of firms (e.g. size, age, etc.) for which we do not have sufficient information will be captured by the firm-fixed effect implied by such kind of models. Despite some potential imperfections in this database, due to the missing observations, its use is of considerable interest for the study of FDI determinants in general and the pollution haven hypothesis in particular, because it allows to control for firm-level and sectoral characteristics. Those characteristics, such as the importance of economies of scale, holding specific advantages, explain in a large part the firms location abroad. In the case of the pollution haven hypothesis, the sector of the firm is of a prime importance. To assess how representative is this database, the DGTPE notes that for 83% of the countries covered by the survey, the NAF sector was filled for more than 75% of the French subsidiaries (for each country). Moreover, a quick analysis of the balance of payments indicates that in 2000, 80% of the stocks of French investments concerned 12 countries (381 billions € out of 465 billions. Source: French Central Bank). A comparison with the DGTPE database shows that these countries host 60% of the French international

subsidiaries present in the database.

From the host country point of view, each country may receive several or none French FDI in a given year. However, we construct our database in a suitable manner for performing conditional logit estimations. For each subsidiary, which appears a single year in our database, i.e. when the investment decision occurred, the dependent variable takes the value 1 for the chosen country and 0 for the other countries in the sample. Thus, the total number of observations corresponds to the number of firms multiplied by the number of alternatives (countries in the sample).

We concentrate on the manufacturing industry, excluding the two-level NAF93 code DF "Coke, Petroleum Refining and Nuclear Industry" which corresponds to specific sectors whose location determinants are beyond the scope of this study. Since a monopolistic competition is assumed by the theoretical model, we remind here that French manufacturing industries considered in this empirical work match the characteristics involved by such a frame (important number of sellers who provide differentiated products).

Finally, our empirical sample covers 1374 French investments in 74 countries from 1996 to 2002[6].

1.2.2 Explanatory variables

As we have seen through our base theoretical model developed in Chapter 2, the profitability of a location for a firm depends on the market potential of the location and the firm's marginal cost of production, the latter being a function of the total factor productivity, the production factor costs and market failures.

[6] See Appendix 3.B.

The market potential

The market potential is a general concept regarding the impact of demand on firms' location. Gross domestic product of the host country or its population are the most commonly used proxies for demand variables, but they are very partial. Indeed, measuring the local demand through these variables presents the major inconvenience to not take into account the demands emanating from nearby countries and the facility or difficulty to reach them. In this study we exceed these limits by using the concept of market potential of a location. Here, market potential (MP) means "demand accessibility". This concept was introduced by Harris (1954) who proposed, as a measure of the potential demand that a firm faces, the sum of economic sizes of surrounding markets weighted over distances: $MP_i^H = \sum_{j=1}^{N} \frac{GDP_j}{dist_{ij}}$. Harris's (1954) idea is that producers tend to locate in the regions that guarantee them a significant degree of accessibility to various markets. The concept was then validated by its deduction from the standard model of the new trade theory, such as presented in Equation 4 in Chapter 2 (Krugman, 1992; Head and Mayer, 2004). However, the presentation of the market potential à la Harris is insufficient because of the omission of the price index which allows to take into account the effect of competition. Besides, this simplification supposes that the simple distance includes all costs, while the literature on the border effects on trade between countries refutes this hypothesis by underlining the importance of obstacles bound to borders (McCallum, 1995; Head and Mayer, 2000).

The Market Potential we use in our work is derived from theory (See Section 3 in Chapter 2) and is given by the following expression: $MP_i = \sum_j \left[\frac{\phi_{ij}\mu E_j}{G_j}\right]$, with $\phi_{ij} = \tau_{ij}^{1-\sigma}$, $G_j = \sum_i \int_{n_i} \left[c_i(v)\tau_{ij}\right]^{1-\sigma} dv$, σ denotes the elasticity of substitution between two varieties, c_i is the marginal production cost in country i; τ_{ij} is the trade

cost, and μE is the share of the income spent on the purchase of manufactured goods (See 3.A). Moreover, it is essential to consider, besides the distance, additional trade costs induced by crossing borders and sharing or not a common language, while estimating the market potential of all possible destinations. Following Redding and Venables (2004) and Head and Mayer (2004), we build a measure of market potential that aggregates the local demand and the demands emanating from nearby markets, while taking into account the effect of demand's depreciation due to obstacles related to shipping goods in space and across borders. The estimation technique is presented in Appendix 3.A.

Moreover, given that market potential values have been calculated using estimators of trade regression, the standard-errors of Equation 3.3 may be biased as they include also trade equation's errors. We use the bootstrap technique in order to obtain correct standard-errors[7].

Total factor productivity (TFP)

Since there is no available data on total factor productivity, we use here two proxies: per capita GDP ($GDPcap$), which is a commonly used variable for productivity approximation, and the estimated TFP growth (TFP_growth), capturing hence simultaneously cross country differences in TFP levels and growth, respectively.

For TFP_growth construction, we apply a "Growth Accounting" calculation method, following the technique developed by Robert Solow (1956) to calculate

[7] The bootstrap is a computer-intensive statistical technique that plays an increasingly important role in modern statistical analysis and applications. Introduced firstly by Efron (1979), this method is essentially a form of a larger class of methods that resample from the original data set, and thus, are called re-sampling procedures. Its first application was in estimating parameters of complex distributions and its accuracy (standard error) and determining their confidence intervals. Because of the bootstrap's generality, it now has been applied to a much wider class of problems, including error rate estimation in discriminated analysis, subset selection in regression, logistic regression and classification problems, and many others (Chernick, 1999).

the rate of technological progress. According to this technique and our theoretical model's assumptions, the sources of output growth are: contribution of capital growth $\alpha\frac{\Delta K}{K}$; labor growth $\beta\frac{\Delta L}{L}$, pollution growth $\delta\frac{\Delta Poll}{Poll}$, and contribution of total factor productivity growth $\frac{\Delta TFP}{TFP}$. Thus, the technological progress in our study (TFP_growth) equals output growth which is not explained by factors growth ($TFP_growth = \frac{\Delta TFP}{TFP} = \frac{\Delta GDP}{GDP} - \alpha\frac{\Delta K}{K} - \beta\frac{\Delta L}{L} - \delta\frac{\Delta Poll}{Poll}$)[8].

Production factor costs

Following the theoretical model, the marginal cost of production faced by a firm is function of capital, labor and pollution costs.

Capital and labor costs In our study, we capture capital and labor costs through the often used "countries' relative endowments in production factors" proxy, represented by the variable KL. KL is the ratio K/L, with K the capital stock, and L the total labor force[9]. Labor-abundant countries that have a weaker K/L ratio are supposed to have lower wages than capital-abundant countries[10]. Conversely, capital-abundant countries with a higher K/L ratio are supposed to have lower capital costs than labor-abundant countries. Thus, a negative relationship between KL and the probability of attracting FDI would imply attractiveness for a less costly labor force. K/L controls for the differences in relative factor endowments, referring to the comparative advantage in the standard Heckscher-Ohlin international trade

[8] The coefficients α, β and δ are obtained by running regression: $\ln GDP = \alpha \ln K + \beta \ln L + \delta \ln Poll + \varepsilon$, for each country-group, separately, assuming for accuracy that countries from the same group have similar factor shares.

[9] The capital stock is calculated by using the following formula: K_t= gross fixed capital formation$_t$ + 0.95 capital stock$_{t-1}$. Due to data availability (particularly concerning transition countries), the initial stock is represented by the gross fixed capital formation in 1990.

[10] This is valid when the same commodities are produced and when preferences are identical. For two countries with identical demand patterns, relative factor prices should reflect relative factor scarcities.

model.

Regarding the potential endogeneity between KL and our dependent variable, we recall that capital is available worldwide, as highlighted in a recent report from the French Board of Economical Analysis (Fontagné and Toubal, 2010). What encourages the investment in a country by a foreign company rather than a local and better informed one, is that the former holds a specific advantage (in terms of technical know-how, organizational capacities...) as compared to the local firm, rather than the mere opportunity of a movement of capital as suggested by Mundell (1957). This firm specific advantage has been evolved by Dunning (1977), under the OLI paradigm (Ownership-Localisation-Internalisation). Therefore, the transfer of capital associated with the establishment of a subsidiary is not necessarily significant, and the risk of endogeneity of KL variable is weak.

Pollution cost The most complex cost to be represented is the environmental regulation, for which there is no available precise measure. Thus, it is necessary to have recourse to proxies in order to represent it in the best way. This task is even harder in our case since the extent of our sample forces us to resort to dynamic measures of the environmental regulation for a panel of various countries. To address this problem, some studies have undertaken the construction of environmental indexes with the aim of representing countries 'environmental policy as correctly as possible. But these works that have used or developed environmental indexes were conducted on a few years and countries. For illustration, we can cite the complex index created by Dasgupta et al. (2001), which evaluates the environmental performance of 31 countries in 1990 using UNCTAD reports and focusing on the state of regulations, existing laws, controls and enforcement measures, for air, water, land and vital resources. This index, which was also used by Eliste and Fredriksson

(2002) who expanded it to 62 countries, presents the advantage of being available for heterogeneous countries, but has the disadvantage that it only relates to one year. Another index much more general since it takes into account 68 variables grouped into 20 indicators, The Environment Sustainability Index, was used by Smarzynska and Wei (2004), but it was only created in 2001. Thus, we had recourse to different proxies that allowed us to compute a global and quite exhaustive Environmental Regulation index for each country in our sample (see Appendix 3.B). This index has initially been computed following two different techniques: Z-score method (Box 3) and Principal Component Analysis (PCA)[11]. Since the Z-score method is commonly used for computing aggregate indexes, while PCA analysis is rather used in data description and for a reduction of data dimensionality, we retain Z-score ER index (ER) for our core analysis, and use PCA ER index in a robustness test. The obtained values of the index, which are presented in Appendix 3.B, confirm in a large extent the results of our analysis of the environmental policies in Chapter 1. European developed countries have the highest values, while CIS and developing countries have the worst ranks. In the middle, we mostly find emerging and CEE countries.

[11] In statistics, principal components analysis is a technique that can be used to simplify a dataset. Indeed, scoring principal components through PCA allows identifying specific trends by weighting components following their contribution to the global variance in the dataset. More formally it is a transform that chooses a new coordinate system for the data set such that the greatest variance by any projection of the data set comes to lie on the first axis (then called the first principal component), the second greatest variance on the second axis, and so on. PCA can be used for reducing dimensionality in a dataset while retaining those characteristics of the dataset that contribute most to its variance.

Box 3: The Z-score method

The Z-score method is a common statistical way of standardizing data on one scale so a comparison can take place. We first calculate for each variable and year, the distance between each country's value and the mean of the group expressed in standard-errors, following the formula: $z = \left(X_{jt} - \overline{X}_t\right)/\sigma_t$. We thus obtain values that allow to classify the countries below or above the mean. Then, we calculate the unweighted average of all variables' z-scores. Finally, we apply the standard normal percentile technique which gives the value 0 to the least average Z-score and 100 to the highest.

Our ER index integrates four variables, which have the advantage of permitting cross national comparisons in a systematic and quantitative fashion.

Multilateral Environmental Agreements (MEAs ratified):

This variable distinguishes countries having ratified several international environmental agreements, proving this way their governments' concern about environmental protection. We add up for each year the number of agreements ratified by a country, since it is the ratification rather than the signature that imposes compliance to international environmental treaties (see Smarzynska and Wei, 2004, for the use of international treaties as a proxy for environmental regulation stringency). We consider here nine major multilateral environmental agreements which have been adopted before or during our period of study[12]. Thus, for each country in a given year, the MEAs measure takes value "0" if no ratification occurred, "1" for a single MEA ratified previous to or during that year, and so on, until taking value "9" for countries that have ratified all the MEAs considered in our study.

[12]Multilateral Environmental Agreements included: the Ramsar Convention, the Convention on Migratory species, the Vienna Convention, the Basel Convention on hazardous waste trade, the Convention on Biological Diversity, the United Nations Framework on Convention for Climate Change, the Kyoto Protocol, the Biosafety Protocol and the Stockholm Convention on Persistent Organic Pollutant.

International NGOs (INGOs' members/million of population):

This variable represents the density of international non-governmental organizations with membership. As mentioned by Dasgupta et al. (2001) and Smarzynska and Wei (2004), international NGOs make local population sensitive to environmental problems, and also put pressure on governments to respect laws. Thus, a more important presence of international NGOs in a country would imply a more stringent environmental regulation.

ISO 14001 (ISO 14001 certifications/billion US$ GDP):

We have integrated for each country the number of ISO 14001 certifications normalized by the country's GDP[13]. Even if ISO certification is a private and voluntary initiative, this variable manages to express a global state of mind prevailing in a country. For instance, in the environmental approach adopted in Mexico at the beginning of this century, these voluntary initiatives were encouraged by federal institutions. For illustration, this variable is also used in the construction of the Environment Sustainability Index jointly initiated by the Yale Center for Environmental Law and Policy and Columbia University. One can suppose that a higher number of 14001 ISO certified firms is the consequence of strict standards and controls imposed by the government. Moreover, countries where this variable is the most important should be considered as countries where population is the most sensitive to environmental quality, implying thus a greater concern of firms about environmental issues.

GDP per unit of energy use:

This variable actually represents the inverse of energy intensity. The idea is that regulatory restrictions tend to raise the GDP per unit of energy used, or in

[13]ISO 14001 standard is the widespread standard related to the environmental management. ISO 14001 environmental management standards help organizations to minimize the negative effect of their operations on environment, and to comply with applicable laws and regulations.

other words to reduce energy-intensive production[14]. The interest of using such an output-oriented quantitative indicator is that it provides an assessment of the effectiveness of preceding variables (see Cagatay and Mihci, 2003, for similar quantitative indicators). This allows to distinguish countries that apply concrete environmental measures from the ones that adopt a "theoretical" environmental policy not really restrictive to firms. We control for latitude when constructing this variable, since relative energy use may be influenced by cross-country differences in average temperatures, rather than expressing real energy efficiency. Thus, the obtained variable, GDP/unit of energy used*latitude, is assumed to be netted out of the climate impact and to capture therefore the environmental regulation effect.

Our approach differs from previous studies using a single proxy for stringency of environmental regulation, since grouping all the above mentioned variables in a single index allows us to encompass the general environmental regulation of countries according to different more specific environmental aspects. For instance, some countries may have a small number of ISO 14001 certified firms, but high energy efficiency. The use of one variable rather than the other in the regression would then give an incomplete vision of the local environmental regulation. For example, Smarzynska and Wei (2004), using several proxies related to a particular dimension of the environmental policy and taken separately in successive estimations, did not manage to capture the general aspect of the environmental regulation, which may have prevented them from proving explicitly pollution havens. Moreover, introducing a single and specific proxy for environmental regulation stringency can lead to biased results. For example, if we only use the MEAs variable as the environmental proxy without controlling for other aspects of the environmental policy climate, it could capture in this case the state's willingness to keep reliable relationships on in-

[14]However, this variable may also capture some effects of technical progress.

ternational arena, which is usually favorable for FDI, rather than its direct concern to international, and much less to domestic environmental compliance. Similarly, if variables are not grouped, even their simultaneous introduction in a same regression could conduct to misled interpretations, due to the specific meaning of each one.

Table 3.1 presents the correlations between the four variables components of the ER index, the ER index and the per capita GDP. Some component variables are well correlated, e.g. INGOs and Energy efficiency variables (0.5214), or INGOs and ISO 14001 variables (0.4580), while others, e.g. INGOs and MEAs, have a smaller correlation coefficient (0.2459). This lends support to our argument that these variables measure each one a distinct aspect of environmental regulation, and that taken together they represent the overall environmental policy stringency. Moreover, the correlation between per capita GDP and the ER index indicates that the two variables are correlated, but not in such a way that would prevent ER index of capturing the proper effect of the environmental regulation stringency.

Table 3.1: Cross correlation table for GDP per capita, ER index and its components

Variables	*GDPcap*	*ER index*	*MEAs*	*ISO*14001	*INGOs*	*Energy intensity*
GDPcap	1.0000					
ER index	0.7372	1.0000				
	(0.0000)					
MEAs	0.3020	0.5893	1.0000			
	0.0000)	(0.0000)				
*ISO*14001	0.4118	0.5519	0.2900	1.0000		
	(0.0000)	(0.0000)	(0.0000)			
INGOs	0.6192	0.6920	0.2459	0.4580	1.0000	
	(0.0000)	(0.0000)	(0.0000)	(0.0000)		
Energy intensity	0.6762	0.8099	0.4962	0.3325	0.5214	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	

The introduction of per capita GDP as a proxy for TFP enables us also control-

ling for countries' development level that could be correlated with the stringency of the environmental regulation. Indeed, Figure 3.1 shows a positive correlation between per capita GDP and our Environmental Regulation index. We also observe that a level of economical development could be consistent with disparate levels of environmental regulation. Hence, this confirms the correlation displayed in Table 3.1, and that our Environmental Regulation index should capture in the regressions a proper environmental effect distinct from the only effect of economical development.

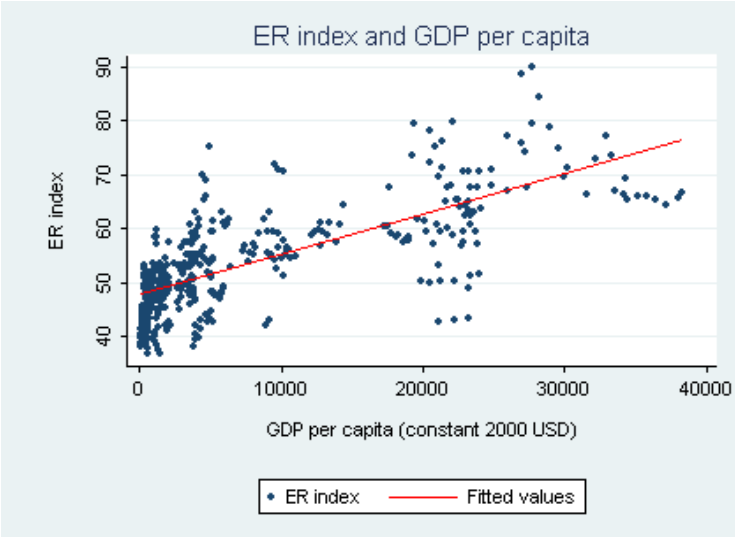

Figure 3.1: Relationship between ER index and GDP per capita

Governance factors

One of the theoretical assumptions of our model is the existence of market failures that can affect the marginal production cost, e.g. judicial corruption and malpractice, deficient social norms, high transaction costs, information asymmetries, etc. These are usually associated to the quality of governance in a country. Indeed, bad governance generates additional costs and creates a feeling of insecurity among investors, especially in developing countries or transition economies where gover-

nance failings are rather frequent. In this work, we use two governance indicators developed by Kaufmann et al. (2005): the corruption level ($CORRUP$) and the government regulatory quality ($REGULQUAL$). $CORRUP$ is the inverse of the original Kaufmann index which reflects the control of corruption in states, with a higher value meaning a better governance outcome. Our corruption variable should then have a negative effect on location decisions as a result of greater corruption that may be one reason for excessive deregulation harming economic efficiency. At the opposite, we expect the attractiveness of a location to increase with the government ability to implement promoting regulations ($REGULQUAL$). Moreover, we include a third variable capturing quality of doing business in a country, a dummy variable $FREE$ taking value "1" for countries considered by the Freedom House Organization as to be free according to their political rights and civil liberties of citizens. Recently, several studies have analyzed the relationship between fundamental democratic rights and FDI (Harms and Ursprung, 2002; Jensen, 2003; Li and Resnick, 2003; Busse, 2004), and found that multinational corporations are more likely to be attracted by countries in which democracy is respected. Greater checks that exist under democratic institutions prevent the state from predatory rent-seeking, making the government's commitment to private property credible, reducing expropriation risks for foreign investors and thus attracting more FDI to democratic societies. Democracy can also diminish information asymmetry by encouraging participation. The influence that producers, consumers, trade unions, environmental organizations, and other societal organizations exert on the process of setting standards provides these parties with more knowledge about the production methods.

Preferential Trade Agreements *(PTA)* and colonial relationships

In order to control for any potential effect on location choice of trade openness

between host countries and France, we add to the base variables defined by the theoretical model the variable PTA. Variable PTA takes value "1" if a country is a EU-member or has contracted a preferential trade agreement with the European Union, consequently with France, and 0 otherwise.

Finally, we include a dummy ($COL45$) controlling for ex-colonial relationships between France and potential FDI locations, which takes value "1" for countries in colonial relationship with France post 1945, and 0 otherwise.

Appendix 3.E presents descriptive statistics for the independent variables and information about the data.

2 Empirical results

Column (1) of Table 3.2 shows results from conditional logit estimations for our global sample of countries. Besides variables presented in the preceding section, our estimations include also dummy variables that we have created by grouping countries in five homogeneous clusters: *Developed* for high-income countries, *Emerging* for emerging countries, $TrCEEC$ for transition CEEC, $TrCIS$ for transition countries of CIS, and *Developing* for other developing (low and middle income) countries. Variables are log-linearized, and KL and ER variables have been lagged one-year to avoid any possible endogeneity with the dependent variable[15].

[15] In order to test the exogeneity status of some explanatory variables, we based our approach on the propositions of Grogger (1990), who discussed testing for exogeneity of the regressors and proposed the use of a Hausman specification test after estimation of the model by IV. Taking the ER index for example, we suppose that policy creation in year t may be function of the number of foreign firms established that year or before, with no certitude for the next years. Hence, we run two regressions: one including ER index in t, and another with ER in $t-1$. The statistic (chi2= 12.68; Prob>chi2 = 0.4724) of the Hausman specification test does not allow us to reject the null hypothesis, indicating that model with one-year lagged ER index performs better, i.e. coefficients are consistent and efficient.

2.1 Overall analysis

We observe that results are consistent with theory and our predictions. Concerning our core variable, environmental regulation, it seems to be an important factor for French manufacturing firms' location decision. The estimated coefficient of the environmental regulation index is negative and consistently significant at the 1% level, indicating that a more stringent environmental regulation deters French manufacturing investments. Also market potential, total factor productivity, existence of a preferential trade agreement and ex-colonial relationships appear to be important attractive factors for French direct investments abroad. Moreover, French firms seem to be attracted by labor-abundant countries, an increase in the K/L ratio having a negative and significant effect on the location decision. Finally, host countries' governance and democracy influence French firms' decision to settle or not in a country, since $CORRUP$ and $FREE$ variables have significant coefficients with the expected signs. Thus, democratic societies attract French FDIs, while a high level of corruption discourages them. $REGULQUAL$ is not significant, which may be due to the high correlation between Kaufmann's variables. The dummy variables $Emerging$ and $Developing$ are significant and indicate that between 1996 and 2002, French firms preferred to establish predominantly in emerging economies compared to transition and developed countries, but with much less preference for developing countries.

To go further in our analysis, we run separate regressions on two sub-samples: high-polluting firms ($HPoll$, Model (2)), and less-polluting firms ($LPoll$, Model (3)). $HPoll$ point out to the common most polluting sectors: Basic metal industries (NAF 3-digit codes 27.1-27.5), Chemical and parachemical industry (NAF codes 24.1–24.3 and 24.5–24.7), and Manufacture of pulp, paper and paperboard (NAF

Table 3.2: Conditional logit estimates (coefficients)

	(1) All	(2) HPoll	(3) LPoll	(4) Chow-type test
$\ln MP$	0.604***	0.867***	0.571***	0.606***
	(0.045)	(0.183)	(0.053)	(0.046)
$\ln GDPcap$	0.440***	0.638*	0.417***	0.327***
	(0.122)	(0.381)	(0.156)	(0.107)
TFP_growth	0.012***	0.008	0.013***	0.013***
	(0.004)	(0.012)	(0.003)	(0.004)
$\ln KL_{t-1}$	-0.578***	-0.836***	-0.548***	-0.464***
	(0.117)	(0.327)	(0.143)	(0.100)
$\ln ER_{t-1}$	-1.667***	-2.332***	-1.577***	-1.725***
	(0.240)	(0.710)	(0.222)	(0.251)
$\ln ER_{t-1} * HPoll$				-0.926**
				(0.422)
$HPoll$				3.680**
				(1.680)
$\ln CORRUP$	-1.077***	-1.812**	-0.984***	-1.048***
	(0.202)	(0.810)	(0.286)	(0.203)
$\ln REGULQUAL$	-0.404	-0.024	-0.431	-0.336
	(0.254)	(0.892)	(0.282)	(0.254)
$FREE$	0.316***	0.176	0.344***	0.348***
	(0.095)	(0.345)	(0.089)	(0.096)
PTA	0.421***	0.067	0.457***	0.486***
	(0.144)	(0.673)	(0.130)	(0.136)
$COL45$	0.788***	-0.564	0.905***	0.776***
	(0.104)	(3.194)	(0.128)	(0.107)
$Emerging$	0.984***	1.687***	0.899***	1.010***
	(0.193)	(0.748)	(0.184)	(0.192)
$TrCEEC$	0.279	0.380	0.267	0.331*
	(0.183)	(0.753)	(0.171)	(0.177)
$TrCIS$	0.462*	1.167	0.396	0.407
	(0.279)	(0.911)	(0.285)	(0.281)
$Developing$	-0.855***	-0.603	-0.900***	-0.858***
	(0.227)	(0.928)	(0.271)	(0.224)
LR chi2 (H_0: $lnER_{t-1} * HPoll = 0$ and $HPoll = 0$)				5.78
Prob > chi2				0.0556
Pseudo R^2	0.0650	0.1005	0.0630	0.0540
N. of obs.	96054	10740	85314	96054

Bootstrap standard errors in parentheses.
* p<0.1, ** p<0.05, *** p<0.01

code 21.1); and $LPoll$ refer to the other less-polluting firms. By definition, the most polluting firms should be more affected by a stricter environmental regulation.

Examining estimation results of the two models, we first notice that a high number of coefficients keep sign and significance, which attests to the robustness of our main results. Nevertheless, parameters estimates reveal some particular characteristics specific to most polluting firms. TFP growth, existence of a democratic society, preferential trade agreements and ex-colonial relationships do no longer have a significant impact on location choice of high-polluting firms in column (2), whilst they still do for the less-polluting ones in column (3). Regarding the estimated coefficient of environmental regulation index, it remains negative and significant in both models, implying that environmental regulation influences both high-polluting and less-polluting firms. Moreover, the effect of the environmental regulation on the location decision of the most polluting firms appears to be stronger than the one found for the less polluting firms. However, as we cannot directly compare coefficients for our two sub-samples, we perform a Chow-type test in order to check for statistical difference between ER coefficients (Model 4). Thus, the last column of Table 3.2 shows an effect of ER index for high-polluting firms (interaction term $ER_{t-1}*HPoll$) statistically different from the effect reported for less-polluting firms. We then test for the null hypothesis $H_0 : \beta_{LPoll} = \beta_{HPoll}$. The Chi2 value of 5.78 allows us to reject the null hypothesis of an identical behavior between most polluting and less polluting sectors at the 5.6% level. Everything else equal, all industries have interest to avoid additional costs induced by stricter environmental regulation since there is generally no totally "clean" manufacturing sector, but this effect is even stronger for the most polluting sectors. Moreover, the environmental regulation seems to be a more decisive factor for the most polluting firms, since as above mentioned, four

variables become non significant in Model (2). On the contrary, those variables keep significant effects on location choice of less-polluting firms, and are thus more likely to offset the ER effect. Hence, our empirical results highlight evidence of pollution haven hypothesis for the most polluting firms.

To draw more precise conclusions, we aim to interpret the magnitude of the environmental regulation's effect on French firms' location. If one needs a regression coefficient expressing effects of units of X on the probability of Y, the "elasticity" is suggested. Nevertheless, conditional logit estimates allow only calculation of individual elasticities for each alternative and we cannot have a uniformed effect for all of them. However, we can first calculate the predicted probability P^1 of getting FDI when ER value is fixed at its sample mean. Then, we change ER variable by one standard deviation, and recalculate the probability P^2 of getting FDI. The difference in the predicted probabilities ($P^2/P^1 = [1 + (st.dev(ER)/mean(ER))]^{\hat{\beta}}$) can be interpreted as the effect of a one-standard deviation change in ER on the probability of attracting FDI, when all other variables are held constant at sample mean values. Thus, we find for the global sample in Model (1) that a 1-standard deviation shock on ER index would decrease the attractiveness of the "average country" (in terms of ER value) by 24.6%. For illustration, following ER values reported in Table 3.9, Chile ("average country") has 24.6% less chances than Uruguay to receive French FDI, and as much more chances than Ecuador. For the most and the less polluting firms this effect represents 32.7% and 23.5%, respectively. Consequently, this way of evaluating the magnitude of ER effect is of a big interest as it permits to examine the effect on every alternative, not only on the average country.

This strongly deterrent effect of strict environmental regulations on firms location choice confirms the importance of the use of firm-level data when seeking for the

pollution haven hypothesis. Indeed, our results corroborate those suggested by the location choice studies that detect a weak relationship between environmental stringency and manufacturing plant locations (Levinson, 1996; List and Co, 2000). However, unlike these two studies, our analysis explores international differences in environmental policy that are more exacerbate across countries, and this may partly explain why the negative relationship is emphasized in our work. Comparing our findings with those of Raspiller and Riedinger (2005), who also examine French industries but find that pollution intensive goods are more likely to be imported from stringent countries, we suggest some explanations for our divergent results. Firstly, the study of Raspiller et Riedinger (2005) considers imports of 1999, while the index of environmental stringency of Esty and Porter that they use is related to the year 2001. However, the relative stringency of countries changed between 1999 and 2001, and countries that were relatively less stringent in 1999 may have strengthened their environmental policy (see Table 3.9), making the use of their variable of interest inappropriate. This is confirmed in their robustness test using the prior index of Eliste and Fredriksson, whose coefficient turns to be insignificant. Moreover, the main result of this study comes from a regression incorporating only the environmental severity index and dummy variables for countries. When the authors incorporate other explanatory variables, such as factor costs, the negative coefficient on the environmental severity of originating countries loses significance. More generally, their specification suffers from omitted variable bias.

2.2 Country-group analysis

Given that a significant ER effect was found for all, high-polluting and less-polluting firms, we conduct our extended empirical analysis on the full sample of French firms

locating abroad, in order to assess the behavior of all manufacturing sector firms and consider the largest number of observations. Based on the previous results, which provide evidence of a strong pollution haven effect, we intend to distinguish which countries are the most likely to constitute pollution havens. To this goal, we need to introduce interaction terms between the environmental regulation index and country-group dummies. However, as noted by Ai and Norton (2003) and Norton et al. (2004), the marginal impact of an interaction effect in a non-linear model is not simply the coefficient for this interaction. Because there are two additive terms and each can be positive or negative, the interaction effect may have different signs for different values of covariates. In order to deal with this complication, we will apply a procedure developed by Norton et al. (2004) that computes correct magnitudes and standard errors of the interaction effect (Section 2.2.2).

2.2.1 Basic results

Table 3.3 displays marginal effects of Model (1) variables as well as ER interaction terms with *Developed*, *Emerging*, $CEEC$, CIS, and *Developing* dummies in the respective columns. All explanatory variables maintain their sign and significance across all country-group models, as compared to Model (1). Concerning the effect of the environmental regulation for specific country groups, only looking at Table 3.3 results, we observe positive and significant interaction terms which seem to offset the negative ER variable's marginal effect for CIS and *Developing* countries in columns (8) and (9), meaning that more stringent environmental regulation in these countries attracts FDI. On the contrary, the smaller magnitude of the positive interaction term for $CEEC$ (not offsetting the ER variable's marginal effect), the insignificant interaction term for the emerging economies and the negative strongly significant interaction term for developed countries confirm a pollution haven effect

Table 3.3: Logit estimates with country-groups interaction terms (marginal effects)

	(5)	(6)	(7)	(8)	(9)
$\ln MP$	0.006***	0.006***	0.006***	0.006***	0.006***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$\ln GDPcap$	0.003***	0.003***	0.004***	0.004***	0.003**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
TFP_growth	0.0001**	0.0001***	0.0001***	0.0001***	0.0001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$\ln KL_{t-1}$	-0.005***	-0.005***	-0.005***	-0.006***	-0.005***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$\ln ER_{t-1}$	0.006	-0.019***	-0.020***	-0.021***	-0.020***
	(0.005)	(0.003)	(0.003)	(0.003)	(0.003)
$\ln ER_{t-1} * Developed$	-0.032***				
	(0.006)				
$\ln ER_{t-1} * Emerging$		0.001			
		(0.008)			
$\ln ER_{t-1} * TrCEEC$			0.017**		
			(0.007)		
$\ln ER_{t-1} * TrCIS$				0.130***	
				(0.022)	
$\ln ER_{t-1} * Developing$					0.027***
					(0.008)
$\ln CORRUP$	-0.009***	-0.011***	-0.010***	-0.010***	-0.010***
	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)
$\ln REGULQUAL$	-0.003	-0.004	-0.003	-0.002	-0.003
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
$FREE$	0.003***	0.003***	0.004***	0.004***	0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
PTA	0.007***	0.006***	0.006***	0.005***	0.005***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$COL45$	0.006***	0.011***	0.012***	0.012***	0.012***
	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)
Country-group dummies	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.0559	0.0538	0.0541	0.0574	0.0543
N. of obs.	96054	96054	96054	96054	96054

Bootstrap, adjusted standard errors for intragroup correlation in parentheses
* p<0.1, ** p<0.05, *** p<0.01

for these country-groups. However, as previously mentioned, the interaction effect's magnitude and significance may vary across the range of predicted values, and these early conclusions can be misleading.

2.2.2 Norton et al. methodology for interaction effects

To facilitate the computation and the interpretation of interaction effects in non linear models, the procedure developed by Norton et al. (2004) has been implemented in Stata software through the inteff module, and is suitable for logit and probit models. With the aim of adapting this methodology to our conditional logit model, we first run estimation of Model (1) through a logit model with adjusted standard-errors for intragroup correlation[16]. Since the results are consistent with those found with the conditional logit, we can then use them and apply the methodology recommended by Norton's et al. (2004). The methodology allows us to visualize for each country-group the correct interaction effect through two figures: the first stands for the amplitude of the interaction term's marginal effect, and the second for its statistical significance. The respective figures for our five country-groups are displayed in the Appendix 3.C.

First, for Developed countries in Figure 3.2, we notice on the Y-axis of the first graph a negative interaction effect lying between -0.38 and -0.003. Moreover, it is strongly significant since the z-statistics on the Y-axis of the second graph are below the bottom horizontal line representing the critical value of -1.96, and corresponding to the 5% significance level. Therefore, since ER is not significant in Table 3.3, its marginal effect for Developed countries lies between -0.38 and -0.003.

Second, we observe that Figure 3.3 regarding Emerging economies shows a negative interaction term, but not significant, since observations have z-statistics lying

[16] Estimation results available upon request.

between the critical values (-1.96; +1.96) (the latter being represented by the upper horizontal line on the Y-axis). Therefore, the ER marginal effect for Emerging economies is negative, and corresponds to the ER marginal effect of - 0.019 in Model (6).

Next, we examine Figure 3.4 corresponding to CEEC, and we observe that the interaction effect is positive across all observations, but statistically insignificant across practically the entire range of predicted probabilities of choosing a CEE country (X-axis). Moreover, the few observations for which this interaction term is statistically significant, namely those having the smallest predicted probabilities (below 0.02), have also the lowest marginal effects that don't offset the ER variable's marginal effect from Model (7). Hence, the environmental regulation's effect for CEEC corresponds globally to the ER variable's marginal effect reported in Model (7) of Table 3.3, i.e. - 0.020.

As regards Figure 3.5 for CIS countries in Appendix 3.C, we observe a positive interaction effect, statistically significant for almost all the observations, and taking values that generally offset the negative ER marginal effect of -0.021 in Model (8). However, a negative effect of ER index does still exist for a minor part of CIS observations for which this positive interaction term is not statistically significant, implying thus the negative ER marginal effect of -0.021 which was obscured in Table 3.3.

Finally, the opposite of the pollution haven effect is found for nearly the entire group of Developing countries. Examining Figure 3.6, we underline a highly significant positive marginal effect for the interaction term $ER_{t-1} * Developing$, offsetting the negative ER marginal effect of -0.020 in Model (9) until reaching positive values up to 0.26. That means French firms are attracted by a more rigorous environmental

regulation in this country-group.

To sum up, our country-group analysis highlights evidence of pollution haven effects for Developed countries, Emerging economies, and CEEC, i.e. a more stringent environmental regulation in these countries deters French FDI. At the opposite, except for a minor part of CIS observations for which a pollution haven effect was found, this country group and Developing countries tend to attract French firms when their environmental regulation becomes more severe. These findings indicate that as well as they are dissuaded from investing in strongly regulated countries, French firms' are reluctant to locate in countries where the environmental policy is considered to be too lenient. Thus, the decision to invest seems to be bounded between a minimum and a maximum of ER levels. In this interval, the French firms invest, otherwise they do not.

2.2.3 A non-linear effect of environmental regulation?

In order to test for this potential nonlinearity in the ER effect on French firms' location, we run three complementary regressions, including firstly ER squared, and then interaction terms between ER and dummies ranging countries according the median and the quartiles of ER index. These results are reported in Table 3.4.

Results from the estimation of Model (10) confirm our assumption of a nonlinear effect of the environmental regulation, since the ER coefficient is positive while ER squared turns out to be significantly negative. At lower ER values, environmental regulation has a positive effect on French FDI, whilst it has a negative effect on firms' location decision at higher values of ER index[17].

[17] In a different context, involving inward FDI in the United States, Fredriksson et al. (2003) also find a nonlinear impact of environmental regulation on FDI in some specifications. However, they report a U-shaped relationship, and suggest that US states with relatively strict regulations may attempt to attract foreign firms by overcompensate them.

Table 3.4: Testing for non linearity in ER index (marginal effects)

	(10)	(11)	(12)
$\ln MP$	0.006***	0.005***	0.007***
	(0.000)	(0.001)	(0.000)
$\ln GDPcap$	0.004***	0.004***	0.004***
	(0.001)	(0.001)	(0.001)
TFP_growth	0.0001**	0.0001**	0.0001**
	(0.000)	(0.000)	(0.000)
$\ln KL_{t-1}$	-0.006***	-0.005***	-0.006***
	(0.001)	(0.001)	(0.001)
$\ln ER_{t-1}$	0.750***	0.077***	-0.049***
	(0.108)	(0.011)	(0.006)
$(\ln ER_{t-1})^2$	-0.094***		
	(0.013)		
$\ln ER_{t-1} * ERup50$		-0.103***	
		(0.011)	
$\ln ER_{t-1} * ERto75$			0.058***
			(0.008)
$\ln CORRUP$	-0.009***	-0.007***	-0.011***
	(0.003)	(0.003)	(0.002)
$\ln REGULQUAL$	-0.003	-0.001	-0.006**
	(0.003)	(0.002)	(0.002)
$FREE$	0.002**	0.003***	0.002**
	(0.001)	(0.001)	(0.001)
PTA	0.005***	0.004**	0.006***
	(0.002)	(0.002)	(0.002)
$COL45$	0.008***	0.012***	0.005***
	(0.002)	(0.002)	(0.002)
$ERup50$		1.000***	
		(0.000)	
$ERto75$			-1.000***
			(0.000)
Country-group dummies	Yes	Yes	Yes
Pseudo R^2	0.0589	0.0598	0.0589
N. of obs.	96054	96054	96054

Bootstrap, adjusted standard errors for intragroup correlation in parentheses
* p<0.1, ** p<0.05, *** p<0.01

Further, we wonder about the range of ER values where the switch from a positive to a negative effect of the ER index takes place. First, we run Model (11) including an interaction term between ER and a dummy $ERup50$ taking value "1" for more regulated countries (ER superior to the median), 0 otherwise. Hence, the separate ER variable captures the environmental effect for less regulated countries (ER inferior to the median). The estimation results confirm the findings of Model (10): stringency of environmental regulation deters FDIs at higher values of ER, and attracts them at lower values. Apart from most of observations for which we find strongly negative and statistically significant values, our Figure 3.7 for the respective interaction term ($ER_{t-1} * ERup50$) in Appendix 3.C shows some insignificant observations, positively significant values, and negatively significant values that do not offset the positive effect of ER variable. Therefore, amongst countries with an ER superior to the median, some of them still have a positive impact of their environmental regulation on FDI. Consequently, we add a quartile to the median and reclassify countries depending on whether their ER is situated below or above the third quartile. Model (12) includes thus an interaction term between ER and a dummy taking value "1" for countries with their ER included in the first three quartiles, ($ER_{t-1} * ERto75$). The separate ER variable captures the environmental effect on FDI for countries with their ER in the last quartile, i.e. the most regulated ones. We finally find a strong pollution haven effect for the latter. Concerning the interaction term, we observe in Figure 3.8 that it is positive and significant for nearly all the observations, generally offsetting the ER negative marginal effect of -0.049 in Model (12). However, we should note some discrepancies: a few observations are negative, some are not significant, and for other ones the positive interaction effect doesn't offset the negative ER variable's effect. In all cases, the ER marginal effect

for these few observations is therefore negative. Hence, we have a negative ER effect on FDI in the up quartile of ER index, a positive effect below ER median, and an ambiguous effect in the third quartile of ER index. The turn-over is thus expected to be in the observed range of data, and more precisely in the third quartile.

Explanations for this nonlinear relationship, and especially for the positive effect of ER in the less developed countries, are closely related to international competitiveness, since exports must often meet product standards higher than those of the producing developing country[18]. Many of the factors shaping the competitiveness at the foreign subsidiary level, despite its own "clean" and highly performing technologies, are, in fact, determined at the level of the hosting national economy. Among these factors one could mention the provision of environmental infrastructure, such as water pipes, wastewater treatment facilities and landfills for waste, etc.. Similarly, firms from specific sectors could use natural resources in their production process, and then need the inputs to be relatively clean in order to be able to produce an acceptable output (manufacture of food and beverages, wood, etc.). Another argument would be that multinational firms should respect a minimum of environmental standards requested by their internal global policy, meeting generally well international standards. Indeed, there are numerous examples of corporate culture and concern about brand image affecting business preferences over regulatory standards. By the late nineties, more than 80 multinational enterprises had established social codes of conduct, with an overwhelming majority of these codes applied to all of a firm's units and sub-contractors (Kolk, van Tulder and Welters, 1999). Thus, when creating a new subsidiary or searching for domestic partners, since they

[18]Investors from developed countries often undertake business in the developing countries in order to benefit from production costs, reexporting then their products to other developed or developing countries (vertical multinationals). This is unlikely to occur with investments in developed countries which are often driven to supply the local market demand (horizontal multinational).

should adopt standards that are consistent with their corporate culture and with their brand image, multinational corporations would prefer to be ensured that a minimum compliance to international environmental standards is already in place, in order to facilitate investments and technology transfers. Similarly, as firms try to develop globally identifiable brands, they will be sensitive to anywhere big regulatory violations that could harm the brand image (Spar, 1998). Finally, the decisions of investing abroad are often long-term decisions that commit firms for the future. Faced with alternatives that all actually give opportunity to lower environmental costs, multinational firms should then favor countries with a policy design providing more flexibility for meeting future more stringent environmental standards.

2.3 FDI mode of entry analysis

Multinationals may enter a host market by different modes of FDI, e.g. greenfield investments, joint ventures, mergers and acquisitions (M&A). Given the explosion of cross-borders M&A in the nineties, questions arose about the characteristics and the impacts of each mode, and some studies recently attempt to respond to these interrogations (UNCTAD, 2000; Mattoo et al., 2004; Raff et al., 2009). However, this heterogeneity of FDI has not been well documented in the context of the pollution haven hypothesis. One reason may be the lack of information. Moreover, as mentioned by Basile (2004), location analyses generally examine either aggregate investments or greenfield investments, and rarely contrast greenfield and acquisition entry. Luckily, in our database, this information about the FDI mode of entry is available for some firms, for which we know if the location choice takes the form of an acquisition of a local firm (M&A) or a creation of a new firm (greenfield investment). Since this information is not exhaustive as it would be required for a strong

analysis of each mode of FDI, our ambition in this section is just to exploit data that is of great interest, and to assess the sensitivity of our results to the FDI mode of entry. Thus, this attempt consists in providing some early results.

Thus, we run two separate regressions, one on the sub-sample of acquired firms in Model (13), and in Model (14) on the sub-sample of created firms. Results are reported in Table 3.5 below.

We observe that results are similar for both kinds of FDI, and that they look like those of Model (1) despite some changes in magnitudes for M&A. Comparing the two types of FDI, we only notice small differences in the magnitudes of the market potential, the environmental regulation, and the $FREE$ variables. However, these small changes do not contribute to mitigate previous results. The larger coefficient on the market potential variable in Model (14) is consistent with a higher incentive for greenfield investments to capture a new market share. However, we rather expected a higher sensitivity of greenfields investments to governance factors, i.e. $FREE$, since those investments are disadvantaged by lack of information about business "habits". As regards the environmental regulation, its larger negative coefficient on the creation of firms suggests that in our sample, greenfield investments are more attracted by a decrease in environmental stringency, which could mention that they are less likely to use modern and cleaner technologies than M&A. Although generally, greenfield investments are expected to bring more advanced techniques, this opposite case can occur if investors want to benefit from the independence provided by the greenfield form to take advantage of weak regulations and use costless and more polluting techniques. If this is true, it would partly explain the strong negative effect of environmental regulation on location choice found above. It would underline a specificity of greenfield investments driven by pollution haven motives.

Table 3.5: Conditional logit estimates by FDI mode of entry

	(13) M&A	(14) Greenfield
$\ln MP$	0.229***	0.706***
	(0.082)	(0.090)
$\ln GDPcap$	0.636*	0.651***
	(0.337)	(0.218)
TFP_growth	0.017	0.009
	(0.011)	(0.007)
$\ln KL_{t-1}$	-0.683**	-0.771***
	(0.309)	(0.183)
$\ln ER_{t-1}$	-1.558***	-2.167***
	(0.455)	(0.350)
$\ln CORRUP$	-0.228	-0.560
	(0.493)	(0.396)
$\ln REGULQUAL$	0.434	0.560
	(0.848)	(0.474)
$FREE$	1.096***	0.434**
	(0.237)	(0.171)
PTA	0.514**	0.439*
	(0.241)	(0.245)
$COL45$	1.171***	1.383***
	(0.439)	(0.195)
$Emerging$	-0.281	0.859***
	(0.296)	(0.265)
$TrCEEC$	-0.400	0.405
	(0.350)	(0.255)
$TrCIS$	-1.873	-0.382
	(5.216)	(0.525)
$Developing$	-1.816***	-0.900**
	(0.429)	(0.371)
Pseudo R^2	0.1078	0.0842
N. of obs.	26470	35702

Bootstrap standard errors in parentheses
* p<0.1, ** p<0.05, *** p<0.01

Since the investigation of M&A and greenfield investments is beyond the scope of this actual work, our analysis should be extended to draw general conclusions about the determinants of each mode of FDI. However, it contributes to take into account some heterogeneity of FDI. Results mention that in a framework of pollution haven hypothesis, the impact of the environmental regulation on FDI does not substantially differ with the FDI mode of entry. Nevertheless, we should be cautious in interpreting this result which requires to be confirmed through the use of more reliable data. This will be undoubtedly the subject of further extended analysis.

3 Robustness checks

Tables 3.6 and 3.7 present results from some robustness checks. Table 3.6 reports results of regressions testing alternative proxies for our core model variables, while Table 3.7 presents robustness checks of our main results obtained through alternative estimation methods.

In Models (15), (16) and (17) of Table 3.6, we assess the sensitivity of Model (1) results to the environmental regulation variable used. We successively replace ER by three alternative environmental regulation variables: $ER(PCA)$, $GASUNLEAD$ and $ENVTAX$. $ER(PCA)$ is an environmental regulation index including the same component variables as ER (Z-score), but computed through the PCA method. $GASUNLEAD$ variable represents the market share of unleaded versus leaded gasoline. Damania et al. (2003) have previously used the lead content in gasoline to represent the stringency of environmental policy, and they recall that this variable had also been used by Deacon (1999) and Hilton and Levinson (1998) to proxy the environmental regulation in other kinds of studies. Indeed, since lead constitutes a harmful air pollutant, relatively strict countries should allow a lower lead content

Table 3.6: Robustness tests with alternative variables (coefficients)

	(15) ER	(16) ER	(17) ER	(18) KL	(19) MP
lnMP	0.608***	0.437***	0.540***	0.395**	
	(0.045)	(0.070)	(0.115)	(0.056)	
ln$GDPdist$					0.882***
					(0.091)
$Adjacency$					0.336**
					(0.131)
$LangEthn$					0.199*
					(0.117)
ln$GDPcap$	0.537***	0.584***	-0.054	-0.209***	0.486
	(0.117)	(0.216)	(0.323)	(0 .063)	(0.135)
TFP_growth	0.012***	0.007	0.035***	0 .022***	0.014***
	(0.004)	(0.005)	(0.013)	(0 .003)	(0.004)
lnKL_{t-1}	-0.685***	-0.347*	-0.409		-0.665***
	(0.111)	(0.209)	(0.300)		(0.130)
lnRER				-1.846***	
				(0.382)	
lnRIR				0.877***	
				(0.411)	
ln$ER_{t-1}(PCA)$	-1.880***				
	(0.317)				
$GASUNLEAD_{t-1}$		-0.005***			
		(0.002)			
ln$ENVTAX$			-1.367***		
			(0.244)		
lnER_{t-1}				-1.917***	-2.593***
				(0.300)	(0.326)
ln$CORRUP$	-0.908***	0.545	-1.807**	-1.454***	-1.799***
	(0.208)	(0.401)	(0.805)	(0.399)	(0.192)
ln$REGULQUAL$	-0.457*	0.253	-3.352***	-1.561**	-0.170
	(0.253)	(0.548)	(1.038)	(0.706)	(0 .244)
$FREE$	0.324***	0.659***	-0.033	-0.151	0.143
	(0.093)	(0.156)	(0.660)	(0.108)	(0.093)
PTA	0.408***	-0.434**	0.428***	-0.110	-0.059
	(0.121)	(0.197)	(0.119)	(0.215)	(0.219)
$COL45$	0.887***	1.033***		0.335**	0.604***
	(0.110)	(0.226)		(0.161)	(0.179)
$Emerging$	0.982***	-0.122		0.372*	1.198***
	(0.198)	(0.287)		(0.202)	(0.180)
$TrCEEC$	0.276	-0.534*		-0.128	0.748***
	(0.185)	(0.292)		(0.218)	(0.173)
$TrCIS$	0.468*	0.500		-0.503	0.679***
	(0.284)	(0.450)		(0.335)	(0.258)
$Developing$	-0.899***	-1.418**		-1.773***	-0.650***
	(0.237)	(0.556)		(0.249)	(0.226)
Pseudo R^2	0.0637	0.0354	0.0355	0.0785	0.0676
N. of obs.	96054	37698	9642	39443	96054

Bootstrap standard errors in parentheses
* p<0.1, ** p<0.05, *** p<0.01

in gasoline. Data concerning lead contents being not available for all countries and years in our sample, we rather include in our analysis the market share of unleaded gasoline which is a closely related measure: in relatively strict countries, unleaded gasoline should be promoted against leaded gasoline (Model 16). Finally, in Model (17), $ENVTAX$ represents the total environmental tax revenues in the European countries, expressed as a share of their GDP. Although our sample is restricted to European countries in this case, this variable has the twofold advantage of being directly observed in those countries, as well as to be the most close to our base theoretical model. In all of these models, the environmental regulation variable keeps its negative and significant effect on firms' location choice, even if Models (16) and (17) show some different results for the other explanatory variables, that could be explained by the different sample composition and size as compared with Model (1).

The common use of the KL variable, that is proportional to the ratio of wages to capital cost under the assumption that all countries have a common production function, could be too restrictive. Errors in this variable may be correlated with environmental regulation, which would result in bias. To check the potential bias induced, we decide to perform a robustness test by introducing two alternative variables, i.e. the real exchange rate RER and the real interest rate RIR (Model 18, Table 3.6). RER is used as a proxy for differences in real wage levels and RIR is a proxy for capital cost differences. Our empirical results show that RER is significantly negative and RIR is significantly positive. The negative impact of RER is consistent with the fact that French investors are seeking for a cheaper workforce. As regards RIR, we could explain its positive sign (opposite to the one predicted by the theoretical model), following two judgments. First, French investors, originates from a developed country (capital abundant), are more likely

to seek for another comparative advantage than the capital cost, i.e. a cheap labor force. Given that these two variables are interdependent, as labor force is cheaper in labor abundant countries which have usually higher capital costs, it seems that the seeking for a cheaper labor force prevails on the seeking for a cheaper capital in our case, since French investors could come with their own capital (much cheaper). Second, since access to capital is an important factor for per capita GDP, there may also be multicollinearity between these two variables. Indeed, our results indicate for such a bias, as $GDPcap$ effect turns to be negative. Nevertheless, all other variables are rather robust, and especially the ER effect that keeps a close magnitude.

Next, we test for the robustness of our Market Potential variable in Model (19), where we introduce more common measures of market size and its accessibility, namely the variables $GDPdist$ (GDP of host country normalized by its distance from France), $Adjacency$ (sharing a common border), and $LangEthn$ (sharing a common, ethnic groups' language). Since all variables keep sign and significance, our results are robust to different market size variables used.

In Table 3.7 we report alternative estimations to Model (1). First, we look to test our empirical results by controlling for industry fixed effects. Model (20) corresponds to a logit estimation including dummies for each 4-digit NAF Codes of subsidiaries' sectors, controlling thus for industry fixed-effects. Results are strongly similar to those of Model (1), since in our study the conditional logit is by construction a firm fixed-effects model.

In Models (21) and (22), we control for time-invariant factors and present estimation results of regressions including countries fixed-effects. Moreover, following Train (1986), we are supposed to correct the biases induced by the IIA while integrating country fixed effects. Model (19) shows the ER turning to be insignificant,

Table 3.7: Robustness tests with alternative specifications (coefficients)

	(20) FElogit	(21) FEclogit	(22) FEclogit	(23) IVclogit
$\ln MP$	0.609***	1.645**	1.905**	0.481***
	(0.052)	(0.798)	(0.840)	(0.054)
$\ln GDPcap$	0.347**	-0.226	-0.230	0.378***
	(0.117)	(0.805)	(0.819)	(0.113)
TFP_growth	0.013***	0.006	0.008*	0.008**
	(0.004)	(0.005)	(0.005)	(0.004)
$\ln KL_{t-1}$	-0.484***	-2.010***	-1.981***	-0.831***
	(0.104)	(0.465)	(0.449)	(0.103)
$\ln ER_{t-1}$	-1.797***	0.258		
	(0.272)	(0.768)		
$\ln MEA_{t-1}$			-1.134**	
			(0.470)	
$\ln ER_predicted$				-51.813***
				(6.221)
$\ln CORRUP$	-1.063***	0.266	0.306	-18.830***
	(0.256)	(0.565)	(0.576)	(2.187)
$\ln REGULQUAL$	-0.366	1.966***	2.196***	-1.158**
	(0.330)	(0.672)	(0 .696)	(0.396)
$FREE$	0.344***	0.140	0.122	4.738***
	(0.098)	(0.176)	(0.175)	(0.487)
PTA	0.477***	-0.109	-0.078	0.091
	(0.118)	(0.201)	(0.206)	(0.158)
$COL45$	0.769***	-3.229	-2.892	0.686***
	(0.140)	(8.583)	(8.610)	(0.208)
$Emerging$	1.013***	0.156	-0.604	0.746***
	(0.164)	(1.508)	(2.146)	(0.169)
$TrCEEC$	0.324**	-3.355***	-4.716***	-0.038
	(0.160)	(0.723)	(1.129)	(0.170)
$TrCIS$	0.422*	-5.520	-6.527	0.940***
	(0.244)	(8.019)	(8.290)	(0.206)
$Developing$	-0.859***	-3.581	-4.654	-1.291***
	(0.217)	(7.307)	(7.314)	(0.267)
Industry fixed-effects	Yes	No	No	No
Country fixed-effects	No	Yes	Yes	No
Pseudo R^2	0.0543	0.1394	0.1397	0.0643
N. of obs.	95981	96054	96054	70477

Standard errors in parentheses
* p<0.1, ** p<0.05, *** p<0.01

probably because of its small variation during the period of study. The use of MEA variable, a commonly used proxy for environmental regulation with relatively more important time-variance than our ER index, confirms in Model (22) the significant and negative effect of environmental regulation on firms' location choice, while controlling for all other country specific-effects[19].

As a last robustness check, we analyze the most important and debatable issue, namely, the environmental regulation endogeneity with regard to foreign investments. Indeed, as suggested by some political economy models (e.g. Cole et al., 2006), countries could be conducted to reduce their environmental standards in order to attract FDI. To deal with this problem and check the robustness of our previous results, we need to run an instrumental variable estimation. Our methodology consists in applying an instrumental estimation, running two independent regressions. In the first step, we regress the assumed endogenous ER variable on a new variable FDI representing the total number of French firms locating in each country yearly, and on four exogenous variables: $CORRUP$, $FREE$, $GNIcap$ (per capita income) and $UNEMPL$ (unemployment)[20]. The $UNEMPL$ and $GNIcap$ variables are supposed to act as exclusion restrictions, since consumers' preference for environment (represented by their wellbeing: unemployment rate and income [21]) should have an effect on FDI through their impact on the stringency of the environmental regulation. In the second step, we run our base model by using the predicted ER variable. Second step estimation results are presented in Model (23). IV results

[19] We also made an attempt to test a nested logit specification, considering thus that the location decision is decided at two levels. Since results are very similar to those of clogit, we do not present this test as an additional robustness check.

[20] See Table 3.11 in Appendix for the empirical results of the first step estimation.

[21] The higher the income, the higher the willingness to pay for the normal good - the environment. As for the unemployment rate, there would be an opposite relation, the preferences for environmental quality passing onto a second level compared to the economic and financial uncertainty.

indicate that, after controlling for endogeneity, the ER variable (as the most of our variables) keeps sign and significance.

Conclusion

In this chapter we have tested the pollution haven hypothesis through an analysis of the impact of the environmental regulation on French manufacturing firms' location choice. Basing this empirical work on an economic geography model that has the advantage of considering a complete set of location choice determinants like market potential, production factors and governance quality, we use firm-level data related to French firms' locations in the world to test this hypothesis. We first tested it on a pooled sample of countries, and then made a distinction between five groups of countries: Developed countries, Emerging economies, Transition CEEC, Transition countries of CIS, and Developing countries. By further developing a complex index encompassing different aspects of the environmental regulation, we have succeeded in expressing the stringency of environmental regulation in a satisfying way and then in revealing the existence of a strong pollution haven effect.

Empirical results of the base model show that in presence of heterogeneous countries, French manufacturing industries prefer to locate in countries with more lenient environmental regulations, thus confirming an essential role played by environmental policy in determining firms' location. Moreover, this effect is reinforced for the most polluting firms. In order to go further into our analysis, we attempt to identify countries that are the most likely to constitute pollution havens. Estimations including interaction terms between environmental regulation and country groups validate existence of pollution haven effects for developed countries, emerging economies and CEEC. On the contrary, concerning most CIS and developing countries included in

our sample, which are supposed to be less regulated, a more stringent regulation seems rather to attract investments. This suggests a nonlinear effect of the environmental regulation stringency on French firms' location choice, which is confirmed in complementary regressions that highlight existence of a threshold situated in the third quartile of the ER index, from which the effect of ER index on FDI switches from a positive impact to a negative one. Thus, manufacturing French firms locate preferably in locations with less stringent environmental policy, provided that regulation is not more lenient than an accepted level guarantying wealthy business environment. Otherwise, under those last circumstances, French firms prefer destinations with improving quality of the environmental policy. An estimation involving the mode of FDI entry suggests that though greenfield investments are more sensitive to environmental regulations, results are confirmed whatever the type of FDI considered. Robustness tests finally confirm the stability of our results across different specifications, including alternative proxies for our core variables and alternative estimation methods.

Nevertheless, the only approval or rejection of the pollution haven hypothesis is not sufficient to respond to fears related to the impact on firm location of heterogeneous environmental regulations across countries. Researches analyzing to which extent pollution havens imply a real threat to the environment would be of a great interest. This would be the purpose of the next chapter.

Appendix 3

3.A Market Potential estimation

As seen in Chapter 2, the quantity of a composite good M that a firm h produces in country i and would ship to any destination country j in a model à la Dixit and Stiglitz and Krugman is given by the following expression:

$$q_{ij}(h) = \frac{\sigma - 1}{\sigma} \frac{[c_i(h)\tau_{ij}]^{-\sigma}}{\sum_i \int_{n_i} [c_i(v)\tau_{ij}]^{1-\sigma} dv} \mu E_j \tag{A.1}$$

and the total net profit that a firm h could earn in any potential location i:

$$\Pi_i(h) = \frac{c_i(h)^{1-\sigma}}{\sigma} \sum_j \phi_{ij} \frac{\mu E_j}{G_j} - F_i(h) \tag{A.2}$$

with σ denotes the elasticity of substitution between two varieties, and $\sigma > 1$; $c_i(h)$ is the marginal production cost of the firm h in country i; τ_{ij} is the trade cost supported by the consumer in the importing country j; μ is the share of their income E that consumers spend on the purchase of the composite good M; and $F_i(h)$ is the firm's fixed cost.

Krugman's market potential has the advantage of being deduced strictly from theory, and we write it:

$$MP_i = \sum_j \left[\frac{\phi_{ij} \mu E_j}{G_j} \right] \tag{A.3}$$

where $\phi_{ij} = \tau_{ij}^{1-\sigma}$, $G_j = \sum_i \int_{n_i} [c_i(v)\tau_{ij}]^{1-\sigma} dv$. Nevertheless, compared to the form proposed by Harris (1954), its calculation needs estimators for the unknown φ_{ij} and G_j parameters. In this study we apply the same strategy as Head and Mayer (2004) and estimate these parameters using information about international trade

flows. The aggregate value of exports of country i towards country j, denoted X_{ij}, results from the multiplying of the mass of varieties produced in country i and sent to country j by each variety's export price p_{ij} (including trade costs):

$$X_{ij} = \int_{n_i} p_{ij}(v)\, q_{ij}(v)\, dv = \int_{n_i} \frac{c_i(v)^{1-\sigma}\phi_{ij}\mu E_j}{G_j} dv \tag{A.4}$$

By grouping the terms according to the indexes and then transforming them in logarithm, we obtain:

$$\ln X_{ij} = \ln\left(\int_{n_i} c_i(v)^{1-\sigma} dv\right) + \ln(\mu E_j/G_j) + \ln \varphi_{ij} \tag{A.5}$$

Following Redding and Venables (2004), we estimate the first two terms by using exporter and importer fixed effects, denoted here EX_i and IM_j, respectively. The bilateral access to the market (φ_{ij}) is considered, similarly to Head and Mayer (2004), to be a function of distance (d_{ij}), contiguity ($B_{ij} = 1$ if countries i and j share a common border and 0 otherwise), common language ($L_{ij} = 1$ if i and j share a language and 0 otherwise) and an error term, ϵ_{ij}. The trade equation to be estimated is then:

$$\ln X_{ij} = EX_i + IM_j - \delta \ln d_{ij} + \beta B_{ij} + \lambda L_{ij} + \epsilon_{ij} \tag{A.6}$$

This equation is regressed on the bilateral trade flows of 168 countries over the period 1990-2000 (Feenstra's database on world trade flows, NBER) and 79 countries over the period 2001-2004 (Chelem database). The variables necessary to the calculation of ϕ_{ij} are taken from CEPII Distances database.

Using the specifications $\hat{\phi}_{ij} = d_{ij}^{-\hat{\delta}} \exp\left(\hat{\beta} B_{ij} + \hat{\lambda} L_{ij}\right)$ and $\mu E_j/G_j = \exp(IM_j)$, we calculate the market potential.

3.B List of countries and detailed statistics about FDI, ER index and Market Potential

Table 3.8: FDI occurences

Country	**FDI**								
	Total	**HPoll**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Algeria	35	1	1	6	5	1	8	5	9
Argentina	42	9	8	7	10	14	2	1	0
Australia	34	8	4	6	6	5	8	4	1
Austria	13	1	3	4	2	2	0	2	0
Azerbaijan	3	0	1	0	1	0	1	0	0
Bangladesh	1	1	0	0	0	1	0	0	0
Bolivia	1	0	0	0	0	0	0	0	1
Brazil	1	1	0	0	1	0	0	0	0
Bulgaria	9	2	4	2	3	0	0	0	0
Cameroon	3	1	0	0	1	2	0	0	0
Canada	67	8	5	11	10	14	16	6	5
Chile	21	4	0	4	4	3	6	3	1
China	124	31	35	26	28	20	15	0	0
Croatia	12	2	1	3	3	1	4	0	0
Czech Rep.	40	9	8	6	10	9	7	0	0
Denmark	9	2	0	2	3	1	2	1	0
Dom. Rep.	1	0	0	0	0	1	0	0	0
Ecuador	2	0	0	0	0	1	1	0	0
Egypt	8	3	0	0	1	2	2	1	2
Estonia	3	1	0	0	1	0	2	0	0
Ethiopia	2	0	0	0	2	0	0	0	0
Finland	28	3	2	3	3	5	5	6	4
Gabon	3	0	1	0	0	2	0	0	0
Germany	88	17	18	24	11	15	10	7	3
Ghana	3	0	1	1	1	0	0	0	0
Greece	7	2	1	0	1	0	1	1	3
Guatemala	3	2	1	0	1	0	1	0	0
Honduras	1	1	0	0	1	0	0	0	0
Hungary	23	3	4	4	6	1	5	2	1
India	54	11	12	14	10	7	6	4	1
Indonesia	2	1	0	2	0	0	0	0	0
Iran	3	0	0	0	1	1	1	0	0
Ireland	11	1	1	2	1	3	4	0	0
Italy	23	2	5	5	8	3	2	0	0

Country					**FDI**				
	Total	**HPoll**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Ivory Coast	8	1	1	4	1	1	1	0	0
Jordan	7	5	1	0	4	1	1	0	0
Kazakhstan	8	1	1	0	3	0	1	2	1
Korea	23	5	2	6	6	5	4	0	0
Latvia	14	3	0	4	1	5	4	0	0
Lebanon	8	1	3	2	1	0	2	0	0
Lithuania	4	1	1	1	1	1	0	0	0
Malaysia	31	7	5	6	3	2	5	5	5
Mexico	38	6	11	5	4	5	7	2	4
Morocco	36	3	8	6	11	5	6	0	0
Mozambique	1	0	0	0	0	1	0	0	0
Netherlands	19	4	2	1	3	5	4	2	2
New Zealand	6	2	0	3	3	0	0	0	0
Norway	7	0	2	0	1	3	0	1	0
Pakistan	5	1	0	0	0	2	0	2	1
Paraguay	1	0	0	0	0	1	0	0	0
Peru	9	0	3	0	2	0	4	0	0
Philippines	13	3	0	4	2	3	3	0	1
Poland	60	11	27	17	6	4	4	1	1
Portugal	26	8	6	4	3	4	6	3	0
Romania	34	3	8	7	3	7	6	0	3
Russia	45	8	11	10	12	8	4	0	0
Saudi Arabia	2	1	0	0	1	0	1	0	0
Senegal	3	0	0	1	1	0	1	0	0
Slovakia	56	9	7	6	9	7	15	8	4
Slovenia	5	1	1	1	0	1	1	0	1
South Africa	31	9	7	2	10	1	11	0	0
Spain	57	4	11	8	9	4	12	12	1
Sri Lanka	2	1	1	0	1	0	0	0	0
Sweden	16	4	1	1	3	3	4	4	0
Switzerland	20	5	2	1	6	4	3	4	0
Thailand	4	1	0	0	2	0	1	1	0
Trin. Tobago	1	0	0	0	0	0	1	0	0
Turkey	13	3	0	0	0	6	2	5	0
Ukraine	7	0	2	1	1	1	1	1	0
U.A.Emirates	9	2	2	3	2	2	0	0	0
U. Kingdom	54	11	14	11	11	6	12	0	0
Uruguay	5	1	2	1	1	0	0	0	1
Uzbekistan	1	0	0	0	1	0	0	0	0
Venezuela	5	3	2	1	0	1	1	0	0
Total	1374	255	260	249	263	213	237	96	56

Table 3.9: ER index values

Country	**Country group**	**ER index**							
		Mean	1996	1997	1998	1999	2000	2001	2002
Denmark	Developed	79.61	88.43	89.84	84.35	78.82	74.92	69.66	71.26
Finland	Developed	73.31	73.66	78.09	76.14	79.72	70.43	67.65	67.50
Sweden	Developed	72.88	62.27	70.56	70.89	77.16	75.80	74.05	79.43
Ireland	Developed	70.78	67.58	79.53	75.30	70.55	67.99	66.94	67.58
Switzerland	Developed	70.13	66.32	72.98	77.17	73.63	69.19	65.44	66.18
Netherlands	Developed	66.09	72.35	69.45	68.08	63.84	63.39	60.67	64.86
Norway	Developed	65.80	66.88	66.06	65.84	65.34	64.36	65.61	66.53
Hungary	Tr. CEEC	65.64	58.22	59.56	61.83	69.88	65.90	68.90	75.18
U. Kingdom	Developed	65.09	67.76	65.17	64.43	63.02			
Slovenia	Tr. CEEC	64.58	55.10	58.97	61.63	63.01	71.77	70.89	70.66
Austria	Developed	63.44	71.30	65.03	65.29	62.20	59.49	57.05	63.72
Uruguay	Developing	61.16	61.08	61.53	61.70	60.69	60.44	63.10	59.55
Spain	Developed	60.15	58.72	59.50	59.34	61.01	57.34	60.74	64.39
New Zealand	Developed	59.02	56.64	61.08	59.58	58.78			
Germany	Developed	58.93	60.70	59.53	59.93	58.71	56.82	57.41	59.43
Italy	Developed	58.84	60.52	60.32	59.25	58.33	57.40	57.62	58.48
Australia	Developed	58.57	58.87	58.04	61.70	61.54	59.47	57.12	53.21
Slovakia	Tr. CEEC	58.07	55.14	57.49	60.62	59.07	57.41	58.18	58.59
Estonia	Tr. CEEC	58.00	52.31	52.76	54.81	57.08	63.01	60.56	65.43
Portugal	Developed	57.79	59.51	59.49	58.99	57.75	56.53	56.05	56.23
Morocco	Emerging	57.73	59.79	58.49	58.31	57.22	56.73	56.41	57.13
Czech Rep.	Tr. CEEC	57.33	54.07	54.64	61.26	59.36			
Argentina	Emerging	55.49	56.82	57.12	56.45	55.33	53.82	55.93	52.95
Latvia	Tr. CEEC	55.38	53.42	53.09	53.14	56.40	57.60	55.16	58.87
Greece	Developed	55.10	55.35	55.15	54.33	56.39	55.24	54.43	54.81
Croatia	Tr. CEEC	55.04	54.01	55.02	54.44	54.68	55.29	55.33	56.50
Poland	Tr. CEEC	54.25	52.86	53.67	53.99	55.13	53.35	54.98	55.76
Chile	Emerging	52.52	54.60	53.84	53.40	51.96	51.48	50.80	51.57
Korea	Emerging	52.12	52.50	54.52	54.70	51.29	50.60	50.12	51.11
South Africa	Emerging	51.87	48.52	52.74	52.20	52.57	52.13	52.85	52.10
Thailand	Emerging	51.75	57.51	48.69	54.54	53.29	49.69	48.73	49.80
Lithuania	Tr. CEEC	51.33	48.78	48.96	49.26	51.63	53.37	53.04	54.25
Paraguay	Developing	51.22	50.55	49.65	48.97	53.44	53.45	52.30	50.15
Egypt	Emerging	51.20	52.54	52.70	52.28	51.98	51.64	50.03	47.21
Bangladesh	Developing	51.06	53.07	52.44	51.71	50.77	49.17	51.20	49.03
Romania	Tr. CEEC	50.91	49.85	49.22	51.59	51.10	50.33	52.83	51.44
Philippines	Emerging	50.90	51.32	52.23	53.43	51.60	49.83	50.48	47.37
India	Emerging	50.78	51.41	51.69	51.27	50.90	50.49	49.60	50.09
Malaysia	Emerging	50.58	48.75	50.81	55.14	51.16	48.95	50.54	48.68
Canada	Developed	50.36	50.20	49.86	50.40	50.29	48.99	51.27	51.50

Country	Country group	ER index							
		Mean	1996	1997	1998	1999	2000	2001	2002
Jordan	Emerging	50.35	49.39	48.72	50.52	52.68	52.22	50.53	48.35
Bulgaria	Tr. CEEC	49.97	48.56	48.10	47.65	49.74	51.74	51.87	52.16
Pakistan	Emerging	49.64	52.26	51.50	50.83	49.71	48.93	48.08	46.14
Peru	Emerging	49.52	48.85	51.01	51.01	49.88	49.15	48.07	48.66
Algeria	Developing	49.06	52.20	50.63	50.61	49.51	48.03	47.09	45.32
Turkey	Emerging	48.91	49.34	53.07	51.47	49.85	47.40	46.17	45.08
China	Emerging	48.73	49.35	49.00	49.30	48.93	48.50	47.90	48.10
Brazil	Emerging	48.47	49.77	50.22	49.35	48.42	47.54	46.04	47.92
Senegal	Developing	48.29	49.69	49.12	48.66	47.78	46.93	48.84	46.99
Sri Lanka	Developing	48.20	49.03	48.53	48.08	47.16			
Iran	Emerging	48.17	48.84	48.69	48.14	47.02			
Trin. Tobago	Developing	48.02	48.24	47.65	46.94	49.26			
Mexico	Emerging	48.00	48.39	47.98	47.73	46.83	48.95	47.96	48.19
Bolivia	Developing	47.42	47.69	47.13	46.38	48.12	47.61	47.31	47.67
Guatemala	Developing	47.38	48.42	47.75	47.54	48.77	47.93	46.78	44.48
Lebanon	Developing	46.87	47.79	46.82	46.57	48.94	47.55	46.02	44.37
Honduras	Developing	46.58	47.72	46.94	46.16	45.51	48.40	46.87	44.46
Russia	Tr. CIS	45.68	47.43	46.97	46.27	45.47	44.83	44.14	44.63
Indonesia	Emerging	45.67	46.22	48.51	47.75	45.30	44.60	43.20	44.10
Ukraine	Tr. CIS	45.26	42.27	43.97	43.28	47.57	46.89	46.16	46.68
Uzbekistan	Tr. CIS	44.36	43.24	42.62	44.29	46.02	45.33	44.36	44.66
Ecuador	Developing	44.01	45.04	44.44	44.42	43.32	45.03	44.07	41.76
Ivory Coast	Developing	43.87	45.67	45.06	44.47	43.51	42.92	42.36	43.10
Saudi Arabia	Developing	43.30	44.43	43.76	42.94	42.06			
Ghana	Developing	43.25	45.71	45.09	44.44	43.58	42.52	41.54	39.88
Venezuela	Developing	43.15	43.43	42.86	44.62	44.00	42.78	41.76	42.60
U.A.Emirates	Developed	43.03	43.42	43.12	42.55				
Dom. Rep.	Developing	41.94	42.10	41.13	42.58	41.96			
Cameroon	Developing	41.59	43.05	42.37	41.60	40.77	39.37	41.74	42.20
Mozambique	Developing	41.45	41.48	43.27	42.67	41.92	40.41	39.62	40.79
Azerbaijan	Tr. CIS	40.62	39.31	38.64	37.66	36.88	40.93	45.99	44.92
Gabon	Developing	40.56	39.71	41.27	42.89	42.02	40.52	39.41	38.09
Ethiopia	Developing	39.33	40.56	39.83	38.86	38.06			
Kazakhstan	Tr. CIS	38.89	39.67	39.19	40.62	40.13	38.32	37.49	36.79

Table 3.10: Market potential values

Country	**Country group**	**MP**							
		Mean	1996	1997	1998	1999	2000	2001	2002
Algeria	Developing	11.10	11.20	11.36	11.26	11.29	11.31	10.64	10.64
Argentina	Emerging	3.90	3.95	3.95	3.95	3.95	3.94	3.79	3.79
Australia	Developed	2.47	2.61	2.61	2.61	2.61	2.57	2.12	2.12
Austria	Developed	29.60	30.07	30.07	30.08	30.07	30.03	28.43	28.43
Azerbaijan	Tr. CIS	4.81	4.11	5.11	4.78	5.01	5.05		
Bangladesh	Developing	3.81	3.92	3.92	3.94	3.96	3.19	3.88	3.88
Bolivia	Developing	3.90	3.90	3.88	3.85	3.87	3.92	3.95	3.95
Brazil	Emerging	2.29	2.35	2.35	2.35	2.34	2.32	2.17	2.17
Bulgaria	Tr. CEEC	11.20	11.35	11.35	11.34	11.34	11.30	10.85	10.85
Cameroon	Developing	4.36	4.41	4.39	4.36	4.39	4.28	4.35	4.35
Canada	Developed	48.68	48.78	48.78	48.78	48.78	48.75	48.43	48.43
Chile	Emerging	3.18	3.22	3.21	3.22	3.22	3.21	3.07	3.07
China	Emerging	12.52	15.55	15.65	15.47	15.58	15.31	5.06	5.06
Croatia	Tr. CEEC	14.54	14.63	14.60	14.68	14.67	14.66	14.28	14.28
Czech Rep.	Tr. CEEC	22.73	23.06	23.07	23.04	23.04	23.03	21.94	21.94
Denmark	Developed	20.78	21.71	21.71	21.71	21.71	21.67	18.50	18.50
Dom. Rep.	Developing	6.44	6.60	6.63	6.39	6.37	6.37	6.38	6.35
Ecuador	Developing	4.64	4.75	4.72	4.73	4.73	4.72	4.41	4.41
Egypt	Emerging	6.94	6.91	6.98	6.96	7.04	6.85	6.93	6.93
Estonia	Tr. CEEC	10.87	10.80	10.88	10.90	11.01	10.96	10.76	10.76
Ethiopia	Developing	2.76	2.84	2.79	2.80	2.90	2.79	2.62	2.58
Finland	Developed	9.73	9.87	9.88	9.88	9.91	9.88	9.35	9.35
Gabon	Developing	3.06	3.01	2.93	2.99	3.02	3.07	3.21	3.21
Germany	Developed	41.48	46.21	46.21	46.21	46.21	46.17	29.68	29.68
Ghana	Developing	4.25	4.28	4.22	4.23	4.33	4.24	4.20	4.25
Greece	Developed	8.08	8.22	8.23	8.26	8.26	8.22	7.69	7.69
Guatemala	Developing	5.83	5.87	5.82	5.81	5.81	5.81	5.82	5.84
Honduras	Developing	5.14	5.21	5.16	5.15	5.08	5.18	5.12	5.10
Hungary	Tr. CEEC	14.57	14.79	14.76	14.77	14.77	14.73	14.10	14.10
India	Emerging	4.80	5.00	5.00	5.00	5.00	4.58	4.49	4.49
Indonesia	Emerging	4.27	4.41	4.48	4.48	4.48	4.44	3.80	3.80
Iran	Emerging	4.43	3.90	4.56	4.59	4.59	4.49		
Ireland	Developed	24.92	25.24	25.24	25.24	25.23	25.15	24.18	24.18
Italy	Developed	12.03	12.26	12.26	12.26	12.26	12.22	11.50	11.50
Ivory Coast	Developing	3.59	3.64	3.60	3.63	3.63	3.61	3.51	3.51
Jordan	Emerging	9.16	9.27	8.80	9.25	9.40	9.10		
Kazakhstan	Tr. CIS	4.28	4.39	4.37	4.40	4.39	4.23	4.08	4.08
Korea	Emerging	6.28	6.47	6.47	6.47	6.48	6.38	5.83	5.83

Country	Country group	MP							
		Mean	1996	1997	1998	1999	2000	2001	2002
Latvia	Tr. CEEC	9.96	9.97	9.97	10.02	9.96	9.96	9.91	9.91
Lebanon	Developing	6.75	6.76	6.69	6.88	6.85	6.57		
Lithuania	Tr. CEEC	10.23	10.19	10.26	10.25	10.28	10.29	10.16	10.16
Malaysia	Emerging	9.61	9.68	9.68	9.68	9.68	9.62	9.45	9.45
Mexico	Emerging	8.08	8.18	8.18	8.16	8.17	8.16	7.85	7.85
Morocco	Emerging	9.88	10.08	10.09	10.10	10.10	10.08	9.36	9.36
Mozambique	Developing	1.94	1.84	1.97	1.90	2.01	2.01		
Netherlands	Developed	63.02	68.46	68.46	68.46	68.46	68.43	49.43	49.43
New Zealand	Developed	2.68	2.90	2.90	2.90	2.90	2.87	2.16	2.16
Norway	Developed	11.72	11.95	11.95	11.95	11.95	11.91	11.17	11.17
Pakistan	Emerging	6.07	6.47	6.47	6.47	6.47	4.81	5.90	5.90
Paraguay	Developing	4.12	4.11	4.07	4.10	4.08	4.09	4.22	4.22
Peru	Emerging	3.87	3.93	3.93	3.94	3.94	3.93	3.72	3.72
Philippines	Emerging	4.58	4.56	4.58	4.58	4.58	4.48	4.63	4.63
Poland	Tr. CEEC	14.45	14.69	14.65	14.65	14.65	14.64	13.93	13.93
Portugal	Developed	10.51	10.66	10.66	10.66	10.65	10.64	10.14	10.14
Romania	Tr. CEEC	9.17	9.33	9.32	9.32	9.32	9.28	8.80	8.80
Russia	Tr. CIS	6.83	6.97	6.98	6.98	6.98	6.93	6.48	6.48
Saudi Arabia	Developing	4.22	4.97	3.96	4.95	4.55	3.88	3.61	3.61
Senegal	Developing	3.88	3.85	3.88	3.97	3.90	3.86	3.92	3.77
Slovakia	Tr. CEEC	23.03	23.25	23.25	23.20	23.26	23.22	22.50	22.50
Slovenia	Tr. CEEC	19.19	19.41	19.47	19.43	19.43	19.39	18.58	18.58
South Africa	Emerging	2.79	2.72	2.72	2.72	2.72	3.07		
Spain	Developed	11.98	12.18	12.18	12.18	12.18	12.15	11.49	11.49
Sri Lanka	Developing	2.73	2.75	2.74	2.77	2.80	2.67	2.70	2.70
Sweden	Developed	10.68	10.89	10.89	10.89	10.89	10.85	10.20	10.20
Switzerland	Developed	56.14	57.04	57.04	57.04	57.04	57.00	53.93	53.93
Thailand	Emerging	3.52	3.60	3.60	3.60	3.60	3.52	3.37	3.37
Trin. Tobago	Developing	4.98	5.00	4.98	5.04	4.88	5.03		
Turkey	Emerging	7.59	7.78	7.78	7.79	7.78	7.71	7.16	7.16
Ukraine	Tr. CIS	8.78	8.80	8.83	8.87	8.88	8.81	8.62	8.62
U.A.Emirates	Developed	4.42	4.38	4.41	4.41	4.58	4.31		
U. Kingdom	Developed	21.12	21.84	21.84	21.84	21.84	21.78	19.35	19.35
Uruguay	Developing	6.10	6.11	6.11	6.11	6.12	6.10	6.07	6.07
Uzbekistan	Tr. CIS	3.66	3.54	3.70	3.72	3.79	3.54		
Venezuela	Developing	5.61	5.62	5.63	5.61	5.63	5.63	5.57	5.60

3.C Interaction effects in clustered logit estimations

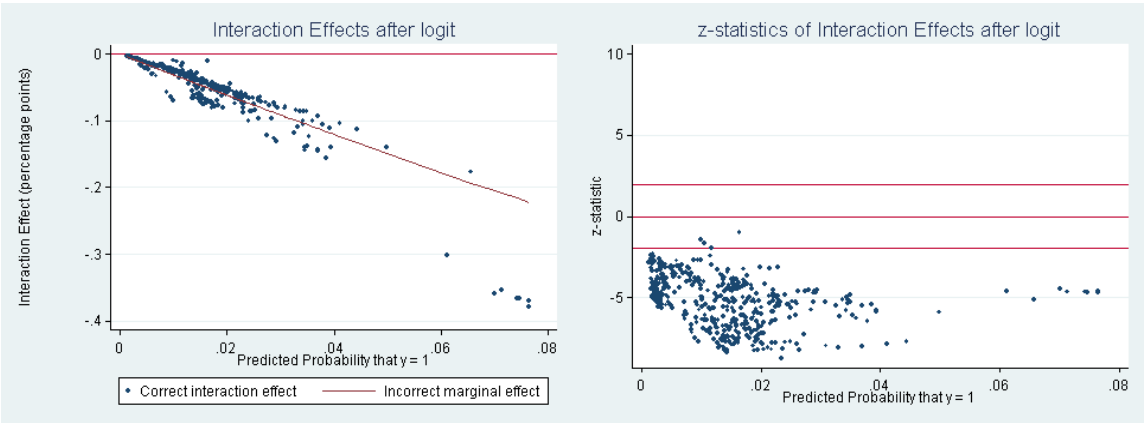

Figure 3.2: Interaction effect for Developed countries

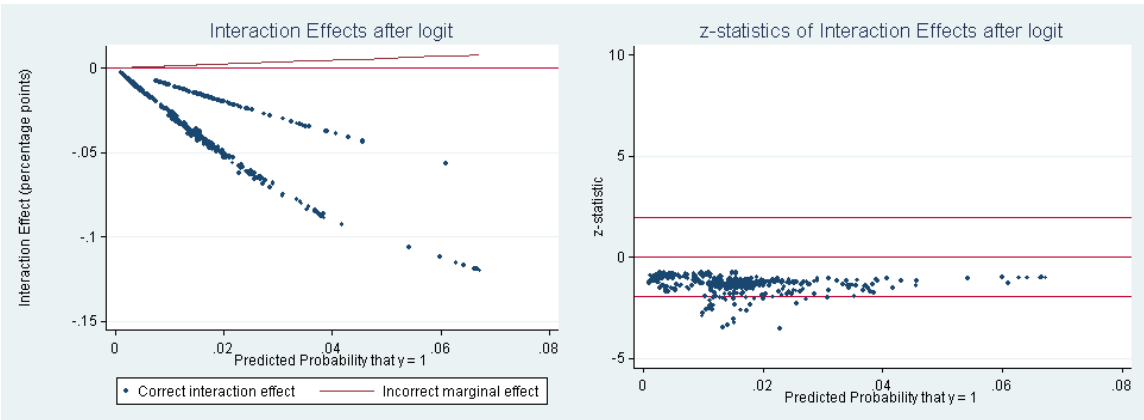

Figure 3.3: Interaction effect for Emerging economies

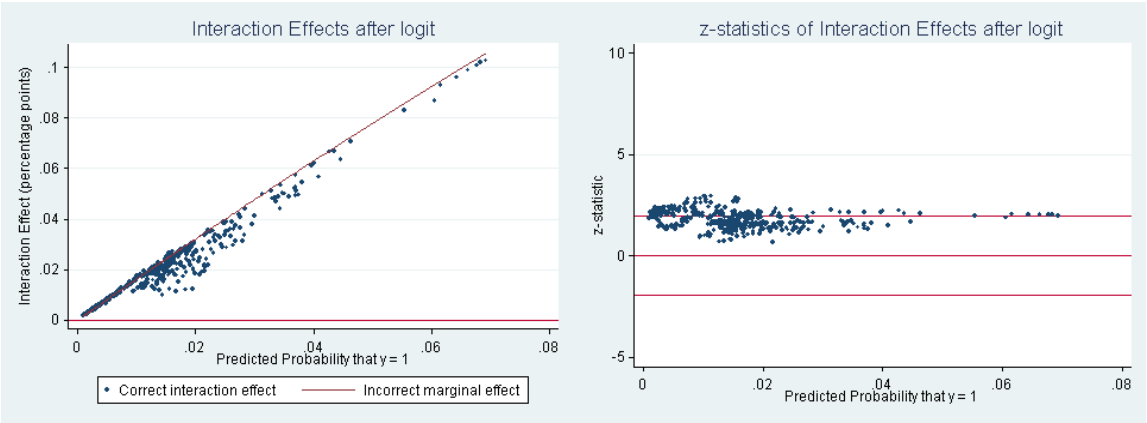

Figure 3.4: Interaction effect for CEEC

Figure 3.5: Interaction effect for CIS

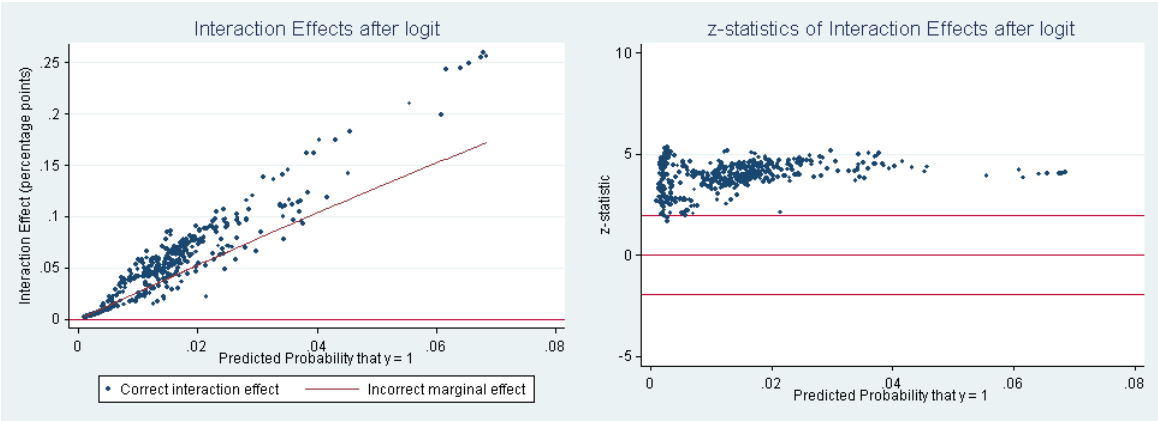

Figure 3.6: Interaction effect for Developing countries

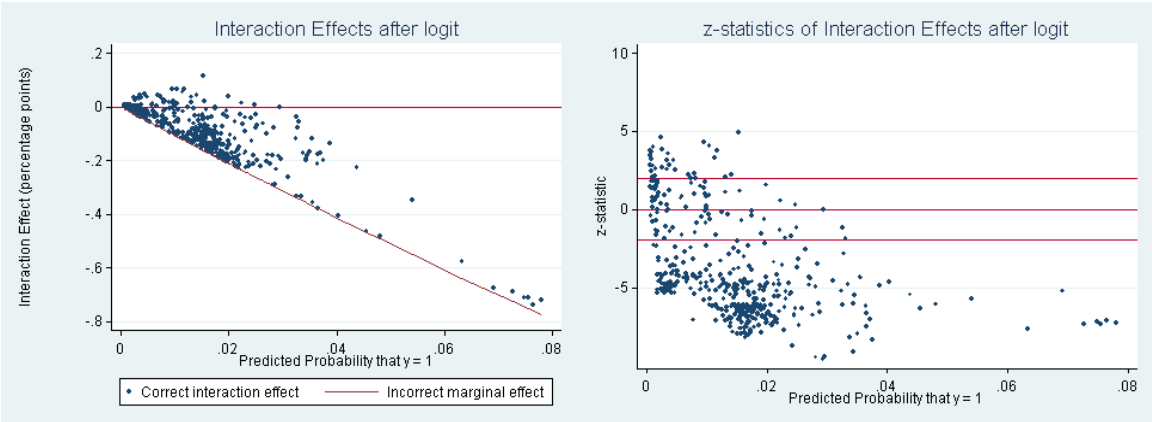

Figure 3.7: Interaction effect for the high median of ER index

Figure 3.8: Interaction effect for the first three low quartiles of ER index

3.D IV first stage estimation

Table 3.11: First stage estimation for ER endogeneity test

Dependent variable lnER	IV first stage estimation clogit
lnFDI	-0.0006
	(0.001)
ln$CORRUP$	-0.342***
	(0.034)
$FREE$	0.081***
	(0.014)
ln$UNEMPL$	-0.008
	(0.009)
ln$GNIcap$	-0.006
	(0.011)
Constant	5.1492***
	(0.206)
R^2	0.5804
N. of obs.	416

Standard errors in parentheses
* p<0.1, ** p<0.05, *** p<0.01

3.E Data summary

Table 3.12: Descriptive statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
MP	11.1613	12.3426	1.8357	68.4638	96054
$GDPcap$	7289.2386	9013.7306	95.4479	38302.6094	96054
TFP_growth	-2.0331	9.9872	-95.3050	28.888	96054
KL_{t-1}	22334.8144	28264.9816	224.6915	150149.625	96054
RER	103.9347	12.1902	53.46917	159.2242	53281
RIR	109.788	14.1108	17.54	184.05	53281
$ER_{t-1}(Zscore)$	53.1217	9.3336	36.8798	93.5585	96054
$ER_{t-1}(PCA)$	51.7485	6.2833	38.4950	67.9619	96054
$GASUNLEAD_{t-1}$	65.3025	34.7952	0	100	55884
$ENVTAX$	2.8921	0.8439	1.47	5.39	23271
FDI	3.2550	4.6799	0	35	96054
$UNEMPL$	8.9979	4.7715	0.9	27.3	75338
$GNIcap$	10255.01	9165.321	330	41060	96054
MEA_{t-1}	6.0815	1.1019	2	8	96054
$CORRUP$	33.4696	9.7613	17.9116	56.7732	96054
$REGULQUAL$	4.4413	0.7789	2.1764	5.9688	96054
$FREE$	0.5408	0.4983	0	1	96054
PTA	0.2604	0.4389	0	1	96054
$COL45$	0.0811	0.273	0	1	96054
$GDP/dist$	1.80E+08	6.68E+08	3.59E+05	4.37E+09	96054
$Adjacency$	0.0572	0.2323	0	1	96054
$LangEthn$	0.1224	0.3278	0	1	96054

Table 3.13: Data definition and sources

Variable	Definition	Sources
Dependent variable	Location choice	Subsidiaries-Survey 2002, French Directorate of Treasury and Economic Policy
MP	Market potential	Data on international trade: R.Feenstra and R.Lipsey, NBER 1990-2000; Chelem, CEPII, 2000-2004; Geographic data: CEPII
Adjacency and *LangEthn*	Dummy variables for sharing common border and language, respectively	CEPII, 2000-2004; Geographic data: CEPII
GDPdist	Gross Domestic Product (of the host country) divided by the distance between France and the host country	GDP: World Development Indicators, World Bank; Distance : DISTANCES database of CEPII
GDPcap	Per capita Gross Domestic Product at constant 2000 prices	World Development Indicators, World Bank
TFP_growth	Total factor productivity growth	Authors calculation; World Bank & International Energy Agency data
KL	Country relative endowments in production factors (capital versus labor)	World Development Indicators, World Bank + authors calculation
ER	Environmental regulation index	Authors calculation
	Multilateral Environmental Agreements	Earthtrends, World Resources Institute
	ISO 14001	International Organization for Standardization
	International NGOs	Center for the Study of Global Governance
	GDP per unit of energy use, controlled for latitude	World Bank; DISTANCES (GEO) database of CEPII (for latitude)
GASUNLEAD	Market share of unleaded versus leaded gasoline	United Nations Environment Programme (UNEP)
ENVTAX	Total environmental tax revenues, % GDP.	EUROSTAT.
CORRUP	Corruption	Governance Indicators 1996-2004, D. Kaufmann, A. Kray and M. Mastruzzi
REGULQUAL	Regulations improving firms' general environment	Governance Indicators 1996-2004, D. Kaufmann, A. Kray and M. Mastruzzi
PTA	Preferential trade agreements with EU, hence with France	Preferential trade agreements database (PTAs)
COL45	Colonial relationship with France post 1945	DISTANCES database of CEPII
FREE	Dummy taking value 1 if the country is considered democratic (average of Political Rights and Civil Liberties lying between 1.0 and 2.5)	Freedom House.
Developed	High-income countries	World Bank Country Classification, excluding TrCEEC, TrCIS and EMERG economies
Emerging	Emerging countries	Morgan Stanley Capital International (MSCI) classification
TrCEEC	Central and Eastern European Countries	Multiple sources
TrCIS	Commonwealth of Independent States	Multiple sources
Developing	Other developing (low and middle income) countries	World Bank Country Classification, excluding some CEEC, CIS and EMERG
ERup50; *ERto75*	Dummies taking value 1 for countries with ER index above the median value and in the first (lower) three quartiles, respectively	
FDI	Total annual number of French manufacturing location decisions in a country.	Subsidiaries-Survey 2002, French Directorate of Treasury and Economic Policy + authors calculation.
UNEMPL	Unemployment, % labor force.	World Development Indicators, World Bank
GNIcap	Gross national income per capita, based on purchasing power parity	World Development Indicators, World Bank

Chapter 4

French FDI and Pollution Emissions: an Empirical Investigation

Introduction

The strong version of the pollution haven hypothesis states that free international trade leads to the relocation of dirty-good production from stringent regulation countries (the North), to lax regulation countries (the South) (Copeland and Taylor, 2004). Although the common fear related to this statement is that while these mechanisms lower pollution in the developed countries, it is to the detriment of the developing world where pollution rises and probably causes an increase of overall pollution, only a few studies tried to empirically estimate the direct effect of trade or pollution haven-driven capital relocation on pollution emissions (Grossman and Krueger, 1993; Antweiler et al., 2001; Dean, 2002; He, 2006).

Most studies consist of searching for pollution havens by evaluating trends in dirty-good production, consumption or trade, focusing on the loss of competitiveness at the international level and the fear that environmental regulation may reduce net

exports in the manufacturing sector (Tobey, 1990). Another strand of the literature focuses rather on trends in plant locations and the loss (gain) of attractiveness of regulated (less-regulated) countries (Xing and Kolstad, 2002; List and Co, 2000; Keller and Levinson, 2002). In both cases, these studies are conducted without concern for the environment, or more precisely to pollution levels. In our view, these analyses remain incomplete because a fundamental related issue consists of determining if such pollution havens represent a threat by increasing pollution levels, or at the contrary contribute to the reduction of emissions levels.

As mentioned by Copeland and Taylor (2004), some studies measuring trends in dirty-industry output rather than pollution levels implicitly assume that changes in the composition of a country's output correspond to changes in environmental quality. This is a strong and even incorrect assumption since it does not account for the possibility that a better environmental quality could be consistent with an increased dirty-good production, because the techniques of production may change and become cleaner due to trade, income growth or technological progress. Regarding studies focusing on foreign direct investment (FDI), they suggest two potential exclusive impacts of FDI on pollution. If multinational firms (MNFs) from developed and regulated countries do not intend to take advantage of lax regulations in developing countries, and adopt the same production methods in both source and host country, more FDI in developing countries should make them cleaner. The second alternative works in opposite direction and suggests that if multinationals locate in some countries because of their lax environmental regulation, FDI should be positively correlated with pollution in host countries. Our point of view is slightly different as regards to the impact of each alternative. We think that each alternative could prevail, but its effect on the pollution levels in host country is ambiguous. In

other words, firms may adopt the same production methods in source country and abroad but still increase pollution in host countries. Alternatively, they may take advantage from lax regulations and nevertheless improve environment quality by reducing pollution.

Indeed, FDI impact on pollution is complex. As mentioned above, it is often argued that Multinational firms (MNFs) are likely to use modern and less polluting techniques in foreign subsidiaries. It is cost-effective for them to use the same technology in different countries, even where environmental laws are weaker. Moreover, as suggested in Chapter 3, reputation is important to MNFs, and the largest ones often have to respect corporation's code of conduct comprising environmental principles. If we consider global pollution, in this case whether the firm produces at home or abroad may not change anything. Nevertheless, we frequently see examples of MNFs breaking environmental or safety laws. We can cite the example of former Texaco, which merged with the energy company Chevron in 2001. While drilling in the Ecuadorian Amazon from 1964 to 1990, Texaco was accused of deliberately hampering environmental regulations by dumping toxic wastewater and spilling crude oil. Ecuadorians claimed that to save money, the firm had chosen to use environmental practices that were obsolete and did not meet industry standards in the United States. Thus, if MNFs enter a country to benefit from weaker environmental regulations and produce at lower costs, FDI will hamper environment quality and increase global as well as local pollution.

Another argument is that, all other things being equal, if pollution abatement systems are more efficient in developed countries, it would be better that MNFs produce and pollute there, rather than producing in developing countries. In the latter case, pollution would increase at the global level.

If we examine local pollution, one additional plant in the host country is supposed to increase local pollution levels. However, the entry of the MNF may crowd out inefficient local firms, reducing thus pollution emissions. Furthermore, environmental benefits from FDI can arise from spillover effects that might raise the productivity of local firms, making their production more environmentally-friendly, finally resulting in a decrease of total pollution emitted.

Even if not investigated in this work, we should discuss another channel through which FDI may affect pollution levels, i.e. the shipment of goods. Indeed, transport may have two opposite effects on pollution. On one hand, if FDI takes place for a motive of markets supply, it would be less damaging that a firm produces in the foreign country rather than shipping goods from its country of origin. On another hand, if FDI is motivated by a reduction of costs and production is reexported to the country of origin, this would increase pollution emissions.

While there are many ways in which FDI can impact the environment and particularly the pollution levels, there is no theoretical presumption that a particular effect dominates. The relationship between FDI and pollution is thus an empirical issue. Of major concern is the impact of FDI on global pollution, but empirical investigation of this issue is difficult. Indeed, considering the overall impact of FDI on global pollution would require taking into account all the mechanisms mentioned above, using data for the country of origin as well as for host countries, and integrating pollution resulting from transportation. This exercise, though very interesting, is not possible in the scope of this work. Therefore, in this chapter we will look at one of the channels described above, namely the contribution of FDI to local pollution, and more precisely to air and water pollution. Examining local pollution is essential. Indeed, threats to ecosystems, health problems, and pollution-related

economic inefficiency are often exacerbated at local levels. Moreover, as demonstrated above, local pollution is intimately tied to global pollution, and a worsening of local pollution due to FDI is consistent with a global pollution augmentation if pollution management in home country was initially more efficient than the one in host country. The relationship between FDI, environmental regulation and local pollution levels taking various and opposite shapes, finally resulting in an indeterminate theoretical outcome, it should be investigated by robust empirical tests, which is the purpose of this chapter.

We consider in our work that searching for pollution havens constitutes only the first step in responding to fears related to the existence of heterogeneous environmental regulations between economies, and we intend to clearly identify the impact of such pollution havens on host countries' pollution emissions. We refer to the most recent literature on pollution havens to examine the related hypothesis. Indeed, while much of the earlier literature has focused on the pollution haven hypothesis and the impact of the environmental regulation on trade or plants location, recently some authors (e.g. Ederington and Minier, 2003; Cole et al., 2006; Levinson and Taylor, 2008) examine the opposite relationship, i.e. the effect of trade (plant location decision or foreign investment flows) on environmental policy. They often refer to political economy literature to argue that industries put pressure on local governments to under-regulate environment, which implies the endogeneity of the environmental regulation. In the literature on plant location, only the studies of Cole et al. (2006) and He (2006) account for the influence of FDI on environmental regulations, which deserves to be improved.

The objective of this chapter is to determine the real interactions between foreign direct investment, environmental regulation and pollution emissions. We attempt

to provide an exhaustive empirical analysis to clearly disentangle each relationship between the three variables of interest, and to shed new light on the environmental impact of pollution havens that we demonstrated in previous chapter. Since this chapter is a continuation of the previous one, we carry on this further investigation of the pollution haven hypothesis on France. Moreover, as a major investing country, not only in terms of foreign affiliates but also as regards the level of its outward FDI, examining France and the impact of its significant FDI on the pollution of hosting countries is worthwhile[1]. Thereby, we use a consistent data set on French investment flows at a disaggregate sector-level, in a mix of developed, emerging, developing and transition countries for years 1999-2003; and we estimate a system of three simultaneous equations to model the determination of FDI, taking into account the endogeneity of environmental policy and considering the impact of FDI and regulation on pollution.

This chapter is organized as follows. In Section 1 we present and discuss dominant works that previously examined the relationship between FDI and the environment. In Section 2 we expose the empirical methodology and the estimates results. In Section 3 we present an extending analysis, and in Section 4 we report some robustness tests.

1 Theoretical background

1.1 Trade, FDI and environmental regulation

Most past researchers who have been interested in the relationship between the environment and the international trade have focused on the impact of environmental

[1] France is often ranked as the third largest investing country. In 2009, it was the second one, with an amount of FDI of $220 billion (Source: UNCTAD).

regulation on international trade or foreign direct investment flows, according to the pollution haven hypothesis. Indeed, the problem consisted of evaluating if exogenous environmental regulation was a deterrent to international flows. As mentioned in Chapter 2, the first results from these studies were quite ambiguous and did not converge to a global conclusion concerning this issue. Some authors found no empirical proof of the pollution haven hypothesis, (Grossman and Krueger, 1993; Jaffe et al.,1995; Wheeler, 2001; Eskeland and Harrison, 2003), others showed weak evidence (List and Co, 2000; Smarzynska and Wei, 2004), and a few detected stronger empirical evidence (Keller and Levinson, 2002). In all these works, environmental regulation was considered as exogenous. More recently, some authors consider that the environmental regulation is endogenous. Examining trade flows, Edenington and Minier (2003) argue that the environmental regulation could be used as a secondary trade barrier to protect domestic industries. Their estimates of a system of two simultaneous equations provide support for modelling pollution abatement costs endogenously while studying their impact on net imports, and show that this impact is stronger than in previous estimates with environmental regulation treated exogenously. Levinson and Taylor (2008) use a simple theoretical model to describe mechanisms like terms of trade effects or unobserved heterogeneity among industries, by which the endogeneity of pollution abatement costs that are often used to represent environmental stringency constituted a source of bias in previous empirical work and may have led to an effect opposite to the pollution haven one. Results of their estimations with no correction for endogeneity show a weak relationship between net exports and pollution abatement expenditures, while they emphasize a significant negative relationship when the authors instrument for pollution abatement costs.

In the literature on plant location or capital flows, still fewer studies explicitly

account for endogeneity of environmental policy. Cole et al. (2006) address the question of the endogeneity of environmental regulation to fill the gap in the literature which has, according to them, largely studied the impact of environmental policies on FDI, and too rarely the opposite relationship. They show through a political economy model of local environmental policymaking, that in an imperfectly competitive local market where firms join a lobby group, the FDI's effect on environmental policy is conditional on the government's degree of corruptibility, and they confirm the predictions of the model by their empirical investigation.

In their work, Cole et al. (2006) concentrate on the impact of FDI on environmental policy, with a lesser attention paid to the inverse relationship predicted by the pollution haven hypothesis between the two variables. Nevertheless they instrument FDI to take account of that opposite causality. In this chapter, we are interested in both relationships, thus we consider simultaneously the reciprocal effects of FDI and environmental regulation in two distinct equations.

1.2 Trade, FDI and the environment

In the past century, researchers concerned with the environmental quality have rapidly established a link between pollution levels and income per capita, giving rise in the nineties to a large empirical literature about the relationship between the environment and the income per capita. The seminal work of Grossman and Krueger in 1993 has depicted a hump-shaped relation between some measures of air quality and income per capita, implying that pollution may first increase with income per capita and then falls with higher income. This work constituted the starting point of what is called the Environmental Kuznets Curve literature in reference to the Simon Kuznets' (1955) finding of a hump-shaped relation between inequality and

per-capita income. Moreover, although the notions of scale, technique and composition effects had already been referred to, Grossman and Krueger (1993) were the first who explicitly introduced these three concepts to give an empirical evidence of the environmental impacts of trade. Their study first evaluates the relative magnitudes of the scale and technique effects on three air pollutants concentrations, but it mostly investigates the compositional effect of further trade liberalization between the United States and Mexico, using results from a computable general equilibrium model. On the one hand, their results show that air pollution increases with per capita GDP at low income levels but decreases with GDP at higher levels of income; on the other hand, they show that differences in environmental regulations between Mexico and USA do not play a major role in determining intersectoral resource allocations. Combining the evidence on the three effects, their findings suggest that NAFTA (North-America Free Trade Agreement) should be beneficial to Mexico's environment.

Antweiler et al. (2001) brought a substantial improvement to the work of Grossman and Krueger (1993). They develop a theoretical model to decompose the impact of trade on pollution into scale, technique and composition effects, and use a consistent dataset on sulfur dioxide concentrations to estimate jointly the three effects using a single-equation reduced-form model. They find that when openness is conditioned on country characteristics, its impact on pollution concentrations resulting from the composition effect is highly significant but relatively small. At the opposite, estimates of the trade-induced scale and technique effect imply a net reduction in pollution. Finally, the authors find that combining the estimates of the three effects, trade liberalization appears to be beneficial to the environment. Besides, in an alternative specification, Antweiler et al. (2001) introduce FDI to test for a

potential impact of FDI on their results. Although their results were much mitigated, their exercise represents broadly the unique direct investigation of the FDI consequences on environment quality in the literature.

Dean (2002) also estimates the impact of trade and growth on water pollution in Chinese provinces through scale, composition and technique effects. But, according to her, these few econometric studies that test for a relationship between trade openness and environmental damage found some counter-intuitive results because they lie on single-equation models that include a single variable representing the effects of trade openness, which is insufficient to capture the opposite and simultaneous effects of trade on environment. In her work, Dean (2002) uses a Heckscher-Ohlin model with endogenous factor supply, which leads to a two-equation-system that captures the impact of trade liberalization on environment through its direct effect on the composition of output, and its indirect effect via income growth. The model thus disentangles the two effects, but its estimates using Chinese provincial data on water pollution show that these effects work in opposite directions and did not achieve to bring out a clear overall impact on emissions in China.

2 Empirical work

In this empirical study we are concerned with three closely related issues. First, the extent to which environmental regulation affects FDI flows. Second, that environmental regulation should be affected in turn by foreign investment. The third issue follows from the two preceding, and consists in determining the impact of such interactions on the environment. An appropriate way to model our issues is to consider them through three simultaneous equations: the first modelling the impact of environmental regulation on FDI; the second equation modelling the impact of FDI

on environmental regulation; and the third equation modelling the overall impact on pollution level.

2.1 FDI specification

To estimate the impact of environmental regulation on FDI flows, we rely on the methodology that we adopted in Chapters 2 and 3, as well as referring to the large literature on FDI determinants and pollution havens. We showed in Chapter 2 that the profitability of a location for a firm depends on the market potential of the location and its total factor productivity, the firm's production costs (capital, labor, and environmental costs), and some market failures. Since the factors determining a firm's location choice also prevail in the determination of FDI flows, we model the FDI flows in a country as a function of these factors.

$$FDIman_{it} = \beta_1 ER_{it} + \beta_n D^n_{it} + \varepsilon_{it} \tag{4.1}$$

While in Chapter 3 we examined plant location decisions, in this chapter the dependent variable $FDIman_{it}$ is a quantitative measure representing the gross French foreign direct investment manufacturing flows[2] in host country i at time t, with $t =$ years 1999-2003. Indeed, given that our present purpose is to evaluate the impact on pollution levels, the flows of investments seem to be a more appropriate measure than location decisions since emissions levels are directly affected by the amount of flows. The period of study is particularly well-adapted to our purpose since it follows years of FDI deregulation across the world. Especially in developing and transition countries, in 1999, highly polluting sectors which were previously restricted to FDI have been liberalized, notable among them is the pharmaceutical industry. This

[2] NAF 1993, section D except subsection DF related to coke and petroleum refineries.

creates an incentive to assess if such liberalizations have been accompanied by pollution levels increases. As regards the data related to $FDIman$ variable, they have been made available for us from the Department of the Balance of Payments of the French Central Bank. The supplied database provides the level of French investments by sector (NAF 1993 three-digit codes) and host country. As far as we know, this data had not been used in a previous work, which gives a special interest to this study. However, FDI flows recorded from the balance-of-payment statistics include not only equity capital, but also reinvested earnings and inter-firms loans. In other words, they comprise the financing of new investments, cross-border mergers and acquisitions, retained earnings of subsidiaries and inter-firm loans. Therefore, the amount recorded can be exaggerated by financial flows that are not correlated with the creation, the acquisition or the expansion of foreign subsidiaries, and this may affect our results since the impact of FDI on pollution may be under-estimated. Nevertheless, the share of financial flows was not predominant during our period of study, and it has been increasing from the year 2003[3].

To measure the stringency of environmental regulation ER_{it}, we construct an index of environmental regulation similar to our Environmental Regulation index in Chapter 3, compound of the same four complementary environmental variables: the number of multilateral environmental agreements ratified, the number of ISO 14001 certifications, the number of INGOs' members and the energy efficiency[4]. Nevertheless, in this chapter we do not incorporate the same multilateral agreements and we focus rather on those directly related to international trade and industrial pollution[5].

[3]France is the first country that has recently adjusted its FDI flows data from 2002, by separating data on equity capital and other capitals flows.

[4]We also use the Z-score method to compute this index. This method has been developed in Chapter 3.

[5]Multilateral Environmental Agreements included in our index are: the Vienna Convention;

As related to explanatory variables in vector D_{it}^{n}, we also mostly follow the same methodology than in Chapter 3. We calculate market potential MP_{it}, and total factor productivity growth TFP_growth_{it} in country i at time t following commonly used methods. We also capture capital and labor costs through the countries' relative endowments in production factors, represented by the variable KL. KL is the ratio K/L, with K the capital stock[6] and L the total labor force. The market failures that affect a firm's location abroad being usually associated to the quality of governance in a country, they are proxied by three institutional quality variables: the corruption level ($CORRUP$) and the government regulatory quality ($REGULQUAL$) developed by Kaufmann (2005)[7], and the dummy variable $FREE$ taking "1" for countries considered by the Freedom House Organization as to be free according to their political rights and civil liberties of citizens, 0 otherwise. Moreover, dummy variable PTA is introduced to control for a potential effect on investments of trade openness between host countries and France, and dummy ($COL45$) is introduced to control for ex-colonial relationships between France and host countries. PTA takes value "1" if a country is a EU-member or has contracted a preferential trade agreement with the European Union, consequently with France, and 0 otherwise; while $COL45$ takes value "1" for countries in colonial relationship with France post 1945, and 0 otherwise[8].

On the other hand, in addition to these factors we further explicitly include

the Basel Convention on hazardous waste trade, the Biosafety Protocol, the United Nations Framework on Convention for Climate Change, the Kyoto Protocol and the Stockholm Convention on Persistent Organic Pollutant.

[6]The capital stock is calculated by using the following formula: K_t= gross fixed capital formation$_t$ + 0.95 capital stock$_{t-1}$. Due to data availability (particularly concerning transition countries), the initial stock is represented by the gross fixed capital formation in 1990.

[7]$CORRUP$ is the inverse of the original Kaufmann index which reflects the control of corruption in states (a higher value meaning a better governance outcome). It should then have a negative effect on investments as a result of a greater corruption.

[8]See Chapter 3 for more detailed explanations concerning these variables.

in this chapter standard control for agglomeration effects that have been largely discussed in the literature on determinants of foreign direct investment, and we use the stock of total inward FDI in host country ($FDIstock$).

While Equation (4.1) is consistent with the pollution haven literature and expresses the FDI as a function of determinants, including environmental regulation, new theories suggest a certain impact of FDI on environmental regulations. To allow for this opposite causality and potential endogeneity of environmental regulation, we model the latter as a function of FDI flows and other exogenous variables that we present below.

2.2 Environmental regulation specification

According to political economy models which suggest that the environmental regulation should be affected by trade or FDI flows, we consider in the specification of the environmental regulation the effect of French direct investment. Principally, we introduce the variable $FDIman_{it}$ of Equation (4.1) that represents the investments from French manufacturing industries. Since it would be unlikely that marginal investments would have an impact on domestic policies, we have to focus on countries where France represents a major investing country. We thus calculate for all countries the share of the net French investment in the total net foreign investment. Data on net outward French investment is published by the French Central Bank, while those on total net foreign investment come from the World Bank. We also complemented this information by referring to official documents from the French Minister of Economy, Industry and Employment, that give detailed analyses of French FDI. Finally, we keep in our sample the countries where the net French investment represents more than 10% of total net foreign investment and/or where France is at

worst the fifth most important investing country.

Moreover, unlike Cole et al. (2006) who considered the effect of global FDI, we suggest that only manufacturing industries should negatively influence environmental regulation. We thus also include in our specification the FDI from French non manufacturing sectors ($FDInonman_{it}$) to test this assumption[9]. The environmental regulation could thus be expressed as following:

$$ER_{it} = \alpha_1 FDIman_{it} + \alpha_2 FDInonman_{it} + \alpha_n V_{it}^n + \delta_{it} \tag{4.2}$$

V_{it}^n includes a number of supplementary control variables. We take into account the corruption ($CORRUP$), which usually is expected to have a negative effect on environmental regulation. Indeed, bad governance and weak institutional quality affect the efficiency of policies, and they may hamper the adoption and the enforcement of environmental policies. For this reason, many less regulated countries also suffer from corruption, e.g. poorer African countries. However, some countries may strengthen their regulation so as it gives them a bargaining power to extort payments from firms. Therefore, a positive relationship between corruption and environmental regulation is also likely to occur. The gross national income per capita $GNIcap$ and the rate of unemployment $UNEMPL$ are explanatory variables reflecting the preferences for a good environment. The demand for a better environmental protection is expected to increase with the national income. Inversely, it is expected to decrease with unemployment, since environmental issues become preoccupations of secondary importance when unemployment prevails in an economy. We also introduce the share of the manufacturing sector in the economy, $MANUFempl$, which represents the labor intensity of manufacturing industries. Unlike Cole et al. (2006)

[9] NAF 1993, all sections except section D related to manufacturing industries.

who express this industrialization measure in terms of output in the specification of the environmental policy, we use here a measure in terms of input. We consider that the measure in terms of outputs would be more appropriate in the pollution equation, as described below. $MANUFempl$ should be negatively correlated to environmental regulation. Thus, a greater part of workers in the manufacturing sector put pressure to protect their industry from foreign competition, which is consistent with a weakening of environmental regulations. Alternatively, $MANUFempl$ should be positively correlated to environmental regulation if it reflects the share of non pollution-intensive manufacturing in the economy. Finally, we introduce the level of industrial pollution CO_2man_{it} to represent the marginal benefit of environmental regulation.

2.3 Pollution specification

To estimate the effect of FDI on environmental quality, we observe its impact on carbon dioxide (CO_2) emissions from manufacturing industries. We choose the CO_2 for many reasons. First, CO_2 is produced at important levels by manufacturing industries[10]. During the last decade, CO_2 emissions from manufacturing industries represented more than 20% of total CO_2 emissions in France. Second, CO_2 is currently (and for about 15 years) the most "popular" pollutant since it is the main greenhouse gas that is behind the principal concern of environmentalists and politicians, namely global warming. For this same reason, carbon dioxide is the subject of strengthening regulations at local levels as well as at the international level, as seen with the launching of the Kyoto Protocol in 1997 and its enforcement in 2005.

[10]Nonetheless, CO_2 it is not the main pollutant emitted by industries. For exemple, SO_2 is emitted in higher quantities and had often been used in literature as a measure of local pollution. But data on SO_2 emissions from manufacturing industries only exist for particular countries and years that do not match to our study.

However, as described in Chapter 1, its regulation remains heterogenous among developed and developing countries[11]. Moreover, despite CO_2 contributes to global pollution, it is fairly to consider that it is a local pollution indicator, jointly emitted with other local pollutants, i.e. NOx, CO. As an illustration, the correlation between CO_2 emissions from manufacturing industries and water pollution resulting from industrial activities, measured by the Biological Demand in Oxygen, is 0.90 in our database (See Section 3). Finally, CO_2 has available detailed data of its emissions by activity, for a large panel of developed, emerging, transition and developing countries from 1960 to today. With all these characteristics, CO_2 as a proxy of environmental pollution, is particularly well-adapted to our study.

Since our purpose in this chapter is to determine if foreign direct investment from French manufactures contributes to an increase of pollution emissions due to manufacturing activities, we use CO_2 emissions from fuel combustion in manufacturing industries ($CO2man$) as the dependent variable in the pollution Equation (4.3).

$$CO2man_{it} = \gamma_1 FDIman_{it} + \gamma_2 ER_{it} + \gamma_n F^n_{it} + \eta_{it} \tag{4.3}$$

The standard approach consists in analyzing the impact of trade liberalization on environment by decomposing its environmental impact into scale, technique and composition effects[12]. Scale effects refer to the increase in the size of an economy

[11] Actually, CO_2 is a measure of global pollution, with large policy implications. While the direct implication of pollution haven hypothesis is the shifting of pollution from developed to developing countries, which raises some ethical and local questions, another fear is that the improvement of environment quality in developed countries is more than compensated by the deterioration of natural resources in developing countries. This issue is emphasized in the case of transboundary pollution, because the efforts conceded by some countries in terms of environmental policy and pollution reduction would be annihilated if polluting production moves to less regulated countries, finally leading in an increase of global emissions. In literature, this mechanism is called "carbon leakage" when it concerns the CO_2 emissions.

[12] Studies focusing on the determinants of various pollutants detect some differences depending

that results from liberalization and, *ceteris paribus*, is likely to increase pollution. The technique effect refers to the positive environmental consequences of changes in production methods that accompany trade liberalization and income growth. Indeed, liberalization-induced higher income causes people to increase their demand for a cleaner environment and stricter environmental regulations, encouraging firms in adopting cleaner production processes and reducing emissions. Finally, the composition effect represents the change in the industrial structure of an economy, as with trade liberalization each country specializes in those activities in which it has a comparative advantage. The impact of the composition effect on pollution emissions depends therefore upon the determinants of a country's comparative advantage. Since these three effects should play in opposite directions, empirical studies often attempted to assess the overall effect of trade liberalization on pollution.

We measure the scale effect through the gross domestic product (GDP) of the country. Since GDP represents the economic activity inside a country's borders, it is the economic variable the most likely to capture the effect of the local economic activity on pollution. The composition effect had often been captured through the ratio (K/L) in literature (e.g., Antweiler et al., 2001). However, high KL ratios in an economy could be consistent with an increased share of high-tech services that are not energy intensive (e.g., telecommunications). We use here a more accurate measure expressing the share of the manufacturing sector in terms of outputs, i.e. the share of the manufacturing sector value added in GDP ($MANUFsh$). This variable is more likely to capture the share of the manufacturing sector compared with the primary and the secondary sectors than KL ratio. Though capturing the

on the pollutant considered. For instance, Cole et al. (2005) and Bruneau and Renzetti (2009) show that CO_2 emissions seem to be particularly affected by the composition effect in United Kingdom and France, respectively. We will see below that this effect would be captured by the variable $MANUFsh$, while we also introduce variables controlling for the scale effect and the technique effect which are generally common to other pollutants.

intra-manufacturing sector composition would have been still more informative, we can suppose that an economy where the manufacturing sector prevails should have a higher level of CO_2 emissions, thus we expect a positive estimate coefficient for this variable. Moreover, we distinguish our work in two other ways. First, the technique effect is captured through a consistent index representing environmental regulation (ER), which is a much more precise and direct measure of technique effect than income levels or other proxies often used. Second, we investigate here the impact of FDI on pollution emissions while most of studies consider only trade liberalization effects. More precisely, we are interested in studying the impact of French FDI of Equation (4.1) on the environmental quality of host countries, in order to say if pollution havens –if they are verified in Equation (4.1)–, are really threatening to the environment. To do this, we introduce in Equation (4.3) the dependent variable $FDIman_{it}$ of Equation (4.1) to capture its direct effect on pollution emissions. In this way, we isolate the effect of French FDI, while the effect of FDI from other countries and that of local firms are already captured by the scale, the technique and the composition effects.

2.4 Estimation

Simultaneous estimation of Equations (4.1), (4.2) et (4.3) allows us to treat both the environmental regulation and the level of FDI as endogenous variables and should reveal their effect on pollution levels. Regarding the estimation method, three-stage least squares (3SLS) are more efficient than two-stage least squares (2SLS) under the assumption that the equations in the system are well identified, while two-stage least squares are more robust to specification error. Results of a Hausman specification test indicate that we can accept the null hypothesis that the coefficients do not

systematically differ between 2SLS and 3SLS estimates.

The model being correctly identified, Table 4.1 reports 3SLS estimates of Equations (4.1), (4.2) and (4.3) for French FDI from manufacturing industries ($FDIman$) in Model (1), French FDI from most polluting industries ($FDImanMP$) in Model (2), and those on less polluting industries ($FDImanLP$) in Model (3)[13]. In all models, variables are log-linearized (apart from the total factor productivity growth, the unemployment rate and the share of the manufacturing sector value added in GDP, yet expressed in percentage, and the three dummy variables representing the political and civil rights, the preferential trade agreements and the former colonial relationship). Variables capturing the relative endowments in production factors, the share of the manufacturing sector in the economy and the stock of total FDI have been lagged one-year to avoid any possible endogeneity with the dependent variable.

[13] Manufacturing industries correspond to all sectors from the Division D of NAF 1993 classification. The subsection DF (Manufacture of coke, refined petroleum products and nuclear fuel) is excluded from our sample on account of special characteristics. We remain consistent with literature and general view by considering as polluting industries those belonging to sectors of Manufacture of pulp, paper and paperboard (21.1 three-digit NAF codes), Chemical and parachemical industry (24.1-24.3 and 24.5-24.7), Manufacture of rubber and plastics (25.1-25.2), Manufacture of other non-metallic mineral products (26.1-26.8), Basic metal industries (27.1-27.5). Remaining sectors are considered as less polluting sectors.

Table 4.1: Regressions estimates

	(1)	(2)	(3)
	$lnFDIman$	$lnFDImanMP$	$lnFDImanLP$
TFP_growth	-0.015	-0.037	-0.019
	(0.018)	(0.036)	(0.023)
$lnMP$	0.687**	1.369***	0.849***
	(0.286)	(0.511)	(0.328)
$lnKL_{t-1}$	0.981***	1.507**	0.819**
	(0.334)	(0.594)	(0.409)
$lnER$	-7.511***	-9.281***	-6.720***
	(1.285)	(2.071)	(1.543)
$lnREGULQUAL$	-3.735	1.790	-4.724
	(3.887)	(6.201)	(4.093)
$FREE$	1.985**	1.540	3.823***
	(0.906)	(1.338)	(1.161)
$lnCORRUP$	-3.858	1.063	-3.139
	(2.438)	(3.910)	(2.865)
PTA	0.446	-0.227	1.473**
	(0.562)	(1.069)	(0.750)
$COL45$	0.754	1.588	1.620
	(0.958)	(1.698)	(1.182)
$lnFDIStock_{t-1}$	0.371	0.599	0.219
	(0.229)	(0.443)	(0.286)
	$lnER$	$lnER$	$lnER$
$lnFDIman$	-0.060*		
	(0.032)		
$lnFDInonman$	0.002	0.016	0.010
	(0.017)	(0.015)	(0.012)
$lnCORRUP$	-0.601***	-0.386***	-0.540***
	(0.184)	(0.146)	(0.158)
$lnGNIcap$	0.237***	0.225***	0.254***
	(0.062)	(0.048)	(0.053)
$MANUFempl_{t-1}$	0.010**	0.015***	0.013***
	(0.005)	(0.003)	(0.003)
$UNEMPL$	0.000	-0.006	-0.002
	(0.005)	(0.004)	(0.004)
$lnCO2man$	-0.091**	-0.142***	-0.137***
	(0.042)	(0.027)	(0.025)
$lnFDImanMP$		-0.024*	0.001
		(0.014)	(0.004)
$lnFDImanLP$		0.000	-0.043***
		(0.006)	(0.016)
	$lnCO2man$	$lnCO2man$	$lnCO2man$

$lnFDIman$	0.094***		
	(0.035)		
$lnGDP$	0.522***	0.490***	0.546***
	(0.053)	(0.049)	(0.047)
$MANUFsh$	0.056***	0.058***	0.055***
	(0.011)	(0.011)	(0.011)
$lnER$	-1.028***	-1.012***	-1.130***
	(0.141)	(0.146)	(0.136)
$lnFDImanMP$		0.090***	0.022
		(0.025)	(0.014)
$lnFDImanLP$		0.015	0.046*
		(0.017)	(0.027)
R-squared	0.28	0.20	0.28
N. of obs.	106	106	106

Standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01.
Constant terms not reported.

Model (1) reports results for all manufacturing industries. The estimate of Equation (4.1) shows a coefficient of environmental regulation negative and statistically significant at the 1% level, as expected by the pollution haven hypothesis. This finding confirms the fact that the French FDI is attracted by lax environmental regulations. A 1% decrease of environmental regulation would increase FDI by more than 7.5%, representing an important deterrent effect. This result refutes previous empirical studies which, by treating the level of environmental regulation as exogenous, did not identify an impact of environmental policy on FDI; and it confirms the few previous works that found a significant but quite small impact.

The market potential, the relative endowments in production factors and variable $FREE$ are also significant in the specification of FDI. The market potential has a positive and significant impact on FDI referring to the demand motivation of FDI. The coefficient on KL is also positive and significant at the 1% level, implying that in our sample, French FDI is attracted by countries that are relatively-abundant in capital. Variable $FREE$ shows that democracy attracts French manufacturing FDI.

In order to express more precisely the impact of the environmental regulation on French FDI, we try an analysis evaluating what would occur if a lax country adopted a stricter environmental policy. As an illustration, we compare the impact on French FDI flows in Morocco if Morocco had adopted the environmental regulation of Germany in 2000. We find that every thing else equal, replacing the ER index value of Morocco by the value of Germany would lead to about a 80% decrease of FDI flow in Morocco in 2000. This result highlights the strong effect of the environmental regulation. We try the same analysis with the market potential, and we find that if Morocco had have the market potential of Germany in 2000, the total manufacturing FDI would have increased by more than 100%. Therefore, the market potential also seems to be an important determinant of French FDI.

The estimate of Equation (4.2) shows that French manufacturing FDI is negatively correlated to the environmental regulation of host countries, while $FDInonman$ is insignificant, confirming our hypothesis that only manufacturing industries should have an impact on environmental regulation. These results are consistent with predictions of political economy models suggesting that firms may lobby to under-regulate corrupted host countries. Apart from the $UNEMPL$ variable that is insignificant, other control variables included in V^n are all highly significant. Consistent with previous theoretical and empirical results in literature (Damania, Fredriksson and List, 2003; Fredriksson and Svensson, 2003), we observe that corruption prevents countries from setting up an efficient environmental policy. Inversely, in richer countries where the income per capita is higher, the environmental regulation is stricter, in accordance with population and governments preferences. $MANUFempl$ displays a positive relationship with ER. Since less-polluting industries are those likely to be more-intensive in labor, the positive coefficient on $MANUFempl$ indi-

cates that the greater the share of less-polluting industries in economy, the stricter the environmental regulation. Reciprocally, the greater the share of most-polluting industries in economy the less-strict the environmental regulation. The significant and negative coefficient on $CO2man$ seems to assert the latter statement: an economy that has a larger part of its manufacturing polluting, which is consistent with a higher level of pollution, sees its environmental regulation lowered. In this case, the level of pollution does not reflect the marginal benefit of increasing environmental regulation but the pressure from polluting industries to lessen regulation.

The results of the pollution equation regression in Model (1) represent the third concern of this chapter, as it regards the impact of FDI on CO_2 emissions. Everything else being equal, more French manufacturing FDI increases the pollution emitted in host countries. Empirical findings related to scale, technique and composition effects are consistent with theory: the scale and composition effects raise pollution emissions, while the technique effect drops it. The technique effect is captured by the environmental index representing environmental stringency. Thus, the negative relationship between pollution emissions and ER should refer to a reduction of pollution emissions due to the adoption of cleaner technologies following strengthened regulations.

While estimations resulting from regressions on all manufacturing sectors in Model (1) are of a great interest since they enable us to draw general conclusions about the manufacturing French FDI, we expect that more detailed analyses focusing on highly polluting industries in Model (2) and less polluting ones in Model (3) would bring out additional explanations. Indeed, examining the estimate of Equation (4.1) for both models, we first observe that the environmental regulation ER has a negative impact on polluting FDI ($FDImanMP$, Model (2)) as well as on less

polluting one ($FDImanLP$, Model (3)), with a coherent higher elasticity of polluting FDI. Also the market potential and the relative capital endowment variables keep their significantly positive impact through both models. The variable $FREE$ that was significant in Model (1) remains significant in Model (3) regarding less-polluting industries, but lose significance in explaining polluting FDI. This suggests that the environmental regulation could be the main determining factor of French polluting FDI.

The estimates of Equations (4.2) and (4.3) while decomposing manufacturing industries into polluting and less-polluting bring out complementary information to our previous preliminary conclusions. First, examining the estimate of Equation (4.2), we observe that $FDImanMP$ and $FDImanLP$ variables are negative and significant in Models (2) and (3), respectively. This shows that the negative impact of FDI on the environmental regulation in Model (1) results from polluting as well as less polluting French FDI. Second, the estimate of Equation (4.3) emphasizes results from Model (1), since both FDI from polluting and less-polluting industries increase the level of CO_2 emissions from manufacturing, with an expected more significant impact of polluting FDI. Moreover, the impacts of $FDImanMP$ and $FDImanLP$ in the Equations (4.2) and (4.3) highlight the interest of considering separately each variable as endogenous, since their impact appears in each respective model while it is occulted in other specification. Finally, other coefficients in the estimates of Equations (4.2) and (4.3) are close to those depicted in Model (1) and lead to the same conclusions.

It is worth discussing here the different modes of FDI, principally greenfield investments and mergers and acquisitions (M&A). Indeed, it is often hoped that spillover effects exist and that FDI acts as a vehicle through which new ideas, tech-

nologies, and working practices can be transferred to domestic firms (Wang and Blomström, 1992). Furthermore, it is expected that the impact of FDI on pollution levels differs with regard to the mode of entry. FDI through greenfields seems to be more likely to transfer new, better and cleaner technology than M&A, at least at the time of entry. Indeed, cross-border M&A can be followed of better technology especially when acquired firms are restructured to increase the efficiency of their operations. Moreover, with greater linkages in the case of M&A, there is greater potential for spillovers of FDI to be larger than in the case of greenfield investment. Therefore, even if M&A investment does not transfer newer equipment and technology at inception, it is expected to have a more positive impact on the local economy, especially through vertical linkages, whereas greenfield investment takes time and efforts to develop such linkages. This is due to the fact that M&A have a more developed network of local and regional suppliers, whereas greenfields enterprises are more likely to rely on imported supplies. We do not have information about the mode of entry of FDI in our database. However, annual reports of the French Central Bank shows that for our period of study (1999-2003), the share of M&A in the equity capital of FDI represented about 71%, 77%, 68%, 36% and 45%, respectively. Therefore, during our period of study, the share of M&A was on average larger than the share of greenfield investment. Since as described above, beneficial effects of M&A are enhanced in the long term, the reduction of pollution emissions that would result from M&A undertaken in years 1999-2003 is more likely to be captured in subsequent years. This may be one explanation of the positive relationship found between French FDI and pollution emissions. Moreover, these results are consistent with the findings of Chapter 3, which suggest that greenfield investment between 1996 and 2002 were not necessarily a vehicle of cleaner technologies.

3 Extended analysis

To assess the sensitivity of our results to the choice of instruments, and to extend our analysis, in this section we test several alternative specifications of base Models (1), (2) and (3). Since one principal concern in this study is to check for the impact of French FDI on pollution, in order to be more exhaustive, the primary attempt is to run estimates on another pollutant that would differ from CO_2 for some characteristics. For instance, this pollutant would be preferably related to another medium. The Biological Demand in Oxygen (BOD), whose data are published by the World Bank, is an appropriate pollutant, since it represents emissions of organic water pollution resulting from industrial activities, is a measure of local pollution, and is available for a panel of years and countries. Table 4.2 reports estimates of base models using BOD (BOD) in Models (4) to (6) and Table 4.3 reports estimates using BOD per worker ($BODw$) in Models (7) to (9). The use of each of these two variables is of a particular interest. The use of BOD is a direct robustness test of our regressions on CO_2 emissions, and both have the advantage of estimating the impact on total emissions which are the ultimate concern of the environmental policies implemented to reduce pollution. However, intensive approaches are often adopted by governments that attempt to control emissions intensities rather than total emissions (e.g., carbon tax), the objective being to make pollution intensity fall even if total emissions rise (this negative relationship has been demonstrated by Bruneau and Echevarria, 2009). In such cases, environmental regulation would more directly affect pollution intensity like the BOD per worker than total emissions. Similarly, Models (4) and (7) concern total French manufacturing FDI, whereas Models (5) and (8) examine with more details polluting FDI and Models (6) and (9) less polluting one.

Table 4.2: Robustness tests (BOD)

	(4)	(5)	(6)
	$lnFDIman$	$lnFDImanMP$	$lnFDImanLP$
TFP_growth	-0.017	-0.017	-0.017
	(0.021)	(0.031)	(0.020)
$lnMP$	0.642*	0.985*	0.631
	(0.388)	(0.555)	(0.388)
$lnKL_{t-1}$	1.269***	1.363**	1.224***
	(0.416)	(0.585)	(0.414)
$lnER$	-7.747***	-11.341***	-7.223***
	(1.347)	(1.869)	(1.344)
$lnREGULQUAL$	-5.662	-5.627	-6.296
	(5.227)	(7.487)	(5.043)
$FREE$	1.394	1.578	1.636
	(1.056)	(1.537)	(1.079)
$lnCORRUP$	-2.957	-1.704	-3.353
	(2.808)	(3.915)	(2.815)
PTA	-0.318	-1.126	0.039
	(0.798)	(1.163)	(0.815)
$COL45$	0.635	1.730	0.441
	(1.128)	(1.652)	(1.127)
$lnFDIStock_{t-1}$	0.732**	1.288***	0.594**
	(0.297)	(0.434)	(0.296)
	$lnER$	$lnER$	$lnER$
$lnFDIman$	-0.102***		
	(0.022)		
$lnFDInonman$	0.015	0.022	0.014
	(0.014)	(0.015)	(0.014)
$lnCORRUP$	-0.467**	-0.329*	-0.518**
	(0.200)	(0.188)	(0.203)
$lnGNIcap$	0.207***	0.136**	0.230***
	(0.067)	(0.064)	(0.069)
$MANUFempl_{t-1}$	0.013***	0.012**	0.014***
	(0.005)	(0.005)	(0.005)
$UNEMPL$	0.001	0.006	0.000
	(0.005)	(0.005)	(0.006)
$lnBOD$	0.009	0.037	-0.019
	(0.039)	(0.037)	(0.038)
$lnFDImanMP$		-0.084***	
		(0.018)	
$lnFDImanLP$		0.003	-0.098***
		(0.010)	(0.025)
$lnBODw$			

	$lnBOD$	$lnBOD$	$lnBOD$
$lnFDIman$	0.197***		
	(0.049)		
$lnGDP$	0.397***	0.380***	0.437***
	(0.072)	(0.060)	(0.063)
$MANUFsh$	0.048**	0.058***	0.052***
	(0.019)	(0.018)	(0.017)
$lnER$	-0.060	0.585**	-0.115
	(0.253)	(0.276)	(0.231)
$lnFDImanMP$		0.217***	
		(0.039)	
$lnFDImanLP$		-0.027	0.102**
		(0.032)	(0.052)
R-squared	0.42	0.37	0.41
N. of obs.	67	67	67

Standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01.
Constant terms not reported.

Globally, results of Models (4)-(6) related to BOD are similar to those in Table 4.1, and confirm the sign and significance of our variables of interest. Thus, the environmental regulation deters manufacturing FDI, manufacturing FDI lowers the strictness of environmental policy and increases the emissions of water pollution. These conclusions are valid whether we examine global manufacturing FDI (Model (4)), polluting FDI (Model (5)) and less polluting FDI (Model (6)). More particularly, in the estimate of Equation (4.2), we observe that polluting as well as less polluting FDI negatively influence the environmental policy in relative Models (5) and (6). In the estimate of Equation (4.3), they increase the emissions of water pollution.

In Table 4.3 below, results of Models (7)-(9) using BOD per worker are roughly similar as regards to estimates of Equations (4.1) and (4.2). A one-percent increase in environmental policy discourages global manufacturing by more than 7%, and discourages polluting manufacturing FDI and less polluting manufacturing FDI

by about 10.4% and 6.4%, respectively. The estimate of Equation (4.2) displays also negative and strongly significant impact of $FDIman$, $FDImanMP$ and $FDImanLP$ on environmental policy in Models (7), (8) and (9), respectively. Moreover, we notice interesting opposite effects of FDI on $BODw$ for Equation (4.3) estimate. Thus, in Model (7), the impact of total manufacturing FDI on $BODw$ is significantly negative, which means that an increase of French manufacturing FDI decreases the water pollution emitted by worker in host country. Moreover, while $FDImanMP$ becomes insignificant in related Model (8), $FDImanLP$ variable becomes significantly negative in Models (8) and (9). These results first suggest that the decreasing impact of French manufacturing FDI on $BODw$ in Model (7) reflects mainly the decreasing impact of $FDImanLP$. Secondly, comparing Models (4)-(6) to (7)-(9), on one hand, results on the Biological Demand in Oxygen indicate that an increase of French manufacturing FDI increases pollution whether the sector is highly polluting or less polluting. On the other hand, examining the Biological Demand in Oxygen per worker which reflects the pollution intensity, we observe that the less polluting French manufacturing FDI seems to improve the local environmental efficiency. This result should refer to the "pollution halo hypothesis". According to this hypothesis, multinational firms are less pollution intensive than their domestic counterparts, thus trade liberalization facilitates transfers of technology that would be beneficial to the environment. Moreover, this suggestion captured through the BOD per worker is consistent with the fact that the transfer of technology is generally admitted to take place through the training of local workers. It emphasizes positive impacts of M&A through vertical linkages, which happens more rapidly than the above mentioned positive impacts resulting from restructuring. Therefore, it seems that when we examine simultaneously FDI and pollution emissions, benefits

from vertical linkages are more likely to be captured, especially through the pollution intensity of production. Combining opposite effects of FDI on BOD and BOD per worker, we can say that French manufacturing FDI improves local pollution intensity despite the fact that it augments pollution emissions.

Table 4.3: Robustness tests (BODw)

	(7)	(8)	(9)
	$lnFDIman$	$lnFDImanMP$	$lnFDImanLP$
TFP_growth	-0.012	-0.019	-0.014
	(0.020)	(0.031)	(0.019)
$lnMP$	0.804**	1.044*	0.715*
	(0.387)	(0.566)	(0.366)
$lnKL_{t-1}$	1.368***	1.721***	1.450***
	(0.412)	(0.592)	(0.391)
$lnER$	-7.175***	-10.428***	-6.436***
	(1.295)	(1.823)	(1.266)
$lnREGULQUAL$	-6.979	-9.511	-7.639*
	(4.839)	(7.152)	(4.602)
$FREE$	2.870**	2.986*	3.054***
	(1.153)	(1.661)	(1.081)
$lnCORRUP$	-0.123	0.895	0.571
	(2.906)	(4.147)	(2.720)
PTA	0.568	0.127	0.652
	(0.763)	(1.122)	(0.716)
$COL45$	1.013	1.362	0.925
	(1.157)	(1.685)	(1.100)
$lnFDIStock_{t-1}$	0.809***	1.131***	0.816***
	(0.296)	(0.429)	(0.281)
	$lnER$	$lnER$	$lnER$
$lnFDIman$	-0.107***		
	(0.014)		
$lnFDInonman$	0.019	0.018	0.017
	(0.014)	(0.015)	(0.014)
$lnCORRUP$	-0.462**	-0.303	-0.450**
	(0.203)	(0.203)	(0.207)
$lnGNIcap$	0.230***	0.197***	0.262***
	(0.068)	(0.067)	(0.070)
$MANUFempl_{t-1}$	0.007	0.010*	0.007
	(0.005)	(0.005)	(0.005)
$UNEMPL$	0.008	0.009	0.007
	(0.007)	(0.006)	(0.006)

lnBOD			
lnFDImanMP		-0.070***	0.016*
		(0.013)	(0.009)
lnFDImanLP		-0.002	-0.138***
		(0.012)	(0.021)
lnBODw	-0.322**	-0.117	-0.414***
	(0.149)	(0.152)	(0.150)
	lnBODw	*lnBODw*	*lnBODw*
lnFDIman	-0.084***		
	(0.026)		
lnGDP	0.066*	-0.000	0.072**
	(0.038)	(0.031)	(0.034)
MANUFsh	-0.013	-0.008	-0.008
	(0.010)	(0.009)	(0.009)
lnER	-0.402***	-0.117	-0.282**
	(0.133)	(0.142)	(0.128)
lnFDImanMP		0.033	0.041***
		(0.020)	(0.013)
lnFDImanLP		-0.064***	-0.141***
		(0.017)	(0.027)
R-squared	0.43	0.39	0.43
N. of obs.	67	67	67

Standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01.
Constant terms not reported.

4 Robustness tests

We run two additional robustness tests of our results (Table 4.5 in Appendix 4.C). In Models (10) to (12), we introduce as an additional control the GDP per capita (*GDPcap*), which is a commonly used variable for productivity approximation. In Models (13) to (15), we incorporate in the three equations, four regional dummies grouping countries into four homogeneous clusters, to take into account fixed effects for countries of a same region[14]; and we also incorporate time specific-effects. Results of Models (10)-(12) with *GDPcap* are broadly similar in sign and significance to

[14]High-income, Emerging, Transition CEEC, and Developing countries.

those of Table 4.1 and confirm previous results, while $GDPcap$ is not significant. Models incorporating fixed effects also display very similar results. However, in the estimate of Equation (4.3), we note that only FDI from less polluting industries has an impact on pollution, and this impact is negative.

Finally, in order to enlarge our scope of study, we relax the assumption that French FDI could influence environmental regulation in host countries. We are thus allowed to consider the total sample of countries present in our database. Countries are listed in Appendix 4, and results appear in Table 4.6 in Appendix 4.C. For most of variables, we draw the same conclusions as suggested by our previous results, especially in Model (16) which is related to all manufacturing industries: a stricter environmental regulation deters French FDI, and an increase in French FDI raises pollution emissions. However, the impact of French FDI on environmental regulation in Equation (4.2) deserves a particular attention. Surprisingly, the relationship between the two variables remains significant in the three models. But in the present case, it is a positive relationship. In other words, the higher the French FDI in host countries, the stricter the environmental regulation. This may refer to the "welfare effect" mentioned by Cole et al (2006). They argued that an increase in the investments intensifies the level of competition in a country, and therefore reduces the government's incentive to lower the pollution tax for stimulating output and raising consumer welfare. Moreover, this situation is more likely to occur when the corruptibility of governments is lower. This statement remains consistent with the actual situation since we are considering all hosting countries of French FDI, and not only those where French investors have influence. Thus, when French investors do not have a sufficient power for lobbying to under-regulate host countries, French FDI would rather positively affect environmental regulation. Moreover, results from

Models (17) and (18) suggest that the environmental regulation only deters most polluting FDI, while it is the FDI from less polluting firms that raises pollution. A potential explanation is that when we do not concentrate on significant host countries for French investors, French polluting FDI becomes probably marginal, while FDI from less polluting sectors is more determined by other factors than a lenient environmental regulation since it could not lower it.

Conclusion

Whereas previous empirical literature has investigated the impact of environmental regulations on foreign direct investment, fearing the emergence of pollution havens, two important but largely ignored empirical issues behind this topic are whether foreign direct investment influences environmental regulations and whether such pollution havens increase pollution. In this chapter, we consider mutual relationships between the FDI, the environmental regulation and the pollution, as to confirm the pollution havens hypothesis in the case of France and determine its impact on pollution in host countries. We use detailed manufacturing French investments data to estimate a system of three equations where FDI, environmental regulation and pollution are modeled endogenously. This essay is thus interesting since it represents, to our knowledge, the first attempt to empirically estimate how French FDI affects pollution levels in host countries. Our results consolidate our findings of Chapter 3 proving the pollution haven hypothesis in the case of French FDI. They further confirm recent works detecting a negative impact of environmental regulation on FDI location, while we take into account the endogeneity of environmental regulation. The endogeneity of FDI is besides reflected by a decreasing impact on environmental policy. We further improve our interpretations by conducting separate regressions

for FDI from most polluting and FDI from less polluting sectors. Those regressions show that environmental regulation exerts a negative impact on more polluting FDI as well as on less polluting FDI, with an expected stronger effect on more polluting one. They also demonstrate the negative correlation between both kinds of French FDI and the environmental policy of host countries. However, in a specification including all countries and not only those where French investment is of a prime importance, it appears that French FDI is positively related to the host country's environmental regulation.

Regarding the environmental impact of FDI, we observe a positive relationship between French manufacturing FDI and pollution emissions in host countries, whether we examine CO_2 air pollution or a more local water pollution. This damaging impact is more significant from most polluting FDI. Looking at the specific case of increasing emissions of CO_2, even if in our study we do not particularly focus on transboundary pollution, our results could be compatible with the existence of a carbon leakage. This is consistent with the latest annual study from the Global Carbon Project, published on 17th of November 2008 in the Nature Geoscience review, which mentions that CO_2 emissions reached a record of about 10 billion GtC in 2008. Researchers besides specify that emissions from developing countries not under the Kyoto Protocol became larger than those of developed countries four years ago, but they warn against too hasty conclusions since they recall that a large part of those emissions are in fact due to production from firms originating in developed countries but relocated in developing ones. They illustrate their remarks with the example of the United Kingdom, whose CO_2 emissions dropped by 5 % between 1992 and 2004, while its emissions based on consumed goods, mostly produced in the South, rose by 12%. Implications from our results have been observed through

the recent climate change conference of Copenhagen, in December 2009. It seems that this issue of carbon leakage was the stake of huge negotiations, from which at last it followed a larger implication from emerging and South countries for reducing CO_2 emissions, and probably strengthening environmental regulation.

Finally, a few different specifications measuring the impact of FDI on water emissions by worker exhibit an opposite relationship: greater FDI from less polluting sectors is consistent with a reduction of pollution intensity. Such a result indirectly refers to the use of cleaner technologies by French firms than done by their local counterparts and to a small transfer of technologies. Thus, on account of this result, while in this work we have been mainly interested in the effect of foreign direct investment on total emissions, a further investigation of its impact on pollution intensity is worthwhile. Combining opposite effects of FDI on BOD and BOD per worker, we can say that French manufacturing FDI improves local environmental efficiency despite the fact it augments pollution emissions. Or we can say that French manufacturing FDI augments pollution emissions, even if it improves local environmental efficiency. The challenge would be to reach a situation where the extent to which French firms improve local environmental efficiency causes a reduction of pollution. If this goal is achieved, we would have a fresh look on the pollution haven debate. Further investigation should concentrate on examining the conditions or the characteristics from both source and host countries that may facilitate the assimilation of a better environmental management promoted by FDI.

Appendix 4

4.A Data summary

Table 4.4: Data definitions and sources

Variable	Definition	Sources
$FDIman$	Flows of French foreign direct investment. NAF 1993 classification, Section D "Manufacturing industries", except subsection DF "coke and petroleum refineries".	French Central Bank, Department of the Balance of Payments.
$FDImanMP$	Division D 3-digit NAF 1993 codes 21.1, 24.1-24.3, 24.5-24.7, 25.1-25.2, 26.1-26.8, 27.1-27.5.	French Central Bank, Department of the Balance of Payments.
$FDImanLP$	Division D 3-digit NAF 1993 codes, excluding those corresponding to $FDImanMP$ and those belonging to DF subsection (23.2 and 23.3).	French Central Bank, Department of the Balance of Payments.
MP	Market potential	Data on international trade: R.Feenstra and R.Lipsey, NBER 1990-2000. Chelem, CEPII, 2000-2004. Geographic data: CEPII.
TFP_growth	Total factor productivity growth	Authors calculation using data from World Development Indicators, World Bank.
$GDPcap$	GDP per capita (constant 2000 US$).	World Development Indicators, World Bank.
KL	Country relative endowments in production factors, (capital versus labor).	World Development Indicators, World Bank.
ER	Environmental regulation index	Authors calculation
	Multilateral Environmental Agreements	Earthtrends, World Resources Institute
	ISO 14001	International Organization for Standardization
	International NGOs	Center for the Study of Global Governance

	Energy efficiency (GDP/unit of energy used)	World Bank
$CORRUP$	Institutional quality variable of corruption.	Governance Indicators 1996-2004, D. Kaufmann, A. Kray and M. Mastruzzi.
$REGULQUAL$	Regulations improving firm's general business environment.	Governance Indicators 1996-2004, D. Kaufmann, A. Kray and M. Mastruzzi.
$FREE$	Dummy taking value 1 if a country is considered democratic.	Freedom House Organization.
PTA	Dummy taking value 1 if a country has a preferential trade agreement with EU.	Preferential trade agreements databse (PTAs).
$COL45$	Dummy taking value 1 if a country had a colonial relationship with France post 1945.	DISTANCES database from CEPII.
$FDIstock$	Stocks of FDI.	UNCTAD FDI statistics database.
$FDInonman$	Flows of French foreign direct investments. NAF 1993 classification, all sections except section D "Manufacturing industries".	French Central Bank, Department of the Balance of Payments.
$GNIcap$	Gross national income per capita.	World Development Indicators, World Bank.
$MANUFempl$	Number of employees in manufacturing industries/total employment.	ILO Laborsta database.
$CO2man$	CO_2 emissions (kt) from manufacturing industries, ISIC 15-37 except 23 "Manufacture of coke, refined petroleum products and nuclear fuel".	IAE database, Source OCDE.
BOD	Biochemical oxygen demand (kg/day).	World Development Indicators, World Bank.
$BODw$	Biochemical oxygen demand (kg/day/worker).	World Development Indicators, World Bank.
GDP	Gross domestic product	World Development Indicators, World Bank.
$MANUFsh$	Manufacturing value added as a share of GDP.	World Development Indicators, World Bank.

4.B Countries in the sample

Main analysis: Argentina, Austria, Belgium, Canada, Czech Republic, Germany, Egypt, Greece, Hungary, Italy, Japan, Republic of Korea, Morocco, Netherlands, Poland, Romania, Slovakia, Slovenia, Switzerland, Turkey, United Kingdom, Uruguay, Venezuela.

Robustness test: Albania, Argentina, Australia, Austria, Belgium, Bulgaria, Bolivia, Brazil, Canada, Switzerland, Chile, China, Costa Rica, Czech Republic, Germany, Denmark, Dominican Republic, Ecuador, Egypt, Spain, Estonia, Finland, Great Britain, Greece, Honduras, Indonesia, Ireland, Iceland, Italy, Japan, Kazakhstan, Korea, Sri Lanka, Lithuania, Latvia, Morocco, Moldova, Mexico, Macedonia, Malaysia, Nicaragua, Netherlands, Norway, New Zealand, Pakistan, Panama, Peru, Philippines, Poland, Portugal, Romania, Russia, Saudi Arabia, El Salvador, Slovakia, Slovenia, Sweden, Thailand, Trinidad and Tobago, Turkey, Ukraine, Uruguay, USA, Venezuela, Vietnam.

4.C Robustness tables

Table 4.5: Sensitivity analysis

	(10)	(11)	(12)	(13)	(14)	(15)
	$lnFDIman$	$lnFDImanMP$	$lnFDImanLP$	$lnFDIman$	$lnFDImanMP$	$lnFDImanLP$
TFP_growth	-0.022	-0.028	-0.031	-0.005	-0.032	-0.008
	(0.021)	(0.034)	(0.027)	(0.020)	(0.041)	(0.021)
$lnGDPcap$	-1.018	1.741	-2.208			
	(1.310)	(1.945)	(1.593)			
$lnMP$	0.869***	1.298***	0.920**	0.632*	1.548**	-0.017
	(0.315)	(0.487)	(0.390)	(0.331)	(0.651)	(0.350)
$lnKL_{t-1}$	1.691*	0.226	2.258*	0.810*	1.421*	1.295***
	(1.011)	(1.486)	(1.209)	(0.428)	(0.741)	(0.447)
$lnER$	-7.887***	-9.001***	-7.469***	-7.558***	-7.980***	-7.196***
	(1.326)	(2.017)	(1.588)	(1.371)	(2.340)	(1.514)
$lnREGULQUAL$	-3.627	1.241	-4.477	-5.448	7.674	-10.056***
	(4.151)	(5.653)	(4.660)	(3.785)	(6.867)	(3.826)
$FREE$	2.496***	1.223	4.992***	1.748**	-1.465	3.907***
	(0.944)	(1.293)	(1.175)	(0.857)	(1.606)	(1.009)
$lnCORRUP$	-3.660	2.034	-4.240	-3.484	7.068	-6.648**
	(3.044)	(4.589)	(3.552)	(2.744)	(4.780)	(2.914)
PTA	0.231	0.009	1.104	0.348	-2.834**	3.061***
	(0.644)	(1.005)	(0.828)	(0.747)	(1.445)	(0.853)
$COL45$	0.455	2.140	1.032	0.825	3.113*	1.365
	(1.115)	(1.800)	(1.416)	(0.997)	(1.881)	(1.029)
$lnFDIStock_{t-1}$	0.587**	0.456	0.621*	0.539**	0.986*	0.370
	(0.276)	(0.426)	(0.340)	(0.265)	(0.505)	(0.272)
	$lnER$	$lnER$	$lnER$	$lnER$	$lnER$	$lnER$
$lnFDIman$	-0.033			-0.035*		
	(0.025)			(0.019)		
$lnFDInonman$	0.003	0.023	0.007	0.001	-0.002	0.001
	(0.014)	(0.015)	(0.012)	(0.011)	(0.016)	(0.010)
$lnCORRUP$	-0.527***	-0.386**	-0.499***	-0.533***	-0.535***	-0.511***
	(0.157)	(0.162)	(0.144)	(0.160)	(0.169)	(0.151)
$lnGNIcap$	0.227***	0.229***	0.230***	0.206***	0.216***	0.219***
	(0.052)	(0.054)	(0.049)	(0.050)	(0.044)	(0.047)
$MANUFempl_{t-1}$	0.014***	0.014***	0.016***	0.010**	0.010***	0.013***
	(0.004)	(0.003)	(0.003)	(0.005)	(0.004)	(0.004)
$UNEMPL$	-0.002	-0.005	-0.003	-0.001	-0.005	-0.002
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.003)
$lnCO2man$	-0.127***	-0.105***	-0.156***	-0.107***	-0.160***	-0.121***
	(0.034)	(0.027)	(0.023)	(0.027)	(0.025)	(0.022)
$lnFDImanMP$		-0.043***	0.000		0.012	0.003
		(0.014)	(0.005)		(0.015)	(0.004)
$lnFDImanLP$		-0.001	-0.018		-0.005	-0.036***
		(0.006)	(0.014)		(0.006)	(0.013)
	$lnCO2man$	$lnCO2man$	$lnCO2man$	$lnCO2man$	$lnCO2man$	$lnCO2man$
$lnFDIman$	0.141***			-0.039		
	(0.034)			(0.025)		
$lnGDP$	0.473***	0.507***	0.509***	0.741***	0.663***	0.729***
	(0.053)	(0.048)	(0.047)	(0.041)	(0.043)	(0.041)
$MANUFsh$	0.056***	0.060***	0.056***	0.029***	0.034***	0.035***
	(0.011)	(0.011)	(0.011)	(0.008)	(0.008)	(0.008)
$lnER$	-0.927***	-0.940***	-1.118***	-1.901***	-1.746***	-1.960***
	(0.143)	(0.144)	(0.139)	(0.155)	(0.137)	(0.142)
$lnFDImanMP$		0.081***	0.021		0.040**	0.015*
		(0.025)	(0.014)		(0.017)	(0.008)
$lnFDImanLP$		0.016	0.084***		-0.014	-0.080***
		(0.017)	(0.027)		(0.011)	(0.020)

R-squared	0.29	0.20	0.31	0.42	0.35	0.41
N. of obs.	106	106	106	106	106	106

Standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01.
Models (13), (14) and (15) include regional and time fixed-effects. Constant terms not reported.

Table 4.6: Sensitivity analysis on a global sample

	(16)	(17)	(18)
	$lnFDIman$	$lnFDImanMP$	$lnFDImanLP$
TFP_growth	0.012	-0.003	0.0005
	(0.030)	(0.031)	(0.029)
$lnMP$	1.173***	0.946**	1.138***
	(0.403)	(0.410)	(0.391)
$lnKL_{t-1}$	1.328***	1.391***	1.284***
	(0.392)	(0.403)	(0.383)
$lnER$	-3.176*	-3.664**	-2.075
	(1.847)	(1.849)	(1.757)
$lnREGULQUAL$	-6.614*	-1.087	-6.100*
	(3.527)	(3.606)	(3.442)
$FREE$	1.939**	0.399	2.514***
	(0.797)	(0.815)	(0.778)
$lnCORRUP$	-2.927	-0.081	-1.536
	(2.457)	(2.505)	(2.72)
PTA	-0.420	-0.434	-0.383
	(0.591)	(0.606)	(0.579)
$COL45$	2.549*	1.364	3.497***
	(1.339)	(1.377)	(1.314)
$lnFDIStock_{t-1}$	2.089***	2.018***	2.304***
	(0.441)	(0.447)	(0.425)
	$lnER$	$lnER$	$lnER$
$lnFDIman$	0.136***		
	(0.022)		
$lnFDInonman$	-0.024*	-0.010	-0.010
	(0.013)	(0.011)	(0.009)
$lnCORRUP$	-0.260*	-0.526***	-0.357***
	(0.140)	(0.119)	(0.122)
$lnGNIcap$	0.078*	0.140***	0.071*
	(0.043)	(0.040)	(0.040)
$MANUFempl_{t-1}$	0.013***	0.019***	0.010***
	(0.003)	(0.003)	(0.003)
$UNEMPL$	-0.015***	-0.020***	-0.011***
	(0.004)	(0.004)	(0.003)
$lnCO2man$	-0.373***	-0.269***	-0.319***

	(0.033)	(0.030)	(0.025)
$lnFDImanMP$		0.065***	0.002
		(0.025)	(0.007)
$lnFDImanLP$		-0.0001	0.100***
		(0.008)	(0.018)
	$lnCO2man$	$lnCO2man$	$lnCO2man$
$lnFDIman$	0.106***		
	(0.028)		
$lnGDP$	0.506***	0.676***	0.493***
	(0.054)	(0.045)	(0.056)
$MANUFsh$	0.024***	0.028***	0.022***
	(0.005)	(0.006)	(0.005)
$lnER$	-1.365***	-1.227***	-1.426***
	(0.090)	(0.084)	(0.110)
$lnFDImanMP$		-0.006	0.014
		(0.033)	(0.013)
$lnFDImanLP$		0.013	0.102***
		(0.016)	(0.034)
R-squared	0.40	0.28	0.45
N. of obs.	275	275	275

Standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01.
Constant terms not reported.

General Conclusion

Environmental questions have become more and more crucial at both national and international levels. Internationalization of environmental issues started in the seventies when developed countries undertook the strengthening of their environmental policies, thus leading to interjurisdictional differences in regulatory stringency feared to affect the international location of firms. Environmental disasters such as the Bhopal catastrophe in 1984 intensified the internationalization of environmental problems. Finally, the liberalization of trade and foreign direct investment in the nineties gave rise to concerns about their environmental effects. With the emergence of different levels of development and an increasing mobility of firms, the trade and environment debate has taken a particularly heated form for the last two decades. Recently, this debate resumed when France considered the introduction of a carbon tax, and then decided to abandon it. At the European level, the allocation of free permits for highly polluting industries, e.g., cement and steel production, because they have been judged to be internationally exposed, also raised questions. Thus, the objective of this research was to contribute to the existing literature on trade and environment, by integrating new theoretical elements and conducting more exhaustive empirical tests. We further investigate the aspect related to the impact of FDI on pollution that has been often ignored.

When determinants of foreign investment are examined, discussions focus on

two key issues: firstly the determinants of the mobility of firms, and secondly the consequences of such a mobility on both source and host countries. The study of the pollution haven hypothesis does not depart from this rule, but differs somewhat from the traditional approaches of FDI with emphasis on a novel and crucial aspect: the environmental aspect. Therefore, in this dissertation, we explore both key issues, by examining if lax environmental regulations are a determinant of firms location decision (i.e. the strict pollution haven hypothesis), and then, investigating the consequences of these decisions in host countries in terms of pollution harming.

Do international differences in environmental regulations lead to the relocation of firms from regulated and developed countries to less regulated and poorer ones? As argued by Bhagwati (1993), there should be little cause for concern from an efficiency point of view if individual countries adopt different environmental policies, as long as these policies are set optimally. However, concern should raise if countries competing to attract firms set suboptimal standards. A number of earlier works addressed the normative question of what is an optimal environmental policy (e.g., Oates and Schwab, 1988; Levinson, 1997). However, a test of this question is hardly feasible since one would need to know the efficient level of regulation in countries. Keeping this in mind, we examine in Chapter 1 the environmental policies implemented in different groups of countries to compare their relative stringency. We show that as expected, developed countries are relatively stringent and developing and CIS countries relatively lenient. In addition, we emphasize the fact that transition and emerging countries have an intermediate position.

The first focus of this dissertation is the positive issue related to the environmental regulation impact on firms location decision and FDI. Actually, whether multinational firms respond to international variation in environmental regulations

has important implications in both a positive and a normative sense, for trade as well as environmental policies. Despite fairly intuitive and theoretical justifications, this question did not find a clear answer in the empirical literature. One reason is a misspecification bias in former theoretical attempts, most of them relying on Heckscher-Ohlin frameworks considering that exogenous environmental regulations are the only motive for trade. Therefore, in Chapter 2, we propose an exhaustive theoretical modelling of the pollution haven hypothesis. We use an economic geography model that is well-adapted to study the recent spatial distribution of firms, in which we further highlight the impact of environmental regulation and market failures on firms' location decision. This theoretical model presumes that the profitability of a firm in locating in a country increases with the market potential and the global factor productivity in that country, and decreases with production factor costs and market failures. Specifically, since pollution is considered as a production factor in the model, its negative effect on the profitability of a firm is emphasized.

We empirically examine the implications of the model in Chapter 3, using French firm-level data from manufacturing industries over the period 1996-2002. The test of a pollution haven hypothesis based on a theoretical specification was rare in literature. We further attempt to pay attention to the sources of bias in previous empirical works, i.e. omitted variables bias and unobserved heterogeneity. Empirical results show evidence that environmental regulation plays a significant role in determining the international spatial allocation of French firms. This result improves earlier findings in the sense that it enhances the former small, even insignificant effect found in studies on plant location choice within a single country (Bartik, 1989; Levinson, 1996). Moreover, it is in line with more recent studies that control for unobserved attributes of industries or countries (Keller and Levinson, 2002; Levinson and Tay-

lor, 2008). In addition, the estimated effect is found to be non-linear, and does not depend on the type of FDI mode of entry. One explanation for the non-linear relationship is that too bad environmental conditions affect firms competitiveness.

We investigate the second key issue related to the study of the determinants of firms location in Chapter 4. We analyze the impact of location decisions driven by pollution haven-seeking on the pollution levels in host countries. Indeed, although this issue is crucial, it has been rarely examined in literature. Some works study the determinants of pollution levels (Cole et al., 2005), but only a very few explore the role played by FDI (one exception is He, 2006). However, FDI should alter pollution emissions through manifold mechanisms (e.g., pollution havens seeking or technological spillovers), and the overall outcome is worth being empirically analyzed on account of the fears related to the pollution haven hypothesis on one hand and the well-documented FDI beneficial effects on the other hand. Using French manufacturing FDI data and manufacturing CO_2 emissions in major recipient countries, we estimate in Chapter 4 a system of three equations to capture FDI effects on pollution levels, beside considering environmental regulation endogenously determined. The endogeneity of the environmental regulation has been suggested recently as a major shortcoming that prevented previous works from detecting a strong pollution haven effect (Cole et al, 2006; Levinson and Taylor, 2008). Results confirm the findings of Chapter 3 regarding the deterrent environmental regulation effect on firms location, and mention that the environmental regulation weakens with growing FDI. Moreover, our results suggest that pollution emissions rise with the increases of FDI, whereas pollution intensity decreases. The increase of pollution emissions suggests that FDI is less virtuous than expected and that multinational firms use less cleaner techniques abroad than at home. However, this finding is consistent

with large anecdotal evidence. For illustration, in 2009, an investigation by the government in Liberia has concluded that the Firestone Rubber Plantation Company has polluted local water sources. The Firestone Tire and Rubber Company has been accused of contaminating the water in the town where it runs a rubber plantation, and it has been blamed for causing harms ranging from skin diseases to birth defects. An important precision is that all rubber produced in Liberia is sent to the United States for processing into tires and no processing or manufacturing is done in Liberia, which strongly alludes to the pollution haven hypothesis... Turning to our results, the pollution intensity decrease may nevertheless refer to somewhat technological spillovers of FDI.

Finally, in Chapter 4 as well as in Chapter 3, we confirm the robustness of our results through several tests.

We wish the present work has at least partially contributed to the trade and environment debate, by tackling major issues and trying to improve some of the shortcomings in the related literature. Nevertheless, this work obviously should be improved in many ways. An interesting new aspect to incorporate in pollution haven hypothesis investigation is the firms heterogeneity which has been recently stressed by the modern theory of multinational firms. Indeed, examining which firms are more likely to seek for pollution havens would have large implications, especially regarding FDI environmental impacts. Further apparent extensions of our results would rely on qualitative firm-level or environmental data internationally available. For example, this would improve empirical results of Chapter 3 by enabling to go further into the investigation of the role of the FDI mode of entry. In Chapter 4 also the distinction of FDI environmental impact with regard to the mode of entry is worth being considered. Moreover, we will be soon able to rely on data from the

recent European Union Emission Trading Scheme which imposes a homogeneous regulation to the European countries. It would be an interesting topic of future work to examine the behavior of firms in function of the permit allocation method. Conducting a similar work to the present one would constitute an appropriate assessment of the efficiency of the EU ETS. Finally, investigating the impact of FDI on global pollution and incorporating the transport cost in the analysis would be a fruitful area for further research.

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