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THREE ESSAYS ON THE IMPACT OF THE LOG EXPORT BAN POLICY IN DEVELOPING COUNTRIES

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Summary

The log export ban (LEB) reform is a policy which prohibits the export of unprocessed timber. This reform was adopted to promote industrialisation, exports and employment in the processed wood sector, as well as to combat deforestation and protect endangered species. The reform has gained significant support over the two last decades in several developing countries. However, the removal of the reform by some countries has questioned its effectiveness. As with any policy, it is difficult to achieve several objectives through the adoption of a single policy according to Tinbergen's rule.

The aim of this thesis is to assess the impact of this reform on some of the objectives commonly advanced at the time of its implementation: (1) the impact on the industrialisation of the timber sector; (2) the impact on employment in timber processing companies; (3) the impact on deforestation.

Chapter 1 looks at the impact of the reform on the production and export of sawnwood and veneer in 86 developing countries between 1990 and 2019. The results show that countries that have adopted the reform have experienced an increase in processed wood production compared with non-adopters. This effect is very significant in the case of sawnwood, but more mitigated for veneer. On the export side, the increase is greater for sawnwood, while the policy has no effect on veneer exports.

Chapter 2 analyses the causal effect of the reform on employment in the wood-processing industry using a sample of 1,739 firms located in 74 developing countries over the period 2006-2018. The results suggest that firms located in countries having adopted the reform recorded an increase in employment in the processed wood sector of around 25% compared to firms in non-adopting countries. This effect is heterogeneous according to job type. The reform has a

positive impact on production jobs, permanent employment, and unskilled jobs. On the other hand, there is no effect on non-production jobs, temporary jobs and skilled jobs.

Chapter 3 estimates the impact of the reform on deforestation in 100 developing countries from 2000 to 2019. Estimates show that countries having implemented the reform have experienced an increase in deforestation. This effect of the reform is persistent over time. Another important conclusion of this chapter is that agricultural occupation and the wood-processing industry are major channels through which the reform affects deforestation.

Keywords: Log export ban; Forestry sector; Industrialization; International trade; Processed wood; Employment; Deforestation; Impact analysis; Developing countries.

JEL classifications : C21 ; E24 ; F13 ; F18 ; L73 ; O13 ; O14 ; O57 ; Q23.

Resumé

La réforme de l'interdiction d'exportation de grume est une politique visant à prohiber l'exportation de bois non-transformé. Cette réforme est adoptée pour promouvoir l'industrialisation, l'exportation et l'emploi dans le secteur du bois transformé ainsi que la lutte contre la déforestation et la protection des espèces en danger. L'adoption de cette réforme a connu une croissance importante durant les deux dernières décennies dans plusieurs pays en développement. Toutefois, la suppression de la réforme par certains pays questionne son efficacité. Comme toute politique, il est difficile d'atteindre plusieurs objectifs à travers l'adoption d'une seule politique selon la règle de Tinbergen.

L'objectif de cette thèse est d'évaluer l'impact de cette réforme sur une partie des objectifs souvent avancés lors de sa mise en uvre : (1) l'impact sur l'industrialisation du secteur bois ; (2) l'impact sur l'emploi dans les entreprises de transformation du bois ; (3) l'impact sur la déforestation.

Le chapitre 1 concerne l'impact de la réforme sur la production et l'exportation de bois de sciage et de placage dans 86 pays en développement entre 1990 et 2019. Les résultats montrent que les pays qui ont adopté la réforme ont enregistré une hausse de la production de bois transformé par rapport aux non-adoptants. Cet effet est très important dans le cas du bois de sciage, mais plus mitigé pour le bois de placage. Du côté des exportations, l'augmentation est plus importante pour le bois de sciage et la politique est sans effet sur les exportations de bois de placage.

Le chapitre 2 analyse l'effet causal de l'adoption de la réforme sur l'emploi dans l'industrie de transformation du bois en utilisant un échantillon de 1 739 entreprises localisées dans 74 pays en développement enquêtées sur la période 2006-2018. Les résultats suggèrent que les firmes localisées dans les pays ayant adopté la réforme enregistrent une hausse de l'emploi dans le secteur du bois transformé d'environ 25% par rapport aux entreprises dans les pays non-adoptant. Cet effet est hétérogène selon les types d'emploi. La réforme agit positivement sur les emplois de production, sur l'emploi permanent et sur l'emploi non-qualifié. En revanche, il n'y a aucun effet pour les emplois de non-production, les emplois temporaires et les emplois qualifiés.

Le chapitre 3 estime l'impact de l'adoption de l'interdiction d'exportation de grume sur la déforestation en se focalisant sur 100 pays en développement de 2000 à 2019. Les estimations montrent que les pays ayant appliqué la réforme connaissent une hausse de la déforestation. Cet effet de la réforme est persistant dans le temps. Une autre conclusion importante de ce chapitre est que l'occupation agricole et l'industrie de transformation du bois sont des canaux majeurs par lesquels la réforme affecte la déforestation.

Mots clés : Interdiction d'exportation de grume ; Secteur forestier ; Industrialisation ; Commerce international ; Bois transformé ; Emploi ; Déforestation ; Analyse d'impact ; Pays en développement.

Classification JEL : C21 ; E24 ; F13 ; F18 ; L73 ; O13 ; O14 ; O57 ; Q23.

Contents

List of Figures

List of Tables

Chapter 1

Introduction générale

1.1 Contexte et justification

Nos modes de vie actuels sont soumis à de nombreux défis liés à la mondialisation des systèmes économiques, au changement climatique, à la préservation de la biodiversité, et à la lutte contre la pauvreté et les inégalités. Ces défis sont néanmoins bien plus prégnants dans la plupart des pays en développement où les populations semblent plus vulnérables aux crises provoquées par ces défis.

Les défis liés au reflux de la mondialisation

La crise financière mondiale de 2008/2009 a coïncidé avec le début d'un ralentissement du processus de mondialisation (Antràs, 2020). Ce processus met en évidence une tendance au reflux des mouvements économiques internationaux appelé par certains économistes "slowbalization".[1] La localisation et le mode de gouvernance sont des aspects importants de la mondialisation. Les entreprises doivent non seulement décider où localiser leurs activités, mais aussi si elles préfèrent en garder le contrôle ou les déléguer à des parties externes. Des évènements récents comme la pandémie de COVID 19 et la guerre en Ukraine ont aggravé les risques géopolitiques qui pèsent sur la fiabilité des chaînes de valeurs mondiales (Della Posta, 2023). Aussi, les tensions entre les États-Unis et la Chine se sont accrues et de nombreux pays occidentaux se sont retrouvés vulnérables parce qu'ils dépendent de pays étrangers, comme la Chine, pour certains facteurs critiques, produits intermédiaires ou biens finaux. Tous ces évènements ont contribué à fragiliser les CVM et conduisent à la questionner. Avec la crise du COVID-19, un nouveau débat est apparu examinant si la mondialisation excessive de la production n'a pas créé de nouvelles vulnérabilités économiques (Miroudot, 2020). Cette crise a beaucoup fragilisé les CVM par un arrêt ou une perturbation de production de plusieurs entreprises. Elle a conduit à des restrictions sur le commerce international empêchant un approvisionnement fluide auprès des fournisseurs d'intrants dans d'autres zones potentiellement touchées par la crise. Ainsi, la localisation des entreprises devient un élément crucial dans ce contexte de chaîne de valeur mondiale fragilisé, avec de nouvelles stratégies d'entreprises. Ces stratégies commerciales, ap-

[1] Consulté le 05/09/2023: https://braddelong.substack.com/p/reading-paul-krugman-notes-on-globalization).

pelées *outsourcing*, *off-shoring*, *insourcing*, *reshoring* ou *back-shoring*, affectent la structure organisationnelle de l'entreprise (Kandil et al., 2020). Pour répondre à cette vulnérabilité, le *back-shoring* consistant à relocaliser les entreprises dans le pays d'origine est privilégié. Kinkel (2014) fait la distinction entre le *back-shoring* captif, qui est le retour des activités des usines étrangères détenues par l'entreprise, et le *back-shoring* externalisé, qui est le retour des activités des fournisseurs étrangers vers l'entreprise.

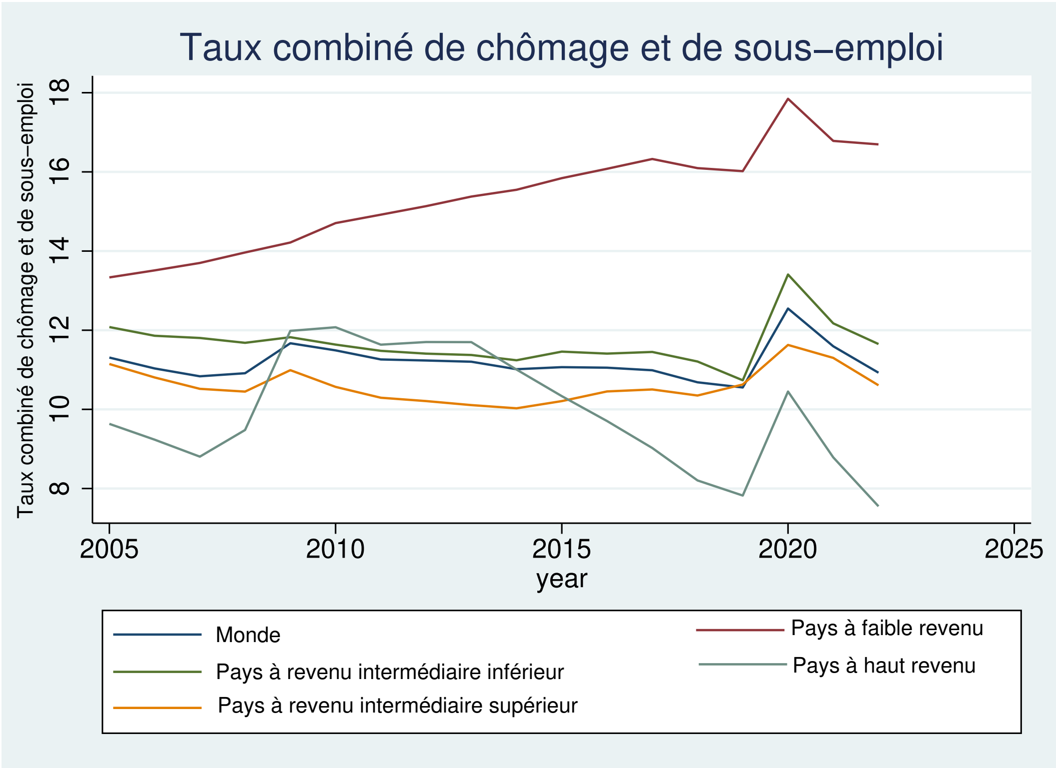
Pour les pays en développement, la participation aux CVM exerce des pressions en faveur dune progression le long de la chaîne favorisant ainsi des activités à plus forte valeur ajoutée.[2] L'intégration de la CVM et la progression sur la chaîne requiert des produits à valeur ajoutée élevée. Pour les pays exportateurs de matières premières brutes, nous assistons à une promotion de la transformation locale de ces matières. Dans le cas particulier des pays en développement riche en forêt tropicale, la promotion de la transformation domestique du bois peut contribuer à renforcer la participation aux CVM avec potentiellement un effet d'entraînement sur d'autres secteurs de l'économie. Cette promotion nécessite une baisse considérable des exportations de bois afin de garantir la transformation en aval. Généralement, de nombreux pays riches en ressources forestières appliquent des barrières comme l'interdiction d'exportation de grume afin de promouvoir la transformation locale des bois, souhaitant ainsi promouvoir davantage les entreprises domestiques et la consommation locale.

Les défis liés à l'emploi

Le chômage et le sous-emploi sont des défis courants dans les pays en développement. Les prévisions du rapport 2023 de l'OIT fait état d'un taux de chômage de 6,3% en Afrique subsaharienne et de 11,2% en Afrique du Nord qui ont enregistré une hausse considérable depuis la pandémie de covid 19. Sur le continent africain, la grande majorité de la population qui est jeune vit avec moins de 3 dollars par jour. Cette tranche de la population est contrainte à s'adonner à des activités sous-payées dans des conditions de travail précaires.[3] Toutefois, les mesures traditionnelles du chômage sont très critiquées car elles ne semblent pas être une indication juste de la tension du marché du travail dans les pays en développement (Phélinas,

[2]Consulté le 26/10/2023: https://www.oecd.org/fr/echanges/sujets/chaines-de-valeur-mondiales
[3]Consulté le 20/09/2023: https://ideas4development.org/chomage-sous-emploi-combattre-idees-recues/

Figure 1.1: Taux combiné du chômage et du sous-emploi



Source: Calcul de l'auteur

2014). Afin de pallier ces limites, des indicateurs combinés utilisant à la fois le chômage et le sous-emploi afin de refléter la situation réelle sur le marché du travail ont été créés par l'OIT.[4] En effet, le sous-emploi est aussi qualifié par certains auteurs de "chômage déguisé". La figure 1.1 montre la tendance globale par niveau de revenu de ces deux indicateurs combinés. Le constat est alarmant dans les pays à faible revenu où la tendance globale de ce taux est ascendante et au-dessus des autres niveaux de revenu. Aussi, l'écart tend à s'agrandir avec le temps.

Parmi les multiples initiatives pour lutter contre le chômage et le sous-emploi, selon l'OIT, le développement de CVM peut être un important canal de création d'emploi, en particulier dans les pays en développement. Pour Hollweg (2019), l'émergence des CVM a offert aux pays en développement de nouvelles possibilités de s'intégrer dans l'économie mondiale avec des perspectives d'emploi. En effet, les CVM sont d'importants vecteurs de création d'emplois, employant environ 17 millions de personnes dans le monde et représentant 60% du commerce

[4]Consulté le 20/09/2023: https://ilostat.ilo.org/fr/data/

mondial.[5] Plusieurs exemples dans le monde suggèrent que les CVM produisent une transformation structurelle du marché de l'emploi en créant plus d'emplois, en proposant des salaires plus élevés et de meilleures conditions de travail. Au Bangladesh, par exemple, l'émergence du secteur de l'habillement d'exportation orienté vers les CVM a contribué à l'emploi de plus de trois millions de personnes au cours des deux dernières décennies (Farole, 2016). Toutefois, la crise de subprime a conduit l'industrie du vêtement à supprimer plus de 11 millions d'emplois dans les 18 mois qui ont suivi la crise mondiale, les pays les plus affectés étant la Chine, l'Inde et le Pakistan.[6] Ainsi, le reflux de la mondialisation cité dans la première partie de notre travail montre clairement l'intérêt pour les gouvernements de mettre en place des politiques visant à consolider les CVM pour réduire le chômage en faisant la promotion locale des entreprises à plus grande valeurs ajoutée. Dans le cas des pays riche en ressource forestière, il s'agit d'encourager la transformation locale du bois. Ainsi, ces pays mettent en place l'interdiction d'exportation de grume pour attirer des industries de transformation étrangères afin de participer à la résilience des chaînes de valeurs et promouvoir la création d'emploi.

Les défis liés au changement climatique et à la protection de la biodiversité

Le changement climatique mondial touche toutes les régions du monde. Les dernières décennies ont été marquées par la récurrence des catastrophes naturelles et des évènements extrêmes. Ce réchauffement global de la planète a des conséquences sur les écosystèmes naturels, la santé humaine et les activités économiques (GIEC report, 2023).[7] L'une des causes majeures de ce changement climatique est l'action humaine par la combustion des produits fossiles, mais aussi par la déforestation qui contribue jusqu'à 20% des émissions globales de gaz à effet de serre.[8] Face à cette situation, plusieurs initiatives sont développées par les pays, dans des cadres nationaux, régionaux et internationaux, soit pour en atténuer les effets, soit pour tenter de s'y adapter. Il s'agit entre autres des COP sur le climat (produisant des accords multilatéraux à

[5] Consulté le 10/09/2023: https://blogs.worldbank.org/jobs/global-value-chains-way-create-more-better-and-inclusive-jobs

[6] Consulté le 01/10/2023: https://www.wto.org/french/res$_f$/$books p_f$/$wtr14-2c_f.pdf$

[7] Consulté le 01/10/2023: https://climat.be/changements-climatiques/changements-observes/rapports-du-giec/2023-rapport-de-synthese

[8] Consulté le 01/10/2023: https://www.lse.ac.uk/granthaminstitute/explainers/whats-redd-and-will-it-help-tackle-climate-change/

l'image de l'accord de Paris en 2015) et la biodiversité, l'initiative REDD+, etc. Ces actions visent à promouvoir la transition écologique de nos modes de vie en encourageant, entre autres, la décarbonation des activités économiques et la protection de la biodiversité, (ex. bonne la gestion des forêts tropicales pour permettre à la fois la protection des espèces et la séquestration du carbone). Cependant, les pays en développement, dont les contraintes budgétaires sont fortes, sont moins axés sur les questions liées au changement climatique et particulièrement la transition énergétique. La transition énergétique vers des énergies renouvelables et décarbonées est marquée par un retard alarmant des pays en développement.[9] La croissance des investissements internationaux dans les énergies renouvelables a presque triplé depuis l'accord de Paris en 2015 mais est essentiellement concentrée sur les pays développés. Ces investissements ont aussi connu un recul d'environ 70 milliards de dollars en 2022 comparé à 2021 alors que les besoins devraient se chiffrer à 1700 milliards de dollars en 2030. A l'aune de ces défis liés à ces financements pour une meilleure transition bas carbone, les pays en développement riches en ressources forestières peuvent être en première ligne pour participer à la conservation de cette ressource afin de promouvoir la séquestration du carbone et protéger la biodiversité. En effet, les forêts tropicales absorbent environ 25% des émissions de CO_2.[10] Parmi celles-ci, les forêts des six pays du bassin du Congo captent environ 610 millions de tonnes nettes de CO_2 par an soit davantage que l'Amazonie qui est à environ 110 millions de tonnes par an à cause d'une déforestation plus forte.[11] Cela met clairement en évidence le niveau réel de participation des pays en développement riches en ressources forestières dans la lutte contre le changement climatique. Ainsi, plusieurs initiatives sont entreprises afin de renforcer la préservation des forêts tropicales dans le monde. Le dernier sommet en date est celui du *One Forest Summit* au Gabon décidé à la COP27 pour remobiliser l'attention politique autour de la sauvegarde de ces forêts, menacées par la déforestation et la surexploitation. La particularité de ce sommet a été de combiner la protection du climat et de la biodiversité qui sont intimement liés. Les objectifs fixés pour la biodiversité sont de protéger 30% des aires marines et terrestres mon-

[9]Consulté le 10/09/2023: https://www.lesechos.fr/monde/enjeux-internationaux/transition-energetique-le-retard-alarmant-des-pays-en-developpement-1959186

[10]Consulté le 10/09/2023:https://www.rtbf.be/article/premier-sommet-mondial-des-forets-tropicales-des-credits-carbone-pour-les-pays-protecteurs-de-la-biodiversite-11160807

[11]Consulté le 01/10/2023: https://www.lefigaro.fr/international/ouverture-du-sommet-one-forest-au-gabon-pour-proteger-les-forets-tropicales-20230301

diales d'ici 2030 afin d'éviter l'extinction d'un grand nombre d'espèces animales et végétales. Toutefois, étant donné la contrainte budgétaire évoquée plus haut, la conservation des forêts tropicales nécessite des moyens financiers colossaux car le coût d'opportunité de la conservation est élevé. En 2009, lors de la COP15 sur le climat, les pays industrialisés se sont engagés dans le cadre de l'accord de Copenhague à affecter 30 milliards de dollars à un fonds vert pour le climat entre 2010 et 2019 avec un objectif de plus de 100 milliards de dollars par an d'ici 2020. Ces objectifs sont restés au stade de promesse. Les 100 milliards n'ont jamais été atteint. Le bilan sera examiné lors de la COP 28 afin de fixer l'objectif à partir de 2024.[12] Par ailleurs, cette conservation des forêts est particulièrement difficile pour les pays en développement qui sont sujets à une exploitation illégale importante. Ainsi, les pays en développement riches en ressources forestières sont incités à élaborer des stratégies de lutte contre l'exploitation abusive de la forêt et de protection des espèces en voie de disparition. L'interdiction d'exportation de grumes peut s'inscrire dans cette stratégie.

En résumé, la politique de l'interdiction d'exportation de grume semble être un outil permettant de relever ces trois grands défis interdépendants du 21ème siècle pour les pays en développement : (1) promouvoir un développement plus ancré sur le local afin de réduire les chocs de la mondialisation, (2) promouvoir l'emploi et des bonnes conditions de travail et (3) contribuer à la lutte contre le réchauffement climatique et la préservation de la biodiversité. Ainsi, l'objectif de cette thèse est d'évaluer l'efficacité de la politique d'interdiction d'exportation de grume dans l'atteinte des objectifs économiques et environnementaux des pays en développement riches en ressources forestières. Il s'agira pour nous d'étudier l'impact de l'interdiction d'exportation de grumes sur les principaux objectifs fixés par les pays l'ayant adoptée.

[12]Consulté le 13/09/2023: https://unfccc.int/fr/processus-et-reunions/les-conferences/sharm-el-sheikh-climate-change-conference-november-2022/five-key-takeaways-from-cop27/mobiliser-davantage-de-soutien-financier-pour-les-pays-en-developpement

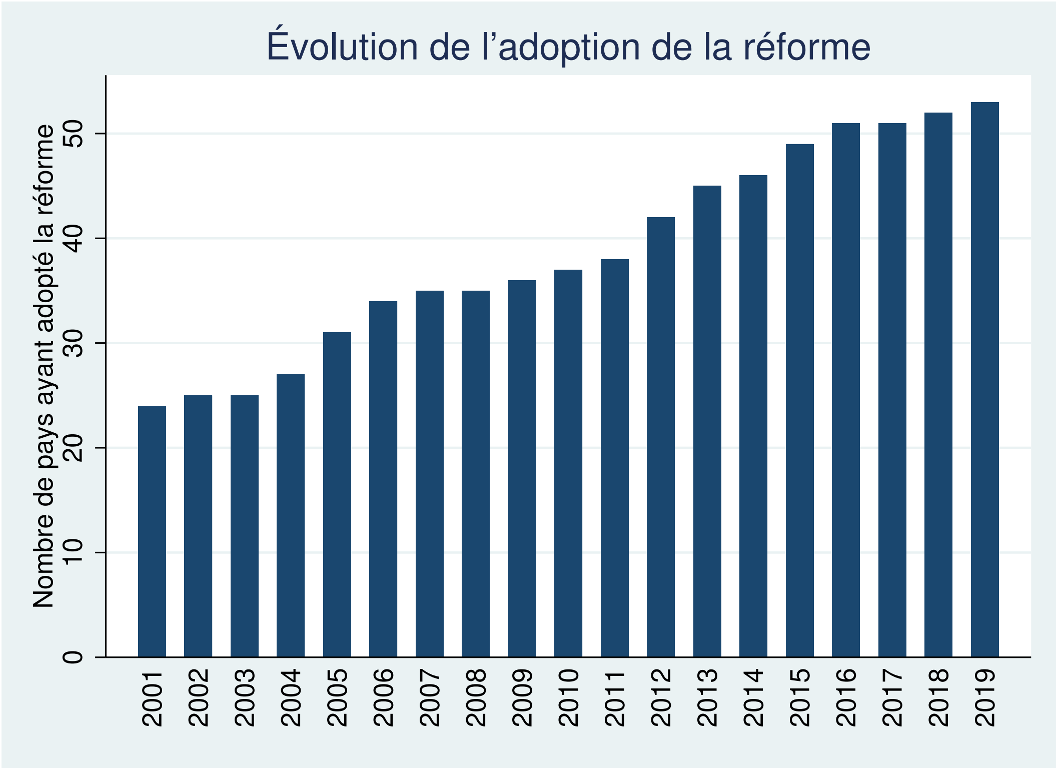
1.2 L'interdiction d'exportation de grume dans les PED : un aperçu.

La réforme d'interdiction d'exportation de grume est une politique industrielle, commerciale et forestière qui consiste à prohiber l'exportation de grumes non-transformés. Les politiques d'interdiction d'exportation de grumes visant à préserver la couverture forestière et à favoriser le développement économique local ont été mises en oeuvre par des pays/régions riches en forêt dès le début du 20ème siècle (Resosudarmo and Yusuf, 2006). La Colombie-Britannique (Canada) et de l'Alaska (États-Unis) en ont été les précurseurs. Aujourd'hui, cette mesure est mise en oeuvre dans la plupart des pays riches en ressources forestières. Une cinquantaine de pays en développement l'ont adopté (Figures 1.2 et A2). Les raisons spécifiques d'application de cette politique sont multiples : le contrôle de la déforestation, la protection des espèces à grande valeur, la protection des espèces en danger, la promotion de la transformation locale de bois et la création d'emplois (Kishor et al., 2004).

Toutefois, au cours de la dernière décennie, certains pays, notamment la Guinée Équatoriale, la Guinée Bissau et la Biélorussie sont revenus en arrière en abandonnant cette mesure. Dans la même temps, d'autres pays l'ont adopté pour la première fois à l'image de Belize, Albanie, Angola, Gambie, Laos, Libéria, Myanmar, Namibie et Soudan du Sud.[13] Les pays de la CEMAC sont actuellement en pleine réflexion concernant l'adoption de cette politique au niveau communautaire afin d'harmoniser cette interdiction d'exportation de grume initiée par le Gabon. Cette politique d'interdiction d'exportation de grumes s'accompagne souvent d'autres politiques, notamment l'interdiction d'exploitation forestière et l'interdiction d'exportation de bois de sciage qui est le niveau de transformation basique du bois.

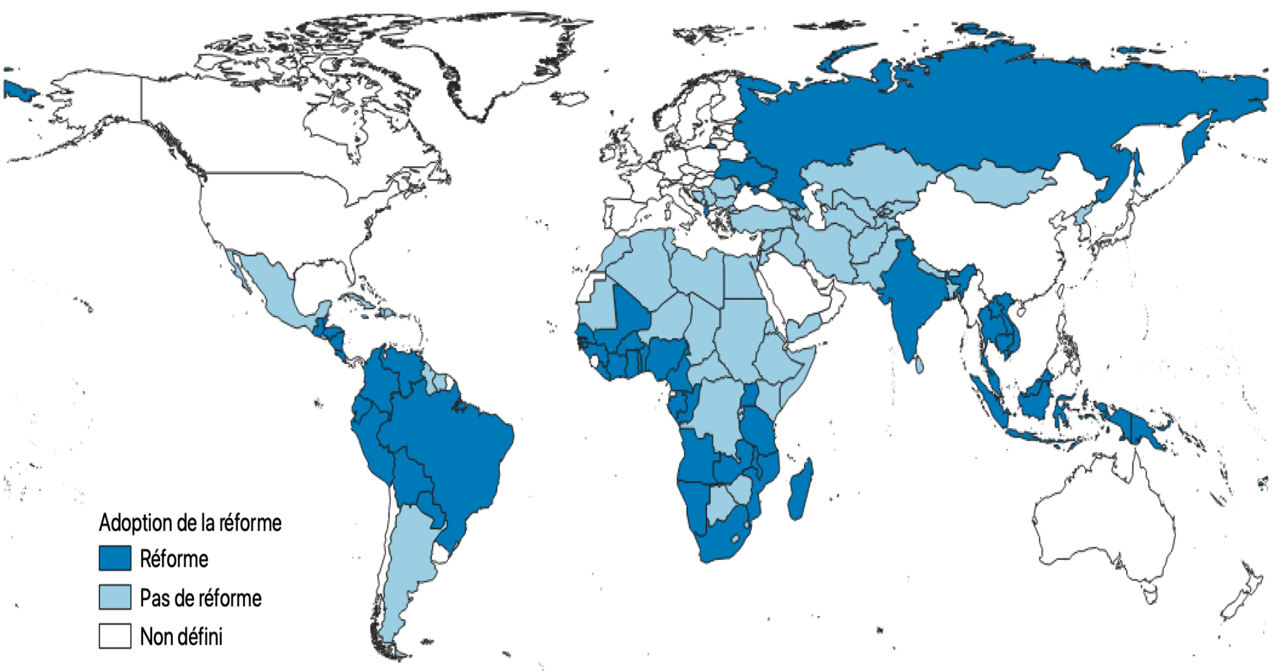
[13]Consulté le 01/09/2023: https://www.forest-trends.org/known-forest-product-export-restrictions/

Figure 1.2: Évolution du nombre de pays ayant adopté l'interdiction d'exportation de grumes



Source: Calcul de l'auteur

Figure 1.3: Échantillon de pays utilisé dans cette étude



Source: Calcul de l'auteur

1.3 Débat sur l'efficacité de la réforme

1.3.1 L'effet de la réforme sur l'industrialisation de la filière

L'une des raisons en faveur de l'adoption de la mesure d'interdiction d'exportation de grumes est la promotion et le développement du secteur de transformation du bois (bois de sciage, placage et contreplaqué). Il existe deux tendances dans la littérature concernant cet effet. Une littérature met en exergue un effet positif de la réforme sur l'industrie du bois (von Amsberg, 1998; Dudley, 2004; Resosudarmo and Yusuf, 2006). Grâce à la réforme, l'industrie de transformation nationale de bois n'est plus en concurrence avec les industries étrangères pour l'approvisionnement en bois, qui est généralement bon marché dans le cas des pays en développement riches en ressources forestières. Les industries de transformation peuvent donc produire en grande quantité grâce au faible coût de la matière première. Cette expansion stimule l'apparition de nouveaux investissements dans l'industrie de transformation du bois. L'arrivée de nouveaux capitaux permet d'augmenter le ratio capital-travail, facilite le transfert de technologie et en retour, accroît la productivité du travail. Cette plus grande efficacité de l'industrie de transformation du bois doit lui permettre d'être plus compétitive sur le marché mondial en exportant du bois transformé de plus grande valeur-ajoutée. L'effet escompté de la réforme est donc positif sur la production et l'exportation des produits en bois transformés. Certaines études empiriques soutiennent cet argument. Pour Amoah et al. (2009), la réforme d'interdiction d'exportation a augmenté la production de produits du bois transformés au Ghana. En Indonésie, Resosudarmo and Yusuf (2006) montrent, avec un modèle d'équilibre général calculable, que la réforme peut avoir des avantages sur la production de bois transformé à long terme.

À l'opposé, la promotion des industries de transformation du bois en aval pourrait ne pas suffire à créer des incitations pour améliorer la production et l'exportation de bois transformé, et le gain net de bien-être pour l'industrie du bois pourrait être négatif. Cet impact négatif de la réforme sur la transformation du bois est lié aux prix des grumes. En effet, l'un des principaux écueils de la mise en oeuvre de la réforme est la réduction significative des prix des grumes. Par exemple, à la suite de l'interdiction des exportations de grumes au Costa Rica, les prix intérieurs des grumes sont tombés à 20-60% des niveaux de prix internationaux, selon Kishor and Constantino (1993). Cette chute pourrait conduire à des techniques d'exploitation et de transformation inefficaces et peu rentables selon Barbier and Rauscher (1994) et donc à une réduction de la production de bois transformé. Plusieurs études empiriques soutiennent cet argument. En Indonésie, par exemple, Resosudarmo and Yusuf (2006) ont constaté que la production de bois de sciage est moins importante cinq ans après la mise en oeuvre de la réforme que ce qu'elle aurait été sans cette réforme. Par conséquent, la capacité de production des industries de transformation du bois en aval pourrait diminuer après un certain temps en raison des inefficacités liées à la réduction des prix des grumes.

1.3.2 L'effet de la réforme sur l'emploi du secteur bois

L'emploi dans l'industrie forestière comprend l'exploitation forestière et la transformation du bois. L'effet de la réforme peut affecter différemment les activités d'exploitation forestière et de transformation du bois. Du côté de l'exploitation forestière, il s'agit de l'activité en amont de la chaîne de production de l'industrie forestière. Avant l'adoption de cette politique, la plupart des pays en développement riches en forêt sont exportateurs de grumes, représentant une part considérable des exportations en volume. L'activité d'exploitation forestière est florissante et répond à la demande internationale de bois. Après l'adoption de la réforme, deux tendances se dessinent en ce qui concerne l'activité d'exploitation forestière. D'une part, l'adoption de la réforme dans les pays disposant d'un avantage comparatif dans la production de grumes réduit l'exploitation forestière et donc l'emploi dans ces pays (Dudley, 2004). En effet, la réforme entraîne une diminution de la demande internationale adressée au marché national du bois, ce qui provoque une baisse du prix intérieur des grumes, rendant l'exploitation forestière moins rentable. Toutefois, la réforme pourrait aussi augmenter l'emploi dans l'exploitation forestière. La baisse des prix des grumes permet à l'industrie nationale de transformation du bois de s'approvisionner en grumes à moindre coût.

L'emploi dans l'industrie de transformation du bois, avant l'adoption de la politique, est faible dans la plupart des pays en développement en raison de la faible industrialisation du secteur, dominé par de petites unités de production. L'adoption de la réforme pourrait alors accroître l'emploi car elle exige une transformation du bois avant exportation. La baisse du prix des grumes permet aux transformateurs de bois nationaux de s'approvisionner en grumes à moindre coût. L'augmentation de l'offre de grumes accroît la demande intérieure de main-d'oeuvre et crée davantage d'emplois dans l'industrie de transformation du bois. Pour Resosudarmo and Yusuf (2006), la réforme permet de créer des emplois, généralement dans les petites industries à forte intensité de main-d'oeuvre. De plus, la réforme est aussi adoptée afin d'attirer les investissements directs étrangers (IDE) dans l'industrie de transformation du bois, avec un double effet sur l'emploi. D'une part, la demande intérieure de grumes adressée aux exploitants augmente avec l'introduction de nouveaux acteurs, ce qui augmente l'emploi en aval de la filière. D'autre part, les IDE permettent d'introduire de nouvelles entreprises dans les pays d'accueil qui ont recours à de la main d'oeuvre nationale. Enfin, il est aussi nécessaire de regarder le type d'emploi généré. Par exemple, d'après l'analyse de Marchand and Zerbo (2023), chapitre 2 de cette thèse, seul le niveau de transformation facile du bois augmente de manière significative après l'adoption de la politique. Ce niveau de transformation nécessite peu de compétences, pourvoyeur alors d'emplois peu qualifiés mais abondants. Ainsi, la réforme peut avoir des effets différents selon les types d'emploi.

1.3.3 L'effet de la réforme sur la déforestation

L'effet de la réforme sur la déforestation fait l'objet d'un débat controversé. Certaines études soulignent l'effet bénéfique de l'adoption de la réforme sur la déforestation. La baisse du prix des grumes réduit les profits et les incitations à l'exploitation forestière et, par conséquent, la déforestation. De même, un prix plus bas des grumes devrait réduire l'abattage illégal en éliminant les incitations à prendre des risques élevés pour un faible profit (Resosudarmo and Yusuf, 2006). Par exemple, Tumaneng-Diete et al. (2005) ont constaté que la réforme a amélioré la conservation des forêts aux Philippines.

En outre, la réforme peut accroître la déforestation pour plusieurs raisons. Tout d'abord, la réforme, en réduisant le prix des bois en grumes, pousse à la baisse les bénéfices de l'exploitation forestière et certains exploitants forestiers peuvent se tourner vers d'autres activités gourmandes en terres forestières comme l'agriculture. En effet, la réforme peut accroître la déforestation par le biais de l'agriculture qui est une activité proche de l'exploitation forestière nécessitant des compétences similaires. Ensuite, les exploitants forestiers restants pourraient être incités individuellement à atteindre le niveau de profit antérieur avant que le prix des grumes ne chute, en intensifiant l'extraction des grumes. La pression exercée sur la forêt pourrait donc atteindre voire dépasser le niveau antérieur d'activités d'exploitation forestière avant l'adoption de la réforme. Enfin, du côté de l'industrie de transformation du bois, l'attraction des IDE peut aussi entraîner un accroissement de la pression sur la ressource forestière.

1.4 Résultats et contribution de la thèse

L'objectif de cette thèse est d'évaluer l'impact de l'adoption de la réforme de l'interdiction d'exportation de grume sur l'industrialisation de la filière bois, sur l'emploi dans la filière bois et sur la déforestation au regard du contexte décrit dans la Section 1.1 et l'état de la réforme exposé dans la Section 1.2. Ainsi, dans la suite de cette partie nous présenterons respectivement les résultats des trois chapitres de cette thèse.

1.4.1 La réforme et l'industrie de la transformation du bois

Dans le chapitre 2, nous évaluons l'impact de l'adoption de la réforme d'interdiction de l'exportation de grume sur la dynamique de croissance de l'industrie de transformation du bois et les opportunités de commerce en utilisant des données issues de l'Organisation Internationale pour les Bois Tropicaux (ITTO).[14] Nous estimons l'impact de la réforme au niveau macroéconomique en utilisant des données de panel pour 86 pays en développement entre 1990 et 2019. Nous analysons l'impact de la réforme en nous concentrant sur le volume de la production de bois transformé plutôt que sur le prix. De plus, notre étude se concentre également sur l'effet de la réforme sur la dynamique d'exportation de bois transformé comme Amoah et al. (2009). Notre analyse porte sur le bois de sciage et le placage, deux types de bois transformé qui diffèrent en termes de complexité dans leur processus de production. Nous utilisons l'appariement par score de propension (PSM) comme méthodologie pour estimer l'effet moyen du traitement sur

[14] Consulté le 01/10/2023: https://www.itto.int/fr/

les traitées (ATT) par la réforme comme développé par Rosenbaum and Rubin (1983). Nous trouvons un effet positif et significatif de la réforme sur la production de bois de sciage et de placage, mais l'effet est plus important pour le bois de sciage. En outre, nous constatons également un effet positif et significatif sur l'exportation de bois de sciage et un effet non significatif sur l'exportation de bois placage. Nos résultats suggèrent que la réforme influence l'étape la moins complexe de la transformation du bois plutôt que l'étape la plus complexe. Par conséquent, le développement de la production et des exportations de bois transformé plus complexe, comme le placage, nécessite plus que l'interdiction d'exportations de grumes. Les bois hautement transformés nécessitent une main-d'oeuvre plus qualifiée et des machines plus avancées sur le plan technique qui reposent sur des politiques industrielles et d'emploi plus complexes que l'interdiction d'exportation de grume.

1.4.2 La réforme et l'emploi dans l'industrie de transformation du bois

Le chapitre 3 analyse l'impact de l'adoption de la réforme sur l'emploi dans le secteur de la transformation du bois en utilisant des données de World Bank Enterprise Surveys (WBES).[15] L'échantillon d'étude comprend 1 739 entreprises de transformation du bois localisées dans 74 pays en développement. Cette étude apporte une nouvelle analyse à l'argument de l'industrie naissante dans le secteur de transformation du bois. La particularité de cette étude est l'analyse de l'hétérogénéité suivant le type d'emploi afin de mesurer au mieux les emplois affectés par l'adoption de cette réforme. Nous utilisons une approche d'équilibrage de l'entropie tel que mise en place par Hainmueller (2012) pour estimer l'effet de traitement moyen sur les entreprises traitées (ATT) par la réforme. Nous trouvons un effet positif et significatif de l'adoption de la réforme sur l'emploi total dans l'industrie forestière, d'environ 25% dans les entreprises situées dans le pays sous réforme par rapport aux entreprises dans le pays non-adoptant. L'analyse d'hétérogénéité de l'emploi nous permet de mieux spécifier les types emplois impactés. Nous différencions ainsi l'emploi de production de l'emploi de non-production puis, parmi l'emploi de production, nous séparons l'emploi permanent de l'emploi temporaire, et l'emploi qualifié

[15] Consulté le 01/10/2023: https://www.enterprisesurveys.org/en/enterprisesurveys

et de l'emploi non qualifié. Cette analyse nous montre que l'emploi de production, l'emploi permanent et l'emploi non-qualifié sont les seuls types d'emploi à être affectés positivement et significativement par la réforme. En robustesse, nous utilisons des variables instrumentales pour les variables endogènes binaires définies par Wooldridge (2015) en utilisant le taux des droits de douane et la part de l'adoption de la réforme par les voisins comme instruments. Cette stratégie d'estimation confirme tous les résultats précédents.

1.4.3 La réforme et la déforestation

Le dernier chapitre de cette thèse analyse l'effet de l'adoption de la réforme sur la perte du couvert forestier. Cette analyse utilise principalement les données de Hansen et al. (2013) utilisés entre autres par Leblois et al. (2017). À l'aide d'un panel de 100 pays en développement allant de 2001 à 2019, nous employons l'approche d'équilibrage par entropie développé par Hainmueller (2012) pour analyser l'impact de la réforme. Nos résultats montrent un effet positif et significatif de la réforme sur la déforestation d'environ 29%. Cet effet demeure robuste par l'ajout progressif d'autres variables de contrôle. De plus, nous vérifions la validité de l'agriculture et de l'industrie forestière comme canaux de transmissions en utilisant l'approche des variables médiatrices mise en évidence par Baron and Kenny (1986). Nos résultats montrent que l'occupation des terres agricoles et le volume de bois transformé remplissent les conditions des canaux de transmission. Ces résultats demeurent stables et consistants à l'utilisation des variables instrumentales pour la variable endogène binaire définie par Wooldridge (2015) et au GMM developpé par Blundell and Bond (1998). Une modification de l'échantillon et une utilisation de mesures alternatives de la déforestation et de la réforme ne changent ni le signe ni la significativité des principaux résultats.

Chapter 2

Revisiting the trade restrictions-industrialization nexus in developing countries: the case of log export ban and wood processing

This chapter is co-written with my supervisor Sébastien Marchand. It is published in Journal of Forest Economics: Vol. 38: No. 2, pp 195-233. http://dx.doi.org/10.1561/112.00000562. In this chapter, I worked particularly on data collection, data analysis, empirical identification strategy, econometrics estimation and results. My co-author worked on the introduction, literature review and conclusion.

Abstract

Many developing countries impose restrictions on the export of logs primarily to promote local wood processing. This study focuses on the Log Export Ban (LEB) policy and investigates if this policy impacts both the production and exports of sawn timber (a less complicated stage of processing) and veneer (a more complicated stage of processing). We implement the propensity score matching method to assess the average treatment effect on the treated (ATT) of the LEB policy in 86 developing countries. We find a positive and significant effect of the LEB policy on both sawnwood and veneer production while the effect is stronger in the case of sawnwood (about 2 %) compared to veneer (about 1 %). Moreover, we also find a positive and significant effect on the exports of sawnwood (around 8 %) while we find no significant results on the exports of veneer. Moreover, we study the short-term ATT of the LEB policy. We find that the ATT during the first 5 years of the LEB policy are higher than estimated ATTs reported in the baseline results. Lastly, we investigate the heterogeneity in treatment effects using control function with some institutional variables. It is worth noting that the impact of the LEB policy on the exports of the two type of processed wood is highly sensitive to the quality of the judicial system and bureaucracy. Overall, our study implies that the LEB policy should be associated to more complex industrial, employment policies and better institutions to produce positive and lasting impact on wood processing industries.

JEL classification: C21, F13, O13, O14, Q23.

Keywords: Log export ban, Wood processing, Developing countries, Propensity score matching.

2.1 Introduction

The long-term development of developing countries is a complex issue with multiple factors. Among them, industrial commodity processing has been advocated by policy-makers and academics in recent decades (UNECA, 2013). In the meantime, most of developing countries are engaged in international trade. Consequently, the pattern and process of industrialization in developing countries have been shaped by different trade and industrial policies (Dodzin and Vamvakidis, 2004; Mukherjee, 2012). One strategy is the export oriented industrialization (EOI) also known as export-led growth. The EOI strategy is based on the postulate that the export growth is the engine of economic growth by improving allocation of resources within the entire economy through an increase of physical and human capital (thanks to economies of scale for instance) and also a technological improvement in response to foreign competition (Balassa et al., 1971; Medina-Smith, 2001; Amoah et al., 2009). However, this strategy relies on long-term investments that call for resources that most of developing countries lack. For instance, industrialization needs trade infrastructure (e.g. modern seaports) and efficient trade procedures (e.g. transparent and quick export checking), strong transportation and energy infrastructures, technical know-how and skilled labour force and lastly better institutions (e.g. efficient legal system and transparent bureaucracy). Without these resources, domestic industries of processed commodities are less competitive than industries located in more developed countries. Accordingly, countries are forced to produce and export raw materials.

To address these problems, the EOI strategy adopted in many countries has been implemented with the promotion of trade protection measures on raw materials to conform with industrial commodity processing purposes. While raw material exports are the main source of revenues for many developing countries, the industrialization strategy leads to process these inputs to get more value-added and export incomes. So, the governments put in place some restrictions on export of raw materials to create a large availability of these goods for local industry and the production of processed goods. These restrictions on primary goods concern countries endowed in natural resources such as timber logs, metal wastes and scraps, precious stones and chromite, and raw hides and skins (Schulz, 2020). According to Schulz (2020), in the last two decades, export prohibitions on these raw materials have become central in trade and industrial policy in developing countries[1].

The case of forestry in developing countries, above all in Africa, is particularly relevant. In many forest-rich countries (e.g., Ghana, Gabon, etc.), several governments decided to develop their industry through the promotion of the processing relating to primary, secondary, and tertiary wood products for export[2]. These countries adopted restrictions on raw logs from quotas and tax on exports to strict export ban. The wisdom behind the log export ban (LEB) policy is both to promote local processing (with employment benefits) (Amoah et al., 2009; van Kooten, 2014) and to encourage a more sustainable management of forests (Resosudarmo and Yusuf, 2006). However, the implementation of the LEB policy has not been uniform in all developing countries. Some countries have implemented the LEB policy for more than two decades while others countries have decided to remove it or have been enacted it recently. Thus, what is the real effect of the LEB policy on the wood industrialization of country adopters? What is the effect of the LEB policy on trade opportunities in terms of processed wood exports? The purpose of this study is twofold: (1) to assess the impact of the LEB policy on the dynamic of processed timber production growth and (2) to assess the impact of the LEB policy on trade opportunities, specifically in terms of processed wood export dynamics.

At our knowledge, all former studies on the impacts of the LEB policy on wood processing industry are country-specific and often focus on the price analysis and the efficiency of wood processing sector (in terms of logging) of the reform (von Amsberg, 1998; Dudley, 2004; Resosudarmo and Yusuf, 2006)[3]. Therefore, our contribution to the literature is fourfold. First, we estimate the impact of the LEB policy at the macro-level using panel data for 86 developing countries between 1990 to 2019. Second, we analyze the impact of the LEB policy by focusing on the volume of processed wood production rather than price. Third, as defined by the LEB purpose of export increases, our study also focuses on the effect of the LEB policy on the dynamic of processed wood exports. Fourth, we focus on swan timber and veneer, two kind of processed wood, which are different in terms of complexity of their production process.

We implement the propensity score matching to estimate the average treatment effect on

[1]According to Schulz (2020), 82% of of exports bans in Africa were introduced since 2000.
[2]Schulz (2020) reveals that wood was the most frequently banned at export in Africa.
[3]We go back on the theoretical and empirical literature in Section 2.2.

the treated (ATT) of the LEB policy. We find a positive and significant effect of the LEB policy on both sawnwood and veneer production while the effect is stronger in the case of sawnwood (about 4 %) compared to veneer (about 1 %). Moreover, we also find a positive and significant effect on the exports of sawnwood (around 10 %) while we find no significant results on the exports of veneer. Our results suggest that the LEB policy influences the less complicated stage of wood processing rather than the more complicated stage. As a consequence, the development of production and exports of more complicated processed wood like veneer needs more than the interdiction of log exports. Highly processed woods require more skilled labor and more technically advanced machines that rely on more complex industrial and employment policies than the LEB policy.

Moreover, we study the short-term ATT of the LEB policy. We find that the ATT during the first five years of the LEB policy is higher than the estimated ATTs reported in the baseline results. Regarding the effect of the LEB policy each year from $t+1$ to $t+5$, we find different effects. It is worth noting that we find significant ATTs in all specifications (i.e. until t + 5) for veneer production in contrast to sawnwood production (no significant results). Regarding exports, we find positive and significant ATTs until t+4 on sawn timber exports but the effects vanish progressively. Lastly, we still find no effects on veneer exports.

Moreover, we study the heterogeneity in treatment effects of the LEB policy using the control function. More precisely, we examine if countries that meet the preconditions of LEB adoption record better performance in processed wood production and export. We also analyze if the time length since the adoption of the LEB policy and the quality of institutions (the level of corruption, the quality of law and order as well as the bureaucracy quality) can play on the effect of LEB adoption on processed wood production and export. The results found are comparable to the ATTs results regarding the additive effect of the LEB dummy variable. Moreover, we find several differential effects of the LEB policy mainly according to institutional variables. For instance, we find a positive effect of the interaction term between the LEB dummy and corruption on sawnwood production. This result can be related to the fact that the LEB policy tends to encourage the development of upstream logging activities to meet the increase in the demand for downstream wood activities created by the LEB policy. Given that upstream logging activities are often informal and illegal, high corruption can thus contribute to raising these kinds of activities and then, stimulating sawnwood production. Also, we find that the impact of the LEB policy on the exports of the two types of processed wood is highly sensitive to the quality of law and order and bureaucracy. These results suggest that the development of wood processing needs long-term investments that rely highly on transparent and slim bureaucracy and an efficient legal system.

The remainder of the paper is structured as follows. Section 2.2 discusses the theoretical effects of the LEB policy in the literature and clarifies the contribution of our study. Section 2.3 describes the econometric framework and data. Section 2.4 presents and discusses descriptive statistics and the main results of the study while Section 2.5 shows the robustness checks. Section 2.6 concludes with remarks concerning policy and future research.

2.2 Background

The LEB policy has many implications in terms of forest management and deforestation but also for the wood sector itself and the entire economy in terms of employment, balance of payment, fiscal revenues and industrialisation of the wood industry (von Amsberg, 1998; Dudley, 2004; Resosudarmo and Yusuf, 2006). In this paper, we focus only on the industrialization of the processed wood sector (in terms of volume of production and exports) since the LEB policy was primarily imposed with the objective of promoting this sector. However, the theoretical gains of the LEB policy are not obvious. While trade economists are almost all agreed that log export bans and restrictions should have detrimental effects on the overall economic efficiency of an economy, the impact of a such policy only on the concerned sector is fuzzy (Resosudarmo and Yusuf, 2006).

On the one hand, we can advocate that the LEB policy will have a net positive effect on wood industry. Even though there is a dead-loss due to the ban on log exports in the logging industry, there can be a welfare gain by producing processed wood products far larger than the welfare loss in logging industry (von Amsberg, 1998; Dudley, 2004; Resosudarmo and Yusuf, 2006). Thanks to the ban of exporting logs, the domestic processing industry has not to compete with foreign processors for access to the local timber supply, which is typically cheap in the case of developing countries. Processing industries can thus expand their scale thanks to the low cost of log as a raw material. This expansion can then call for new investments in the processing industry. As a consequence, the incoming new capital will increase the capital-labor ratio and then the marginal productivity of employment. Efficiency should therefore improve in the wood-processing industry that can then be able to compete on the international market by exporting higher-value processed wood. We thus expect a positive effect of the LEB policy both on the production and the exportation of processed wood products. Some empirical studies support such an argument at country level. For instance, Amoah et al. (2009) found that the LEB policy increased the production of processed wood products (sawnwood, veneer and plywood) in Ghana[4]. In Indonesia, Resosudarmo and Yusuf (2006) used a computable general equilibrium model to predict the anticipated impact of implementing the LEB policy on the national economy and on household incomes for various socioeconomic groups. Regarding only the wood sector, they showed that the LEB policy in long run may have benefits for the wood processing production[5].

On the other hand, the promotion of the downstream wood processing industries is not enough to create incentives to improve the production and the exportation of processed wood, and the net gain in welfare for the wood industry can be negative. This negative impact of the reform on wood processing is related to log prices. An important pitfall occurring after the implementation of the LEB policy is a significant reduction of log prices (von Amsberg, 1998; Resosudarmo and Yusuf, 2006). For instance, following a log export ban in Costa Rica, domestic log prices have fallen to 20-60 % of international price levels according to Kishor and Constantino (1993). This fall could lead to inefficient and wasteful logging and processing techniques (Barbier and Rauscher, 1994) and so to a reduction of processed wood production. Several empirical studies support such an argument. For instance, in Indonesia, Resosudarmo

[4]However, they also found that aggregate export price index before the LEB policy (19841995) increased by 129% while the same index decreased by 3.9% during the LEB policy (19952005). Even if the reduction of export price can be more attributed to international factors that the LEB policy alone, these results suggest that exports revenues of wood processing industry is a complex issue that depend both on the competitiveness of the national sector but also on international factors. This issue is nevertheless beyond the scope of this paper that focuses only on production quantity and exports of the wood processing industry.

[5]The authors also show that the reform can have negative effects especially by increasing the rate of log harvesting or by raising the job unemployment (more jobs are lost in the roundwood sector that are created in the wood-processing sector). However, this issue is beyond the scope of our paper.

and Yusuf (2006) found that sawnwood production is less important five years after the implementation of the LEB policy that it would be without the reform. As a consequence, the production capacity of the downstream wood processing industries could decrease after a while due to inefficiencies related to the reduction of log prices.

Despite the controversial theoretical debate and no empirical consensus on the impact of the LEB policy on wood-processing production and exports, many countries still implement this policy. The goal of this study is thus to provide an estimation of the impact of the LEB policy on processed wood production and exports by comparing several developing countries experiencing or not this policy.

2.3 Empirical framework

2.3.1 Data

Our study covers 84 developing countries from 1990 to 2019 that have experienced or not the LEB reform. Information regarding the LEB policy comes from Forest Product Export Restriction (FPER) database[6]. For each country and each year, the LEB treatment variable is coded 1 if the country applies an export ban on log and raw wood or unprocessed log[7]. The ban might cover some species or all species. In the case of some species, the ban covers the main produced and exported species by the country. Moreover, the export quota may also be promoted to protect and develop the domestic processing sector in the same vein as the LEB. That is to say, this restriction might have the same effect as an export ban. However, if countries with export quotas are considered non-treated countries (no LEB countries), this may interfere with our identification strategy since we are comparing treated countries with false non-treated countries. To avoid this issue, we compare all countries with a LEB and export quota and find that all countries under export quota also apply a LEB except DRC. However, the FPER database explains that DRC government did not clearly define when the policy starts and how the policy is applied until today. Also, DRC should apply LEB policy at

[6]One of the primary sources of FPER database regarding log export restriction policy is WTO Trade Policy Reviews. However, this information is not complete. Therefore, the FPER database also uses other information such as primary law on national forest policy (law and decree).

[7]We exclude the countries that have banned logging only to combat deforestation.

Figure 2.1: Sample used in this study: adopters and non adopters LEB

the beginning of 2023 showing clearly that the policy is not applied. Thus, we define DRC as non-treated in our analysis. In short, the LEB variable is coded 1 if a country applies a ban on log export and 0 if not, and all countries considered untreated have no export quota. In our study, they are 39 LEB adopters and 45 non-adopters mapping in Figure A2 and reporting in Table A2 in the Appendix.

We focus on the impact of the LEB policy on two kinds of processed wood, sawnwood and veneer. Sawnwood is the less complicated processing level of wood and consists in producing either by longitudinal sawing or by a profiling process whose thickness exceeds six millimeters. The veneer is considered as a more complicated processing level of wood compared to sawnwood and is made from thin sheets of wood of uniform thickness, not exceeding six millimeter[8]. In addition, it is worth noting that the sawnwood is not the previous level of veneer. The volume of logs used for sawnwood production is so independent of the volume of logs used for veneer production.

Moreover, in our study, we focus on both the production and export of these two processed wooden goods. Regarding production, we use the ratio of sawnwood (or veneer) production on roundwood production which is the main input of processed wood. In this approach, we thus standardize the measure of sawnwood (or veneer) production to capture the relative growth of processed wood rather than its volume increase which can hide some disparities in terms of roundwood use between countries. Regarding export, we use the ratio of sawnwood (veneer) export to the sawnwood (veneer) production. The underlying motivation is to capture one of the main goals of the LEB policy which is to increase the share of exported production of processed wood. The data relating to the production and exportation of processed wood come from the International Tropical Timber Organization (ITTO)[9].

Finally, we use others covariates related to our econometric strategy explained in Subsection 2.3.2. These data come from various sources. Macroeconomic data (i.e. GDP per capita,

[8]While it would have been interesting to consider different classes of processed wood (sliced and peeled veneer for instance), we do not have the classes of sawn or veneer timber. Thus, we used all classes of processed wood and we made our analysis without distinguishing the class of processed wood.

[9]Source: https://www.itto.int/biennal_review/

labor force, agricultural and manufacturing GDP, FDI inflows, exchange rate and inflation) and electricity access come from the World Bank Indicators. Variables related to the quality of institutions come from the International Country Risk Guide (ICRG) (i.e., the quality of government, corruption, the quality of law and order, and the quality of the bureaucracy). Finally, processed log prices come from the International Tropical Timber Organization (ITTO). Table A7 in the Appendix gives a complete description of the variables and their sources.

2.3.2 Econometric model

The baseline model

The purpose of our study is to estimate the impact of the LEB policy on production and export of wood processing industry (sawnwood and veneer). The LEB adoption is thus the treatment variable. The countries implementing the LEB policy are the treated group and the countries which do not apply the policy are the control group. To estimate the causal effect of the LEB policy, we implement a propensity score matching (PSM) strategy that allows us to study the Average Treatment Effect on the Treated (ATT)[10]. The ATT estimation is based on the following equation:

$$ATT = E[(Y_{i1} - Y_{i0})|LEB = 1] = E[Y_{i1}|LEB = 1] - E[Y_{i0}|LEB = 1], \tag{2.1}$$

where LEB is the LEB adoption dummy variable in country i ($1 = $ *adoption* ; $0 = $ *no adoption*). Y_{i1} is the outcome representing either the production or the exportation of veneer or sawnwood of the country that applies the LEB policy and Y_{i0} is the same outcome of the country that does not apply the LEB policy. In this approach, the outcome Y_{i0} is not observable, i.e the outcome of the LEB adopter country if it had not adopted the LEB policy. We can estimate the ATT by comparing the LEB adopters with the non-LEB adopters if the choice of LEB adoption is random.

However, the choice of the LEB adoption or not may be favoured by some observable factors that also affect the outcomes. So, the comparison of the mean value of outcomes between the

[10] All estimations are made with Stata 17.

two groups can lead to the selection on observables. To deal with the selection on observables problem, the PSM methods can be implemented. Based on the observables characteristics, the PSM allows to compare the LEB adopters and the non-LEB adopters[11]. According to unconfoundedness assumption, the differences in outcomes between the LEB adopters and the non-LEB adopters with the same values for covariates are attributable to the treatment. Unconfoundedness assumption implies that all variables that influence treatment assignment and potential outcomes simultaneously have to be observed by the researcher (Caliendo and Kopeinig, 2008). This assumption expressed by $Y_0, Y_1 \perp LEB|X$ means that conditional on the vector of observable factors (X) which are not affected by the treatment, the outcome are independent of the treatment. Under this assumption, the ATT estimation becomes:

$$ATT = E[(Y_{i1}|LEB = 1, X_i)] - E[(Y_{i0}|LEB = 0, X_i)], \quad (2.2)$$

where we have replaced the $E[Y_{i0}|LEB = 1]$ with $E[(Y_{i0}|LEB = 0, X_i)]$

Thus, all matching strategies consist in matching the treated units and comparison units with the same values of X. However, given the high dimensional of covariates X, it is difficult to implement a matching on X. Rosenbaum and Rubin (1983) suggest to implement the matching based on the propensity score of the two groups. The propensity score $p(X) = E[LEB|X_i] = Pr(LEB = 1|X_i)$ is the probability for an individual to adopt the LEB policy given his observed covariates X.

There is another important assumption for PSM application is the common support assumption ($p(X) < 1$). It supposes that the countries with the same covariates values have a positive probability of being both participants and non-participants. Thus, this assumption assumes the existence of comparable counterfactual for each unit treated in each year. That is to say, that this assumption requires the propensity score density function of the two groups has to be proximate. Figure A1 in the Appendix shows the common support assumption test. It shows the pre-matching and post-matching propensity score (kernel) density functions of

[11] As observable characteristics, we use wood industry data (i.e. roundwood exports, veneer and sawnwood prices and imports), macroeconomic data (i.e. GDP per capita, labor force, agricultural and manufacturing GDP, FDI inflows, exchange rate and inflation), institutional quality data (i.e., the quality of government) and electricity access. We explain these covariates in Subsection 2.4.2.

the two groups for the four dependent variables. Propensity score density function of the two groups are very proximate after matching, indicating similar characteristics of covariates in both groups after matching. These results indicate that the common support assumption is satisfied.

Thus, we can rewrite the ATT estimation as follows:

$$ATT = E[(Y_{i1}|LEB = 1, p(X_i)] - E[(Y_{i0}|LEB = 0, p(X_i)] \quad (2.3)$$

Lastly, to estimate the ATT using the PSM, we choose four types of matching identified in the literature. We first begin with the nearest neighbors matching based on the matching with the closest PS and we choose the three types of nearest matching ($n = 1$, $n = 2$ and $n = 3$). Second, we use the radius matching (Dehejia and Wahba, 2002) which is based on the PSM of treated and non-treated located at a certain distance. We retain three radius focused on a small, a medium and a wide radius (respectively for $r = 0.005$, $r = 0.01$, $r = 0.05$). Third, we implement the kernel matching which matches each treated with the distribution of untreated in the common support, with weights that are inversely proportional with the distance from propensity scores of each treated (Heckman et al., 1997). Finally, we use the local linear regression which is comparable to kernel matching with the difference that this last method considers a linear term in weighting function (Heckman et al., 1997).

Robustness tests

In addition, we complete the PSM analysis in two ways. On one hand, we investigate the short-term effects of the LEB adoption using a different measure of the treatment variable. While, in the baseline model, we use a dummy variable that takes the value 1 from the year a country has implemented the LEB policy (until it is withdraw if it is), we now use different dummies to capture the short-term effects. More precisely, we investigate the effect of the treatment variable for the first five years of the LEB adoption and successively the effect of the LEB adoption from $t + 1$ to $t + 5$[12].

[12]That is to say that the dummy variable is successively equal to 1 only for the first five years after the implementation of the LEB policy and 0 otherwise, only for the year after the LEB adoption ($t+1$), the second year after the LEB adoption ($t + 2$), the third year after the LEB adoption ($t + 3$), the fourth year after the

On the other hand, we explore potential differential effects of the LEB policy with the control function regression approach (Wooldridge, 2015). More precisely, we examine several potential heterogeneities in treatment effects: (1) the LEB adoption preconditions meeting, (2) the time length since the adoption of the LEB policy and (3) the quality of institutions (corruption, law and order and bureaucracy quality)[13].

2.4 Results

2.4.1 Graphical evidences

As a first step before the presentation of the estimation results, we plot in Figure 2.2 (1) the mean of both sawnwood and veneer production (measured as the ratio of each processed wood production to log production), and (2) the mean of both sawnwood and veneer exports (measured as the ratio of each processed wood exports to total production of each processed wood) five years before and five years after the LEB adoption.

In the left-top graph related to sawnwood production, more than half of countries have adopters performed at least as well as they did before the adoption of the reform (e.g. Benin, Gabon, Togo and Venezuela). However, there are also many countries that have performed worse than they did before the implementation of the LEB policy (e.g. Ecuador, Laos, Zambia). Also, the countries located in the left-bottom of the graph seem to be stuck at early stages of wood processing. The LEB adoption clearly did not help them to pursue development of sawnwood industry. The right-top graph is related to veneer production. It is worth noting that there are more countries (e.g. Gabon, Côte d'Ivoire and Ghana) producing more veneer (compared to log production) after the LEB adoption than countries experiencing the opposite. However, there are many countries in the left-bottom of the graph. Despite the adoption of the LEB policy, they have not implemented the development of veneer industry. Moreover, the veneer production is distinctly less important than the sawnwood production. This result can suggest that the sawnwood producer countries have not significantly begun the more complicated level of processing (veneer production).

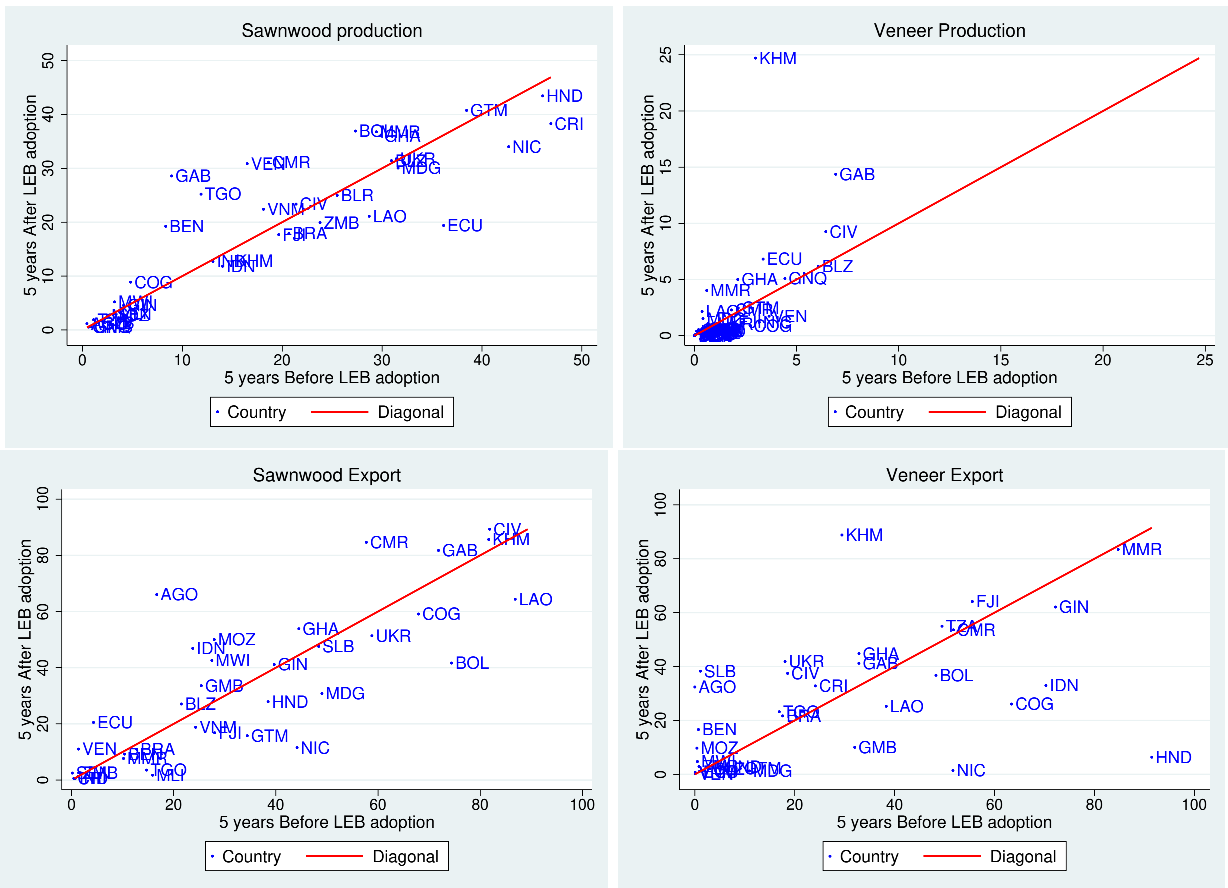
LEB adoption ($t+4$) and the fifth year after the LEB adoption ($t+5$).

[13] All these variables are defined in Table A7 in the Appendix.

The two bottom graphs are related to exports of processed wood. While several countries seem to have increased the share of processed wood exported (e.g. Angola, Gabon and Ghana) after the LEB adoption, many countries have experienced the opposite (e.g., Congo Rep., Laos and Indonesia) or have been bonded at early stages of wood processing exportation.

These graphical analyses suggest that the impact of the LEB policy on wood processing production and exports is quite fuzzy. If the reform has helped some countries to do better in term of production and exports of processed woods, some countries have clearly experienced the opposite and others seem to have been stuck at early stages of wood processing. The impact of the LEB policy on both processed wood production and exports remains thus an empirical issue, to which we now turn with the presentation of the estimation results.

Figure 2.2: Processed wood production and exportation before and after LEB adoption



Source: authors' calculations.

2.4.2 First stage: estimation of propensity scores

We use a probit model to estimate the propensity score of the LEB adoption. Recall that in the second stage, we will estimate the ATT of the LEB policy on four different outcome variables: the production of sawnwood, the production of veneer, the exportation of sawnwood and the exportation of veneer. Moreover, given that the unconfoundedness assumption supposes that each covariate must influence the treatment assignment and potential outcomes simultaneously (Caliendo and Kopeinig, 2008), we do not use the same variables to explain the probability to implement the LEB policy in the first stage. More precisely, we use four variables common to the four models (the real GDP per capita, the industrial GDP, the presence of a coastline and the quality of political institutions and electricity access), several specific variables related to macroeconomic conditions (i.e., labor force, roundwood export, agricultural GDP and FDI inflows for production variables; international trade, exchange rate and inflation for export variables) and several specific wood industry variables (sawnwood export and import prices or veneer export and import prices). It is worth noting that all explanatory variables are lagged by one year.

Table 2.1 reports the estimation results for the sawnwood (cols. 1, 5 and 9) and veneer production (cols. 2, 6, 10) respectively, and the sawnwood (cols. 3, 7, 11) and veneer exports (cols. 4, 8, 12) respectively. Columns 1 to 4 are the baseline model while columns 5 to 8 and 9 to 12 are respectively the baseline plus the quality of political institutions or electricity access. We do not use these two variables in the baseline model and together due to a lack of data.

Regarding the GDP per capita and manufacturing value added, they are expected to have a negative effect on the probability to adopt the LEB policy. Indeed, the countries that achieved some high level of industrial development and GDP per capita should not need the LEB policy to push up the industrialization of the wood industry. The presence of a developed industry sector can help the transfer of useful technology to the wood sector to help its industrialization. Also, high GDP per capita is often associated to a well developed domestic market that is useful for the industrialization of the wood sector. We do find the expected negative effect of the GDP per capita in the columns related to the production of processed wood (cols. 1, 2, 5, 6, 9 and 10) while the effect is positive in the columns related to wood processed exports (cols.

3, 4, 7, 8, 11 and 12).

Also, we use a coastal dummy variable to explain the probability of LEB adoption. In fact, the presence of a coastline suggests that it is more likely to export roundwood and thus to ban these exports.imply the port infrastructure for log export. Compared to landlocked countries, it is likely more easy to export log in coastal country. We find that this variable increases the probability of LEB policy adoption in all specifications expect these considering institutional quality. Regarding the quality of political institutions, we use an aggregated governance index provided by ICRG. This variable takes account the level of corruption, the quality of the bureaucracy, the quality of the legal system and the strength of the popular observance of the law. We assume a negative effect of this variable on the probability to adopt the LEB policy. If a government were able to apply and comply to rule and law and fight the corruption, it would not be necessary to ban log exports. Thus, the quality of political institutions should reduce the probability of LEB policy adoption. We find the expected negative effect of the quality of the governance in all specifications (cols. 5 to 8). Lastly, we use electricity access as one of the main inputs in the wood processing industry. A poor electricity network can thus dampen or even make impossible the development of the wood processing industry. Therefore, it is less likely to implement the LEB policy in a country where electricity access is poor. Thus, we should expect a negative effect on the adoption of the LEB policy. While we do find this effect in the four specifications (columns 9 to 12), the effect is only significant in the veneer export model.

We then add several control variables in the specifications related to the production of processed wood (cols. 1, 2, 5, 6, 9 and 10). First, we use the level of roundwood export to explain the LEB adoption. We find the expected positive effect given that the goal of the LEB policy is to ban the log export to shift it to domestic processed woods. Thus, the increase of high level of roundwood export encourages the LEB adoption. Second, we also control for labor force. Given that the LEB policy has the goal to develop the domestic production of processed wood, more labor force in the economy should encourage the implementation of the policy. We find this expected positive effects. Third, we add the agricultural GDP by assuming a negative effect on LEB adoption. Strong agricultural sector can discourage the adoption of the LEB policy because the country has less incentive to develop its wood industry. Our results confirm the expected negative effect. Fourth, we use foreign direct investments (FDI) and we assume a positive effect. FDI is often oriented toward high value added sectors. For forest endowed countries, the presence of FDI in the economy should incite to develop the production of processed woods to attract more FDI in the forestry sector. As a consequence, the country implements the LEB policy to help the emergence of the processed wood sectors. Also, we can assume that in forest-rich countries FDI are already located in the wood industry. Given that these investments look for more efficiency in production and higher revenues, the country can be incited to ban log exports to help the forestry sectors to growth. Our results confirm the positive effect of FDI on LEB adoption.

Moreover, in the specifications related to wood exports (cols. 3, 4, 7, 8, 11 and 12), we add three other variables. First, we use the level of international trade. The expected effect of trade on LEB adoption is not straightforward. On one hand, countries experiencing more international trade should be less incited to implement a policy aiming at dampening international trade. On the other hand, more open economies that trade raw materials can be incited to develop the production and then the exportation of more processed goods. As a consequence, international trade should increase the probability to adopt the LEB policy. Our results confirm a positive effect of international trade on LEB policy. Then, we add the exchange rate and inflation as covariates to consider price-competitiveness which is an important factor of the success or not of export industries. Regarding the exchange rate, we find a positive effect on the LEB dummy. The appreciation of the exchange rate makes the export of raw timber less attractive and may push governments to implement the LEB reform to stimulate the production and export of processed timber with greater non-price competitiveness. About inflation, we find a negative effect. Inflation increases input prices for domestic industry. Thus, countries with high level of inflation are less likely to apply the LEB policy because inflation could worsen the price-competitiveness of domestic wood processing industries and curb their development.

Lastly, we add two variables specific to sawnwood and veneer which are respectively export prices and volume of imports. In columns 1, 3, 5, 7, 9 and 11 (2, 4, 6, 8 , 10 and 12), we add the sanwwood (veneer) export price. We assume that the export price of processed woods should increase the incentives to adopt the LEB policy. The increase of processed wood production and exportation thanks to the LEB policy will then increase revenues generated by the wood industry thanks to an increase of processed wood export prices. We find a positive and significant effect of sawnwood price on LEB adoption while the effect is negative and significant for veneer. We explain this result by the fact that most of developing countries are first incited to adopt the LEB policy to develop the less complicated step of wood processing, i.e. sawnwood. Finally, we control for the level of sawnwood (veneer) imports in columns 3, 7, 11 (4, 8, 12). We find a negative effect of this variable on the probability to adopt the LEB policy. This result can be explained by the availability of imported processed woods in the country that do not incite to develop the domestic production of processed woods. Moreover, regarding sawn timber, in many developing countries, it have been replaced by cheaper and qualitative superior coniferous sawn timber coming from tropical and sub-tropical plantations[14]. In these countries, the incentive to adopt the LEB policy to produce national sawwood is so less important.

[14]We thank a anonymous referee for this remark.

Table 2.1: Propensity score estimation results

Dep. var.: LEB dummy Model	[1] Sawn. prod.	[2] Veneer prod.	[3] Sawn. export	[4] Veneer export	[5] Sawn. prod.	[6] Veneer prod.	[7] Sawn. export	[8] Veneer export	[9] Sawn. prod.	[10] Veneer prod.	[11] Sawn. export	[12] Veneer export
Log GDP per capita	-0.1778***	-0.2539***	0.1295***	0.0147	-0.1365**	-0.1605***	0.1334***	0.0636	-0.1423**	-0.2366***	0.1916***	0.1927***
	(0.0527)	(0.0560)	(0.0401)	(0.0421)	(0.0569)	(0.0602)	(0.0424)	(0.0454)	(0.0719)	(0.0794)	(0.0625)	(0.0680)
Manufacturing GDP	-0.0010	-0.0031	0.0255***	0.0130*	0.0006	-0.0022	0.0123*	0.0029	-0.0099	-0.0148*	0.0321***	0.0240***
	(0.0060)	(0.0065)	(0.0058)	(0.0068)	(0.0066)	(0.0072)	(0.0064)	(0.0074)	(0.0071)	(0.0078)	(0.0075)	(0.0088)
Coastal	0.0146	0.2150**	0.3651***	0.4292***	-0.5307***	-0.2885**	-0.0688	-0.1214	0.1467*	0.3349***	0.4700***	0.4361***
	(0.0843)	(0.0907)	(0.0851)	(0.0939)	(0.1054)	(0.1126)	(0.1013)	(0.1165)	(0.0882)	(0.0952)	(0.0912)	(0.1022)
Log roundwood export	0.1504***	0.1131***			0.1601***	0.1183***			0.1472***	0.1076***		
	(0.0093)	(0.0102)			(0.0106)	(0.0116)			(0.0100)	(0.0110)		
Log Labor force	0.0771***	0.0561**			0.0811***	0.0601**			0.0686***	0.0448*		
	(0.0207)	(0.0218)			(0.0241)	(0.0256)			(0.0218)	(0.0233)		
Agricultural GDP	-0.0228***	-0.0254***			-0.0189***	-0.0188***			-0.0207***	-0.0230***		
	(0.0049)	(0.0054)			(0.0054)	(0.0059)			(0.0055)	(0.0061)		
FDI inflows	0.0277***	0.0411***			0.0341***	0.0556***			0.0193**	0.0304***		
	(0.0070)	(0.0085)			(0.0085)	(0.0105)			(0.0078)	(0.0095)		
International trade			0.0054***	0.0048***			0.0061***	0.0058***			0.0030***	0.0028**
			(0.0010)	(0.0010)			(0.0010)	(0.0011)			(0.0011)	(0.0012)
Log Exchange rate			0.0667***	0.0701***			0.0476***	0.0461***			0.0708***	0.0688***
			(0.0129)	(0.0135)			(0.0142)	(0.0151)			(0.0138)	(0.0145)
Inflation			-0.0053***	-0.0054***			-0.0062***	-0.0058***			-0.0094***	-0.0096***
			(0.0016)	(0.0015)			(0.0016)	(0.0016)			(0.0029)	(0.0029)
Log sawnwood price	0.4192***		0.2703***		0.4240***		0.2303***		0.4204***		0.2462***	
	(0.0516)		(0.0501)		(0.0606)		(0.0593)		(0.0542)		(0.0530)	
Log veneer price		-0.0765**		-0.0708*		-0.0801*		-0.0964**		-0.0660*		-0.0713*
		(0.0359)		(0.0372)		(0.0414)		(0.0428)		(0.0376)		(0.0397)
Log sawnwood import			-0.0766***				-0.0878***				-0.1237***	
			(0.0113)				(0.0125)				(0.0139)	
Log veneer import				-0.0242*				-0.0176				-0.0616***
				(0.0140)				(0.0158)				(0.0164)
Quality of government					-0.9043***	-1.2693***	-1.0829***	-1.9314***				
					(0.3094)	(0.3271)	(0.3230)	(0.3563)				
Electricity access									-0.0021	-0.0012	-0.0001	-0.0060***
									(0.0019)	(0.0021)	(0.0020)	(0.0023)
Constant	-3.7441***	0.4699	-3.4776***	-0.7234*	-3.4501***	0.5344	-1.9664***	0.6534	-3.6594***	0.7053	-3.2779***	-1.3285**
	(0.6955)	(0.6892)	(0.4411)	(0.3888)	(0.7747)	(0.7542)	(0.5051)	(0.4402)	(0.7823)	(0.8020)	(0.5447)	(0.5243)
Observations	2,075	1,682	1,750	1,441	1,634	1,383	1,401	1,198	1,792	1,459	1,524	1,251
Pseudo-R2	0.18	0.11	0.08	0.06	0.17	0.12	0.08	0.07	0.17	0.10	0.10	0.06

Note: In all columns, the dependent variable is LEB adoption (dummy variable). Columns 1, 5 and 9 concern the sawnwood production model, columns 2, 6 and 10 concern the veneer production model, columns 3, 7 and 11 concern the sawnwood export model and columns 4, 8 and 12 concern the veneer export model. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

2.4.3 Second stage: the matching results

The ATT of LEB adoption on the outcomes variables are presented in Table 2.2. For each outcome variable, we estimate several ATT according to four types of matching, i.e. nearest neighbor (cols. 1 to 3), radius matching (cols. 4 to 6), local linear regression matching (col. 7) and kernel matching (col.8). Before presenting the estimation results of the ATT, we discuss the results of several diagnostic tests used to assess the quality of the matching estimation. Firstly, we test whether our two groups are comparable by using the pseudo-R^2. The pseudo-R^2 shows how well the vector of covariates explains the probability of LEB adoption and thus provides balanced scores (Sianesi, 2004). For Caliendo and Kopeinig (2008), the good model performance should be associated to a fairly low value of pseudo-R^2 and near to zero. In Table 2.2, the pseudo-R^2 are lower than 0.018 showing that our matching provides balanced scores and confirms the comparability hypothesis. Secondly, we continue with matching quality by testing the conditional independence assumption regarding both observables and unobservables. If there are unobserved covariates which affect the assignment to treatment and the outcome variable simultaneously, a hidden bias might arise (Caliendo and Kopeinig, 2008). On the observable side, we use the Rosenbaum bounds sensitivity test (Rosenbaum, 2002) to check for possible hidden bias due to unobserved variables that could affect the effect of LEB adoption on the outcomes variables. Table 2.2 reports the critical values of the Rosenbaum bounds test between 1.6 and 1.8 for sawnwood production, 1.2 and 1.6 for veneer production, 1.4 and 1.8 for sawnwood export and 1 for veneer export. These results are comparable to others studies (Balima et al., 2016; Caliendo and Künn, 2011; DiPrete and Gangl, 2004; Jacolin et al., 2019) and suggest that the estimation results of the ATT of LEB adoption are robust even in the presence of unobserved heterogeneity. Thirdly, regarding observables covariates, we run the standardized bias test which evaluates the marginal distance distributions of our control variables. This test reveals in most specifications that there are no statistical difference between LEB adopters and LEB non-adopters after matching except for some specifications.

Regarding the estimation results of the ATT on LEB adoption in Table 2.2, we find a positive and statistically significant at 5% for all matching methods on the sawnwood production and 1% for veneer production. For sawnwood production, the magnitude of the effect of LEB adoption is from about 1.67 percentage points (with the largest radius matching) to about 2.43 percentage points (with the 1-nearest neighbor). Regarding the veneer production, the ATT is ranged from about 1.34 percentage points (with the smallest radius matching) to about 1.42 percentage points (with the 2-nearest neighbor). Our results show a much higher effect of LEB adoption on the sawnwood production than veneer production. This result is expected because the production of sawnwood is the less complicated stage of the production of processed wood. Put differently, it is easier for a country banning log export and wishing to industrialize its wood industry to develop first the production of sawnwood.

Regarding the exports of processed wood, we find a positive and significant (at 1% for all specifications) for sawnwood exports while we do not find any significant results for veneer exports. On average, the LEB adopters countries experience higher sawnwood export from about 7.71 percentage points (with the local linear regression matching) to 9.08 percentage points (for 3-nearest neighbor). We do rely these results to the previous explanation regarding the preference to sawnwood rather than veneer. While timber industry in most developing countries is still in the early stages, it is more relevant to invest in the first level of processing like sawnwood. As a consequence, the production level of more processed woods like veneer cannot compensate the need for domestic consumption. Therefore, the LEB policy stimulates the production of veneer (albeit lower than for sawnwood) which is primary oriented to the domestic market instead of to the international market.

Table 2.2: The impact of the LEB policy on outcomes variables: the matching results

Treatment: LEB	1-Nearest Neighbour Matching	2-Nearest Neighbour Matching	3-Nearest Neighbour Matching	Radius Matching r=0.005	Radius Matching r=0.01	Radius Matching r=0.05	Local Linear Regression Matching	Kernel Matching
Dependent variable: Sawnwood Production								
ATT (col. 1 in Table 2.1)	2.4330**	2.0383**	2.0408**	1.7129**	1.7546**	1.6701**	2.0362***	1.7228**
	(1.1081)	(1.0399)	(0.9492)	(0.7768)	(0.7690)	(0.7365)	(0.7528)	(0.7496)
Obs/Treated obs	2062/727	2062/727	2062/727	2062/727	2062/727	2062/727	2062/727	2062/727
Countries	84	84	84	84	84	84	84	84
Pseudo-R2	0.007	0.007	0.008	0.006	0.005	0.006	0.007	0.006
Standardized bias (p-value)	0.094	0.078	0.046	0.156	0.263	0.185	0.094	0.198
Rosenbaum bounds test	1.3	1.2	1.2	1.2	1.2	1.2	1.3	1.2
ATT (col. 5 in Table 2.1)	2.5227*	2.2664*	1.9311	1.5159	1.5723*	1.4232	1.4837	1.4493
ATT (col. 9 in Table 2.1)	1.9665*	1.3859	1.2318	1.4903*	1.7293**	1.9068**	2.3047***	1.9473**
Dependent variable: Veneer Production								
ATT (col. 2 in Table 2.1)	1.3815***	1.4188***	1.3583***	1.3400***	1.3651***	1.3639***	1.3817***	1.3655***
	(0.1961)	(0.1971)	(0.1901)	(0.1790)	(0.1819)	(0.1622)	(0.1630)	(0.1672)
Obs/Treated obs	1669/688	1669/688	1669/688	1669/688	1669/688	1669/688	1669/688	1669/688
Countries	81	81	81	81	81	81	81	81
Pseudo-R2	0.006	0.006	0.005	0.002	0.001	0.001	0.006	0.001
Standardized bias (p-value)	0.207	0.196	0.301	0.903	0.987	0.971	0.207	0.975
Rosenbaum bounds test	1.7	1.5	1.3	1.2	1.2	1.2	1.2	1.2
ATT (col. 6 in Table 2.1)	1.1766***	1.2005***	1.1801***	1.2101***	1.2389***	1.1930***	1.1972***	1.1862***
ATT (col. 10 in Table 2.1)	1.3065***	1.3469***	1.3211***	1.3580***	1.3604***	1.3944***	1.3921***	1.3905***
Dependent variable: Sawnwood Export								
ATT (col. 3 in Table 2.1)	8.5130***	8.8987***	9.0766***	8.3075***	8.2318***	7.9529***	7.7095***	8.0299***
	(2.4550)	(2.6248)	(2.2577)	(1.8353)	(1.7746)	(1.6407)	(1.6450)	(1.7181)
Obs/Treated obs	1736/682	1736/682	1736/682	1736/682	1736/682	1736/682	1736/682	1736/682
Countries	77	77	77	77	77	77	77	77
Pseudo-R2	0.009	0.008	0.008	0.009	0.009	0.008	0.009	0.008
Standardized bias (p-value)	0.026	0.077	0.055	0.040	0.024	0.063	0.026	0.057
Rosenbaum bounds test	1.8	1.6	1.6	1.4	1.4	1.4	1.4	1.4
ATT (col. 7 in Table 2.1)	8.4534***	8.1125***	9.0507***	9.0442***	8.5097***	8.8364***	7.9893***	8.8357***
ATT (col. 11 in Table 2.1)	6.1637*	5.7510*	6.8630**	6.4252***	5.8954**	5.2529**	5.1412**	5.3287**
Dependent variable: Veneer Export								
ATT (col. 4 in Table 2.1)	1.4245	1.4640	2.0951	0.9134	0.7619	1.6877	1.2834	1.6199
	(2.9839)	(2.6390)	(2.5335)	(1.9286)	(2.0092)	(1.9518)	(1.9807)	(1.9924)
Obs/Treated obs	1300/622	1300/622	1300/622	1300/622	1300/622	1300/622	1300/622	1300/622
Countries	67	67	67	67	67	67	67	67
Pseudo-R2	0.014	0.020	0.018	0.010	0.011	0.015	0.014	0.016
Standardized bias (p-value)	0.003	0.000	0.000	0.051	0.016	0.001	0.003	0.001
Rosenbaum bounds test	1	1	1	1	1	1	1	1
ATT (col. 8 in Table 2.1)	-3.2601	-0.9613	0.0819	1.4595	1.3137	2.1462	3.2923	2.1056
ATT (col. 12 in Table 2.1)	-2.0403	-1.7310	-1.7395	-1.8347	-1.8802	-1.3655	-0.6832	-1.4024

Note: To save space, we do not report estimation results information (observations, ...) not related to baseline ATT. Information available upon request. Standard errors in brackets. Nonparametric bootstrap estimation of propensity score matching methods (replications = 500). *** significance level at 1%, ** significance level at 5%, and * significance level at 10%.

2.5 Robustness checks

2.5.1 Dynamic effect of LEB adoption

We complete the PSM analysis by investigating the short-term effects of the LEB adoption. Table 2.3 reports short-term ATTs of the LEB policy on the four outcome variables. We study the effect of the treatment variable for the first five years of the LEB adoption and successively the effect of the LEB adoption in $t+1$ to $t+5$.

Regarding the effect on wood processed production, we find that the ATT during the first five years of the LEB policy are higher than estimated ATTs reported Table 2.2[15]. In details, ATTs are ranged from 2.64 to 3.35 for sawnwood and 1.54 to 1.61 for veneer. Interestingly, while the LEB policy has no impact on veneer exports in the first five years (as in the baseline model reported in Table 2.2), we find a not robust positive impact on sawnwood exports which is smaller than the results of the baseline model in Table 2.2.

Regarding the effect of the LEB policy from t + 1 to t + 5, we find different effects. Regarding the sawn timber production, we find no significant effect suggesting that ATTs of the LEB policy is cumulative. However, we find significant ATTs for each of the first five years on veneer production while the strongest effect occurs in the first year after the implementation of the policy. Also, we find that ATTs becomes progressively weaker until t + 5. Moreover, it is worth noting that we find significant ATTs in all specification (i.e. until t + 5) for veneer production in contrast to sawnwood production. Regarding exports, we find positive and significant ATTs until t+4 on sawn timber exports but the effects vanish progressively. Lastly, we still find no effects on veneer imports.

[15]We use the model reported in column 1 for sawnwood production, in column 2 for veneer production, in column 3 for sawnwood exports and in column 4 for veneer exports of Table 2.1.

Table 2.3: The short-term impact of the LEB policy

Treatment: LEB	1-Nearest Neighbour Matching	2-Nearest Neighbour Matching	3-Nearest Neighbour Matching	Radius Matching r=0.005	Radius Matching r=0.01	Radius Matching r=0.05	Local Linear Regression Matching	Kernel Matching
Dependent variable: Sawnwood Production								
5 years Mean	3.3481***	3.2216***	3.0178***	3.0071***	2.7254***	2.6385***	2.9427***	2.6777***
	(1.2010)	(1.1559)	(1.0634)	(1.0271)	(0.9204)	(0.8589)	(0.8309)	(0.8626)
n+1	1.4170	1.2028	0.9191	1.1304	1.2621	1.0205	1.2621	1.0829
	(1.1956)	(1.0649)	(0.9913)	(0.8505)	(0.8234)	(0.7907)	(0.7819)	(0.7864)
n+2	-0.1235	0.3090	0.3579	0.6044	0.6840	0.7069	0.9370	0.7740
	(1.2129)	(1.1239)	(1.0664)	(0.8881)	(0.8267)	(0.8324)	(0.8106)	(0.7702)
n+3	0.4763	0.8787	0.5700	0.4211	0.3897	0.5896	0.8369	0.6561
	(1.2701)	(1.1229)	(1.0937)	(0.8871)	(0.8450)	(0.8053)	(0.8380)	(0.8264)
n+4	0.2973	-0.0270	0.1623	0.1126	0.3340	0.3361	0.6461	0.4458
	(1.2511)	(1.0928)	(1.1053)	(0.9209)	(0.8559)	(0.7886)	(0.8541)	(0.8167)
n+5	1.4612	0.9415	0.9158	0.5226	0.3303	0.2168	0.5097	0.3258
	(1.3218)	(1.1606)	(1.0701)	(0.9955)	(0.8888)	(0.8624)	(0.8403)	(0.8834)
Dependent variable: Veneer Production								
5 years Mean	1.6100***	1.6063***	1.5760***	1.5774***	1.5784***	1.5429***	1.5639***	1.5458***
	(0.2185)	(0.2201)	(0.2088)	(0.2098)	(0.2032)	(0.1912)	(0.1852)	(0.1871)
n+1	1.4280***	1.3855***	1.3433***	1.2994***	1.3067***	1.2866***	1.2976***	1.2812***
	(0.1987)	(0.2013)	(0.1829)	(0.1950)	(0.1798)	(0.1707)	(0.1734)	(0.1819)
n+2	1.1067***	1.2515***	1.2671***	1.2544***	1.1998***	1.1599***	1.1699***	1.1576***
	(0.2413)	(0.2312)	(0.2245)	(0.2074)	(0.1906)	(0.1849)	(0.1733)	(0.1833)
n+3	1.1578***	1.1387***	1.0691***	1.1141***	1.0403***	1.0480***	1.0497***	1.0413***
	(0.2571)	(0.2471)	(0.2247)	(0.2037)	(0.2090)	(0.1950)	(0.1856)	(0.1931)
n+4	0.8309***	0.9093***	0.8855***	0.9510***	0.9593***	0.9544***	0.9670***	0.9603***
	(0.2632)	(0.2550)	(0.2362)	(0.2300)	(0.2076)	(0.1989)	(0.2036)	(0.1964)
n+5	0.5522**	0.6498***	0.7154***	0.8662***	0.8969***	0.8832***	0.9026***	0.8811***
	(0.2648)	(0.2518)	(0.2335)	(0.2298)	(0.2003)	(0.1853)	(0.1864)	(0.2010)
Dependent variable: Sawnwood Export								
5 years Mean	5.9817**	8.0303***	8.4381***	6.2439***	5.8917***	6.0585***	5.3432***	6.0883***
	(2.9851)	(2.6419)	(2.5296)	(2.1515)	(2.1353)	(1.7736)	(1.8286)	(1.9821)
n+1	9.6944***	9.8762***	8.8985***	7.8821***	8.6906***	8.1811***	7.7007***	8.1859***
	(2.6539)	(2.5269)	(2.1498)	(1.8791)	(1.8543)	(1.7479)	(1.8180)	(1.7696)
n+2	8.2844***	7.1713***	7.4182***	6.7150***	7.2625***	6.8736***	6.4684***	6.8463***
	(2.8628)	(2.6561)	(2.5594)	(1.9513)	(1.9842)	(1.8700)	(1.9431)	(1.9142)
n+3	8.2373***	7.1309***	6.5493**	7.0667***	6.5663***	6.3804***	6.2490***	6.4324***
	(3.1112)	(2.6503)	(2.7126)	(2.0510)	(2.0318)	(1.7720)	(1.9076)	(1.8564)
n+4	8.2168**	7.6620**	6.6976**	6.1568**	5.4947**	5.4394**	5.0356**	5.5212**
	(3.5257)	(3.2196)	(3.1650)	(2.4977)	(2.3103)	(2.2522)	(2.2235)	(2.2280)
n+5	2.8672	0.4721	1.7357	2.8480	3.8324	3.8754	3.8479	3.9133
	(4.5947)	(4.0007)	(3.6635)	(3.5336)	(3.1794)	(2.8540)	(2.7504)	(2.7518)
Dependent variable: Veneer Export								
5 years Mean	-0.1765	-0.3005	-1.1173	-4.5813*	-4.6610*	-3.3685	-1.4848	-3.3701
	(3.4860)	(3.1846)	(2.9982)	(2.7167)	(2.5536)	(2.3855)	(2.4253)	(2.4308)
n+1	1.5135	1.5053	1.9921	2.3195	2.7080	3.2456	3.3195	3.0863
	(2.7880)	(2.8691)	(2.6324)	(2.4490)	(2.2932)	(2.0766)	(2.2777)	(2.0729)
n+2	3.5215	3.3436	2.1970	2.0335	2.1189	2.7799	2.6781	2.6708
	(3.0291)	(2.5929)	(2.5897)	(2.0936)	(2.2358)	(2.1989)	(2.0902)	(2.0644)
n+3	1.8845	3.1531	3.3922	3.1145	3.3142	3.1616	2.8959	3.1771*
	(2.7691)	(2.7644)	(2.4684)	(2.2303)	(2.1530)	(2.0269)	(2.1634)	(1.9133)
n+4	1.4188	2.7920	2.7456	0.3517	3.0285	2.5478	2.1440	2.5974
	(2.9458)	(2.5928)	(2.3585)	(2.2304)	(2.2778)	(2.0939)	(2.1428)	(1.9904)
n+5	0.6906	1.7390	2.3963	0.4396	1.8667	3.2498*	2.7473	3.2863*
	(2.6564)	(2.5950)	(2.4999)	(2.3308)	(2.1688)	(1.8527)	(2.0422)	(1.8337)

Note: Standard errors in brackets. Nonparametric bootstrap estimation of propensity score matching methods (replications = 500). *** significance level at 1%, ** significance level at 5%, and * significance level at 10%.

2.5.2 Exploring heterogeneity in treatment effects

Regarding the significant heterogeneity in economic conditions and institutional structure in developing countries (Acemoglu et al., 2019; Easterly, 2002; Lin and Ye, 2009) and as suggested by Lin and Ye (2009), we explore potential differential effects of the LEB policy.

Following Lin and Ye (2009) and Combes et al. (2019), we use the control function regression approach to test potential sources of heterogeneity[16]. We first start by examining if countries which meet the preconditions of LEB adoption record better performance in processed wood production and export. We then analyze if the time length since the adoption of the LEB policy and the quality of institutions can play on the effect of LEB adoption on processed wood production and export.

Estimation results based on control function approach are reported in Tables 2.4 and 2.5 for sawnwood and veneer production respectively, and in Tables 2.6 and 2.7 for sawnwood and veneer exports respectively. In each column, we run the OLS regression of processed wood production or export on the LEB adoption dummy variable within the common support. The estimated coefficients of the LEB dummy show the mean difference between LEB adopters and LEB non-adopters countries.

The first column in Tables 2.4, 2.5, 2.6 and 2.7 reports the coefficient of the LEB dummy without any control variables. We find a positive and significant effect of LEB policy on the four outcome variables showing that the LEB adopters produce and export more processed wood than non LEB adopters. In column 2, we add the propensity scores from our baseline probit model reported in Table 2.1 to respect the common support as a control function. We find a significant coefficient of the propensity score showing self-selectivity in the models of sawnwood production, sawnwood export and veneer export, unlike the model of veneer production. After controlling for the propensity score, the estimated coefficient of LEB in the models of sawnwood production and export remains positive and significant, and becomes closer to the estimated ATT in Table 2.2. For sawnwood production, the LEB coefficient is about 1.99 in Table 2.4. For sawnwood export in Table 2.6, the LEB coefficient moves from about 7.20 to 17.73. Regarding veneer, the estimated effect of LEB on veneer production remains significant with a magnitude comparable to the estimated ATTs in Table 2.2. However, the LEB coefficient is non significant for veneer export in Table 2.7 as are the estimated ATTs in Table 2.2.

We now turn to the heterogeneity analysis of the treatment effect and begin with processed

[16] See Wooldridge (2015) for more details on control function.

wood production. In column 3, we add the interaction between the LEB dummy and the difference between the estimated propensity score and its sample average. With the addition of this interaction variable, the coefficient of the LEB dummy measures the ATT at mean propensity score. The LEB dummy is still found to have a positive and statistically significant effect. Regarding the coefficient of the interaction term, we find a negative and significant effect in the sawnwood production model in Table 2.4. This result suggests the presence of heterogeneity. More precisely, this results means that the LEB policy is less effective in countries that meet the preconditions of LEB adoption (i.e. higher estimated propensity score). However, we find a negative and non statistically significant effect of the interaction term in the veneer production model in Table 2.5. This result shows no evidence of additional effect on veneer production concerning the LEB adoption preconditions meeting. In column 4, we add an interaction between the LEB dummy and the time since the LEB policy has been adopted. We do not find evidence of this variable. Furthermore, we explore the heterogeneity of the treatment effect with the quality of institutions. In column 5, we add the corruption level and its interaction term with the LEB dummy. While the positive effect of the additive coefficient suggests that corruption reduces sawnwood production in Table 2.4, we do find a positive effect of the interaction term. Therefore, an increase of corruption influences positively the sawnwood production in LEB adopter countries. This result can be related to the fact that the LEB policy tends to encourage the development of upstream logging activities where informal and illegal activities are more common. As a consequence corruption can push forward these illegal and informal logging activities to meet the increase of the demand of downstream wood activities. However, we do not find significant results regarding corruption in the veneer production model of Table 2.5. In columns 6 and 7, we add respectively the quality of law and order, and the quality of bureaucracy. We find that these two institutional variables have a negative effect on both sawnwood and veneer production in LEB adopter countries. These results are related to the fact that better quality of law and order as well as bureaucracy allows to fight against illegal miller and logger which can reduce downstream wood production. Also, the LEB policy is often followed by the creation of special economic zone with restrictive conditions applied to logging activities. These conditions exclude a lot of millers and loggers which then lead to a decrease of logging production and finally to a fall of processed wood production.

Table 2.4: Heterogeneity analysis of the effect of LEB adoption on sawnwood production

Sawnwood production	[1]	[2]	[3]	[4]	[5]	[6]	[7]
LEB	0.3647	1.9957**	2.4150***	1.1059	-4.3216*	4.8292*	7.2959***
	(0.7968)	(0.8978)	(0.9211)	(1.2050)	(2.5749)	(2.6496)	(1.9805)
PS		-7.6699***	-4.6844*	-7.7922***	-8.2017***	-7.9628***	-6.4918***
		(1.9766)	(2.4743)	(1.9795)	(2.0942)	(2.0838)	(2.0518)
LEB*(PS-$\overline{PS}$)			-8.2240**				
			(4.1066)				
LEB*Time				0.0588			
				(0.0531)			
Corruption					-1.0925*		
					(0.6049)		
LEB*Corruption					2.8920***		
					(1.0787)		
Law_order						-0.2831	
						(0.4739)	
LEB*Law_order						-0.9725	
						(0.8606)	
Bureau_quality							3.3004***
							(0.6381)
LEB*Bureau_quality							-3.1084***
							(1.0524)
Constant	21.2239***	23.6170***	22.6855***	23.6552***	26.2488***	24.5485***	17.4087***
	(0.5022)	(0.7940)	(0.9195)	(0.7946)	(1.7283)	(1.8103)	(1.4441)
Observations	1,634	1,634	1,634	1,634	1,575	1,575	1,575
R2	0	0.009	0.012	0.010	0.014	0.012	0.026

Note: robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1.

Table 2.5: Heterogeneity analysis of the effect of LEB adoption on Veneer production

Veneer production	[1]	[2]	[3]	[4]	[5]	[6]	[7]
LEB	1.1719***	1.2117***	1.1985***	1.7960***	0.5313	1.9457***	2.0593***
	(0.1483)	(0.1614)	(0.1636)	(0.2172)	(0.4731)	(0.4913)	(0.3733)
PS		-0.2655	-0.4217	-0.2394	-0.1917	-0.2601	0.0616
		(0.4249)	(0.5288)	(0.4227)	(0.4644)	(0.4565)	(0.4583)
LEB*(PS-$\overline{PS}$)			0.4415				
			(0.8889)				
LEB*Time				-0.0373***			
				(0.0093)			
Corruption					-0.0800		
					(0.1229)		
LEB*Corruption					0.2905		
					(0.1974)		
Law_order						-0.0794	
						(0.0953)	
LEB*Law_order						-0.2730*	
						(0.1591)	
Bureau_quality							0.3530***
							(0.1296)
LEB*Bureau_quality							-0.5192***
							(0.1980)
Constant	1.0926***	1.1924***	1.2512***	1.1826***	1.3559***	1.4516***	0.4366
	(0.0991)	(0.1881)	(0.2223)	(0.1871)	(0.3904)	(0.4054)	(0.3394)
Observations	1,383	1,383	1,383	1,383	1,337	1,337	1,337
R2	0.043	0.044	0.044	0.054	0.044	0.049	0.049

Note: robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1.

In the same vein, we do the same heterogeneity analysis of the treatment effect on processed wood exports. Table 2.6 and Table 2.7 report the results for sawnwood and veneer export respectively. In column 3, the interaction term is not significant in both tables showing no evidence for the precondition meeting of LEB adoption on processed wood export. However, the effect of the LEB dummy still remains positive and significant regarding the sawnwood export and non significant for the veneer export. In column 4, we add the interaction term between the LEB dummy and the time since the introduction of the LEB policy. Unlike the previous results related to production, we now find a negative and significant effect of this interaction term while the additive effect the LEB dummy is positive and significant both for sawnwood and veneer exports. Thus, at the beginning of the introduction of the LEB, the policy contributes to increase processed wood exports (as found in Table 2.3) while its contribution turns to be negative with time. We assume that these results can be related to a lack of good trade infrastructure used by exporters. Just after the introduction of the LEB policy, processed wood exports increase thanks to seaport infrastructures available in the country. However, after a while, seaports become congested following the increase of processed wood exports that need different and better storage facilities than raw log exports. As a consequence, because of a lack of new trade infrastructures to meet the demand of exporters, these latter have to reduce their activities. Finally, we check the heterogeneity in treatment effect on sawnwood and veneer export following the same institutional variables as defined above. We find no evidence of an effect of corruption. However, we find a positive effect of the interaction term between the LEB dummy and both the quality of law and order, and the quality of the bureaucracy in both the sawnwood and veneer export models. In many developing countries where the LEB policy has been implemented, tax is collected at seaport level defined as the timber trade check point. Thus, a higher level of law and order as well as a better bureaucracy quality can drop the time to comply with export procedures and checking and so, in turn, facilitate the transit in the seaport. Also, many European countries for instance require the legal source and impose norms for their wooden imported goods. So, better quality of law and bureaucracy can help exporters of processed woods to sell their products to these countries. At the same time, the additive effect of the LEB dummy is significantly negative on veneer exports when interaction with the quality of law and order (col. 6) or with bureaucracy quality (col.7) are controlled for. Moreover, the magnitude is particularly high. The LEB policy reduces veneer exports by 22.20 % in column 6 and 16.46 % in column 7. As a consequence, the LEB policy should not be introduced in countries with weak law and order or with deteriorated bureaucracy quality at the expense of reducing the exports of veneer. Regarding sawnwood, the additive effect of the LEB dummy is not significant both in columns 5 and 6 and only at 10% for column 7.

Table 2.6: Heterogeneity analysis of the effect of LEB adoption on sawnwood export

Sawnwood export	[1]	[2]	[3]	[4]	[5]	[6]	[7]
LEB	11.9882***	7.2035***	7.2790***	17.7329***	7.3434	1.5715	-8.3124*
	(1.8763)	(1.9522)	(1.9671)	(2.6577)	(6.1019)	(6.0964)	(4.5354)
PS		45.0545***	46.5721***	45.3039***	47.1584***	51.7758***	42.3876***
		(6.1086)	(7.7485)	(6.0390)	(6.4014)	(6.3849)	(6.4003)
LEB*(PS-$\overline{PS}$)			-4.0139				
			(12.6014)				
LEB*Time				-0.6706***			
				(0.1164)			
Corruption					0.6174		
					(1.5906)		
LEB*Corruption					0.0584		
					(2.5564)		
Law_order						2.7913**	
						(1.1551)	
LEB*Law_order						2.1955	
						(1.9468)	
Bureau_quality							-7.8700***
							(1.5652)
LEB*Bureau_quality							9.4349***
							(2.4101)
Constant	17.1646***	-0.6568	-1.2571	-0.7555	-3.1086	-12.4153**	13.8895***
	(1.2516)	(2.7105)	(3.3020)	(2.6796)	(4.9247)	(5.0422)	(4.2059)
Observations	1,389	1,389	1,389	1,389	1,335	1,335	1,335
R2	0.029	0.065	0.065	0.087	0.069	0.080	0.087

Note: robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1.

Table 2.7: Heterogeneity analysis of the effect of LEB adoption on veneer export

Veneer export	[1]	[2]	[3]	[4]	[5]	[6]	[7]
LEB	5.5829***	2.3269	2.2997	5.9231***	-8.6805	-22.2005***	-16.4636***
	(1.6539)	(1.7319)	(1.7343)	(2.2782)	(5.3371)	(5.4252)	(4.1235)
PS		30.1516***	28.5158***	31.3975***	26.1473***	29.4640***	22.3472***
		(5.3854)	(7.0730)	(5.3980)	(5.9761)	(5.6270)	(5.7702)
LEB*(PS-PS)			3.8966				
			(10.9164)				
LEB*Time				-0.2311**			
				(0.0954)			
Corruption					-3.2978**		
					(1.5662)		
LEB*Corruption					5.0727**		
					(2.2018)		
Law_order						-1.2924	
						(1.1214)	
LEB*Law_order						8.5203***	
						(1.7016)	
Bureau_quality							-8.7980***
							(1.5198)
LEB*Bureau_quality							11.2204***
							(2.1438)
Constant	20.3626***	6.5237**	7.2745**	5.9518**	15.9877***	11.0824**	25.8440***
	(1.1875)	(2.7353)	(3.4514)	(2.7394)	(5.3770)	(5.2359)	(4.4333)
Observations	1,094	1,094	1,094	1,094	1,056	1,056	1,056
R2	0.010	0.038	0.038	0.043	0.042	0.065	0.069

Note: robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1.

2.6 Conclusion

The implementation of a international trade restriction policy such as the log export ban (LEB) gives rise the issue of its effectiveness, that is to say, if its primary goals are fulfilled. These goals in the case of the LEB policy is to promote wood processing industry. This study aims at estimating the impact of the LEB policy on both production and exportation of processed wood. We focus on sawnwood and veneer because these two processed wood are different in terms of complexity of their production process.

We use the propensity score matching to assess the average treatment effect on the treated (ATT) of the LEB policy. We find a positive and significant effect of the LEB policy on both sawnwood and veneer production while the effect is stronger in the case of sawnwood (about 4 %) compared to veneer (about 1 %). Moreover, we also find a positive and significant effect on the exports of sawnwood (around 8 %) while we do not find any significant results on the exports of veneer. Moreover, we study the short-term ATT of the LEB policy. We find that the ATT during the first five years of the LEB policy are higher than estimated ATTs reported in the baseline results. Moreover, regarding the sawn timber production, we find no significant effect of the LEB policy for each of the first five years suggesting that ATTs of the LEB policy is cumulative. However, we find significant ATTs for each of the first five years on veneer production while the strongest effect occurs in the first year after the implementation of the policy. Also, we find that ATTs becomes progressively weaker until t + 5. Regarding the exports, we find that the LEB policy is positive and significant until $t+4$ on sawnwood exports. In addition, we investigate the heterogeneity in treatment effects of the LEB policy using control function. We focus on several potential differential effects according to the LEB adoption preconditions meeting, the time length since the LEB adoption and the quality of institutions (corruption, law and order and bureaucracy quality). The results found are comparable to the ATTs results while we find differential effects of the LEB policy mainly according to institutional quality. These latter results confirm the great importance of institutions in terms of policy performances. It is worthy to note that the impact of the LEB policy on the exports of the two type of processed wood is highly sensitive to the quality of law and order and bureaucracy. These results confirm that export of higher value aggregated products need long-term investments to be competitive and these investments are highly dependent on transparent and slim bureaucracy and efficient legal system.

Taken together, threefold conclusions can be drawn. First, the LEB policy has primarily contributed to improving the less complicated stage of wood processing rather than the more complicated processing stage, almost in terms of exports. As a consequence, the development of more complicated processed wood like veneer asks for more than the interdiction of non-processed wood. Veneer needs more skilled labor and more technically advanced machines which call for complex industrial and employment policies. Second, the effect of the LEB policy is decreasing in time suggesting that countries have to accompany the reform with policies that can stimulate long-term investments in the wood processing industry such as trade infrastructure. Third, our result highly the importance of the transparency of the bureaucracy and the performance of the legal system to boost the effect of the LEB policy on exports of both saw timber and veneer. Then, taken together, our results show that the LEB policy can have positive and lasting impacts on production and exports of processed wood if it is associated to more complex industrial, employment policies and better institutions that help to develop trade infrastructure, quality of trade process (e.g. exports procedures), technical know-how and skilled labour force, etc.

Moreover, it is worth noting that the LEB policy has been applied for purposes other than timber industry development. The LEB reform has been implemented to preserve the forest (von Amsberg, 1998) or to increase employment (van Kooten, 2014) in some countries. Accordingly, our results on production and exports of processed woods have to be balanced with the potential consequences of the LEB reform on forest conservation or job opportunities. To our knowledge, there is no studies estimating the impact of the LEB policy both on deforestation and job creation with panel data and for several countries. These research questions are highly interesting for future research agendas.

Appendix A

Table A1: Variables definition

Variables	Definition	Source
Log Export Ban	Log export ban is the dummy variable taking 1 if country apply ban on log export and 0 if not	FPER*
Roundwood export	Volume of roundwood exported (m3)	ITTO**
Sawnwood production	Volume of sawnwood production (m3)	ITTO
Veneer production	Volume of veneer production (m3)	ITTO
Sawnwood export	Volume of sawnwood exported (m3)	ITTO
Veneer export	Volume of veneer exported (m3)	ITTO
Sawnwood price	The average price of Sawnwood export by m3 in FOB (USD)	ITTO
Veneer price	The average price of Veneer export by m3 in FOB (USD)	ITTO
Sawnwood import	Volume of Sawnwood imported (m3)	ITTO
Veneer import	Volume of Veneer imported (m3)	ITTO
Agricultural value added	It includes forestry, hunting, and fishing, as well as cultivation of crops and livestock production (% of GDP).	WDI***
Labor force	The labor force is the supply of labor available for producing goods and services in an economy. It includes people who are currently employed and people who are unemployed but seeking work as well as first-time job-seekers.	WDI
GDP per capita	Per capita gross domestic product in constant 2010 US$)	WDI
Manufacturing value added	Manufacturing refers to industries belonging to ISIC divisions 15-37 (% of GDP).	WDI
FDI inflows	Foreign direct investment are the net inflows of investment to acquire a lasting management interest in an enterprise operating in an economy other than that of the investor (% of GDP).	WDI
Exchange rate	Official exchange rate (LCU per US$, period average)	WDI
Inflation	Inflation reflects the annual percentage change in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals (%).	WDI
Corruption	This is an assessment of corruption within the political system. Such corruption is a threat to foreign investment for several reasons: it distorts the economic and financial environment; it reduces the efficiency of government and business by enabling people to assume positions of power through patronage rather than ability; and, last but not least, introduces an inherent instability into the political process. Higher values indicate higher corruption.	ICRG****
Law and order	This variable forms a single component, but its two elements are assessed separately, with each element being scored from zero to three points. To assess the Law element, the strength and impartiality of the legal system are considered, while the Order element is an assessment of popular observance of the law. Thus, a country can enjoy a high rating 3 in terms of its judicial system, but a low rating 1 if it suffers from a very high crime rate if the law iroutinely ignored without effective sanction (for example, widespread illegal strikes). Higher values indicate higher law and order.	ICRG
Bureaucratic quality	The institutional strength and quality of the bureaucracy is another shock absorber that tends to minimize revisions of policy when governments change. Therefore, high points are given to countries where the bureaucracy has the strength and expertise to govern without drastic changes in policy or interruptions in government services. In these low-risk countries, the bureaucracy tends to be somewhat autonomous from political pressure and to have an established mechanism for recruitment and training. Countries that lack the cushioning effect of a strong bureaucracy receive low points because a change in government tends to be traumatic in terms of policy formulation and day-to-day administrative functions. Higher values indicate higher bureaucracy quality.	ICRG
Quality of government	The mean value of the ICRG variables "Corruption", "Law and Order" and "Bureaucracy Quality", scaled 0-1. Higher values indicate higher quality of government.	Quality Of Government Institute
Electricity Access	Access to electricity is the percentage of population with access to electricity.	WDI
Coastal	Coastal is the dummy variable taking 1 if country is coastal and 0 if country is landlocked	

*Forest Product Export Restriction; **International Tropical Timber Organization; ***World Development Indicators; ****International Country Risk Guide.

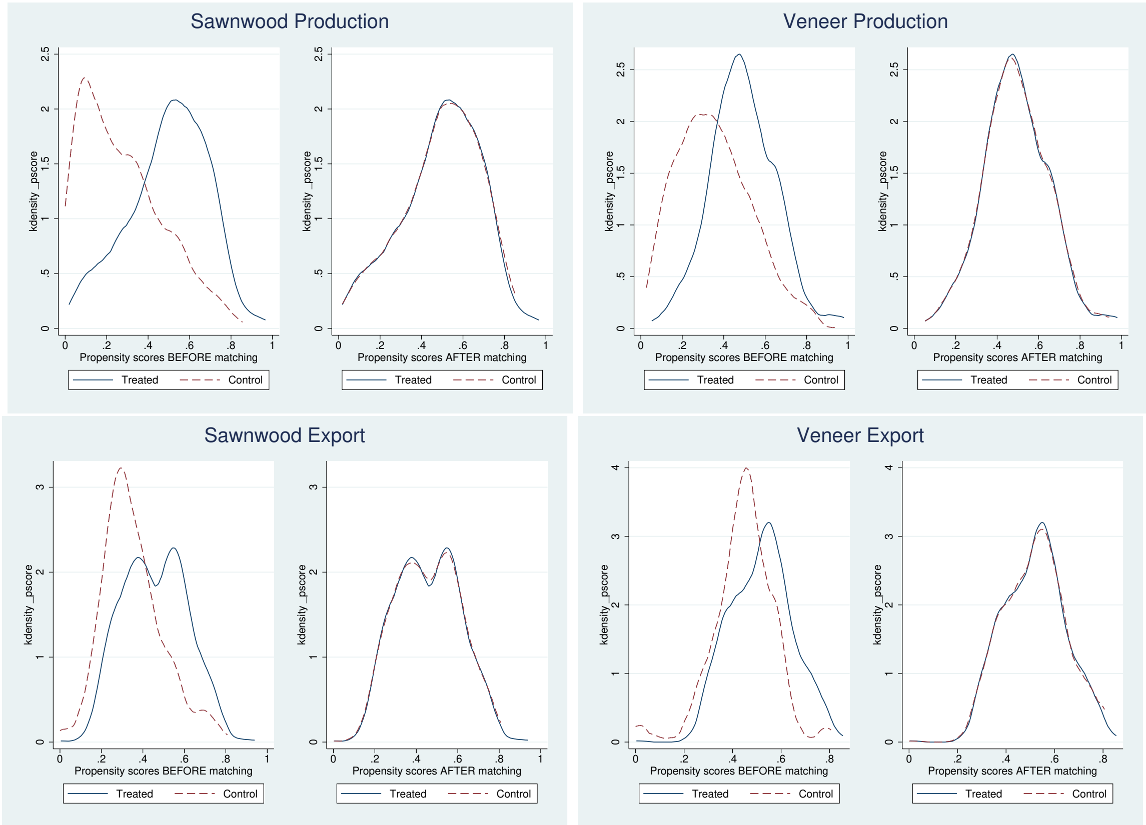
Table A2: Countries list, adoption and end years.

Nř	Country	Income group	Adoption year	Nř	Country	Income group	Adoption year
1	Afghanistan	Low Income		43	Kenya	Lower-Middle Income	
2	Algeria	Upper-Middle Income		44	Kyrgyzstan	Lower-Middle Income	
3	Angola	Lower-Middle Income	2013	45	Lao	Lower-Middle Income	2016
4	Argentina	Upper-Middle Income		46	Libya	Upper-Middle Income	
5	Armenia	Upper-Middle Income		47	Malawi	Low Income	2008
6	Bangladesh	Lower-Middle Income		48	Malaysia	Upper-Middle Income	1985
7	Belize	Upper-Middle Income	2012	49	Mali	Low Income	2000
8	Benin	Low Income	2005	50	Mauritania	Lower-Middle Income	
9	Bhutan	Lower-Middle Income		51	Mexico	Upper-Middle Income	
10	Bolivia	Lower-Middle Income	1996	52	Moldova	Lower-Middle Income	
11	Brazil	Upper-Middle Income	2005	53	Mongolia	Lower-Middle Income	
12	Burundi	Low Income		54	Montenegro	Upper-Middle Income	
13	Cambodia	Lower-Middle Income	1997	55	Morocco	Lower-Middle Income	
14	Cameroon	Lower-Middle Income	1999	56	Mozambique	Low Income	2002
15	Central African Republic	Low Income		57	Myanmar	Lower-Middle Income	2014
16	Chad	Low Income		58	Nepal	Low Income	
17	Colombia	Upper-Middle Income	1967	59	Nicaragua	Lower-Middle Income	2006
18	Congo	Lower-Middle Income	2000	60	Niger	Low Income	
19	Congo Democratic	Low Income		61	Nigeria	Lower-Middle Income	1985
20	Costa Rica	Upper-Middle Income	1996	62	Pakistan	Lower-Middle Income	
21	Cote d'Ivoire	Lower-Middle Income	1995	63	Papua New Guinea	Lower-Middle Income	1990
22	Dominican Republic	Upper-Middle Income		64	Paraguay	Upper-Middle Income	1972
23	Ecuador	Upper-Middle Income	2004	65	Peru	Upper-Middle Income	1972
24	El Salvador	Lower-Middle Income		66	Romania	Upper-Middle Income	
25	Eritrea	Low Income		67	Russia	Upper-Middle Income	
26	Ethiopia	Low Income		68	Rwanda	Low Income	
27	Fiji	Upper-Middle Income	1997	69	Samoa	Lower-Middle Income	
28	Gabon	Upper-Middle Income	2011	70	Senegal	Lower-Middle Income	1998
29	Gambia	Low Income	2012	71	Sri Lanka	Upper-Middle Income	
30	Georgia	Upper-Middle Income		72	Suriname	Upper-Middle Income	
31	Ghana	Lower-Middle Income	1994	73	Tanzania	Low Income	2004
32	Guatemala	Upper-Middle Income	1996	74	Timor-Leste	Lower-Middle Income	
33	Guinea	Low Income	2006	75	Togo	Low Income	2012
34	Guyana	Upper-Middle Income		76	Tunisia	Lower-Middle Income	
35	Haiti	Low Income		77	Turkey	Upper-Middle Income	
36	Honduras	Lower-Middle Income	2007	78	Ukraine	Lower-Middle Income	2005
37	India	Lower-Middle Income	2013	79	Uzbekistan	Lower-Middle Income	
38	Indonesia	Lower-Middle Income	2001	80	Vanuatu	Lower-Middle Income	
39	Iran	Upper-Middle Income		81	Venezuela	Upper-Middle Income	2001
40	Iraq	Upper-Middle Income		82	Viet Nam	Lower-Middle Income	1992
41	Jamaica	Upper-Middle Income		83	Zambia	Lower-Middle Income	1998
42	Kazakhstan	Upper-Middle Income		84	Zimbabwe	Lower-Middle Income	

Table A3: Descriptives statistics

Variable	Observations	Mean	Std. Dev.	Min	Max
Sawnwood production (% - relative to roundwood production)	2,062	22.592	16.37	0	140
Veneer production (% - relative to roundwood production)	1,669	1.796	3.124	0	31.268
Sawnwood export (% - relative to sawnwood production)	1,736	23.827	35.12	0	835.583
Veneer export (% - relative to veneer production)	1,300	23.772	28.17	0	180
LEB dummy	2,062	.353	.478	0	1
Manufacturing, value added (% of GDP)	1,984	13.147	6.117	.721	50.037
GDP per capita (constant 2010 US $)	1,994	3233.3	3107.373	178.802	15190.099
Roundwood export (quantity m^3)	2,062	492966.08	2994022.3	0	51056968
Agriculture, value added (% of GDP)	1,987	17.938	10.874	2.181	57.069
FDI inflows (% of GDP)	1,990	3.388	4.758	-37.155	46.275
Labor force (number of people)	2,062	19328216	53939495	46035	4.947e+08
Total trade (% of GDP)	1,551	72.202	35.259	.167	220.407
Exchange rate (LCU per $)	1,601	4200480.5	1.680e+08	.002	6.723e+09
Inflation (%)	1,460	22.303	185.371	-18.109	4734.914
Sawnwood price (US $)	1,996	474.948	396.309	16.423	6293.706
Veneer price (US $)	1,519	1427.896	1627.09	53.014	19086.178
Sawnwood import (quantity m^3)	1,736	140229.7	352648.5	0	3082760
Veneer import (quantity m^3)	1,300	7937.302	30770.585	0	432140
Electricity access (% of population)	1,763	66.202	32.203	1.554	100
Quality of governance (0-1)	1,637	.437	.115	.111	.75
Corruption (0-6)	1,578	2.271	.803	0	5
Law and order (0-6)	1,578	3.043	1.03	0	6
Bureaucracy quality (0-6)	1,578	1.704	.782	0	3
Coastal dummy	2,062	.77	.421	0	1

Figure A1: Common support propensity



Source: authors

Chapter 3

The log export ban effect on employment: Lessons from wood-processing firms in developing countries

Abstract

This study assesses the impact of log export ban (LEB) adoption on forest industry firm employment in 1,739 firms surveyed between 2006 and 2018 located in 69 developing countries. Using the entropy balancing approach, we highlight that LEB policy adoption significantly increases employment in firms located in adopter countries compared to firms in non-adopter countries. Furthermore, when specifying employment based on production and non-production status, our results remain robust only for production employment. Moreover, another analysis based on skill-biased job and contract type (permanent versus temporary) showed that LEB policy increases only permanent and unskilled jobs. Also, we use alternative estimation and consider potential endogeneity issues using the instrumental variables approach. All the above results remain the same. Our results can be explained by the context of wood-processing industries in developing countries, where companies are labor-intensive and focus mainly on low-complexity wood processing. Our results suggest that LEB policy needs to be supported by other industrial and employment policies. Such policies would, for example, attract more FDI and technology transfers and develop highly qualified training.

JEL classification: C21, F13, J21, O14, Q23.

Keywords: Log export ban, Wood processing, firm's employment, Entropy balancing.

3.1 Introduction

The log export ban (LEB) policy is an environment, trade restriction, and industrialization policy adopted in many forest-rich developing countries. There are three reasons explaining the policy adoption. First, adopters countries aim to produce and export more high-value processed wood (Kishor et al., 2004; Marchand and Zerbo, 2023). Second, LEB policy is adopted to control deforestation, forest degradation and to protect endangered tree species. By applying restrictions on log export, this policy decreases international demand addressed to domestic timber, allowing a decrease in forest pressure (Resosudarmo and Yusuf, 2006). Lastly, LEB aims to stimulate employment in all forest industries (logging and wood processing) (van Kooten, 2014).

Employment in the forest industry involves logging and wood processing. The effect of LEB policy can affect different logging activities and wood processing activities. We first focus on logging activities, which is wood extraction. It is the upstream activity in the forest industry production chain. Before LEB adoption, most forest-rich developing countries were log exporters, accounting for a considerable share of exports by volume. The logging activity is thriving and meeting international demand for wood. After policy adoption, there are two trends of view concerning logging activity. On one view, LEB policy adoption in countries with comparative advantage in log production reduces logging in terms of employment. For Dudley (2004), employment in logging might decrease due to log harvest drop. Indeed, LEB policy adoption allows a decrease in international demand addressed to the domestic timber market. The export prohibition in forest-endowed countries generates a fall in log price from the world price to the domestic lower price. This decrease in log price makes logging less profitable, which can lead to reduced employment. On the other view, LEB could increase logging employment. Indeed, the fall in log prices makes log supply cheap for the domestic wood processing industry. Also, the LEB policy enables the implantation of foreign firms in the wood processing industry. Then, domestic demand for logs addressed to logger increases after policy adoption, leading to more logging employment. However, the LEB effects on logging employment remain ambiguous because there is no clear evidence of whether the increase in domestic demand following the adoption of the reform is equivalent to greater than or less than the former international demand for local log production.

On the wood processing industry side, we meet before policy adoption low level of wood processing like the global industry sector in developing countries. There is a low level of employment in wood processing dominated by small-scale industry. Then, the LEB policy adoption could increase employment. LEB requires wood processing before export. Then, the main logs exported formerly can be processed domestically in the LEB adopter country. Also, the fall in log price linked to LEB adoption enables domestic wood processors to source logs at a lower cost. The log supply rise creates more employment in the wood processing industry. Moreover, according to Resosudarmo and Yusuf (2006), LEB creates more jobs in small, labor-intensive industries. Developing forest-rich countries are often more labor-intensive because of technological drawbacks and low capital investment. Consequently, the growth in log sourcing requires more employment in the wood-processing industry. Moreover, the LEB policy attracts foreign investment in the wood-processing sector, leading to more employment. Indeed, FDI allows the introduction of new industries by mergers and acquisitions or the establishment of new firms in host countries by employing in the domestic labor market. In addition, the wood-processing industry is multiple. There are less and more complex processing levels implying different types of labor. Based on Marchand and Zerbo (2023) analysis, only wood's less complicated processing level significantly increases after policy adoption. This level of processing requires low skills, which is cheaper than a more complex processing level. In addition, the LEB is a medium to long-term policy that requires more permanent and skilled jobs to meet the labor needs of the wood processing industry. Furthermore, the increase in wood sourcing within companies could affect jobs directly linked to production more than other jobs.

Overall, LEB should increase total employment in the processed wood sector, but not all types of employment. Given that LEB policy aims to stimulate the wood processing sector, we focus our analysis on employment in this sector. So, our study aims to assess the causal impact of LEB policy on labor in the wood processing industry at the firm level in developing countries. To our knowledge, no study has investigated this issue so far. We contribute empirically to assess the causal impact of the LEB policy in three points.

First, we contribute to the literature on the infant-industry argument for developing countries, especially in the forest industry sector. The infant industry argument states that developing countries suffer from free trade by specializing in sectors where dynamic learning externalities are low (Saure, 2007). Then, these countries apply restrictive international trade policies to protect novice processing industries against foreign companies well established in developed countries by import substitution. In addition to import substitution, other countries apply restrictions to promote exports by prohibiting the export of raw materials with a comparative advantage in order increase their production of high-value-added goods. For forest-rich developing countries, LEB adoption promotes the wood processing industry. This reform needs more labor. Thus, in addition to the limited literature linking protectionism and employment in the forestry sector, we contribute to the debate on infant-industry protection and employment in the manufacturing sector by linking LEB reform to employment in the wood-processing sector.

Second, using an impact analysis approach, we use a sample of wood-processing firms located in developing countries to make evidence of LEB policy adoption effect on firm-level employment. We use the entropy balancing method developed by Hainmueller (2012) to address selection bias and for efficiency reasons rather than former policy evaluation methods like propensity score matching.

Third, we further investigate heterogeneities of policy effect by focusing on different employments. Firstly, we disaggregate total employment to check the differential impact of LEB on production workers and non-production workers. Secondly, we study the link between LEB policy adoption and jobs based on permanent versus temporary workers. Lastly, we investigate the relationship between LEB policy and skill-biased employment. We check for skill-biased employment based on firm-level data to capture the relationship between LEB policy adoption and low-skilled and high-skilled jobs.

Using the entropy balancing approach to estimate the Average Treatment Effect on the Treated (ATT) of LEB policy, we find a positive and significant effect of LEB policy adoption on forest industry total employment at about 25% in firms located in the country under LEB compared to firms in the non-adopter country. Furthermore, we check the heterogeneity by disaggregating total workers into production and non-production workers. Only production employment is affected positively and significantly by LEB policy. In addition, we break down total employment into permanent and temporary jobs. Only the permanent workers are positively affected by LEB policy adoption. Moreover, we disaggregate permanent employment following skilled and unskilled labor. In this case, LEB policy adoption positively and significantly affects only unskilled jobs. Furthermore, we use an alternative estimation method to support our baseline. We employ instrumental variables for binary endogenous variables as defined by Wooldridge (2015) using tariff rate on customs duty and the share of neighbor LEB policy adoption as instruments. This estimation strategy confirms the results from the baseline model.

The remainder of this paper proceeds as follows. Section 3.2 describes micro and macro data and stylized facts, while the next section provides the identification strategy. Section 3.4 presents our baseline results. Section 3.5 highlights robustness checks. The last section presents the conclusion and discusses the policy implications.

3.2 Data

3.2.1 Employment variables

Our primary source of data is the World Bank Enterprise Surveys (WBES), which surveys the national representative firms in developing countries and used, for instance, by Chauvet and Jacolin (2017); Chauvet and Ehrhart (2018); Cole et al. (2018); Harrison et al. (2014); Garone et al. (2020) and Kouamé and Tapsoba (2019). Our dependent variable is multiple and based on the nature of our analysis. First, total employment measures the total of permanent and temporary workers in production and non-production areas in each company. They work eight hours or more per day. Furthermore, there is some heterogeneity among the employees. So, the total employment can be divided between production and non-production workers.

Production employment is the total of full-time employees involved directly in the production process. They are engaged in processing, fabricating, assembling, inspecting, storing, handling, packing, warehousing, shipping (but not delivering), maintenance, repair, product development, auxiliary production for the plant's use (e.g., power plant), recordkeeping and other services closely linked to these production operations. Non-production employment is the number of full-time non-production workers working outside of the production area. They include all employees not involved in the production work enumerated above.

Moreover, we break down total employment into permanent and temporary workers. Permanent workers are all paid employees contracted for one or more fiscal years, have a guaranteed employment contract renewal, and work up to 8 or more hours per day. Temporary work is defined as all short-term workers with no guarantee to renew their employment contract and work above 39 hours per week during their contract.

Finally, the production process requires skilled and non-skilled employees. Thus, we can decompose the total permanent employment into skilled and non-skilled workers. Skilled employment is the number of full-time skilled production workers. They have some specific knowledge and competencies in their work. They may have attended a secondary school level, university, or technical school. Unskilled workers represent the number of full-time and unskilled production employees. Unskilled employment does not require special training, education, or skill to do this job.

3.2.2 Other firm-level data

In marge of employment data, WBES contains information on business characteristics and performance that are important for our analysis. Our analysis includes firm characteristics such as ownership, size, financial access, labor market regulation, multinational status, firm age, and former annual sales.[1] Thus, we control for ownership variables showing the principal capital held by domestic private agents, foreign agents, and the government. Aguilera et al. (2021) show that state ownership is negatively linked to firm performance. Private owners, foreign owners and the government have different purposes. Generally, governments guide their actions toward social benefits that can contrast with private and foreign ownership purposes. Hijzen et al. (2013) highlight that foreign ownership is associated with higher wages and employment.

Moreover, we include the firm size because the policy effect could be different between large, medium and small firms. Small enterprises have less than 20 employees, medium companies have

[1]Table A5 in the Appendix describes all firm variables used in this study.

between 20 and 99 workers, and large enterprises have more than 100 employees. Furthermore, we control access to credit like Chauvet and Jacolin (2017) to show if the company has a line of credit in a financial institution. Firms with access to credit could raise their production and employment through the new projects and absorb easily new policy effects. We also control labor market regulation that can highlight how authorities regulate employment. For this concern, we use a subjective measure of how the firm manager considers the influence of labor market regulation on a firm's employment. We use a subjective measure to check how this regulation impacts firm employment. This variable is thus a subjective measure of the degree of an obstacle due to law and it ranges from 0 (no obstacle) to 4 (strong obstacle). Following Kouamé and Tapsoba (2019), we include firm age captured by young, mature, and older firms in our estimation. Young represents 1 to 5 years, mature is firm with ages between 6 and 15 years old and older are companies with more than 15 years old. This measure allows for capturing firm production experience.

Furthermore, enterprises that are part of a multinational or large company are in front of company exigences that can affect firm productivity and employment. These firms benchmark with the best firm's performances of the group to increase these productions. This benchmarking could affect the employment of firms that are part of large companies. So the variable *multinational* is a dummy variable, taking 1 for firms of large enterprise groups and 0 otherwise. Lastly, we control the former sales of the firm that can act on the company's production and employment policy. Thus, we use the total annual sales three years ago. Firms that achieved high performance in sales three years ago could affect the supplement revenue to increase production by employing more.

3.2.3 Country level data

Our interest variable is the LEB policy adoption. It comes from the FPER database that identifies prohibition applied on the log export, as explained by Marchand and Zerbo (2023). LEB is a binary variable taking 1 when the firm is in a country under LEB policy and 0 otherwise. LEB is country-level data because the policy is national and specific to each country. Thus, there are 976 firms in non-LEB adopters countries and 667 firms in treatment countries.

We include five main macroeconomic variables that could affect both LEB policy adoption and forest firm-level employment: GDP per capita growth, trade openness, foreign direct investment, the rule of law and government effectiveness.[2] All macroeconomic variables are from World Development Indicators (WDI) for economic variables and World Government Indicators (WGI) for institutional variables. To avoid endogenous problems, we lag each macro-variable for two periods. GDP per capita growth is used to capture the firm-level productivity change linked to economic environment changes. Also, we include the foreign direct investment that is a factor of employment in host countries. Trade openness shows the extent to which countries are open for industrial production for trade purposes. Lastly, the rule of law and government effectiveness control the institutional and political environment which are essential for initial policy targets, policy implementation and firm-level productivity (Kouamé and Tapsoba, 2019).

3.2.4 Graphical evidence

This section presents graphical evidence of the linkage between LEB policy adoption and employment in our sample.[3] Figure 3.1 reports the average of total workers between treatment and control groups. Firms in a country under LEB policy have higher total workers than firms in non-adopter countries. Figure 3.1 compares production and non-production employment based on the LEB policy adoption status. We observe that enterprises under LEB policy have higher levels of production workers. The employment level remains high for the treatment group in non-production areas, but the differences between treated and untreated are slightly low, with an average difference of two workers.

Moreover, focused on permanent and temporary employment, we check the difference between firms under LEB and non-LEB adopters. Figure 3.1 highlights that permanent workers are higher in the treatment group than the control group. However, temporary employment is more elevated in firms under the LEB policy with low differences.

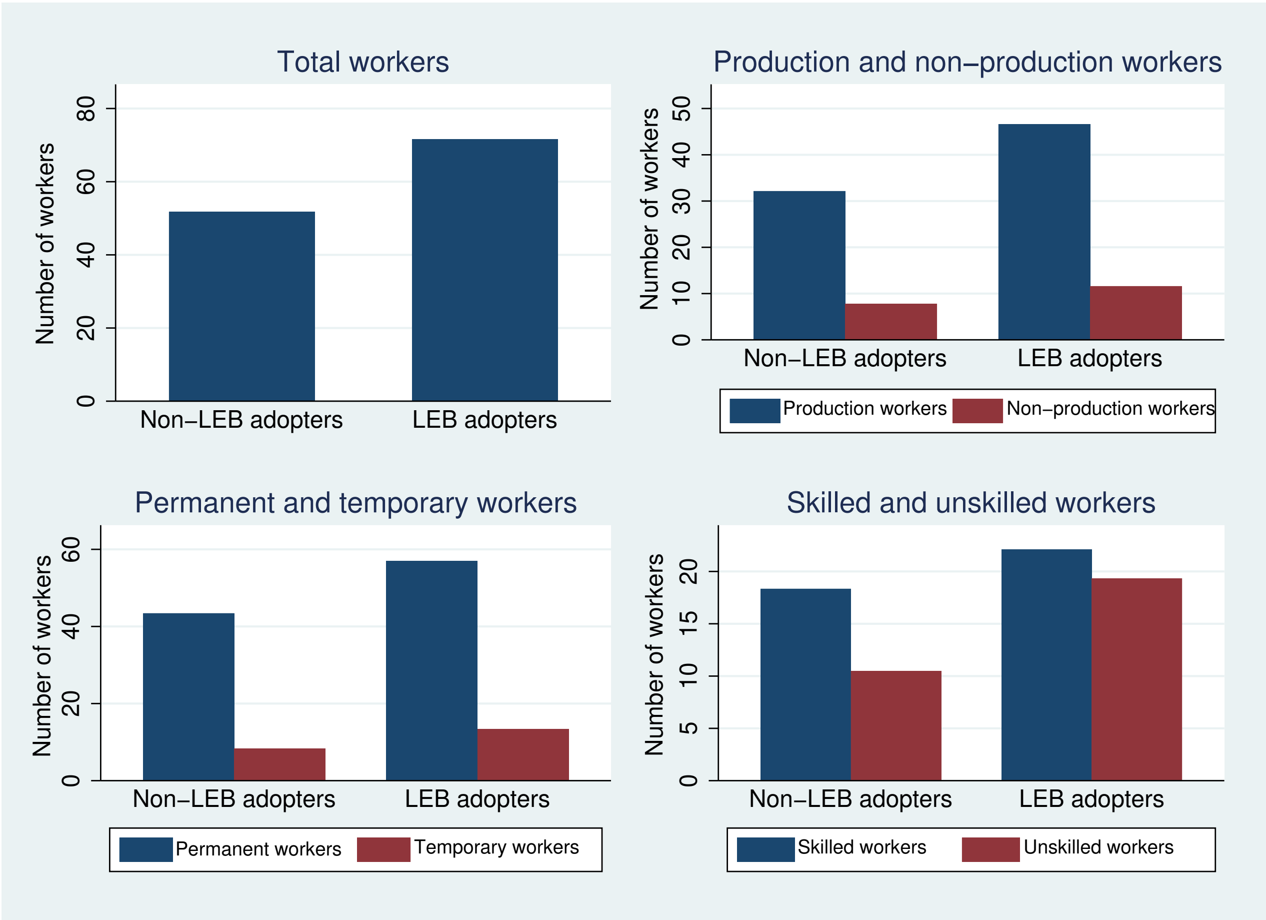
Furthermore, we focus our analysis on skill-biased employment. Figure 3.1 reports the average of skilled and unskilled workers. In each case, the treatment group records more

[2] Table A5 in the Appendix describes these variables.

[3] Table A4 in the Appendix provides t-tests to compare the mean of employment variables between adopter and non-adopter countries. These statistical tests support the graphical evidence presented hereafter.

workers than the untreated group. The number of workers for unskilled employment is much higher in LEB policy adopters related to the untreated group. The difference is lower in the case of skilled. Overall, the treatment group records a higher level of employment than the control units. The t-tests reported in Table A4 confirm each graphical evidence. These stylized facts give an overview of the correlation between our dependent and treatment variables but do not provide any causal relationship.

Figure 3.1: Workers by LEB



3.3 Identification strategy

This study analyzes the effect of the LEB policy adoption on forest industry employment in developing countries. The treatment is attributed to firms in the country under a LEB policy. This policy is applied to increase the employment level in the forest industry. The LEB adoption depends on many factors, including trade openness, foreign direct investment, rule and law and government effectiveness. These factors may also affect the employment level in the forest industry. Thus, LEB will front of a selection bias problem. To address this concern, we focus on a matching approach.

Our potential outcome for this study is wood-processing industry employment noted Y. We denote Y^0, the firms not located in the country under the LEB (T=0) and Y^1, the companies operating in the country under treatment (T=1). Thus, the causal effect is the difference between Y^0 and Y^1. Using a matching approach allows reproducing a situation close to a frame where units are randomly assigned to treatment. We match treated units with untreated regard all pre-treatment characteristics which are as similar as possible. Then, the average treatment effect on treated based on matching can be defined as follows:

$$ATT = E[Y_{i1}|T = 1, X = \chi] - E[Y_{i0}|T = 0, X = \chi], \tag{3.1}$$

where χ is a vector of pre-treatment characteristics described in Subsection 3.2.3, correlated with treatment assignment and potentially correlated with the outcome variable. $E[Y_{i1}|T = 1, X = \chi]$ is the expected outcome for units assigned to treatment, and $E[Y_{i0}|T = 0, X = \chi]$ is the expected outcome for the best counterfactual of the unit that receives treatment.

In this study, we use the entropy balancing method of Hainmueller (2012) to match treated units with their untreated counterfactual group. This identification strategy has been recently applied by Neuenkirch and Neumeier (2016) to analyze the effect of US economic sanction on poverty, Balima (2017) to assess the effect of domestic bond market participation on financial dollarization and Apeti (2023) to assess the mobile money adoption effect on consumption volatility. Entropy balancing is implemented in two steps. The first step is to compute and apply weights to units not exposed to treatment, allowing the average of pre-treatment variables in the control group not to be statistically different from the average in the treated group. This step creates a synthetic group not subject to treatment but with pre-treatment observables very close to the treated group. In the second step, we use the weight from the first stage in regression with the treatment indicator as an explanatory variable to counteract the eventual influence of pre-treatment differences on the treatment effect. In addition, we add time-specific regarding the global financial crisis and country-specific impacts to consider heterogeneity regarding the economic, political, and institutional differences.

As highlighted by Neuenkirch and Neumeier (2016), entropy balancing has several advantages compared to other traditional matching approaches by combining both matching and regression approaches. First, a significant advantage is that entropy balancing is non-parametric, thus requiring no specification of an empirical model for either the outcome variable or selection into treatment. Hence, potential types of misspecification like those, for instance, regarding the functional form of the empirical model, which likely leads to biased estimates, are ruled out. Also, in contrast to regression-based analysis, treatment effects estimates based on entropy balancing do not suffer from multicollinearity, as the reweighting scheme orthogonalizes the covariates concerning the treatment indicator. Second, entropy balancing ensures a high covariates balance between the units treated and the counterfactual group, even in small samples. In traditional matching methods such as nearest neighbor matching or propensity score matching, each treated unitin the simplest caseis matched with the one unit non-subject to the treatment closest to a metric balancing score. Accordingly, the control group is composed of only a subset of the units that are not subject to treatment (Hainmueller, 2012; Diamond and Sekhon, 2013). Thus, with the conventional matching approach, each unit non-assigned to treatment either receives a weight equal to 0 when it does not represent the best match for a treated unit or 1 if it does represent the best match for one treated uni. However, when the number of untreated units is limited and the number of pre-treatment characteristics is large, this procedure does not guarantee a sufficient balance of pre-treatment characteristics across the treatment and control groups. This issue is serious, as a low covariate balance may lead to estimation bias. However, with entropy balancing, the vector of weights attributed to the units not assigned to treatment can contain any non-negative values. Thus, a synthetic control group is designed that represents a virtual image of the treatment group. Entropy balancing can be explicit as a generalization of conventional matching approaches. Finally, by combining the reweighting scheme with regression analysis, entropy balancing allows us to adequately address the longitudinal nature of our data. Thus, we control for both country-fixed and time-fixed effects to control for potential unobserved heterogeneity across countries and bias linked to changes over time, independent of treatment. Regarding structural differences between our two groups, this strategy aims at creating identical macroeconomic and institutional conditions between adopters and non-adopters.

3.4 Empirical results

3.4.1 Descriptive statistics

As defined above, we check for the first stage of our estimation strategy. Table 3.1 shows the simple comparison of pre-reweighting sample means of matching covariates between firms under LEB adoption (column (1)) and control firms, which are our potential synthetic control group (column (2)). Column (3) reveals the mean difference between our two groups. The last column shows the p-value of the difference between the treatment and control groups. Except for trade openness and government effectiveness, the significant difference highlights the bias that could cause a potential selection problem. Thus, it is important to identify an appropriate synthetic control group to fulfill our matching conditions.

Table 3.1: Before reweighting

	(1)	(2)	(3)=(2)-(1)		
	LEB	No LEB	Difference	t-Test	p-Val.
GDP per capita growth$_{t-2}$	5.041	5.506	.465	3.29	0.001
Trade openness$_{t-2}$	71.14	71.761	.621	.425	0.67
Foreign Direct Investment$_{t-2}$	4.243	4.986	.743	2.756	0.006
Rule of Law$_{t-2}$	-.719	-.641	.077	3.406	0.000
Government effectiveness$_{t-2}$	-.565	-.563	.002	0.09	0.928
Observations	667	976			

In Table 3.2, we compute a synthetic control group as defined above by reweighting the control units (column (4)). This approach allows us to build the best synthetic control similar to treatment units. Column (5) reports the mean difference between treatment and control groups. The t-test and the p-value show statistically no difference between all covariates. Thus, statistical evidence highlights the efficacy of entropy balancing to make a perfect synthetic control group related to the treatment group.

Table 3.2: After reweighting

	(1)	(4)	(5)=(4)-(1)		
	LEB	Control	Difference	t-Test	p-Val.
GDP per capita growth$_{t-2}$	5.041	5.041	0.000	-0.000	1.000
Trade openness$_{t-2}$	71.14	71.11	0.03	0.017	0.987
Foreign Direct Investment$_{t-2}$	4.243	4.241	0.002	0.008	0.993
Rule of Law$_{t-2}$	-.719	-.719	0.000	0.005	0.996
Government effectiveness$_{t-2}$	-.565	-.565	0.000	-0.002	0.998
Observations	667	667			

3.4.2 LEB and total employment

Our dependent variable is the total number of workers in each wood-processing firm. Thus, we first estimate the effect of LEB policy adoption on total employment in column (1) with a set of micro-firm level variables using a simple ordinary least-squared (OLS) estimation. For the following columns, we focus on the weights computed previously using the weighted least squared (WLS) method to estimate the effect of LEB on the wood processing firms' employment, as presented in Equation 3.2. In columns (2)-(6), we report the results with firm-level variables and matching covariates used in the first stage to construct our synthetic group added one by one. Putting matching covariates in the second stage improves matching quality, as defined in Section 3.3.

$$log(Employment_{i,t-1}) = \beta_0 + \beta_1 LEB_{i,t-1} + \gamma X_{i,t-1} + \lambda Y_{i,t-2} + \eta_i + \theta t + \epsilon_{i,t} \tag{3.2}$$

where $Employment_{i,t-1}$ is the dependent variable and represents total employment. $LEB_{i,t-1}$ is our interest variable and $X_{i,t-1}$ represents the firm-level variables. $Z_{i,t-2}$ is a set of macro-level variables. η_i, θ_t represent the fixed effect for country and year. $\epsilon_{i,t}$ is the error.

Table 3.3 reports the results. For all columns, we control for country-fixed and time-fixed effects. In each column, the LEB policy adoption increases significantly the total worker number in the wood-processing firms in LEB adopter countries compared to non-adopters. Based on column (6) with the set of covariates, LEB policy adoption increases total employment by about 25%.

Table 3.3: Log export ban and total employment

Total workers	(1)	(2)	(3)	(4)	(5)	(6)
LEB_{t-1}	0.183**	0.181*	0.183*	0.184*	0.261**	0.250**
	(0.085)	(0.106)	(0.103)	(0.103)	(0.102)	(0.107)
Medium firms	1.359***	1.362***	1.363***	1.363***	1.360***	1.372***
	(0.028)	(0.036)	(0.036)	(0.036)	(0.037)	(0.037)
Large firms	2.962***	2.995***	2.990***	2.994***	3.001***	2.998***
	(0.048)	(0.084)	(0.083)	(0.084)	(0.088)	(0.088)
Domestic private	0.002*	0.002	0.002	0.002	0.002	0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Foreign private	0.003***	0.003*	0.003*	0.003*	0.003*	0.003*
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Government	0.002	0.001	0.001	0.001	0.002	0.002
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Access to finance	0.022	-0.004	0.004	0.003	-0.010	-0.011
	(0.031)	(0.045)	(0.045)	(0.045)	(0.047)	(0.047)
Multinational	-0.140***	-0.209***	-0.212***	-0.211***	-0.196**	-0.206***
	(0.053)	(0.080)	(0.078)	(0.078)	(0.079)	(0.079)
Firm age	0.033*	0.049**	0.053**	0.053**	0.045*	0.047*
	(0.020)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)
Labor market Regulation	0.034**	0.018	0.017	0.017	0.019	0.022
	(0.013)	(0.018)	(0.018)	(0.018)	(0.019)	(0.020)
$Sales_{t-3}$	0.011***	0.014***	0.014***	0.014***	0.014***	0.012***
	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
GDP per capita $growth_{t-2}$		0.010	0.009	0.010	-0.004	-0.007
		(0.010)	(0.010)	(0.011)	(0.012)	(0.012)
Trade $openness_{t-2}$			-0.000	-0.000	-0.001	-0.001
			(0.002)	(0.002)	(0.002)	(0.002)
Trade $openness_{t-2}$				-0.002	0.005	0.001
				(0.006)	(0.006)	(0.006)
Rule of law_{t-2}					0.446***	0.743***
					(0.146)	(0.203)
Government $effectiveness_{t-2}$						-0.428**
						(0.187)
Constant	1.679***	2.082***	2.126***	2.120***	2.448***	2.474***
	(0.206)	(0.323)	(0.398)	(0.397)	(0.430)	(0.429)
Observations	1,739	1,600	1,600	1,600	1,600	1,600
Number of countries	74	69	69	69	69	69
Country fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
R Squared	0.84	0.85	0.85	0.85	0.85	0.85

Note: robust standard errors in brackets. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The dependent variable is log of total workers. Estimator: WLS with synthetic control variables approach

3.4.3 LEB and production versus non-production employment

LEB policy adoption aims to promote wood processing in adopter countries before export. The restriction on log export should increase log supply in the domestic processing industry. An increase in log supply for downstream processing could affect different production and non-production, as defined in Section 3.2.1.

Table 3.4: Log export ban and production versus non-production employment

Dependent variables : Production and non-production workers		
	Entropy Balancing (WLS)	
	Production workers	Non-production workers
LEB_{t-1}	0.281**	0.218
	(0.122)	(0.153)
Medium firms	1.195***	0.944***
	(0.047)	(0.058)
Large firms	2.847***	2.229***
	(0.089)	(0.109)
Domestic private	0.002	-0.002
	(0.001)	(0.002)
Foreign private	0.004**	0.001
	(0.002)	(0.002)
Government	0.006*	0.001
	(0.003)	(0.003)
Access to finance	-0.033	0.044
	(0.052)	(0.067)
Multinational	-0.175*	-0.327***
	(0.104)	(0.126)
Firm age	0.021	0.039
	(0.029)	(0.037)
Labor market Regulation	-0.021	0.011
	(0.021)	(0.028)
$Sales_{t-3}$	0.019***	0.009*
	(0.005)	(0.006)
GDP per capita $growth_{t-2}$	-0.020	0.013
	(0.013)	(0.019)
Trade $openness_{t-2}$	0.002	-0.001
	(0.003)	(0.003)
Foreign Direct $Investment_{t-2}$	0.003	0.014*
	(0.007)	(0.008)
Rule of law_{t-2}	0.573***	0.538*
	(0.219)	(0.298)
Government $effectiveness_{t-2}$	-0.115	-0.220
	(0.235)	(0.345)
Constant	2.355***	1.406***
	(0.458)	(0.493)
Observations	1,454	1,453
Number of countries	68	68
Country fixed effect	Yes	Yes
Year fixed effect	Yes	Yes
R Squared	0.83	0.65

Note: robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1.
The dependent variable is log of production workers and log of non-production workers.
Estimator: WLS with synthetic control variables approach.

Table 3.4 reports the estimation with production and non-production workers as dependent variables. LEB policy adoption increases production workers significantly by 1%. But, there is no significant effect of LEB adoption on non-production worker numbers. Indeed, the LEB adoption increases log supply in the volume of wood acquired for processing. Capital and labor are used to absorb input increasing for manufacturing. Developing countries' industries are more intensive in labor and need a lot of employees for the manufacturing process (Menéndez González et al., 2023). So, a rise in the main input supply for the forest industry requires more workers for processing. However, log supply may not significantly affect non-production employment because only the production area is affected by increased log supply for milling.

3.4.4 LEB and permanent versus temporary employment

Then, we focus our analysis on the permanent and temporary workers. The policy implication is different following these two types of employment. Table 3.5 highlights results about permanent and temporary workers as dependent variables. LEB policy adoption increases significantly at 1% permanent employment in firms in the country under LEB policy compared to the control group. This increase is about 25.6%. However, there is no significant effect of LEB policy on temporary employment.

LEB policy is a middle or long-term period policy that could affect a firm's hiring of permanent workers. Then, industrial production of wood is not seasonal. Logging activities are current and the forests take many decades to regrowth. Then, linked to the long-term nature of LEB adoption, industrial processing increases permanent employment to adapt labor for log supply growth and processing activities increase. Furthermore, permanent workers hiring concerns generally temporary workers that are already employed in the firm. An increase in employment during LEB might be mainly the reconversion of temporary workers to permanent workers, which can explain the negative (while non-significant) of the LEB policy on temporary jobs.

Table 3.5: Log export ban and permanent versus temporary employment

Dependent variables : Permanent and temporary workers		
	Entropy Balancing (WLS)	
	Permanent workers	Temporary workers
LEB_{t-1}	0.256***	-0.124
	(0.093)	(0.247)
Medium firms	1.259***	0.459***
	(0.037)	(0.097)
Large firms	2.862***	1.032***
	(0.073)	(0.196)
Domestic private	0.001	0.003
	(0.001)	(0.002)
Foreign private	0.003*	0.001
	(0.001)	(0.003)
Government	0.001	0.001
	(0.003)	(0.006)
Access to finance	0.027	0.123
	(0.041)	(0.109)
Multinational	-0.213**	-0.145
	(0.085)	(0.176)
Firm age	0.050**	0.010
	(0.023)	(0.053)
Labor market Regulation	-0.019	0.107**
	(0.018)	(0.045)
$Sales_{t-3}$	0.013***	0.009
	(0.004)	(0.009)
GDP per capita $growth_{t-2}$	-0.009	-0.007
	(0.011)	(0.029)
Trade $openness_{t-2}$	-0.000	-0.002
	(0.002)	(0.006)
Foreign Direct $Investment_{t-2}$	0.003	-0.013
	(0.006)	(0.014)
Rule of law_{t-2}	0.691***	0.899*
	(0.178)	(0.459)
Government $effectiveness_{t-2}$	-0.299*	-1.074**
	(0.168)	(0.434)
Constant	2.644***	0.516
	(0.375)	(0.785)
Observations	1,600	1,600
Number of countries	69	69
Country fixed effect	Yes	Yes
Year fixed effect	Yes	Yes
R Squared	0.86	0.28

Note: robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1.
The dependent variable is log of permanent and log of temporary employment.
Estimator: WLS with synthetic control variables approach.

3.4.5 LEB and unskilled versus skilled employment

Employment in the industrial sector requires different skills and categories of workers depending on their level of education and training. On the production side, many positions or profiles with specific assets or skills related to their training or experience are somehow involved in the production process. Then, we check the effect of LEB adoption effect on skill-biased employment. Following Díaz et al. (2020), we disaggregated total employment into high-skilled and low-skilled jobs. Skilled and unskilled employment have no similar response to policy or reforms applied in the industry sector.

Table 3.6: Log export ban and unskilled versus skilled employment

Dependent variables : Unskilled and skilled workers		
	Entropy Balancing	
	Unskilled workers	Skilled workers
LEB_{t-1}	0.917***	-0.290
	(0.233)	(0.345)
Medium firms	0.901***	0.844***
	(0.098)	(0.078)
Large firms	2.526***	2.138***
	(0.182)	(0.135)
Domestic private	0.001	0.000
	(0.002)	(0.001)
Foreign private	0.004	0.003
	(0.003)	(0.002)
Government	0.001	0.008*
	(0.006)	(0.005)
Access to finance	0.104	-0.076
	(0.105)	(0.081)
Multinational	-0.035	-0.010
	(0.197)	(0.161)
Firm age	-0.018	0.031
	(0.057)	(0.046)
Labor market Regulation	0.108***	-0.013
	(0.038)	(0.030)
$Sales_{t-3}$	0.011	0.014**
	(0.009)	(0.006)
GDP per capita $growth_{t-2}$	0.070**	-0.050
	(0.032)	(0.047)
Trade $openness_{t-2}$	0.011**	0.011
	(0.005)	(0.008)
Foreign Direct $Investment_{t-2}$	-0.001	0.039***
	(0.013)	(0.012)
Rule of law_{t-2}	0.239	-0.321
	(0.553)	(0.606)
Government $effectiveness_{t-2}$	0.349	0.797
	(0.565)	(0.655)
Constant	0.226	0.850
	(0.797)	(0.813)
Observations	1,421	1,024
Number of countries	68	66
Country fixed effect	Yes	Yes
Year fixed effect	Yes	Yes
R Squared	0.50	0.62

Note: robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1.
The dependent variable is log of unskilled workers and log of skilled workers.
Estimator: WLS with synthetic control variables approach.

Table 3.6 reports results. The dependent variable is unskilled workers in column (1) and skilled workers in column (2). In this table, only the effect of LEB policy on unskilled workers is positive and significant at 1%. There is no significant effect of LEB adoption on skilled workers. A possible explanation of these results is the type of complexity of wood processing generated by the reform. For Marchand and Zerbo (2023), growth in wood processing in developing countries concerns more sawnwood production than veneer wood production. Sawnwood processing does not ask for specific skills. Then, unskilled employment is higher because it requires no particular competencies in the context of low wages and large availability of labor.

3.5 Robustness checks: the IV approach

Our study identifies two potential endogeneity issues defined as the correlation between the error term and the dependent variable. First, the simultaneous bias may emerge because some countries apply LEB to increase employment in the forest industry. Then, the employment level in the forest industry could raise the probability of LEB adoption. Second, potential omitted explanatory variables may explain the employment level. This omitted variable would be in the error term and correlated to our dependent variables.

To answer the endogeneity problem, we use the instrumental variables (IV) method following Wooldridge (2015) for explanatory endogenous binary variables. Thus, we must check variables that fulfill IV conditions. Then, the first stage is the estimation of the effects of the IV and the set of control variables on LEB policy variable. We then employ the probit strategy (Equation 4.6) to estimate the probability of LEB policy adoption because of the binary nature of LEB. This step allows the endogeneity bias elimination from LEB policy.

$$E[LEB|Z_i, X_i) = Pr[LEB = 1|Z_i, X_i] \tag{3.3}$$

In the second step, we use the prediction of LEB policy adoption probability as the interest variable and the set of control variables where employment variables are the outcome as follows:

$$log(Employment_{i,t-1}) = \beta_0 + \beta_1 L\hat{E}B_{i,t-1} + \gamma X_{i,t-1} + \lambda Y_{i,t-2} + \eta_i + \theta t + \epsilon_{i,t} \tag{3.4}$$

To fulfill the instrumental variable conditions, we identify two instruments for LEB policy adoption. We first use the neighborhood variable of LEB policy adoption. The country's policy choice and market orientation correlate with neighboring countries' share following these policies (Buera et al., 2011; Persson and Tabellini, 2009). In the context of regional policy harmonization, countries in specific economic areas attempted to converge toward the same policy. Thus, LEB policy adoption in the neighbor increases the probability of policy adoption in non-adopter countries. In the forest industry employment analysis, the policy adopted by the neighbor cannot directly affect employment in non-adopter countries. The neighborhood effect is from the FPER database as our interest variable and computed as the proportion of neighbors of the country that implemented LEB in period t-2.

Second, we use the tariff rate weighted mean applied on primary products lagged in two periods that come from WDI. This variable highlights each country's international trade dependence level regarding the tariff rate. Then, to avoid retaliation behavior concerning international trade, countries are less motivated to apply strict restrictions on export or import (Bagwell and Staiger, 2001). In addition, higher levels of tariff rates are imputable to countries focused on revenue from customs cordons. Thus, countries with higher tariff rates have fewer incentives to adopt LEB policies that consist of renouncing log export tax.

Tables 3.7, 3.8, 3.9 and 3.10 report the estimation results for total employment, production, non-production employment, permanent and temporary employment, and non-skilled and skilled employment.

Table 3.7: Instrumental estimation for total employment

	Dependant variables: Total workers		
	Entropy balancing	Instrumental variables	
	Total worker	Total worker	
		First stage	Second stage
LEB_{t-1}	0.250**		0.355*
	(0.107)		(0.196)
Medium firms	1.372***	0.039	1.357***
	(0.037)	(0.107)	(0.033)
Large firms	2.998***	0.216	2.949***
	(0.088)	(0.158)	(0.049)
Domestic private	0.002	-0.001	0.002**
	(0.001)	(0.003)	(0.001)
Foreign private	0.003*	0.000	0.004***
	(0.002)	(0.003)	(0.001)
Government	0.002	-0.014	0.005*
	(0.003)	(0.010)	(0.003)
Access to finance	-0.011	-0.153	0.024
	(0.047)	(0.110)	(0.036)
Multinational	-0.206***	0.099	-0.168***
	(0.079)	(0.161)	(0.052)
Firm age	0.047*	0.070	0.022
	(0.024)	(0.073)	(0.023)
Labor market Regulation	0.022	0.052	0.038***
	(0.020)	(0.043)	(0.014)
$Sales_{t-3}$	0.012***	-0.015	0.013***
	(0.004)	(0.010)	(0.003)
GDP per capita $growth_{t-2}$	-0.007	-0.053**	-0.007
	(0.012)	(0.022)	(0.012)
Trade $openness_{t-2}$	-0.001	0.003	0.001
	(0.002)	(0.002)	(0.002)
Foreign Direct $Investment_{t-2}$	0.001	-0.088***	0.000
	(0.006)	(0.016)	(0.005)
Rule of law_{t-2}	0.743***	-0.419*	0.743***
	(0.203)	(0.244)	(0.221)
Government $effectiveness_{t-2}$	-0.428**	-0.177	-0.405*
	(0.187)	(0.220)	(0.218)
Constant	2.474***	-0.806	2.881***
	(0.429)	(0.514)	(0.416)
Instrument			
$Neighbor_{t-2}$		2.128***	
		(0.208)	
Tariff rate $weighted_{t-2}$		-0.133***	
		(0.018)	
Observations	1,600	1,322	1,322
Number of countries	69	58	58
Country fixed effect	Yes	No	Yes
Year fixed effect	Yes	Yes	Yes

Note: robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. Dependent variable is log of total workers. Instruments: neighbor LEB adoption share and tariff rate weighted. Estimator: Instrument Variable by Wooldridge (2015).

Table 3.8: Instrumental estimation for production and non-production employment

	Dependant variables: Production and non-production workers			
	Instrumental variables			
	Production workers		Non-production workers	
	First stage	Second stage	First stage	Second stage
LEB_{t-1}		0.568***		-0.035
		(0.173)		(0.240)
Medium firms	0.087	1.219***	0.080	0.924***
	(0.117)	(0.034)	(0.117)	(0.046)
Large firms	0.273	2.846***	0.268	2.231***
	(0.181)	(0.052)	(0.180)	(0.071)
Domestic private	-0.001	0.001	-0.001	-0.001
	(0.003)	(0.001)	(0.003)	(0.001)
Foreign private	-0.000	0.003***	-0.000	0.002
	(0.004)	(0.001)	(0.004)	(0.002)
Government	-0.012	0.006**	-0.013	0.003
	(0.009)	(0.003)	(0.009)	(0.004)
Access to finance	-0.221*	-0.022	-0.201*	0.094*
	(0.121)	(0.037)	(0.121)	(0.050)
Multinational	0.138	-0.083	0.135	-0.248***
	(0.176)	(0.055)	(0.176)	(0.075)
Firm age	0.162**	-0.006	0.165**	0.057*
	(0.081)	(0.024)	(0.081)	(0.033)
Labor market Regulation	0.044	0.021	0.035	0.025
	(0.047)	(0.014)	(0.047)	(0.019)
$Sales_{t-3}$	-0.003	0.014***	-0.002	0.005
	(0.011)	(0.004)	(0.011)	(0.005)
GDP per capita $growth_{t-2}$	-0.010	-0.018	-0.010	0.011
	(0.024)	(0.012)	(0.024)	(0.017)
Trade $openness_{t-2}$	0.004*	-0.001	0.004*	0.007*
	(0.002)	(0.003)	(0.002)	(0.004)
Foreign Direct $Investment_{t-2}$	-0.093***	0.007	-0.093***	0.001
	(0.017)	(0.005)	(0.017)	(0.007)
Rule of law_{t-2}	-0.394	0.812***	-0.411	0.118
	(0.255)	(0.243)	(0.256)	(0.337)
Government $effectiveness_{t-2}$	-0.236	-0.428	-0.228	0.584
	(0.231)	(0.269)	(0.231)	(0.373)
Constant	-2.101***	2.944***	-2.094***	1.433**
	(0.572)	(0.428)	(0.572)	(0.590)
Instruments				
$Neighbor_{t-2}$	2.894***		2.885***	
	(0.251)		(0.251)	
Tariff rate $weighted_{t-2}$	-0.116***		-0.114***	
	(0.018)		(0.018)	
Observations	1,221	1,221	1,219	1,219
Number of countries	58	58	58	58
Country fixed effect	No	Yes	No	Yes
Year fixed effect	Yes	Yes	Yes	Yes

Note: robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are log of production workers and log of non-production workers. Instruments: neighbor LEB adoption share and tariff rate weighted. Estimator: Instrument Variable by Wooldridge (2015).

Table 3.9: Instrumental estimation for permanent and temporary employment

	Dependant variables: Permanent and temporary workers			
	Instrumental variables			
	Permanent workers		Temporary workers	
	First stage	Second stage	First stage	Second stage
LEB_{t-1}		0.355**		-0.318
		(0.169)		(0.420)
Medium firms	0.010	1.268***	0.035	0.414***
	(0.105)	(0.029)	(0.107)	(0.070)
Large firms	0.223	2.872***	0.216	0.711***
	(0.154)	(0.043)	(0.158)	(0.105)
Domestic private	-0.000	0.001	-0.001	0.002
	(0.003)	(0.001)	(0.003)	(0.002)
Foreign private	0.002	0.003***	0.001	0.002
	(0.003)	(0.001)	(0.003)	(0.002)
Government	-0.013	0.005*	-0.014	-0.005
	(0.009)	(0.002)	(0.010)	(0.006)
Access to finance	-0.167	0.028	-0.158	0.103
	(0.107)	(0.032)	(0.109)	(0.077)
Multinational	0.026	-0.181***	0.102	0.008
	(0.155)	(0.045)	(0.160)	(0.112)
Firm age	0.040	0.046**	0.078	-0.010
	(0.070)	(0.020)	(0.073)	(0.049)
Labor market Regulation	0.047	0.016	0.058	0.072**
	(0.042)	(0.012)	(0.043)	(0.029)
$Sales_{t-3}$	-0.018*	0.009***	-0.018*	0.012*
	(0.010)	(0.003)	(0.010)	(0.007)
GDP per capita $growth_{t-2}$	-0.066***	-0.012	-0.050**	0.008
	(0.021)	(0.011)	(0.022)	(0.026)
Trade $openness_{t-2}$	0.001	0.001	0.002	-0.004
	(0.002)	(0.002)	(0.002)	(0.005)
Foreign Direct $Investment_{t-2}$	-0.070***	0.003	-0.087***	-0.001
	(0.016)	(0.005)	(0.016)	(0.011)
Rule of law_{t-2}	-0.443*	0.781***	-0.411*	0.298
	(0.238)	(0.196)	(0.244)	(0.476)
Government $effectiveness_{t-2}$	-0.241	-0.393**	-0.175	-0.500
	(0.215)	(0.191)	(0.220)	(0.470)
Constant	-0.546	3.140***	-0.838	0.417
	(0.502)	(0.370)	(0.514)	(0.896)
Instrument				
$Neighbor_{t-2}$		2.065***		2.155***
		(0.203)		(0.207)
Tariff rate $weighted_{t-2}$		-0.141***		-0.133***
		(0.017)		(0.018)
Observations	1,360	1,360	1,325	1,325
Number of countries	58	58	58	58
Country fixed effect	No	Yes	No	Yes
Year fixed effect	Yes	Yes	Yes	Yes

Note: robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are log of permanent workers and log of temporary workers. Instruments: neighbor LEB adoption share and tariff rate weighted. Estimator: Instrument Variable by Wooldridge (2015).

Table 3.10: Instrumental estimation for unskilled and skilled employment

	Dependant variables: Unskilled and unskilled workers			
	Instrumental variables			
	Unskilled workers		Skilled workers	
	First stage	Second stage	First stage	Second stage
LEB_{t-1}		0.795**		0.651
		(0.380)		(0.459)
Medium firms	0.092	0.976***	0.086	0.884***
	(0.119)	(0.073)	(0.144)	(0.059)
Large firms	0.306*	2.283***	0.184	2.217***
	(0.184)	(0.113)	(0.248)	(0.096)
Domestic private	-0.001	-0.002	-0.003	-0.001
	(0.003)	(0.002)	(0.004)	(0.002)
Foreign private	-0.001	0.004	-0.003	0.002
	(0.004)	(0.002)	(0.005)	(0.002)
Government	-0.013	0.000	-0.035	0.009*
	(0.010)	(0.006)	(0.023)	(0.005)
Access to finance	-0.202*	0.096	-0.176	-0.036
	(0.122)	(0.079)	(0.142)	(0.062)
Multinational	0.187	0.387***	0.300	-0.207**
	(0.181)	(0.120)	(0.227)	(0.100)
Firm age	0.187**	-0.023	0.036	0.006
	(0.083)	(0.053)	(0.096)	(0.041)
Labor market Regulation	0.040	0.071**	0.018	0.008
	(0.047)	(0.029)	(0.055)	(0.023)
$Sales_{t-3}$	-0.005	0.014*	0.018	0.006
	(0.012)	(0.008)	(0.013)	(0.006)
GDP per capita $growth_{t-2}$	-0.013	0.045*	0.039	0.043
	(0.024)	(0.027)	(0.028)	(0.031)
Trade $openness_{t-2}$	0.004*	0.009	0.005*	0.022**
	(0.002)	(0.006)	(0.003)	(0.009)
Foreign Direct $Investment_{t-2}$	-0.091***	-0.006	-0.179***	0.014
	(0.017)	(0.012)	(0.031)	(0.011)
Rule of law_{t-2}	-0.319	0.906*	-0.094	-2.392***
	(0.260)	(0.541)	(0.330)	(0.831)
Government $effectiveness_{t-2}$	-0.259	-0.387	0.009	3.478***
	(0.235)	(0.604)	(0.299)	(0.950)
Constant	-2.124***	-0.698	-1.840**	0.578
	(0.580)	(0.932)	(0.745)	(1.525)
Instrument				
$Neighbor_{t-2}$		2.871***		2.611***
		(0.252)		(0.293)
Tariff rate $weighted_{t-2}$		-0.110***		-0.070***
		(0.019)		(0.022)
Observations	1,190	1,190	849	849
Number of countries	58	58	56	56
Country fixed effect	No	Yes	No	Yes
Year fixed effect	Yes	Yes	Yes	Yes

Note: robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. Dependent variables are log of unskilled workers and log of skilled workers. Instruments: neighbor LEB adoption share and tariff rate weighted. Estimator: Instrument Variable by Wooldridge (2015).

In each table, we use the probit of the LEB adoption with firm-level data and macro-level data in the first step. We put the two instruments in this estimation to show the effect of neighborhood LEB and tariff rate weighted. For all cases, the neighbor LEB adoption increases the probability of LEB policy adoption, while the weighted tariff rate decreases the likelihood of LEB policy adoption. The significance at 1% of each instrument confirms the validity of our instruments. In the second step, total, production, non-production, permanent, unskilled, and skilled workers are used as dependent variables.

In Table 3.7, LEB policy adoption increases total employment by about 35.5%, but it is significant at 10%. Resolving the endogeneity issue allows an increase in the coefficient from 0.25 to 0.35 for the effect of LEB on total employment. Focused on production and non-production employment in Table 3.8, only production workers are significant at 1%. Compared to the entropy balancing approach, the IV strategy increases the effect of LEB on production workers. In Table 3.9, LEB policy affects positively and significantly permanent workers at about 35.5%. These results validate our estimation with the entropy balancing approach. Table 3.10 shows that LEB policy impacts only unskilled employment, confirming our result in Table 3.6.

3.6 Conclusion

This paper aims to assess the effect of LEB policy adoption on wood-processing firm employment. Our analysis focuses on 1,739 wood-processing firms in 74 developing countries surveyed between 2006 and 2018. We employ an entropy-balancing approach to assess this effect. Our results show that adopting the LEB policy increases employment by around 25% in firms in countries under LEB policy compared to non-adopters countries. A heterogeneity analysis based on production versus non-production work, permanent versus temporary work, and skill-biased employment highlights that LEB policy has differential effects according to the type of employment. Only production workers, permanent and unskilled workers are significantly and positively affected by LEB policy adoption. We then use an instrumental variable as an alternative estimation method to resolve endogenous issues. After considering these problems, LEB policy remains positive and significant for total workers, production, permanent and unskilled employment.

Our results highlight the complexity of economic reform to achieve multiple goals simultaneously. This study shows that the LEB reform has positively affected employment in the processed wood industry, but these effects do not generalize to all types of work. Thus, the LEB reform has had the apparent effect of increasing permanent, low-skilled jobs linked to production activities. These results are logical given the context in which the reform is taking place. Most of the countries concerned have labor-intensive industries with comparative disadvantages in terms of capital and technology. In this way, the reform favors the transformation of processed wood that requires little capital and technology, stimulating employment that is primarily low-skilled.

Our results are significant and suggest that the reform can provide jobs for local populations. Nevertheless, the reform could be extended by measures to stimulate higher-skilled employment. For this, more complex processed wood production needs to be developed. It requires, for example, increasing worker training, creating incentives for innovation and technological development, and encouraging FDI to facilitate technology transfer. In short, our results suggest that the LEB reform alone cannot act on all types of employment.

Finally, an interesting question is whether this reform may have longer-term effects on employment, particularly on skilled jobs. The development of a low-processed wood industry, enabled by the LEB reform, maybe the first step towards a more complex industry. Moving up the value chain takes time, but the first processing stages create a favorable ecosystem for developing more complicated steps. In other words, the LEB reform may benefit the more processed wood industry and skilled employment through its positive effect on the early stages of wood processing. On the contrary, the reform may freeze the development of the wood-processing industry at uncomplicated levels. Further research is needed to explore these issues.

Appendix A

Table A4: t-tests for the mean of employment variables according to LEB reform.

Variables	(1)	(2)	(3)=(2)-(1)		
	LEB	No LEB	Difference	t-Test	p-Val,
Total employment	71.55	51.71	-19.84	-2.26	0.02
Production employment	46.63	32.16	-14.48	-2.52	0.01
Non-production employment	11.60	7.78	-3.82	-3.38	0.00
Permanent employment	57.01	43.43	-13.58	-2.17	0.03
Temporary employment	13.38	8.32	-5.06	-0.94	0.37
Unskilled employment	19.34	10.48	-8.86	-2.06	0.04
Skilled employment	22.11	18.35	-3.76	-1.56	0.12

Table A5: Description of variables

Variables	Description	Source
	Variables at firm-level	
Total employment	Number of permanent and temporary full-time employees	WBES*
Production employment	Number of permanent, full-time production workers are workers (up through the line supervisor level) engaged in production area	WBES
Non-production employment	Number of permanent, full-time non-production workers are those workers not engaged in production area	WBES
Permanent employment	Number of permanent, full-time employees last complete fiscal year with one or more fiscal years contract and guaranteed to renew	WBES
Temporary employment	Full-time temporary or seasonal employees are defined as all paid short-term i.e. for less than a fiscal year contract with no guarantee of renewal	WBES
Unskilled employment	Unskilled production workers are workers with jobs that do not require special training, education, or skill to perform their jobs.	WBES
Skilled employment	Skilled production workers may have attended a college, university, or technical school. Or, a skilled worker may have learned his skills on the job	WBES
Domestic private	% Owned By Private Domestic Individuals, Companies Or Organizations. Domestic are nationals of the country in which the establishment is located.	WBES
Foreign private	% Owned By Private Foreign Individuals, Companies Or Organizations. Foreign ownership refers to the nationality of the shareholders. If the primary owner is a foreign national resident in the country, it is still a foreign-owned firm. If the shares are held by another company or institution and the shareholders of that institution are foreign nationals, then it is foreign-owned.	WBES
Government	% Owned By Government/State. A firm that is a subsidiary of a government-owned firm should be considered government-owned.	WBES
Credit	Establishment Has A Line Of Credit Or Loan From A Financial Institution? A line of credit is an available amount of credit that the establishment can draw upon or leave untapped. Lines of credit usually carry monthly interest rates and are repaid quickly (as soon as the establishments cash flow allows for repayment).	WBES
Multinational	Establishment is part of a larger firm	WBES
Firm age	firm age is captured by young, mature, and older firms. Young represents 1 to 5 years, Mature is firm with ages between 6 and 15 years old, and older are companies with more than 15 years old.	WBES
Labor market regulation	Are labor regulations No Obstacle, a Minor Obstacle, a Major Obstacle, or a Very Severe Obstacle to the current operations of this establishment?	WBES
Sale n-3	Total sales three complete fiscal years ago include the value of all annual sales counting manufactured goods and goods the establishment has bought for trading. If an establishment makes blue jeans and also imports blue jeans to sell, total sales is the value of all blue jeans sold, both produced and imported. Revenue or receipts for all services rendered and any merchandise sales for the year, even though payment may have been received later, are included in total sales. Firms operating on a commission basis should report commissions, fees, and other operating income, not gross billings or sales.	WBES
	Variables at country-level	
Log export ban	Log export ban is the dummy variable taking 1 if country applies ban on log export and 0 if not	FPER**
GDP per capita growth (%)	Annual percentage growth rate of GDP per capita based on constant local currency. GDP per capita is gross domestic product divided by midyear population. GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources.	WDI***
Foreign direct investment (%)	Foreign direct investment are the net inflows of investment to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investor. It is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital as shown in the balance of payments. This series shows net inflows (new investment inflows less disinvestment) in the reporting economy from foreign investors, and is divided by GDP.	WDI
International trade (%)	Trade is the sum of exports and imports of goods and services measured as a share of gross domestic produc	WDI
Government effectiveness	Government Effectiveness captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. Estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution, i.e. ranging from approximately -2.5 to 2.5.	WGI****
Rule and law	Rule of Law captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence. Estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution, i.e. ranging from approximately -2.5 to 2.5.	WGI

* World Bank Enterprise Survey; **Forest Product Export Restriction; ***World Development Indicators; ****Worldwide Governance Indicators

Chapter 4

The impact of log export ban policy on deforestation: Lessons from developing countries

This chapter is currently under review in Forest Policy and Economics. It has already been presented in 71th Congress of AFSE and AFEDEV 2023 Job Market Training.

Abstract

This paper analyzes the effect of the log export ban (LEB) adoption on deforestation in a large sample of 100 developing countries with forest cover higher than 100 Km^2 from 2001-2019. Using the entropy balancing approach, we show that LEB adoption significantly increases deforestation in LEB adopters countries relative to non-LEB countries. Our results remain robust to various robustness tests including an alternative measure of LEB and deforestation. Also, taking into account potential endogeneity issues does not change the policy effect. Furthermore, we investigate the heterogeneity by changing the sample and assessing the policy effect over time. The policy effect stays positive and significant. Moreover, we identified agricultural land occupation and processed wood production as the main channels for increasing deforestation through LEB adoption.

JEL classification: C21, F13, F18, O13, O14, Q23.

Keywords: Log export ban, Deforestation, Entropy balancing, Developing countries.

4.1 Introduction

In most developing forest-rich countries, the industrial processing of timber has increasingly been identified by policymakers as a major process of economic transformation. Resource-based industrialization, however, is in front of poor energy and road infrastructure, political instability and a lack of adequate technical, financial and human resources (Schulz, 2020). Also, domestic timber processing is more competitive in developing countries with domestic and foreign processors that buy domestic raw logs. The competition in buying domestic raw logs is with foreign processors installed in developed countries.

To fulfill this issue, most developing forest-rich countries' government is focused to log export bans and other restriction on unprocessed wood.[1] Log export prohibitions increase the domestic supply of raw logs with a high probability of domestic prices falling. Despite loggers and log exporters losing income, the timber processing industry becomes more competitive vis-à-vis foreign countries' timber processing. Then, domestic and foreign investors are more incentive to invest in the country of origin timber processing.

Moreover, LEB can be implemented to achieve environmental goals in terms of forest management. A LEB is attended to decrease log price from international price to domestic price lower. This drop in profit should decrease logging activities and increase forest conservation. Also, a drop in international demand for domestic logs combined with a profit drop decreases illegal logging incentives. Thus, some countries apply the LEB policy as an environmental policy to fight deforestation and forest degradation. Other countries apply LEB policy to combine both industrialization and environmental purposes.

This study argues that there are losers and winners in LEB policy adoption that can affect behaviors concerning forest resources management. LEB tends to harm loggers and raw log exporters and a part of the profit loss is redistributed to other domestic producers. Then, the profit drop in logging activities increases switching from logging to farming with a forest reconversion perspective. For winners, there is an increase in processing activities because more foreign industries are attracted to invest in domestic large available forest resources. Then,

[1] According to (Schulz, 2020), the Log export ban (LEB) is the most banned policy adopted on the commodity in Africa.

there is a traditional industry with a low processing capacity that need too many logs and a foreign industry with a high capacity of processing that also needs many logs for economic scale purpose. Each winner increases their earnings by increasing log supply which increases forest pressure.

The purpose of this study is thus to assess the impact of LEB policy adoption on deforestation. Our study contributes empirically and theoretically to the few kinds of literature on the environmental effect of LEB in four points.

First, while most studies on LEB policy implement a country's case approach (e.g., Amoah et al., 2009; Fooks et al., 2013; Kishor et al., 2004; Resosudarmo and Yusuf, 2006), we use a large panel of 100 developing countries from 2001 to 2019 to make evidence of LEB adoption's effect on deforestation.[2]

Second, the paper contributes to emphasizing the unexpected effect of LEB policy adoption by highlighting the agriculture and forest industry channels through which LEB increases deforestation (Damette and Delacote, 2011; Wolfersberger et al., 2015). In addition to the effect of LEB on agriculture shown by Maestad (2001), this study is first highlighting empirically and theoretically the evidence of the agriculture and forest industry as transmission channels and their roles in the relationship between LEB and deforestation.

Third, we contribute to the empirical literature by using impact analysis to assess the causal effect of LEB adoption on deforestation. In marge of the propensity score matching used by Marchand and Zerbo (2023) to show the impact of LEB on the forest industry and wood trade growth, our study employs an entropy balancing approach that is revealed an appropriate impact analysis approach that matches better with our study. Our paper first uses the impact analysis method to check the effect of LEB on deforestation.

Finally, we contribute to the literature by highlighting LEB policy adoption as a determinant of deforestation. Former literature on deforestation neglected the forest trade policy associated with tree cover loss. This paper strengthens the LEB policy as a major determinant of deforestation in developing countries. It will help future research to capture LEB policy as a real cause of deforestation.

[2] At our knowledge, only Marchand and Zerbo (2023) investigate the effect of LEB policy (on forest industrialization) with a large panel of developing countries.

This study implements an entropy balancing approach to estimate the Average Treatment Effect on the Treated (ATT) of the LEB policy. We find a positive and significant effect of the LEB policy on deforestation. This result is strong adding progressively other covariates in our baseline analysis. Moreover, we check the validity of our transmission channels using the mediator variables approach. Our results show that agriculture occupation and processed wood fulfilled the transmission channels conditions.

Furthermore, we check the robustness of our analysis using alternative measures of LEB and deforestation. Moreover, we use alternative estimation methods to support our baseline identification strategy. We use instrumental variables for the binary endogenous variable as defined by Wooldridge (2015) using the share of neighbor LEB policy adoption and tariff rate on customs duty as instruments. Also, we employ the GMM estimation approach. In each case, the LEB significantly increases deforestation in our analysis. In addition, we study the heterogeneity in treatment effects of LEB policy by modifying the sample. LEB remains positive and significant at 1%. We also investigate the effect of the LEB policy over time specifically in *t+1*, *t+2*, *t+3*, *t+4* and, *t+5*. The significant effect of LEB on deforestation shows the persistent effect of this policy on deforestation.

The remainder of the paper proceeds as follows. Section 4.2 discusses an overview of the link between LEB and deforestation and the role of the transmission channels. Section 4.3 shows the stylized facts describing the statistical relationship between LEB and deforestation. Section 4.4 describes data and variables while Section 4.5 provides the identification strategy. Section 4.6 presents the results and transmission channels test. Section 4.7 checks the robustness followed by Section 4.8 which shows heterogeneity analysis. The last Section concludes and discusses the policy implications.

4.2 LEB and deforestation

4.2.1 The role of LEB in the deforestation process

The LEB policy is a prohibition applied to unprocessed wood export. This forestry, trade and industrialization policy is adopted for economic and environmental purposes. Some developing countries apply specifically LEB policy to control deforestation or to encourage the domestic processing industry and others apply for both previous reasons (Kishor et al., 2004). The conventional LEB is to protect and promote domestic industries by banning exports of unprocessed wood, allowing industries to obtain their input cheaper than higher world market price (Fooks et al., 2013).

However, there is a relevant controversial debate concerning the LEB effect on deforestation. Some studies highlight the beneficial effect of LEB adoption on deforestation. The lower log prices reduce logging profits and incentives for logging and hence decrease deforestation. Also, a lower log price should decrease illegal logging by eliminating incentives to take high risks for low profit (Resosudarmo and Yusuf, 2006). For instance, Tumaneng-Diete et al. (2005) find that LEB and other trade policies enhanced forest conservation in the Philippines.

An opposite view shows the detrimental effect of LEB adoption on deforestation. LEB decreases the profit of logging and the number of loggers who switch to other activities. The remaining loggers individually try to achieve the former level of profit before the log price drops which necessitates more extraction. Thus, each logger increases his logging capacities. So, forest pressure could achieve the former level of logging activities before the LEB policy adoption. Furthermore, LEB increases deforestation through agriculture and forest industry which are explained in the next subsection.

4.2.2 Transmission channels

Channel of agriculture

We assume that the LEB adoption can increase deforestation through farming. López and Galinato (2005) identify agricultural expansion as one important channel through which trade policy affects forests. As defined by Wolfersberger et al. (2015), land-use competition is mainly between agriculture and forest, and agricultural land expansion represents the major direct cause of deforestation in developing countries. We highlight three channels that can explain this assumption.

First, the LEB adoption aims at dropping the log export to reorient the log production to the domestic industry for processing. The first effect is the log price drop and acts on logging activities that could become less profitable. Thus, the choice facing people with forest land is whether to keep forest land or clear it for alternative use like agriculture. For Arcand et al. (2008) the choice between forest and agricultural use of the land depends on time preference. The short-term agricultural yield vis-à-vis forest growth length time motivates the preference for agriculture. Intuitively, the log price drop decreases the relative price of wood to agricultural goods and should positively affect forests turning into agricultural land.

Second, the LEB decreases the demand addressed to the local logger for log export perspectives. So, the profit decrease generates an employment conversion from logging to nearest activities specifically farming. Moreover, the substitution between logging and farming is facilitated by the proximity between the two activities. Switching from logging to farming is easy because the two activities are technologically similar. Both are labor and land intensive rather than capital-intensive. In developing countries, agriculture is more extensive and needs a lot of land for culture. The employment reconversion increases the agricultural land demand for farming. Thus, the competition between agriculture expansion and forestland leads to forest harvesting. For instance, Gibbs et al. (2010) find that between 1980 and 2000, more than 55% of new agricultural land came from the expense of intact forests and another 28% came from disturbed forests. The deforestation process is reinforced whether agriculture is predominated by small-scale shifting cultivators with fallow land practice.

Third, the LEB policy contributes to decreasing the conversion costs of forests to farming. For small-scale shifting cultivation, a major constraint for expansion is forest accessibility (Maestad, 2001). The LEB policy is implemented because of the presence of a large timber industry that needs infrastructure such as roads. So, when the LEB reform is active, the forest is de facto more accessible for agricultural conversion because of the network infrastructure already installed (Aggarwal, 2018; Kleinschroth et al., 2019).

Channel of forest industry

The LEB policy increases deforestation through the forest industry by influencing both timber harvesting and timber price (Damette and Delacote, 2011). The protectionism linked to LEB policy allows the forest industry to raise log supply in the domestic market with a large availability of logs without an international market perspective. The LEB allows a significant decrease in log prices in the domestic market compared to international prices. For industries only focused on processing activities without logging, a drop in timber price allows the log supply cheaper and creates some exclusivity around the forest resources for industries implanted in the adopter countries. The LEB will create two types of firms in the country's adopters: traditional firms and foreign firms. More precisely, we can identify two channels through which the forest industry could affect deforestation.

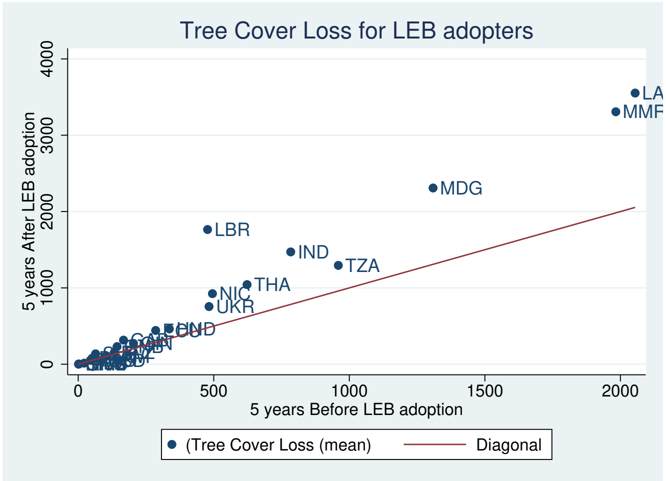
First, the policy favors the creation of traditional or former industries already implanted with low processing technology capacity that need a lot of logs for wood processing. Indeed, the LEB has often discouraged adopting sustainable practices in logging and reduced incentives to adopt modern technology to increase the wood recovery ratios in timber processing (Kishor et al., 2004). They increase the log supply that is cheap to compensate for their technological backwardness. This strategy could increase the pressure on forests.

Second, the policy adoption attracts much investment for resource proximity and the cheap log price. These foreign investments will take advantage of the forest resources with more adaptable technology for processing. Foreign firms will be more intensive in wood utilization with high processing capacities to increase gradually their output production. They can address their input demand for illegal logging to optimize their production. This demand will increase the pressure on forest resources. For foreign permit owner industries, the forest cutdown is more intensive. Indeed, logging activities become more intensive with the high technology level of wood extraction. So, the forest drop increases very much in less time. They grow wood extraction linked to their processing needs. Thus, if firms have a high capacity for processing, they drop a consequent timber for industry processing.

4.3 Stylized facts

This study aims at assessing the effect of LEB policy adoption on deforestation. We will highlight the causal relationship between LEB adoption and deforestation in adopter countries. Thus, we check the country sample that applied the LEB policy during our period analysis. Figure 4.1 shows the growth of tree cover loss five years before and five years after the policy

Figure 4.1: Tree Cover Loss 5 years before and after Log Export Ban adoption



adoption. Although most countries are around the diagonal (45° line) and close to zero, we can observe that several countries are above the diagonal. Thus, five years after the policy adoption, the deforestation level is more important than before LEB implementation. About four-fifth of LEB countries experienced an increase in their deforestation after having introduced LEB. This Figure shows the first overview of the effect of LEB policy adoption on deforestation.

Then, we use our transmission channel identified above to check by statistical evidence the role of LEB. As defined in Section 4.2.2, agricultural land occupation could be the main deforestation reason in developing and emerging countries. In developing countries, the main share of the population is employed in the primary sector, specifically agriculture. Agriculture is almost extensive with the shifting cultivation. Thus, the correlation between deforestation and agricultural land occupation is presented in Figure 4.2. From LEB policy adoption perspectives, we divide our sample by adoption status. So, the correlation between deforestation and agricultural land occupation is very low for non-adopters countries. However, the same link in adopters countries is very high. Figure 4.2 shows an overview of the policy adoption on the relation between deforestation and agriculture occupation. However, we will be confronted with selection bias because the deforestation level can explain the policy adoption in adopter countries. Thus, we restrict the analysis to countries that apply LEB policy to show the link between deforestation and agricultural land before and after the situation. Figure 4.3 shows the evidence of the policy adoption on the relation between deforestation and agricultural land

Figure 4.2: Tree Cover Loss and Agriculture Occupation by LEB

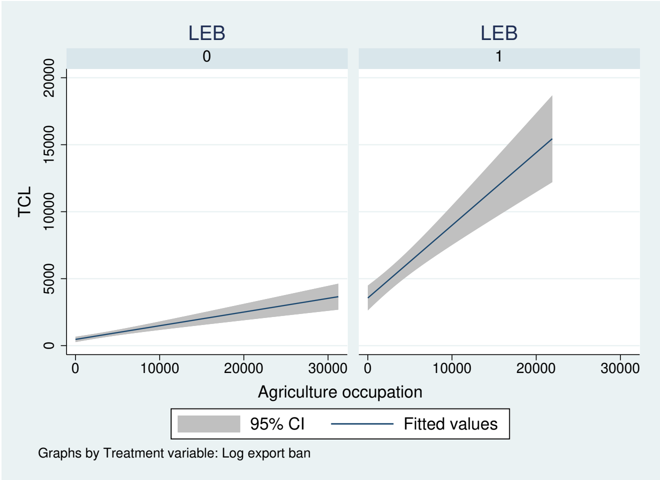
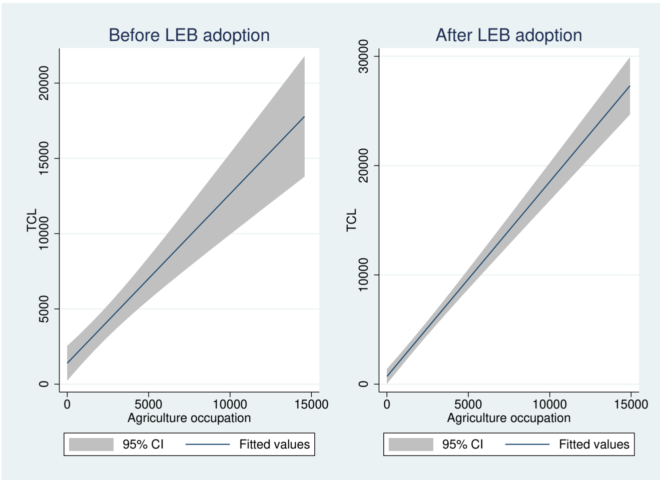


Figure 4.3: Tree Cover Loss and Agriculture Occupation before and after LEB adoption



occupation. The correlation is higher after policy adoption than before. This correlation confirms the transmission channel of LEB adoption that increases the effect of agricultural land expansion on deforestation.

The second channel of our analysis is the forest industry production used as a proxy to measure the forest industry's pressure on deforestation. We follow the same approach as for the agriculture channel analysis to check the correlation between deforestation and processed wood production. Thus, Figure 4.4 shows this correlation between adopter countries and non-adopter countries. We see that the correlation is higher for LEB adopters rather than non-adopters showing the evidence of policy adoption effect. Furthermore, we focus our analysis only on LEB adopters. We check the correlation between tree cover loss and processed wood production before and after the policy adoption. Figure 4.5 shows that the correlation is higher after the policy adoption because the policy adoption attracts too many investors near forest resources for processing purposes. The forest industry growth increases forest extraction.

Figure 4.4: Tree Cover Loss and Processed wood by LEB

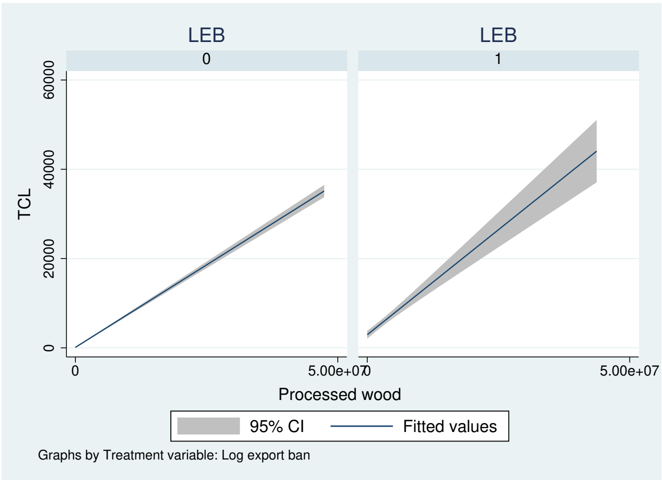
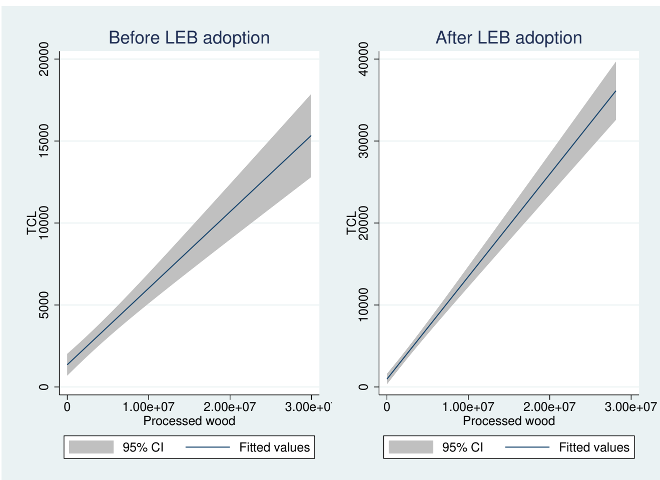


Figure 4.5: Tree Cover Loss and Processed wood before and after LEB adoption



4.4 Data and variables

4.4.1 Deforestation data

The deforestation data or annual forest cover loss is high-resolution data from Hansen et al. (2013) and provides a 1-arc-second grid of land cover estimate representing the share of pixel size that has vegetation more than 5 m tall in 2000. This resolution is estimated each year from 2001 to 2012 for forest loss and forest gain. Forest loss is a stand-replacement disturbance or the complete removal of tree cover canopy at the Landsat pixel scale. Inversely, forest gain has defined the establishment of tree canopy from a non-forest state. From 2013 to 2019, the data are only focused on forest loss based on the forest stand in 2000. There is a lack of data updates concerning forest gain after 2012. Also, the forest gain data is available for the period 2001-2012 without information data by year. Thus, we cannot merge the forest gain data with the forest loss data to get the net deforestation. Therefore, our study uses only the forest loss data from 2001 to 2019 to measure deforestation.

As mentioned by Leblois et al. (2017), we begin by averaging the forest cover of all pixel i of 1 arc-second (AverageCoord) in the year 2000 for each country j (with N pixels inside its borders). Data is computed from satellite imagery for only grid cells i with forest canopy greater than 20%.

$$Fcover_j = \frac{1}{N}\sum_{i=1}^{N} Fcover_i^{1n}, \qquad if(Fcover_i^{1n} < .20 \ \& \ AverageCoord(Fcover_i^{1n}) \in Country_j \tag{4.1}$$

After computing $Fcover_j$, we average the cover of the forest for every 30 arc-second pixels, i.e. about 900 m at the equator, reducing the resolution to meet computing time constraints. Also, we multiply the percentage of forest cover with the annual weighted average of deforestation for 1 arc second ($Defor_j^{30n}$).

$$Defor_j^{30n} = \frac{1}{N}\sum_{i=1}^{N} Fcover_i^{1n} \times Defor_i^{1n}, \quad if \ Pix_i^{1n} \in Pix_j^{30n} \tag{4.2}$$

Then, we use the resolution grids of 30 arc-second and we multiply the deforestation ratios and the forest cover by the surface area of each cell in square km and we add all the cells that have their barycenters inside a given country's border, for a given year y.

$$Defor_{y,j} = \sum_{i=1}^{N} Defor_i^{30n} \times Area_i^{30n}, \qquad AverageCoord(Fcover_i^{30n}) \in Country_j \tag{4.3}$$

Despite criticism of these data because of the distinct lack between tropical forests from the plantation and even herbaceous, it remains the main source of forest cover information (Tropek et al., 2014). Our study considers only developing countries to reduce the potential bias because intensive forest harvesting (with short rotation periods) and/or harvest plantations are scarce (Leblois et al., 2017).

As determined by recent studies (Ajanaku and Collins, 2021; Bauhoff and Busch, 2020; Kinda and Thiombiano, 2021; Morpurgo et al., 2023), our deforestation indicator is the annual decrease in forest cover ($Fcover_{t-1} - Fcover_t$). Also, our sample is focused on countries where the forest area is greater than 10,000 hectares to eliminate countries with low potential in forest resources.

4.4.2 Main interest variables

Our analysis covers 100 developing countries that have forest coverage of more than 10,000 hectares to exclude countries that have no potential forest cover from 2001 to 2019. As defined above, this study assesses the effect of the LEB policy adoption on deforestation. Our interest variable LEB comes from the FPER database that identifies each restriction applied on the log export in all adopter countries and is used by Marchand and Zerbo (2023).[3] LEB is a dummy variable taking 1 for countries that apply restriction on the log export and 0 otherwise. Thus, there are 29 LEB adopters and 71 non-LEB adopters (see Map A2 in Appendix). For each country and each year, the LEB treatment variable is defined as 1 if the country is under a LEB policy and 0 if not. As defined in the law, this ban is applied to log and raw wood or unprocessed. The ban might cover some species or all species. In the case of some species,

[3] The FPER database is accessible via the following link: https://www.forest-trends.org/known-forest-product-export-restrictions/

the ban covers the major produced and exported species by the country. Furthermore, the export quota is used to promote, protect and develop the domestic processing sector like the LEB. So, the quotas on export might have the proximate effect of an export ban. In our study, each quota export adopter is already a LEB adopter except DRC that not clearly define the beginning and application of the policy. Thus, we consider DRC as non-treated in our study.

As explained in Section 4.2.2, we highlight two variables that act as transmission channels of the effect of LEB policy on deforestation: agriculture and the timber industry.

Regarding farming data, we use yearly data on land use for food production that comes from Earth Data.[4] This database maps the global land cover at a 500-meter spatial resolution from 2001 to the present annual time for six different land covers (Sulla-Menashe and Friedl, 2018). The agriculture occupation represents the sum of grassland and cropland collected by localization data in pixels and converted in kilometers focusing on the country area. Agriculture occupation is used to capture the agricultural land expansion on deforestation. Agriculture represents the main sector in many developing countries. The major practice in the country case is the shifting cultivation or agribusiness that needs much space for constant production. Shifting cultivation has been attributed to causing large-scale deforestation in tropical forest-agriculture frontiers in many studies (Angelsen, 1995; Mukul and Herbohn, 2016). Thus, this practice forces farmers to migrate regularly to forest areas to find new land. Also, agricultural land expansion is the main strategy to increase agriculture income and production. Family agriculture migrates for subsistence and the big farmers convert the forestland frequently for crop production on a high scale (Culas, 2007).

Regarding wood industry data, we use processed wood data from ITTO, the main source of tropical timber trade and production.[5] This variable combines sawn wood, veneer and plywood production that represent the processed wood. The main input in the forest industry is wood. Following the low material yield of developing countries in wood processing, processed wood can be used as a proxy to measure the forest industry's pressure on forest resources.

[4]Data accessible at: https://lpdaac.usgs.gov/products/mcd12q1v006/

[5]Data accessible on https://www.itto.int/biennal$_{r}$*eview*/

4.4.3 Others control variables

The set of other control variables is from WDI: GDP per capita, population density, population growth, international trade, exchange rate and mineral rent (see statistics in Table A6 and variable definitions in Table A7).[6] GDP per capita is used to capture the effect of national wealth on forest loss. Focused on the Environmental Kuznets Curve (EKC) hypothesis, GDP per capita and GDP per capita squared should affect respectively the tree cover loss positively and negatively. So, deforestation increases with the income for the low level of income and achieves a threshold where the link becomes negative. So at the beginning of development, countries apply some pressure on forests for logging, firewood and to answer agricultural goods need. This pressure decreases when countries achieve some level of development where the energy of cooking is modern and the secondary and tertiary sectors are well developed reducing the logging activities and farming in rural areas (Culas, 2007). However, other empirical studies show no evidence of the environmental EKC for deforestation (Choumert et al., 2013).

Furthermore, international trade affects the dynamics of deforestation. Countries with comparative advantage in forest resources are generally timber exporters. They answer the demand of the international market by cutting down forests. Also, the cropland expansion and cattle activities for agricultural goods export increase deforestation (Faria and Almeida, 2016). Moreover, the exchange rate is an indicator of wood prices in international markets specifically for log exporters. Thus, the wood price guides the model choice of forest exploitation by the local community and forest industry. For instance, Arcand et al. (2008) show that a depreciation in the real exchange rate exacerbates deforestation in developing countries. In addition, the mineral rent is used as an indicator to assess the effect of mining extraction on deforestation. The extractive industries are invasive in developing natural richest countries occupying more high areas for operation (Kinda and Thiombiano, 2021).

Population density is most widely used in deforestation literature (Bhattarai and Hammig, 2001; Cropper and Griffiths, 1994; Culas, 2007). It is followed by population growth also mentioned as a major factor of deforestation. Government effectiveness and the rule of law are considered for the institutional channel. Ferreira and Vincent (2010) highlight a nonmono-

[6] Data accessible on https://databank.worldbank.org/source/world-development-indicators

tonic impact of governance on timber harvesting. Institutional structure, such as property rights, quality of governance and corruption significantly affect the tropical deforestation process (Araujo et al., 2009; Bhattarai and Hammig, 2001; Culas, 2007).

Finally, we also use the temperature shock data that is available on FAO Statistics and disseminate statistics of mean surface temperature change by country, with annual updates.[7] The temperature shocks capture the effect of floods, forest fires, or droughts considered as proximate causes of deforestation (Geist and Lambin, 2002; Vaglietti et al., 2022).

4.5 Identification strategy

This study aims to analyze whether the LEB has a detrimental effect on deforestation in adopter countries. Thus, our analysis considers treated countries that apply log export restrictions. The LEB adoption reason differs between countries. Deforestation fighting and forest industry promotion are the main objectives of the reform. Since most countries apply LEB to fight deforestation and low value-added forest manufacturing industries, one may have selection because LEB adoption may be correlated with unobservables which may also affect the overall deforestation level. Thus, LEB policy will face the selection bias problem. To circumvent this issue and identify the effect of the LEB policy, we use the matching method namely entropy balancing developed by Hainmueller (2012). This impact assessment strategy is used in economic literature as Neuenkirch and Neumeier (2016) to measure the effect of U.S. sanctions on poverty, Balima (2020) to assess the impact of coup d'état on the debt cost, Apeti (2023) to evaluate the effect of mobile money adoption on households consumption volatility. In this study, our potential outcome is annual deforestation. Thus, countries under the LEB policy are the treatment group and countries without the LEB are the control group. Then, the average treatment effect on treated (ATT) based on matching is defined as follows:

$$ATT = E[Y_{i1}|T = 1] - E[Y_{i0}|T = 0], \tag{4.4}$$

where deforestation is noted Y^0 for the outcome not located in the country under the LEB

[7] Data accessible on: https://www.fao.org/faostat/en/home

(T=0) and Y^1 for a country under treatment (T=1). $E[Y_{i1}|T=1]$ is the deforestation level during the LEB period and $E[Y_{i0}|T=0]$ is the counterfactual result for countries under LEB, i.e. the annual deforestation level for LEB adopter countries if they had not. The problem is that $E[Y_{i0}|T=0]$ is not observable related to the non-random nature of LEB policy adoption. If it was identifiable, the ATT could be easily defined by comparing the tree cover loss in LEB adopters with the non-LEB adoption situation. Thus, we need a good proxy to identify the ATT. So, we match treatment units with control units based on the pre-treatment country-level covariates that are as close as possible and correlated with both LEB adoption and annual deforestation. Under the condition, the treatment group and control group are fairly close and the difference in deforestation is imputable to LEB adoption. Focused on this condition, we can rewrite Equation 4.4 as follows:

$$ATT = E[Y_{i1}|T=1, X=\chi] - E[Y_{i0}|T=0, X=\chi], \tag{4.5}$$

where χ is a vector of pre-treatment characteristics correlated with treatment assignment and potentially correlated with annual deforestation. $E[Y_{i1}|T=1, X=\chi]$ is expected to be the best counterfactual for treatment units. Using entropy balancing to estimate the ATT involves two steps. The first step is to compute the weights for the non-treated group allowing the average of pre-treatment variables in the control group not to be statistically different from the average in the treated group. In this step, we want to ensure that the control group and treated units, on average, are as similar as possible. The second step uses the weight from the first stage in regression with the treatment indicator as an explanatory variable to counteract the eventual influence of pre-treatment differences on the treatment effect. In this regression, deforestation is the dependent variable to assess the effect of the LEB on annual tree cover loss. Furthermore, we control for time and country-specific effects in addition to entropy-balancing covariates, as in the randomized experiment, to increase estimation efficiency and to control for potential unobserved heterogeneity across countries and bias linked to changes over time, independent of treatment. This approach allows using the weighted least squared (WLS) in empirical estimation.

Entropy balancing allows us to estimate the effect of a LEB by comparing LEB and non-LEB countries that are as close as possible to observable characteristics while controlling for time and country-specific effects. This method by doing both a matching and regression approach offers some advantages compared to other impact analysis methods such as propensity score matching (PSM) or difference-in-differences (Neuenkirch and Neumeier, 2016). Entropy balancing is non-parametric in the sense that it requires no empirical model for either the outcome variable or selection into treatment needs to be specified. Hence, potential types of misspecification like those, for instance, regarding the functional form of the empirical model, which likely leads to biased estimates, are ruled out. Moreover, in contrast to regression-based analyses, treatment effects estimates based on entropy balancing do not suffer from multicollinearity, as the reweighting scheme orthogonalizes the covariates concerning the treatment indicator. Also, entropy balancing ensures a high covariates balance between the units treated and the counterfactual group even in small samples. Furthermore, in traditional matching methods such as nearest neighbor matching or propensity score matching, each unit subject to treatmentin the simplest caseis matched with the one unit non-subject to treatment that is closest in terms of a metric balancing score. Accordingly, the non-treated group is composed of only a subset of the units that are not subject to treatment (Hainmueller, 2012; Diamond and Sekhon, 2013). Thus, with the conventional matching approach, each unit non-subject to treatment either receives a weight equal to 0, in the event, it does not represent the best match for a treated unit or 1 if it is the best match for one treated unit. However, when the number of untreated units is limited and the number of pre-treatment characteristics is large, this procedure does not guarantee a sufficient balance of pre-treatment characteristics across the treatment and control groups. This is a serious issue, as a low covariate balance may lead to estimation biased. However, with entropy balancing, the vector of weights imputed to the units not assigned to treatment is allowed to contain any non-negative values. Thus, a synthetic control group is designed that represents a virtual image of the treatment group. Entropy balancing can be explicit as a generalization of conventional matching approaches.

4.6 Empirical results

4.6.1 Descriptive statistics

Table 4.1 shows the comparison of pre-reweighting means of each covariate between countries under LEB policy (column (1)) and the potential synthetic control group (column (2)). Column (3) reports the t-test difference of each covariate in means between the two groups. The p-value in the last column shows the significant difference between our two groups except for population density, trade openness and government effectiveness. Thus, such differences could bias the real treatment effect caused by a potential selection problem. The descriptive findings show why it is important to choose an appropriate synthetic control group by matching approach before assessing the treatment effect.

Table 4.1: Descriptive statistics

	(1)	(2)	(3)=(2)-(1)		
	LEB	No LEB	Difference	t-Test	p-Val
Log GDP Per Capita$_{t-1}$	7.396	7.821	.425	6.342	0.000
Log Agriculture occupation$_{t-1}$	5.721	5.048	-.6736	-4.286	0.000
Log Processed wood$_{t-1}$	12.069	9.489	-2.580	-12.361	0.000
Log Population density$_{t-1}$	3.981	4.042	.061	0.893	0.395
Population growth$_{t-1}$	2.012	1.426	-.586	-7.416	0.000
International trade$_{t-1}$	76.124	78.003	1.880	0.859	0.391
Log Exchange trade$_{t-1}$	4.561	3.696	-.865	-5.223	0.000
Temperature shock$_{t-1}$	1.046	.989	-.057	-1.917	0.056
Government effectiveness$_{t-1}$	-.653	-.477	.176	5.199	0.000
Rule and law$_{t-1}$	-.679	-.480	.199	6.400	0.000
Mineral rent$_{t-1}$	1.298	1.029	-.269	-1.554	0.121
Observations	253	1,068			

In Table 4.2, we compute a synthetic control group as defined in Section 4.5 to reweight the control units (column (4)). This strategy allows us to construct a perfect synthetic group closely similar to those of the treated units. Column (5) shows the difference in means after reweighting. The p-value and the t-test show no statistically significant difference between all covariates. Thus, statistical evidence shows the efficacy of entropy balancing to make a perfect synthetic control group related to the treatment group.

Table 4.2: Covariate balancing

	(1)	(4)	(5)=(4)-(1)		
	LEB	Control	Difference	t-Test	p-Val,
Log GDP Per Capita$_{t-1}$	7.396	7.396	0.000	0.000	1.000
Log Agriculture occupation$_{t-1}$	5.721	5.721	0.000	0.000	1.000
Log Processed wood$_{t-1}$	12.069	12.070	0.000	0.000	1.000
Log Population density$_{t-1}$	3.981	3.981	0.000	0.000	1.000
Population growth$_{t-1}$	2.012	2.0120	0.000	0.000	1.000
International trade$_{t-1}$	76.124	76.120	0.000	0.000	1.000
Log Exchange trade$_{t-1}$	4.561	4.561	0.000	0.000	1.000
Temperature shock$_{t-1}$	1.046	1.046	0.000	0.000	1.000
Government effectiveness$_{t-1}$	-.653	-.653	0.000	0.000	1.000
Rule and law$_{t-1}$	-.679	-.679	0.000	0.000	1.000
Mineral rent$_{t-1}$	1.298	1.298	0.000	0.000	1.000
Reweighted Observations	253	253			

4.6.2 Baseline results

Table 4.3: Log export ban and deforestation

Log Deforestation	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
LEB	0.443***	0.301***	0.289***	0.236***	0.261***	0.275***	0.282***	0.271***	0.281***	0.296***	0.296***	0.295***	0.290***
	(0.060)	(0.068)	(0.067)	(0.063)	(0.059)	(0.059)	(0.059)	(0.060)	(0.066)	(0.069)	(0.070)	(0.074)	(0.072)
Log GDP Per Capita$_{t-1}$		-0.081	3.971***	2.999***	2.106***	1.409	1.129	2.935***	2.892***	2.690**	2.903**	3.049***	2.751**
		(0.121)	(0.680)	(0.659)	(0.774)	(0.902)	(0.977)	(0.973)	(1.087)	(1.102)	(1.179)	(1.165)	(1.127)
Log GDP Per Capita squared$_{t-1}$			-0.280***	-0.209***	-0.139**	-0.097	-0.079	-0.194***	-0.194**	-0.175**	-0.192**	-0.200**	-0.180**
			(0.046)	(0.045)	(0.054)	(0.064)	(0.067)	(0.068)	(0.075)	(0.076)	(0.082)	(0.081)	(0.079)
Log Agriculture occupation$_{t-1}$				2.207***	2.311***	2.216***	2.132***	1.950***	2.036***	1.954***	1.979***	2.158***	2.129***
				(0.334)	(0.341)	(0.346)	(0.350)	(0.386)	(0.413)	(0.432)	(0.444)	(0.434)	(0.431)
Log Processed wood$_{t-1}$					0.067**	0.109**	0.148***	0.127**	0.101*	0.100*	0.103*	0.086	0.070
					(0.032)	(0.044)	(0.052)	(0.060)	(0.056)	(0.056)	(0.056)	(0.056)	(0.054)
Log population density$_{t-1}$						0.148	-0.059	0.157	0.152	0.181	0.162	0.115	0.230
						(0.360)	(0.347)	(0.370)	(0.396)	(0.417)	(0.423)	(0.431)	(0.422)
Population growth$_{t-1}$							0.061	0.016	0.048	0.058	0.058	0.049	0.053
							(0.056)	(0.057)	(0.065)	(0.062)	(0.063)	(0.063)	(0.062)
International Trade$_{t-1}$								0.001	0.001	0.001	0.001	0.001	0.001
								(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Log Exchange rate$_{t-1}$									0.005	0.007	0.004	-0.000	0.006
									(0.025)	(0.025)	(0.026)	(0.027)	(0.022)
Temperature shock$_{t-1}$										0.059	0.060	0.050	0.047
										(0.089)	(0.089)	(0.092)	(0.092)
Government effectiveness$_{t-1}$											0.023	0.036	0.021
											(0.134)	(0.162)	(0.165)
Rule and Law$_{t-1}$												-0.015	0.004
												(0.166)	(0.166)
Mineral rent$_{t-1}$													0.002
													(0.013)
Constant	0.426***	0.290	-13.981***	-25.689***	-24.453***	-22.186***	-20.475***	-18.051***	-17.793***	-17.281***	-18.195***	-19.128***	-18.304***
	(0.140)	(0.737)	(2.493)	(3.094)	(3.314)	(3.467)	(3.828)	(3.346)	(3.663)	(3.831)	(4.150)	(4.223)	(4.035)
Observation	1,897	1,720	1,720	1,720	1,695	1,695	1,695	1,557	1,435	1,405	1,327	1,327	1,321
Number of countries	100	97	97	97	97	97	97	92	90	90	89	89	88
Country fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rsquared	0.963	0.974	0.975	0.975	0.970	0.971	0.972	0.969	0.969	0.968	0.968	0.969	0.969

Note: robust standard errors in brackets. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The dependent variable is Log Deforestation. Estimator: WLS with synthetic control variables approach

Based on the synthetic controls in Table 4.2, we use the WLS method to estimate the effect of LEB on deforestation (ATT) in developing countries. The results in Table 4.3 present the result with a set of matching covariates used in the first stage to build the synthetic group. We put progressively matching covariates in the second stage to see the LEB adoption effect on deforestation for each covariate controlled. We note that including the matching covariates in the second stage of entropy balancing allows matching quality to increase (as in randomized experiments). Columns (1)-(13) including country and time-fixed effects show that the LEB policy adoption significantly increases (at 1%) deforestation in LEB countries compared to non-LEB countries. The magnitude of this effect is between 23.6% in columns (4) and (1) and 44.3% in column (1) showing that our result is robust given the relative stability of the coefficients across all specifications. Focusing on column (13) which is the full matching covariates used in the first stage and shown in Table 4.2, we can estimate the average effect at 29% increase of deforestation after the policy adoption.

4.6.3 Channels

As defined above, LEB adoption increases deforestation in developing countries. This section aims at highlighting the mechanisms underlying our results. Thus, we test the relevance of our two potential transmission channels, agriculture occupation and processed wood quantity, as described in Section 4.2.2. We use the mediator variables approach that matches our analysis as defined by Baron and Kenny (1986). Then, we test the linkages of the mediational model. We first assess their relevance to the mediator variable using a simple country and year-fixed effects regression before testing our channels. This strategy aims to check if LEB adoption affects our two mediator variables defined as the transmission channels. Second, we assess the effect of LEB on deforestation without controlling for mediator variables. Third, we estimate the effect of LEB adoption on deforestation controlling for agriculture occupation and processed wood quantity as mediator variables. In each step, we use the synthetic control variable approach and the WLS estimator.

Table 4.4 shows the result where the coefficient of each regression establishes the mediation. Columns (1) and (2) show that LEB is associated with a positive effect on agriculture occupation and processed wood. This result allows for meeting the first condition of the significant effect of LEB on mediator variables. In column (3), we assess the second condition of the effect of LEB on deforestation without mediator variables. Last, controlling respectively for agriculture occupation, processed wood quantity and both variables, the coefficient of the effect of LEB on deforestation must be less in columns (4), (5) and (6) than the coefficient in columns (3). The last condition is fulfilled. Overall, we can state that our potential transmission channels meet the mediator's variables conditions to support our explanation given in Section 4.2.2 and Section 4.3.

Table 4.4: Transmission channels analysis

Dependent variable	(1) Log Agriculture occupation	(2) Log Processed wood	(3) Log deforestation	(4) Log deforestation	(5) Log deforestation	(6) Log deforestation
LEB	0.036***	0.232***	0.443***	0.154***	0.286***	0.219***
	(0.008)	(0.075)	(0.060)	(0.058)	(0.057)	(0.055)
Log Agriculture occupation				2.435***		2.270***
				(0.334)		(0.320)
Log Processed wood					0.063**	0.067***
					(0.026)	(0.025)
Constant	6.882***	12.722***	0.426***	-16.648***	-0.819**	-16.473***
	(0.008)	(0.149)	(0.140)	(2.302)	(0.360)	(2.190)
Observations	1,897	1,865	1,897	1,897	1,865	1,865
Number of countries	100	100	100	100	100	100
Country fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Covariates	No	No	No	No	No	No
Rsquared	1.000	0.958	0.963	0.973	0.970	0.971

Note: robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. Estimator: WLS with synthetic control variables approach

4.7 Robustness check

4.7.1 Alternative LEB measure

The LEB adoption is not homogeneous in all adopter countries. Other forest policies like sawn wood export ban and logging ban sometimes follow LEB policy. These policies could affect too much the effect of the LEB policy on deforestation. First, we exclude all sawn wood export ban adopters. Second, we drop all logging ban adopters countries in our sample. Lastly, we exclude in our sample countries that apply both the sawn wood export ban and the logging ban. Excluding sawn wood export ban countries (column (1)) increases the LEB effect related to our baseline result (Table 4.5). However, excluding the logging ban adopter and both policy adopters decrease the LEB effect on deforestation. Countries that apply logging bans in addition to the LEBs are most policy-oriented on the timber cut-down restriction. These countries meet a high level of deforestation explaining the logging ban adoption. So, excluding logging ban adopters decrease the effect of the LEB policy on deforestation.

Table 4.5: LEB redefinition

Log Deforestation	(1) Excluding Sawnwood Ban adopter	(2) Excluding Logging Ban adopter
LEB	0.420***	0.177**
	(0.117)	(0.074)
Log GDP Per Capita$_{t-1}$	2.744*	3.035**
	(1.430)	(1.369)
Log GDP Per Capita squared$_{t-1}$	-0.183*	-0.201**
	(0.099)	(0.095)
Log Agriculture occupation$_{t-1}$	1.480***	1.906***
	(0.486)	(0.709)
Log Processed wood$_{t-1}$	0.074	-0.023
	(0.060)	(0.069)
Log population density$_{t-1}$	0.419	0.753
	(0.575)	(0.523)
Population growth$_{t-1}$	-0.003	0.085
	(0.073)	(0.072)
International Trade$_{t-1}$	-0.000	0.003
	(0.001)	(0.002)
Log Exchange rate$_{t-1}$	-0.012	0.027
	(0.043)	(0.033)
Temperature shock$_{t-1}$	0.138	0.078
	(0.138)	(0.106)
Government effectiveness$_{t-1}$	0.079	0.165
	(0.197)	(0.197)
Rule and Law$_{t-1}$	-0.125	-0.132
	(0.213)	(0.179)
Mineral rent$_{t-1}$	0.015	-0.029
	(0.012)	(0.020)
Constant	-16.687***	-20.929***
	(5.301)	(6.247)
Observations	1,158	1,219
Number of countries	78	82
Country fixed effect	Yes	Yes
Year fixed effect	Yes	Yes
Rsquared	0.970	0.971

Note: robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1.

4.7.2 Alternative deforestation measure

The measure of deforestation used in the baseline model is the annual tree cover loss. Following previous studies (Choumert et al., 2013; Culas, 2007; Culas, 2012; Damette and Delacote, 2011; Leblois et al., 2017; Motel et al., 2009), our deforestation data estimated in Section 4.4.1 representing the yearly forest cover drop, is divided by the country area. The annual deforested area relative to the country size allows us to normalize country-level deforestation and control for heterogeneity in country size and the proportion of forest land cover in our sample (Leblois et al., 2017). Indeed, the forest area harvested has a different meaning in small countries and large countries. This approach allows us to avoid heteroscedasticity issues by reducing the variability between countries. Table 4.6 shows in column (1) our baseline result with an entropy balancing approach and full covariates. Column (2) uses the deforestation share of the country's surface area as a dependent variable. Thus, the LEB adoption still increases the deforestation adopter countries compared to non-adopters.

Table 4.6: Deforestation share of country area

	(1) Log Deforestation (Km^2)	(2) Deforestation share of countries area (%)
LEB	0.290***	0.001***
	(0.072)	(0.000)
Log GDP Per Capita$_{t-1}$	2.751**	0.010**
	(1.127)	(0.004)
Log GDP Per Capita squared$_{t-1}$	-0.180**	-0.001**
	(0.079)	(0.000)
Log Agriculture occupation$_{t-1}$	2.129***	0.017***
	(0.431)	(0.003)
Log Processed wood$_{t-1}$	0.070	-0.000
	(0.054)	(0.000)
Log population density$_{t-1}$	0.230	0.000
	(0.422)	(0.001)
Population growth$_{t-1}$	0.053	-0.000*
	(0.062)	(0.000)
International Trade$_{t-1}$	0.001	-0.000
	(0.001)	(0.000)
Log Exchange rate$_{t-1}$	0.006	0.000
	(0.022)	(0.000)
Temperature shock$_{t-1}$	0.047	-0.000
	(0.092)	(0.000)
Government effectiveness$_{t-1}$	0.021	-0.000
	(0.165)	(0.001)
Rule and Law$_{t-1}$	0.004	0.002***
	(0.166)	(0.001)
Mineral rent$_{t-1}$	0.002	0.000
	(0.013)	(0.000)
Constant	-18.304***	-0.101***
	(4.035)	(0.016)
Observations	1,321	1,321
Number of countries	88	88
Country fixed effect	Yes	Yes
Year fixed effect	Yes	Yes
Rsquared	0.969	0.817

Note: robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1.

4.7.3 Alternative estimation methods

Instrumental variable approach

In our analysis, there are two potential endogeneity biases defined as the correlation between the error term and the dependent variable. First, the inverse causality may emerge because some countries apply LEB to combat the over-exploitation generating forest degradation and deforestation. Thus, the deforestation level could raise the probability of LEB adoption. Second, there are potential omitted explanatory variables that may explain the deforestation level. This omitted variable would be in the error term which will be correlated to our outcome. If the endogeneity has an important effect on the OLS estimation, then we will see an overestimation of the LEB policy coefficient value. To resolve the endogeneity issue, we apply the instrumental variables approach as recommended by Wooldridge (2015) for explanatory endogenous binary variables. Finding a good instrument for a LEB policy is not a simple task. The instrument must be correlated to the suspected endogenous variable without impacting the outcomes through another channel. Thus, the first step is the regression of the instrument variable and the set of control variables on LEB policy. We will use the probit approach (Equation 4.6) to estimate the probability of LEB adoption because the policy is a dummy variable. This step allows the endogeneity bias elimination from LEB policy.

$$E[LEB|Z_i, X_i] = Pr[LEB = 1|Z_i, X_i] \tag{4.6}$$

In the second stage, we use the prediction of LEB policy adoption probability as the interest variable and the set of control variables where deforestation is the outcome as follows:

$$log(TCL_{i,t}) = \beta_0 + \beta_1 L\hat{EB}_{i,t} + \gamma X_{i,t-1} + \eta_i + \theta t + \epsilon_{i,t} \tag{4.7}$$

We use two instruments for the instrumentation of the LEB policy variable. The first instrument is the neighborhood effect of LEB policy adoption. The country's choice of policy and market orientation is correlated with the share of neighboring countries following these policies (Buera et al., 2011; Persson and Tabellini, 2009). Also, countries that are in an economic regional area where the policy is harmonized, countries are an attempt to apply the policy already applied by most countries. In these regions, countries try to converge toward the same policy for the economy and environment. Thus, LEB policy adoption in the neighbor increases the probability of policy adoption in non-adopter countries. In the deforestation analysis, the policy adopted by the neighbor cannot directly affect deforestation in non-adopter countries. The neighborhood effect is from the FPER database as our interest variable and computed as the proportion of neighbors of the country that implemented LEB in period t-1. It is worth noting that we also control the neighboring country's deforestation in our estimation because it will be affected by the LEB adoption in a specific country. Indeed, the LEB policy adoption can influence the policy in neighboring countries but also the neighboring country's deforestation levels. The constraint of timber export in adopter countries could reorient international trade to address its demand to a neighbor country that did not apply the LEB policy. Thus, the LEB adoption in the country i could affect deforestation in its neighboring countries.

The second instrument is the tariff rate weighted mean applied on primary products that come from WDI. This variable shows the international trade dependence level of each country regarding the tariff rate. To avoid the reciprocity in multilateral trade that can affect the international trade level, countries are fewer incentives to apply some strict prohibition on export and import (Bagwell and Staiger, 2001). Also, high levels of tariff rates show how much countries are based on revenue from customs cordons. Thus, countries with higher tariff rates are less motivated to apply LEB policies that consist to renounce tax revenue from log export.

Table 4.7 presents the results.

Table 4.7: LEB and deforestation: IV approach

	Entropy (WLS)	Instrumental Variable	
		First stage	Second stage
	Log Deforestation (Km^2)	LEB	Log Deforestation (Km^2)
LEB	0.190***		0.453***
	(0.068)		(0.159)
Log GDP Per Capita$_{t-1}$	1.272	7.849***	3.815***
	(1.066)	(1.277)	(1.174)
Log GDP Per Capita squared$_{t-1}$	-0.062	-0.546***	-0.256***
	(0.073)	(0.085)	(0.081)
Log Agriculture occupation$_{t-1}$	2.265***	-0.023	1.717***
	(0.365)	(0.037)	(0.555)
Log Processed wood$_{t-1}$	0.134**	0.278***	0.084**
	(0.055)	(0.039)	(0.039)
Log population density$_{t-1}$	-0.470	-0.194**	-0.583
	(0.412)	(0.079)	(0.419)
Population growth$_{t-1}$	0.045	0.513***	-0.018
	(0.055)	(0.097)	(0.052)
Temperature shock$_{t-1}$	0.077	0.562***	0.015
	(0.080)	(0.184)	(0.057)
Government effectiveness$_{t-1}$	-0.059	-0.428	-0.209
	(0.164)	(0.292)	(0.144)
Rule and Law$_{t-1}$	0.035	0.835***	-0.099
	(0.153)	(0.256)	(0.153)
Mineral rent$_{t-1}$	0.006	-0.080***	0.004
	(0.013)	(0.024)	(0.011)
Log Neighbors deforestation$_{t-1}$	0.257***	0.126***	0.135**
	(0.068)	(0.046)	(0.054)
Constant	-25.248***	-35.189***	-20.930***
	(4.254)	(5.004)	(5.085)
Neighbor$_{t-1}$		2.621***	
		(0.261)	
Tariff rate weighted$_{t-1}$		-0.091***	
		(0.019)	
Observations	1,201	823	823
Number of countries	74	66	66
Country fixed effect	Yes	No	Yes
Year fixed effect	Yes	Yes	Yes

Note: robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. We control for neighbor deforestation in this estimation and we drop International Trade and exchange rate that can create multicollinearity with our second IV (tariff rate weighted).

The following analysis is focused on column (13) of Table 4.3 where all control variables are used. To address the endogenous problem defined above, we use those two instruments to resolve the inverse causality and the omission variable problem. Table 4.7 shows the entropy balancing and 2SLS describing the first (Equation 4.6) and second stage (Equation 4.7). In the first stage focusing on Equation 4.6, we use the probit model to see the effect of our instruments on LEB policy. The first stage shows the positive and significant effects of the neighbor LEB adoption on the probability of LEB policy adoption while the tariff rate weighted has a negative and significant effect at 1%. Thus, the instruments are valid for the first stage. In the second stage, we extract the prediction of LEB from the probit model and add it to the baseline OLS model. We then focus on the LEB prediction coefficient. The results show that the LEB policy coefficient is significant at 5% with an increase of its magnitude (from 0.19 to 0.453).

GMM estimation

As defined in the last subsection, the estimation of the effect of the LEB policy on deforestation can be challenged by endogeneity issues. We use a panel two-step system GMM estimation developed by Blundell and Bond (1998) with Windmeijer (2005) small sample correction to consider the potential endogeneity caused by simultaneous bias. To deal with the proliferation of instruments problem, we restrict and collapse the instruments (Roodman, 2009). Table 4.8 provides the GMM estimation results. The p-values at 5% of AR(1) and AR(2) and the Hansen tests support the validity of our results. The lagged dependent variable is positive, significant at 1% and lower than 1 showing there is no fallacious regression. In column (1), we still have our entropy balancing strategy and column (2) shows the GMM result. In each case, the LEB dummy is still positive and significant reflecting the positive effect of the LEB policy on deforestation.

Table 4.8: System-GMM

Log Deforestation	(1) Entropy balancing	(2) GMM
Log Deforestation$_{t-1}$		0.782***
		(0.077)
LEB	0.290***	0.323**
	(0.072)	(0.156)
Log GDP Per Capita	2.751**	2.832
	(1.127)	(2.363)
Log GDP Per Capita squared	-0.180**	-0.188
	(0.079)	(0.153)
Log Agriculture occupation	2.129***	-0.008
	(0.431)	(0.032)
Log Processed wood	0.070	0.090***
	(0.054)	(0.032)
Log population density	0.230	-0.105
	(0.422)	(0.074)
Population growth	0.053	-0.006
	(0.062)	(0.059)
International Trade	0.001	-0.001
	(0.001)	(0.003)
Log Exchange rate	0.006	-0.003
	(0.022)	(0.033)
Temperature shock	0.047	-0.415*
	(0.092)	(0.214)
Government effectiveness	0.021	0.004
	(0.165)	(0.225)
Rule and Law	0.004	-0.213
	(0.166)	(0.205)
Mineral rent	0.002	-0.028
	(0.013)	(0.033)
Constant	-18.304***	-9.705
	(4.035)	(8.793)
Observations	1,321	1,221
Number of countries	88	88
Instruments		24
AR1-pvalue		0.000
AR2-pvalue		0.233
Hansen-pvalue		0.334

Note: robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1.

4.8 Heterogeneity

4.8.1 Resampling

To check the stability of our econometric model, we modify our sample on a regional basis following World Bank's classification (Combes et al., 2015). So, we exclude East Asia and the Pacific, South Asia Latin America, the Caribbean and the Sub-saharan Africa region in our estimation to check the robustness. Table 4.9 reports this approach. The LEB policy is still positive and significant at 1%. However, excluding South Asia decreases the LEB adoption effect on deforestation. Indeed, this region of the world is the center of log production and export with high pressure on deforestation. So, the LEB effect is more important in this region compared to other regions. South Asia exclusion in our sample allows for reducing the LEB adoption effect on deforestation.

Table 4.9: Resampling

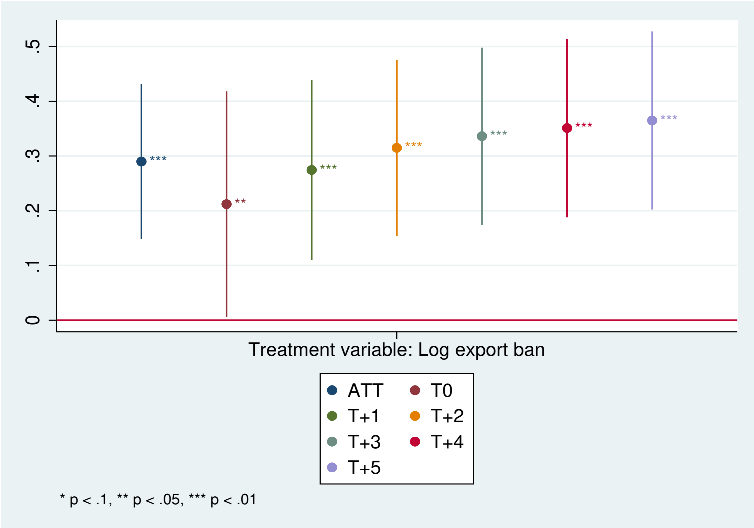
Log Deforestation	(1)	(2)	(3)	(4)
LEB	0.300***	0.191***	0.319***	0.319***
	(0.084)	(0.068)	(0.080)	(0.107)
Log GDP Per Capita$_{t-1}$	2.912**	3.392***	2.292*	1.098
	(1.258)	(1.196)	(1.268)	(1.535)
Log GDP Per Capita squared$_{t-1}$	-0.193**	-0.244***	-0.151*	-0.012
	(0.086)	(0.084)	(0.088)	(0.100)
Log Agriculture occupation$_{t-1}$	2.464***	1.649***	2.285***	1.942**
	(0.460)	(0.396)	(0.476)	(0.780)
Log Processed wood$_{t-1}$	-0.014	0.010	0.069	0.247***
	(0.057)	(0.053)	(0.061)	(0.090)
Log population density$_{t-1}$	0.536	0.206	0.288	-2.260**
	(0.444)	(0.388)	(0.441)	(1.019)
Population growth$_{t-1}$	0.061	-0.013	0.062	-0.027
	(0.061)	(0.063)	(0.062)	(0.063)
International Trade$_{t-1}$	0.002	0.000	0.001	0.002
	(0.001)	(0.001)	(0.001)	(0.002)
Log Exchange rate$_{t-1}$	0.021	0.022	0.001	-0.001
	(0.025)	(0.019)	(0.023)	(0.048)
Temperature shock$_{t-1}$	0.027	-0.060	0.054	0.145
	(0.098)	(0.054)	(0.095)	(0.116)
Government effectiveness$_{t-1}$	-0.060	-0.227*	0.154	0.174
	(0.185)	(0.136)	(0.201)	(0.198)
Rule and Law$_{t-1}$	0.101	0.283*	-0.063	-0.715***
	(0.173)	(0.152)	(0.215)	(0.224)
Mineral rent$_{t-1}$	0.005	0.002	0.002	-0.015
	(0.014)	(0.012)	(0.014)	(0.021)
Constant	-20.660***	-16.773***	-17.403***	-5.849
	(4.752)	(3.969)	(4.512)	(6.238)
Observations	1,181	1,230	1,096	870
Number of countries	79	82	72	57
Without East Asia and Pacific	Yes	No	No	No
Without South Asia	No	Yes	No	No
Without Latin America and the Caribbean	No	No	Yes	no
Without Sub-saharan Africa	No	No	No	Yes
Country fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Rsquared	0.970	0.979	0.968	0.966

Note: robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1.

4.8.2 The effect of LEB over time

Furthermore, we check the time effect of LEB policy adoption. We test whether LEB adoption has a temporary or persistent effect on deforestation. Many policies have effects on policy adoption only in the beginning period. The effect disappears rapidly over time. Figure 4.6 reports the policy adoption effect after one, two, three, four and five years respectively (full estimation results are in Table A8 in Appendix). In each case, LEB is positive and significant showing that LEB adoption increases deforestation. Thus, the effect of LEB adoption is persistent. The effect appears after policy adoption, increases overtime and becomes stable after three years.

Figure 4.6: The effect of LEB on deforestation over time



4.9 Conclusion

This study aims to assess the effect of LEB policy adoption on deforestation. We focus our analysis on a large panel of 100 developing countries with more than 100 Km^2 of forest cover from 2001 to 2019. We use entropy balancing to evaluate this effect. We find that the policy adoption allows increasing tree cover loss by around 29% in LEB country adopters compared to non-adopters. Our finding is robust to various tests including alternative LEB and deforestation measures and alternative estimation methods. We redefine the identification of countries that have adopted the LEB policy by excluding those that have also adopted either the logging ban, the timber export ban, or both bans at the same time. Then, we use deforestation share of the country area as a measure of deforestation. The effect remains positive and significant. We also use (1) an instrumental variable strategy with two instruments of LEB policy and (2) a GMM estimation as identification strategies to resolve endogenous problems of LEB policy. After taking into account these issues, the LEB effect is still positive and significant at 5%. Moreover, we implement a transmission channel analysis that reveals that LEB policy impacts deforestation through agricultural land use and processed wood production. Furthermore, the heterogeneity test reveals that the LEB is positive and significant by resample excluding respectively East Asia and Pacific, Latin America, the Caribbean, and the Sub-saharan Africa region of our analysis. Then, we check the overtime effect of LEB adoption for 5 years after the policy adoption. Overall, LEB adoption is still positive and significant showing that LEB adoption has a persistent effect on deforestation.

In conclusion, based on our results, policymakers front of two distinct options. First, linked to the damageable effect of LEB policy on forests, governments may remove LEB policy to gain in forest conservation. However, this choice leads to renouncing growth in production and trade in the forest industry highlighted by Marchand and Zerbo (2023). Second, policymakers may preserve LEB policy followed by three recommendations to affect the behaviors concerning forest management to add the environmental gain to industrialization and trade gains. Governments must support farmers in mechanized, intensive and sustainable agriculture with high-level training of the rural population. It allows for a decrease in forest conversion for agricultural use or extension of agricultural land around the forest area. Moreover, policymakers may encourage sustainable forest management and combat illegal logging through certification requirements, reinforce property rights and fight corruption around forest management. In addition, policymakers must encourage sustainable downstream production by promoting investments in high-efficiency and low-waste wood technologies.

Appendix A

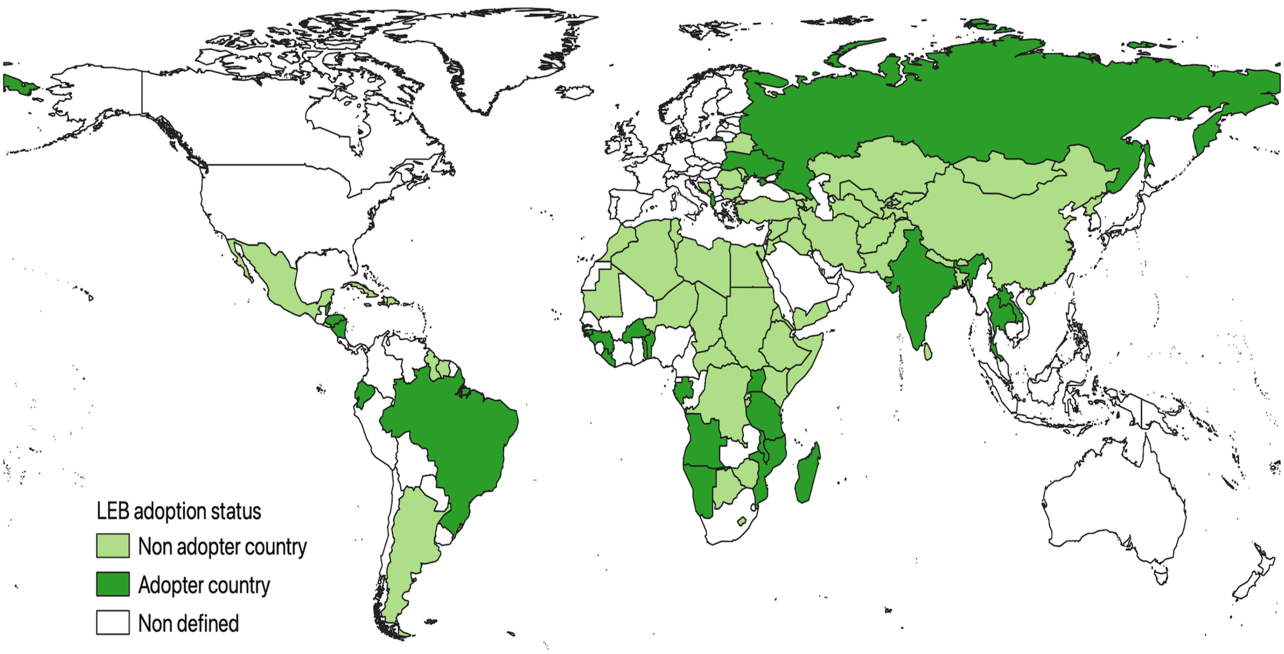


Figure A2: Sample used in this study: adopters and non-adopters LEB

Table A6: Descriptives statistics

Variable	Observations	Mean	Std. Dev.	Min	Max
Deforestation (Km^2)	1,897	1165.768	4989.672	0	56659.328
LEB (0-1)	1,897	.148	.355	0	1
GDP Per Capita (constant 2015 US $)	1,815	3529.962	3055.043	258.629	14200.27
Agriculture occupation (Km^2)	1,897	2283.754	5587.754	.009	31222.973
Processed wood (m^3)	1,865	1231222.7	4980721.2	0	47394000
Population density (resident/Km^2)	1,887	117.776	159.219	1.557	1252.563
Population growth (%)	1,889	1.555	1.297	-4.533	6.559
International Trade (% of GDP)	1,685	76.515	34.921	.167	311.354
Exchange rate (LCU per $)	1,710	748.238	3079.021	.055	42000
Temperature shock (řC)	1,820	1,016	.492	-.499	2.767
Government effectiveness (-2.5 - 2.5)	1,783	-.573	.645	-2.475	1.057
Rule and law (-2.5 - 2.5)	1,786	-.578	.675	-2.447	1.41
Mineral rent (% of GDP)	1,819	.991	2.626	0	25.163
Neighbor deforestation (Km^2)	1,498	3996478.8	12112054	0	1.288e+08
Neighbor (0-1)	1,745	.263	.338	0	1
Tariff rate weighted (%)	1,269	8.024	6.536	0	63.69

Table A7: Variables definition

Variables	Description	Source
Deforestation (Km^2)	Annual forest cover loss with vegetation taller than 5 m in 2020.	Hansen et al. (2013)
Log Export Ban	Log export ban is the dummy variable taking 1 if the country applies a ban on log export and 0 if not.	FPER*
GDP per capita (constant 2015 US $)	GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for the depreciation of fabricated assets or for the depletion and degradation of natural resources. 2015 U.S. dollars.	WDI**
Agriculture occupation (Km^2)	The sum of grasslands, croplands, and cropland/natural vegetation mosaic (Km^2).	Earth Data
Processed wood (m^3)	The sum of the Volume of Sawnwood production, Veneer production, and Plywood production (m^3).	ITTO***
Population density (resident/Km^2)	Population density is midyear population divided by land area in square kilometers. The population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship–except for refugees not permanently settled in the country of asylum, who are generally considered part of the population of their country of origin. Land area is a country's total area, excluding areas under inland water bodies, national claims to continental shelves, and exclusive economic zones. In most cases, the definition of inland water bodies includes major rivers and lakes.	WDI
Population growth (%)	The annual population growth rate for year t is the exponential rate of growth of the midyear population from year t-1 to t, expressed as a percentage. The population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship.	WDI
International trade (% of GDP)	Trade is the sum of exports and imports of goods and services measured as a share of gross domestic produc	WDI
Exchange trade (LCU per $)	Official exchange rate refers to the exchange rate determined by national authorities or to the rate determined in the legally sanctioned exchange market. It is calculated as an annual average based on monthly averages (local currency units relative to the U.S. dollar).	WDI
Temperature shock (řC)	The FAOSTAT Temperature change on land domain disseminates statistics of mean surface temperature change by country, with annual updates. The current dissemination covers the period 19612022. Statistics are available for monthly, seasonal, and annual mean temperature anomalies, i.e., temperature change concerning to a baseline climatology, corresponding to the period 19511980. The standard deviation of the temperature change of the baseline methodology is also available. Data are based on the publicly available GISTEMP data, the Global Surface Temperature Change data distributed by the National Aeronautics and Space Administration Goddard Institute for Space Studies (NASA-GISS).	FAOSTAT
Government effectiveness (-2.5 - 2.5)	Government Effectiveness captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. Estimate gives the country's score on the aggregate indicator, in units of standard normal distribution, i.e. ranging from approximately -2.5 to 2.5.	WGI****
Rule and law (-2.5 - 2.5)	Rule of Law captures perceptions of the extent to which agents have confidence in and abide by the rules of society and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence. Estimate gives the country's score on the aggregate indicator, in units of standard normal distribution, i.e. ranging from approximately -2.5 to 2.5.	WGI
Mineral rent (% of GDP)	Mineral rents are the difference between the value of production for a stock of minerals at world prices and their total costs of production. Minerals included in the calculation are tin, gold, lead, zinc, iron, copper, nickel, silver, bauxite, and phosphate.	WDI
Neighbors' deforestation (Km^2)	The mean annual forest cover loss with vegetation taller than 5 m in 2020 in neighboring countries.	Hansen et al. (2013)
Neighbor (0-1)	Share of neighborhood countries applying log export ban.	FPER
Tariff rate weighted (%)	Weighted mean applied tariff is the average of effectively applied rates weighted by the product import shares corresponding to each partner country. Primary products are commodities classified in SITC revision 3 sections 0-4 plus division 68 (nonferrous metals).	WDI

*Forest Product Export Restriction; **World Development Indicators; ***International Tropical Timber Organization; ****Worldwide Governance Indicators

Table A8: LEB effect over time

Log Deforestation	(1)	(2)	(3)	(4)	(5)	(6)	(7)
LEB adoption (baseline)	0.290*** (0.072)						
LEB adoption (t0)		0.212** (0.105)					
First year after adoption (t+1)			0.274*** (0.084)				
Second year after adoption (t+2)				0.315*** (0.082)			
Third year after adoption (t+3)					0.336*** (0.082)		
Fourth year after adoption (t+4)						0.351*** (0.083)	
Five year after adoption (t+5)							0.365*** (0.083)
Log GDP Per Capita$_{t-1}$	2.751** (1.127)	2.333* (1.369)	2.619** (1.325)	2.612** (1.307)	2.195* (1.297)	2.518** (1.268)	2.475** (1.210)
Log GDP Per Capita squared$_{t-1}$	-0.180** (0.079)	-0.128 (0.092)	-0.145 (0.090)	-0.143 (0.089)	-0.111 (0.089)	-0.140 (0.087)	-0.144* (0.084)
Log Agriculture occupation$_{t-1}$	2.129*** (0.431)	2.466*** (0.928)	2.377*** (0.844)	2.722*** (0.791)	2.780*** (0.703)	2.410*** (0.626)	2.240*** (0.527)
Log Processed wood$_{t-1}$	0.070 (0.054)	0.250*** (0.076)	0.246*** (0.077)	0.274*** (0.071)	0.232*** (0.074)	0.205*** (0.069)	0.201*** (0.076)
Log population density$_{t-1}$	0.230 (0.422)	0.110 (0.619)	0.048 (0.597)	-0.039 (0.580)	-0.041 (0.567)	0.090 (0.554)	-0.009 (0.554)
Population growth$_{t-1}$	0.053 (0.062)	0.014 (0.062)	0.005 (0.062)	0.003 (0.063)	0.018 (0.064)	0.015 (0.065)	0.018 (0.064)
International Trade$_{t-1}$	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)
Log Exchange rate$_{t-1}$	0.006 (0.022)	0.020 (0.021)	0.029 (0.019)	0.028 (0.019)	0.019 (0.022)	0.012 (0.023)	0.009 (0.023)
Temperature shock$_{t-1}$	0.047 (0.092)	0.192* (0.116)	0.163 (0.118)	0.147 (0.112)	0.135 (0.104)	0.120 (0.100)	0.109 (0.099)
Government effectiveness$_{t-1}$	0.021 (0.165)	0.264 (0.248)	0.211 (0.230)	0.219 (0.210)	0.194 (0.199)	0.179 (0.193)	0.105 (0.187)
Rule and Law$_{t-1}$	0.004 (0.166)	-0.383 (0.239)	-0.375 (0.232)	-0.390* (0.224)	-0.466** (0.217)	-0.497** (0.210)	-0.271 (0.201)
Mineral rent$_{t-1}$	0.002 (0.013)	0.004 (0.017)	0.013 (0.014)	0.013 (0.013)	0.016 (0.013)	0.015 (0.013)	0.013 (0.012)
Constant	-18.304*** (4.035)	-21.469*** (6.060)	-21.814*** (5.688)	-22.882*** (5.562)	-21.280*** (5.397)	-21.021*** (5.134)	-19.150*** (4.746)
Observations	1,321	1,095	1,121	1,145	1,168	1,191	1,211
Number of countries	88	88	88	88	88	88	88
Country fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rsquared	0.969	0.967	0.968	0.970	0.970	0.970	0.970

Note: robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. The first column is the baseline result (Column (13) of Table 4.3).The second column constructs a new treatment variable by dropping all observations following the LEB initiation year. Columns [37] consider only observations for 1, 2, 3, 4 and 5 years after the mobile money adoption year, respectively.

Chapter 5

Conclusion générale

Cette thèse consiste à évaluer l'impact de l'adoption de la réforme d'interdiction de l'exportation de grume sur une partie des objectifs souvent avancés lors de sa mise en oeuvre : stimuler la production, les exportations et l'emploi de la filière bois en aval, et lutter contre la déforestation. Ainsi, cette thèse, en évaluant l'impact d'une réforme, est un travail de recherche en économie publique mais est également à la croisée de l'économie industrielle, de l'économie internationale, de l'économie environnementale et de l'économie du travail.

Notre travail permet ainsi de mettre en évidence l'impact de l'interdiction d'exportation de grume en utilisant plusieurs approches économétriques d'analyse d'impact. Aussi, nous donnons une orientation évidente de ces effets sur un panel de pays en développement afin d'éclairer les décideurs publics concernant l'application de cette réforme. Par exemple, nous mettons en évidence que les industries sont beaucoup plus concentrées sur la transformation basique du bois, que tous les emplois ne sont pas impactés de la même façon et que la réforme stimule la déforestation au travers de deux canaux de transmissions.

Le chapitre 2 de cette thèse évalue l'effet de l'adoption de la réforme d'interdiction d'exportation de grume sur l'industrialisation et le commerce du bois transformé dans les pays en développement. Nous trouvons un effet positif de la réforme sur la production de bois transformé. Cet effet est plus important dans la production de contreplaqué qui est moins complexe que la production du bois de placage montrant ainsi les étapes dans le processus d'industrialisation. Aussi, l'effet de cette réforme n'est positive et significative que pour l'exportation de contreplaqué montrant ainsi l'étape réelle de transformation dans les pays en développement. Le chapitre 3 étudie l'impact de l'adoption de la politique d'interdiction d'exportation de grume sur l'emploi dans l'industrie de transformation et trouve un effet positif et significatif sur l'emploi total dans le secteur. L'analyse d'hétérogénéité selon le type d'emploi suggère que seul l'emploi dans la zone de production, l'emploi permanent et l'emploi non qualifié augmentent grâce à l'adoption de la réforme. Le chapitre 4 évalue l'effet causal de l'adoption de la reforme de l'interdiction d'exportation de grume sur la déforestation et met en évidence que les pays ayant adopté la réforme enregistrent une hausse importante de la déforestation comparé au groupe de contrôle. Aussi, l'effet moyen du traitement sur les traités s'intensifie avec le temps durant les cinq premières années. L'occupation des terres agricoles et le volume de production de bois transformé sont les potentiels canaux de transmissions par les quels la réforme affecte la déforestation dans les pays en développement.

Les résultats à l'issue de cette thèse permettent de formuler une série de recommandations. (i) En premier lieu, l'interdiction entraîne une hausse plus importante de la production de bois transformé. Cette hausse concerne en grande partie le bois de transformation simple qui est le sciage permettant d'exporter afin de respecter la mesure. Toutefois, la réforme à elle seule ne suffit pas à encourager une transformation plus avancée. Aussi, l'effet de la réforme tend à disparaître avec le temps au niveau de la production et de l'exportation. Ainsi, les gouvernements doivent mettre en place des politiques industrielles et d'emploi plus complexes et de meilleures institutions qui contribuent à développer l'infrastructure commerciale, la qualité du processus commercial (par exemple, les procédures d'exportation), le savoir-faire technique et la main-d'oeuvre qualifiée. Cela permettra d'attirer des investissements et la technologie nécessaires afin d'amorcer un changement structurel du secteur vers une montée en gamme. (ii) Concernant la volonté d'industrialisation du secteur de la transformation du bois, les entreprises de ce secteur dans les pays en développement emploient majoritairement des travailleurs non-qualifiés en raison des capacités technologiques et du niveau de formation. Ainsi, les gouvernements doivent avoir pour objectifs, d'augmenter la formation des travailleurs, de créer des incitations à l'innovation et au développement technologique, et d'encourager les IDE pour faciliter le transfert de technologie. (iii) Enfin , l'aspect environnemental de la réforme nous confronte à deux situations disjointes. Tout d'abord, compte tenu de l'effet dommageable de la réforme sur les forêts, les gouvernements devraient supprimer cette politique pour protéger la forêt. Toutefois, ce choix conduit à renoncer à la croissance de la production et du commerce dans l'industrie forestière. Deuxièmement, les décideurs politiques peuvent préserver la réforme à condition de soutenir les agriculteurs dans la pratique de l'agriculture mécanisée, intensive et durable avec une formation de haut niveau de la population rurale. Aussi, il faut encourager la gestion durable des forêts et lutter contre l'abattage illégal en imposant des exigences de certification, en renforçant les droits de propriété et en luttant contre la corruption autour de la gestion des forêts. Enfin, les décideurs politiques doivent encourager la production durable en aval en favorisant les investissements dans les technologies du bois à haut rendement et à faible taux de déchets.

Comme tout travail de recherche, cette thèse a des limites. Le manque de disponibilité de données sur le type de bois et le prix ne nous permet pas de distinguer les bois de grandes valeurs des bois de moyennes ou petites valeurs. Aussi, l'absence de données sur l'activité d'extraction du bois pousse à se focaliser uniquement sur l'emploi dans l'industrie de transformation du bois. Ces données auraient permis au chapitre 3 d'analyser l'emploi dans l'industrie du bois allant de la coupe à la transformation industrielle. Aussi, les données de déforestation disponible ne permettent pas de capter la déforestation nette. Ce qui nous contraint à ne pas prendre en compte les gains de forêt enregistrés. Ainsi, les travaux futurs sur cette réforme peuvent se focaliser sur : (i) l'effet de l'adoption de cette réforme sur le prix du bois transformé, (ii) l'effet de la réforme sur l'emploi dans l'activité d'extraction du bois, (iii) l'effet de la réforme sur la structure du prélèvement public, à savoir perte de recettes de porte mais augmentation de la fiscalité intérieure et (iv) l'analyse de la fiscalité comme outil d'incitation.

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