National reforestation, regional deforestation? Cross-border timber trade and forest transition in Vietnam.

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ABSTRACT

The Indochina borderlands are characterized by dense forests, which constitute the natural habitat of many animal and plant species. They are the homeland of several ethnic minority groups. The region's forests are not only subject to conservation policies, but also to various national security concerns. In contemporary Indochina, climate change mitigation projects have brought new opportunities for the three neighbouring countries, Vietnam, Laos and Cambodia, to receive financial support to protect their forests and develop their economies. REDD+ projects are among these climate change mitigation projects. In order to make such projects feasible, scientists working on climate change issues have intensively studied the possibility of leakage, and possible solutions for this problem.

Leakage may happen at a regional level in the Indochina borderlands. Since the mid-1990s, Vietnam has experienced forest transition; decades of net deforestation were followed by a period of net reforestation. The country's wood industry has also experienced significant growth. Vietnam confidently proclaims that it is capable of supplying most of its timber demand itself, thanks to good policies in protecting natural forests and planting trees in deforested areas. But reports by NGOs claim that Vietnam has met its timber needs largely by importing illegal wood from Laos and Cambodia.

Using a panel dataset for 60 provincial units over the period 2005-2011, this study reports regression results using Tobit models, in an attempt to determine whether the Vietnamese borderland with Laos and Cambodia is actually deforesting (reducing its forests) or reforesting (increasing its forests). A number of factors has been controlled for in the statistical analysis, such as border checkpoint density, population, provincial transparency level, wood production, etc. These factors have a significant impact on either deforestation, or on reforestation, or on both.

The main conclusion of this study is that the Vietnamese borderland is subject to less reforestation than other regions in the country and that there is evidence of leakage. When it comes to reforestation and the prevention of deforestation, other regions are more successful. Leakage not only takes place inside the country (i.e., from the coastal area to the borderland), but also happens on a larger, transnational scale, affecting Laos and Cambodia. Legal and illegal wood is imported into Vietnam from Laos and Cambodia, but is then transported further inland, where it is used in the wood processing industries. Most of these industries are located in other regions than the Vietnamese borderland.

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TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

ABBREVIATIONS

A/F	Afforestation & forestation
AFTA	Asian Free Trade Area
ASEAN	Association of South East Asian Nations
C/O	Certificate of Origin
EIA	Environmental Investigation Agency
FAO	Forestry and Agriculture Organization
FCPF	Forest Carbon Partnership Facility of World Bank
FPD	Forest Protection Department
GATT	General Agreement on Tariffs and Trade.
GHGs	Green House Gases
GSO	General Statistic Office of Vietnam
MARD	Ministry of Agriculture and Rural Development (Vietnam)
NTFP	Non-timber forest products
PCI	Provincial Competitive Index
PFES	Payment for Forest Environment Services
REDD+	Reduced Emissions from Deforestation and forest Degradation
R-PP	Readiness Preparation Proposal
SEA	South East Asia
SFEs	State Forestry Enterprises
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
VCCI	Vietnam Chamber of Commerce and Industry
WTO	World Trade Organization

1. INTRODUCTION

When I was a school girl in Vietnam, I was taught to love the country's "golden forests, silver seas". Being a member of the majority ethnic group (Kinh or Viet), I was also told that we should maintain "friendly brotherhood relationships" with the 53 minority ethnic groups in Vietnam. Most of these groups live in the forests, or mountains. I grew up with war stories that happened in places with green, dense forests, where Kinh soldiers were protected by members of other ethnic groups.[1] In my imagination, Vietnamese mountains and forests were mysterious places, inhabited by kind people. When I was older, I had the opportunity to visit the Central Highlands, the Northwestern and the Southwestern mountains, which are known as "Vietnam's uplands" (Sikor, Tuyen, Sowerwine & Romm, 2011 p. 1). However, the beautiful and rich forests I had imagined were nowhere to be seen. Instead, I saw bare hills, eroded soil, and well-arranged plantation areas. The "golden forests" I had learned about were not there. Meanwhile, the so-called "ethnic minorities" (*dân tộc thiểu số*) live in vulnerable environments, often in poverty, where they struggle to make a living.

In addition to poverty, these ethnic minorities also face other challenges, caused by policies and economic strategies of the (predominantly Kinh) government over the upland areas. After the reunification of the country in 1975, units of the Vietnam People's Army were allocated to remote mountainous areas in order to fight remaining enemy forces (Thayer, 2009). These army units set up training areas, checkpoints, and even companies to support their activities. Consequently, large numbers of Kinh people migrated to the uplands under the "New Economic Zone" program (Dang, Goldstein & McNally, 1997). Migrants and army units not only altered the landscape through deforestation and expanding farms in order to feed their growing population, but also changed the indigenous people's livelihoods. After 1990, forests were classified and placed under strict conservation programs (McElwee, 2009). Many of these forests are now national nature reserve areas, where local people are prohibited from entering, hunting, and collecting timber and/or non-timber forest products (NTFP).

In 2007, the Vietnamese government approved the "Plan on organization of the implementation of the Kyoto Protocol under the United Nations Framework Convention

[1] For instance, in secondary schools in Vietnam, students have to read novels set in forests during the war, such as *Đất nước đứng lên* and *Rừng Xà Nu* by Nguyên Ngọc / Nguyễn Trung Thành.

on Climate Change in the 2007-2010 period".[2] One year later, Vietnam registered as a pilot country under the UN-REDD Programme. Under this program, any effort of protecting forests is acknowledged, and reforestation is awarded by direct payment. Therefore, the reduction of carbon emissions by reforestation is high on the national environmental agenda. In April 2008, the Vietnamese Prime Minister signed Decision no. 380/QD-TTg concerning "The Pilot Policy for Payment for Forest Environmental Services".[3] According to this decision, Ho Chi Minh City and six provinces: Son La, Lam Dong, Dong Nai, Hoa Binh, Binh Thuan and Ninh Thuan would be appointed as pilot locations to apply payment for forest environment services (PFES). PFES in Vietnam is a "financing mechanism" designed to support local efforts in managing forest resources and conserving biodiversity at local level (UN-Water, 2011 p. 1). The first phase of the UN-REDD Programme in Vietnam has been completed. The country received a funding of 30 million US dollars from Norway for implementing the second phase in December last year.[4] The Forest Carbon Partnership Facility (FCPF) of the World Bank also lists Vietnam as Readiness Project Identification Note, in which the country will have access to a Readiness Fund of 230 million USD. The World Bank's grant became active in November 2012.[5]

In the meantime, many scholars have focused on the risk of leakage in climate mitigation projects, including ones in the forestry sector (Aukland, Moura-Costa, & Brown, 2003; Gan & McCarl, 2007; Wunder, 2008; Angelsen, 2009; Angelsen, Brockhaus, Sunderlin & Verchot, 2012). Leakage in this sector refers to the displacement of deforestation to other regions as a result of forest conservation in one location. In order to measure leakage on a global scale, Gan and McCarl (2007) have developed a theoretical model, which estimates a transnational leakage of 42% to 95% if one unilaterally country reduces its forestry production. Decreasing production will limit supply and induce more leakage for REDD projects if demand for forest products is inelastic to price (Wunder, 2008).

[2] Source: http://vietnam-redd.org/Upload/CMS/Content/Library-GovernmentDocuments/47_2007_QD-TTg.pdf. Localised on 14 March 2013
[3] Source: http://vietnam-redd.org/Upload/CMS/Content/Library-GovernmentDocuments/380-QD-TTg.pdf. Localised on 14 March 2013
[4] Source: http://vietnam-redd.org/Web/Default.aspx?tab=newsdetail&zoneid=107&subzone=157&temid=592&lang=en-US. Localised on 24 March 2013.
[5] Source: http://www.forestcarbonpartnership.org. Localised on 24 March 2013.

Recently, several studies have been conducted on the forest transition that Vietnam experienced in the mid-1990s (Mather, 2007; Meyfroidt & Lambin, 2008a). Forest transition happens when the forest cover area of a certain locality, country or region is increasing, and net deforestation gives way to net reforestation. Since the 1990s, Vietnam's forests have been expanding rapidly, and in the meantime, the country's wood industry has also experienced significant growth. The export of wood and wood products from Vietnam to its main export markets (such as the US, the EU, and Japan), is increasing annually. In the period 2000-2010, the exploitation of wood and other forest products accounted for more than 70% of the gross output of Vietnamese forestry (with a total value of 671.58 million USD), five times as much as the income brought about by planting trees and other forestry practices (GSO, 2011). Moreover, the exploited timber volume from Vietnamese forests is 2.7 million m^3/year in 2005 (FAO, 2009 p. 21), while the average demand of timber for the domestic wood processing industry is about 11.3 million m^3/year (McElwee, 2004 p. 107). Thus, there is a big gap between domestic supply and demand.

Despite this gap, Vietnam confidently asserts that it is capable of supplying most of its timber demand itself, thanks to good policies in protecting natural forests and planting trees in deforested areas. But reports by NGOs that have investigated the cross-border timber trade between Vietnam and its neighbouring countries, suggest the opposite. These reports claim that Vietnam has met its timber need by importing illegal wood from Cambodia (Chatham House, 2009) and Laos (EIA, 2011). In order to protect the planted forests, the Vietnamese wood industry has relaxed its domestic timber demand by importing raw materials, mainly from other Asian countries such as Laos and Cambodia, as well as Indonesia and Malaysia. When some of these countries started to protect their forests by banning log export, illegal trade increased. Meyfroidt and Lambin (2009) discovered that a large amount of the imported timber from Laos and Cambodia comes from illegal sources during the period 1987-2006.

Following the existing research on logging in Laos and Cambodia and wood import to Vietnam, I have become interested in one geographical zone in particular: the borderland between Vietnam and its two neighbouring countries. By studying forest cover and land use change of Vietnamese provinces in the region, I hope to learn more about the impact of trade, plantations and logging on deforestation, reforestation, and the leakage of climate change mitigation projects. In this thesis, I will try to answer the following questions:

1) Do Vietnamese provinces that border Laos or Cambodia experience more or less deforestation than provinces that do not border these countries; and do they experience more or less reforestation?
2) What are the factors that contribute to deforestation and reforestation in the Vietnamese borderland?

In order to answer the research questions, the study is designed into five parts. The preceding part one discussed main topics of the thesis, in which I will elaborate upon my research questions. Part two will provide a background to the issues through a review of the existing literature on the topics of forest transition and leakage, followed by some facts about the forest transition process in Vietnam. In addition, I will discuss emerging problems of Vietnam's forest protection policies, as well as their possible relevance to forest cover change in Laos and Cambodia. The literature review will be linked to statistical analysis by several hypotheses, which will be tested with two dependent variables: deforestation and reforestation. The panel dataset, explanatory variables, and testing method will be discussed in part three. In this part, several solutions are suggested in order to overcome endogeneity and unobserved effect problems. Regression results in part four will include a discussion of new findings based on the tests of hypotheses. In conclusion, part five sum up the issues and findings.

2. BACKGROUND AND LITERATURE REVIEW

In this part, I will give an overview of the relevant academic literature for my topic of study. I will provide a theoretical discussion of the links between forest transition and leakage, in the context of the Indochina borderlands. I will analyze the impact of markets located at border crossings on forest cover change, as well as the various causes of deforestation and reforestation in Vietnam. By doing do, I hope to provide a better understanding of the livelihoods, economic practices, and interactions between people and forests in the Vietnamese borderland.

2.1 Deforestation and reforestation from a forest transition perspective

2.1.1 Deforestation

Deforestation has been defined as a permanent loss of tree cover (Kaimowitz & Angelsen, 1998). There are many direct and indirect causes for deforestation. According to Kaimowitz and Angelsen, one direct and consistent cause of deforestation is the conversion of forest land into crop and pasture areas. A need to increase food production in order to feed growing populations and raise national income leads to the decision of clearing forests for cultivation (Angelsen & Kaimowitz, 2001). In later stages of agricultural production, a declining land investment, such as insufficient use of fertilizers, can exhaust the soil, which can lead for more forest clearance as farmers want more fertile land (Abdulai & Binder, 2006).

Thus, agriculture and forests compete with each other for land, and are involved in dynamic processes of land use change. In order to clarify these processes, Angelsen (2007) has linked land rent with agriculture expansion and deforestation speed by using the von Thünen approach. When land rent is assumed to be only agricultural and forest rent, high or low land rent will change forest cover by clearing more or less land for cultivation. For example, an increase in agriculture rent combined with a decrease of forest rent will speed up land clearance and bring about deforestation. Interchanging shifts of agricultural rent and forest rent result in different conditions of forests, but the causal relationship is never straightforward, and depends on various factors. One important factor deciding land rent, according to the von Thünen approach, is the distance to markets, cities, or population centres. As it affects the purposes of land use, the distance to these places can determine land rent. If agricultural or forest lands are near city centres, their rent is likely to be higher. And the shorter the distance to a market, the better the institutions for managing forests. By contrast, remote areas usually have weak institutions and law enforcement, and insecure forest land tenure. As a result, forests in these areas are subject to unsustainable management and excessive exploitation.

Another potential driver of deforestation is logging. Unsustainable logging leads to the exploitation of forests in a way rather different from land conversion. Some people argue that logging does not have as large an impact as clearing land for agriculture expansion. They argue that in the case of sustainable logging, cutting down trees is carried out together with planting and protecting trees. In such a case, the forest cover will remain at a sustainable level. However, Ngaiza (1991) has questioned whether such a sustainable system could exist, especially when it comes to small-scale commercial logging. Having investigated the local forest management system in Tanzania, he doubts whether this exploitation method is followed in situations lacking of effective management systems. Local-level management will become difficult as soon as an exploited area is seen as a potential for generating high income. The potential for quick profit creates incentives for illegal exploitation and corruption in the system that is supposed to be sustainable. More on a macro level, Ross (2001) has described a situation in which the timber export boom in Southeast Asia, particularly in Indonesia, the Philippines and Malaysia, has led to government failure in managing the resources. Policy makers in these countries could not keep up with the resource boom, causing a breakdown in forestry institutions. Because of the weak enforcement of forestry laws in these countries, trees were not systematically replanted.

Land conversion and logging involve a wide range of deforestation agents, including but not limited to farmers, loggers, plantation companies, and rangers (Angelsen & Kaimowitz, 1999). These agents and their activities constitute the first level of deforestation. The next level is called "immediate causes" (ibid., p. 75), which include institutions, market forces and infrastructure construction. The term "institutions" signifies a wide range of policies in land and forestry management in particular and the rules of game in general. Devolution processes, whereby states allocate the property rights of land to households, sometimes fail to assure effective forest protection (Thanh & Sikor, 2006; To, 2008). When laws and regulations do not guarantee land rights, insecurity makes farmers reluctant in investing more in their land. Because of the lack of fertilizers, land erodes and degrades, which causes farmers to clear new land. The next direct driver concerns infrastructure projects, such as road construction. Implementing these projects can also accelerate deforestation because they make access to remote forests easier. Sometimes it is the other way around, when the clearing of a forest area makes road construction possible (Angelsen, 2009). The last driver concerns market forces, such as a price increase of agricultural products. Higher prices for agricultural products encourage forest removal, as more people will want to cultivate land for more agriculture and forest products. Market forces are reinforced by trade liberalization and export promotion policies, leading to structural changes that can drive up prices and generate pressure on forests.

Trade and trading methods are among indirect causes of deforestation. Other indirect causes are population pressure, economic growth, and technological change. Angelsen and Kaimowitz (1999) refer to these drivers as “underlying causes” (p. 75), the third level of deforestation because of their complicated correlation with deforestation. For example, when the population of a region increases, the need to have more food will stimulate the rapid conversion of forest into agriculture land. However, evidence of population pressure on deforestation is not always clear. In fact, population growth may also lead to positive institutional changes, and actually limit deforestation (Ross, 2001).

The third underlying cause concerns economic growth, or the general increase in income, which can drive both deforestation and reforestation. The relationship between income levels and relative environmental conditions are the main topics addressed by the theories underlying the Environmental Kuznets Curve. These theories suggest that an increase in income in developing countries will initially lead to an accelerated rate of deforestation. When the average income reaches a certain level, the increasing rate of deforestation comes to a halt, and the reforestation process will begin. While it may sound convincing, finding conclusive empirical evidence to support these theories is not easy. The debate on whether or not the curve is confirmed by statistical tests is still going on. Using data of 76 developing countries in the period 1961-1992, Koop and Tole (1999) suggest that the theory’s inverted-U shape is irregular due to differences in social characteristics between countries. Following a review of the literature and empirical tests of the Kuznets curve, Stern (2004) concluded that the theory’s statistical results are not robust. Instead, he suggests that new emission reduction technologies, aided by a high income society, are likely to improve the environment.

Technological change can also affect forests in different and contradictory ways. On the one hand, technological change in agriculture can affect forests positively. Technology progress – such as irrigation or technologies that increase aggregate supplies, raises rural wages, or affects inelastic products – can reduce pressure on forests (Angelsen & Kaimowitz, 2001). On the other hand, labor intensive technologies, which encourage the fast transfer from forests to farm land, generally lead to deforestation, as is the case in Indonesia with palm oil trees (Angelsen & Kaimowitz, 1999).

2.1.2 Reforestation and forest transition

Forest transition is a term referring to a specific pattern of forest cover change over time, namely a change from "decreasing to expanding forest areas" (Mather, 1992 p. 367). In a forest transition pattern, the decreasing line stops, and an increasing slope replaces it (see figure 2.1). The study of forest transition attempts to explain when and why an area that has previously experienced deforestation will reverse the trend and begin to experience reforestation. In recent years, this field of study has attracted many scholars, and it now constitutes a new direction in research on land use change.

Rudel et al. (2005) suggest two pathways in the forest transition: forest scarcity and economic development paths. The former concerns efforts to increase forest cover areas by governments and local communities, when the number of forest products available does not meet the demand. In this way, deforestation has led to the depletion of forest resources, and a decrease in supply. In the meantime, if the demand of these products remains stable or goes up, there will be a gap in the market. The gap will then drive up the price or attract traders from other locations. The country faces a decision: either to import forest products from elsewhere, or become self-sufficient by avoiding further deforestation, replanting forests, and setting up forest conservation projects. The second forest transition pathway constitutes the abandonment of agricultural land, leaving space for reforestation. It means that economic growth can go together with an increase in income in non-agricultural jobs. Migration from rural to urban areas reduces pressure on forests. In this case, rural areas will not have enough labour to expand agriculture, and farm lands may even be abandoned. In addition, government policies promote the reforestation of these lands for economical or political reasons.

Angelsen (2007) uses the concept of "shifts of land rent" to describe four stages of forest transition: triggers (1), reinforcing loops (2) and stabilizing loops (3 and 4). In the first stage, *trigger* refers to the "initial shift in the agriculture land rent", driven mainly by road construction (p. 33). Remote areas are now accessible, and forests become destinations for resettlement programs, and/or natural resource-exploiting activities. Migration and population growth will drive up agriculture land rent in these areas, and accelerate deforestation. New roads and infrastructure systems, in turn, are the products of political consideration and rent-seeking activities. State consideration commonly involves military control aimed at protecting territories, solving border conflicts, and stabilizing local politics. Rent-seeking activities, such as logging, mining, and hydropower, involve a wide range of actors, including the ruling elites.

In the second stage of *reinforcing loops*, deforestation continues when agriculture rent becomes higher and dominates the land rent. In this stage, forest rent generated from the prices of forest products and environmental services (if any) is much less than agriculture rent. There are several reasons for the higher agriculture land rent in this period. Population and economic growth put further pressure on forests. Technological developments, especially those which contribute to the added value of farm products, raise the speed of agriculture land expansion even more. Local customs and underdeveloped institutions cannot keep up with the current development pace, which leads to land speculation.

In the last stages of *stabilizing loops*, land degradation and higher incomes elsewhere pull down agriculture rent, due to land abandonment (as described above with regard to the economic development path). At the same time, forest rent quickly goes up, outweighing the value of agriculture land rent. The forest scarcity path is at work, which encourages the conservation of forests, the planting of trees, and the supply of environmental services. What is noteworthy about these two final stages is that they include institutional change. As a result of the efforts of both the state and local people, the curve of deforestation changes. Forest rent increases, which gives the state incentives to protect forests, by avoiding deforestation and conserving forests. At the same time, the state also encourages local households to plant trees, and increases forest cover areas through afforestation and reforestation. Forest management also adapts quickly and moves towards facilitating environmental services.

Forest transition theory provides an opportunity for tackling climate change. As will be discussed in the next section, REDD+ is a good policy to reduce green house gases emission (GHGs). If we can answer when and why a developing country experiences forest transition, financial compensation for the country's efforts will encourage further emission abatement.

2.2 Trade and leakage

2.2.1 Climate mitigation and leakage

By signing the Kyoto Protocol in 1997, developed countries (in Annex I) agreed to cut down GHGs emissions compared to a baseline. Every Annex I country got a fixed amount of allowed carbon emission. As a country emits more than the allowed level, it has to pay for the exceeded amount. Leakage arises as a problem in cutting GHGs emission. Leakage means that GHGs emission reduction in one area can contribute to more emission at another location, either inside or outside a particular territory. Accordingly, leakage is referred to as "displaced emission" by the United Nations Framework Convention on Climate Change (UNFCCC) (Angelsen, Brockhaus, Sunderlin & Verchot, 2012 p. xv).

Leakage can be viewed from different perspectives. On the one hand, leakage could be an indicator of a healthy economy, as no borders or transaction costs prevent the displacement of emissions abroad (Wunder, 2008). An international company can abate GHGs at home, but locate its polluted sectors to other places, and emit instead in foreign countries. Thus, polluting enterprises have the opportunity to emit GHGs in locations where the pollution abatement is less costly than in their home country. Trade is at work, because polluters can trade emission abatement with each other (Perman, Ma, McGilvray & Common, 2003). Moreover, production displacement to developing countries spurs economic growth and encourages cumulative investment in these countries (Romer, 2012). On the other hand, if leakage occurs at places where little or no carbon emission has been before, the total emission reduction at a global scale will not be enough to resolve the impact of climate change. Nevertheless, Aukland, Moura-Costa, and Brown (2003) assure that the presence of leakage does not undermine climate change mitigation projects' targets, as long as policy makers develop suitable strategies to account for and deal with it. In order to do so, it is necessary to clarify what causes leakage and how it happens.

The topic of leakage in climate change mitigation projects in forestry was first discussed in 1997. Brown, Cabarle and Livernash (1997) defined leakage as an "unexpected loss of estimated net carbon sequestered" (p. 5). This means that the GHG emission reduction of a forestry project is lower than the targeted amount, and leakage is the difference between the projected and the real reduction. In this definition, leakage is seen as a number, a quantity that can be measured. Several years later, Moura-Costa, Stuart, Pinard and Phillips (2000) referred to leakage as an "externality" that may be caused by the mitigation project (p. 44). With their new definition, Moura-Costa, Stuart, Pinard and Phillips described leakage as a process, whereby carbon emissions take place somewhere else, outside the mitigation location. Recently, leakage in forestry is seen as a problem of displacing deforestation to other places, when one region implements forest conservation policies (Gan & McCarl, 2007). Particularly, in the case of avoided deforestation policy, Murray (2008) suggests that "leakage occurs when efforts to control emissions in one place cause emissions to shift to another place that is not subject to the policy" (p. 7). In these definitions, leakage is understood as a dynamic process, whereby emission moves from one territory to another. In order to control GHGs emission, governments and institutions make policies and set up climate change mitigation projects. However, these policies and projects have implementation boundaries, and leakage is the displacement of GHGs emission outside these boundaries.

Under the Kyoto Protocol, the forestry sector is a target of mitigated climate change policies. The COP 13-2007 in Bali recognized Reduced Emissions from Deforestation and forest Degradation (REDD) as a key policy for GHG emission reduction. Both parties – i.e., developed countries in Annex I and developing countries – realized REDD+ as a "golden opportunity" for fulfilling their duties of cutting GHG emission and reducing the negative impact of climate change (Angelsen, 2008b p. 466). Rich nations can pay deforested countries to stop deforestation and get credits for emission reduction quota at home. Meanwhile, poor nations can get extra financial support from the North to develop their economies. However, in order to set up baselines for crediting REDD+ effectively, scientists have extensively discussed the chances of leakage in REDD+ projects (Angelsen 2008a; Angelsen 2009; Angelsen, Brockhaus, Sunderlin, & Verchot, 2012). Finding out how much the leakage of these projects is constitutes a significant challenge because the rate of leakage varies across regions and requires more data and economic analysis.

Based on an assessed order of leakage, Aukland, Moura-Costa, and Brown (2003) categorize leakage as primary and secondary types. These two types are then divided into several sub-types, depending on the responsible actors. Within the framework of this thesis, the two sub-types of primary leakage, "activity shifting" and "outsourcing", (ibid., p. 124) are particularly relevant. "Primary leakage" refers to the partial or entire negative transfer of the GHG emission reduction benefits of a project. The projects' agents do not have alternative arrangements for their livelihood or activities, and therefore emit elsewhere. If this is the case, these agents can reduce emission at the projects' locations, but they will increase emission at other places. "Activity shifting" refers to the displacement of emission to another area, while "outsourcing" is the purchase of commodities elsewhere. For example, logging companies in Vietnam are no longer allowed to log in protected forests. If they carry out activities in Laos and Cambodia, it is called activity shifting. But if they purchase logs or timber from Laos, Cambodia, or elsewhere, and trade it to Vietnam, it is called outsourcing. Reducing the timber harvest in one area can, indeed, have impact on a larger region. In their study on the impact of climate change on the global timber market, Sohngen, Mendelsohn and Sedjo (2001) confirm that policies designed to limit local timber production can increase the number of trees chopped down elsewhere.

According to Wunder (2008), there are three types of forestry mitigation projects: Afforestation and Reforestation - A/F, REDD – Set-aside Conservation, and REDD – Sustainable Forest Management (p. 67). Even though leakage may occur in all three types, Wunder suggests that there is more evidence of leakage in REDD than in A/F. REDD conservation may encourage production elsewhere because it reduces supply and raises prices of timber and agriculture products. While the conversion of forest land into agriculture land can drive up deforestation, wood harvesting activities can degrade forests. Moreover, reduced deforestation can contribute to forest degradation due to the inevitable need for timber. In a situation where the output demand for REDD products, such as timber, crops, and livestock, is inelastic to price, REDD projects will induce more leakage. The reason is that supply reduction of those products will not lead to a reduction in demand, but create a larger gap between supply and demand. Finally, Wunder notes that high-value logging, especially rare species, can induce larger leakage than agriculture activities (p. 72).

2.2.2 Logging, timber trade, and leakage at border zones

a) Logging and timber trade

Barbier, Burgess, Bishop and Aylward (1994) demonstrate the connection between timber trade and deforestation in Indonesia. Using the pooled OLS regression method and time series data, they proved that log production (including sawn wood, plywood, and trade sectors) leads to a reduction in forested area. The development of timber trade and the wood industry in Indonesia is associated with forest conversion and the cutting down of forests. According to Barbier, Burgess, Bishop and Aylward, conversion forests are different from production forests, which are mainly plantation forests. But nearly 50% of these production forests in Indonesia are identified as conversion forests (p. 29). Because of data limitation, the authors could not separate the tropical timber trade from the total log production, but they did believe that most of the materials supplied for timber production and trade come from forest conversion.

Another way to create profit from logging is cutting down and trading high-value species. Species in high demand, such as rosewood, yellow balau, talauma, hinoki, shan mu etc., are now endangered. Nowadays, these species are listed as rare in Southeast Asia. The protected list does not prevent the logging and trading of these species, however. On the contrary, logging gangs and influential traders merely find new ways to disguise the business, and pay well to get the products. One of the tricks in cross-border trade is to use local people to collect large amounts of logs of rare species. Border residents can transport small amounts of wood without having to pay export or import duties. It is also easier for them to trade less than the quota amount (applied especially to border residents) because they do not need to clear customs (Schoenberger & Turner, 2008).

Timber trade does not only involve rare species that the domestic market can not supply. There can also be cross-border trade in normal products, when a high demand induces trade profits. In order to protect domestic industries and prevent them from being taken over by foreign companies, states implement protectionism policies, in which trading barriers with high tariffs and complicated license restrictions are constructed. However, when the domestic supply falls short, the gap between demand and supply induces more commercial activities. In addition, free trading zones reinforce trading relationships between member countries. In the case of Thailand, after the logging ban in 1989, the country lowered tariffs for imported logs (Pangsapa & Smith, 2008). This aimed at stabilizing the supply of cheap imported logs from neighbouring countries and supporting the domestic wood processing industry. The ASEAN free trade zone, which has a zero tariff level among its members, has made it cheaper to import wood from other, less developed countries, such as Laos and Myanmar, where forests and trees are abundant.

b) Trade and leakage at border zones

Analyzing the economic drivers shaping borderlands in Europe and North America, Clement (2004) acknowledged that "freer trade and market-oriented policies" have led to a shift from a traditional view of borders to a modern view (p. 48). In the traditional view, borders were considered as barriers to trade, and different laws and regulations by governments prevented companies from establishing and investing in border zones. The situation has changed, however, as a result of GATT/WTO negotiations and a regional integration agenda that has made cross-border trade more profitable. Globalization processes have brought down national tariff barriers and cleared traces of protectionism from border regions, attracting new industries, labour, commerce activities, and regional development. 'Closed' borders have turned into 'open' borders, especially at international border points, where economic flows between neighbouring countries are now supported instead of prevented. As a result, the borderland appears as an attractive region to avoid high tariffs, and production and export can be combined in one place, with a short distance to the neighbouring country's market.

Clement (2004) also describes how transnational cooperation at the borderlands is reinforced by three economic concepts: economies of scale, externalities and transaction costs. Economies of scale are considered as ways to lower average cost. In state management, economies of scale signifies public goods such as roads, airports and infrastructure. Transaction costs refer to situations in which lack of information about markets, laws and regulations constraints business and trade activities. A good information environment can lower transaction costs. In realizing potential economies of scale and lowering transaction costs, neighbouring countries can facilitate regional collaboration and development. Regarding negative externalities, Clement recommends that regional cooperation should be directed at better management of negative spill-over effects, such as pollution or diseases. Governments not only need to admit the existence of these problems, but also to cooperate with each other in ensuring that the border region's investors maintain a sustainable environment on both sides of the border.

In order to lower transaction cost, adjust investors' activities, and force enterprises to take responsibility, a transnational cooperation needs good institutions. However, not every borderland authority is successful in achieving good laws and regulations. As viewed by Pangsapa and Smith (2008), deregulation, in addition to transnational investment, is one of the reasons leading to the unsustainable exploitation of natural resources at the border zones in South East Asia. According to them, investments in dam projects have made Thailand become the main exporter of negative externalities in the region, especially in the borderland of Laos, Myanmar, and Cambodia. Environmental degradation and polluting projects in less-developing countries, such as Laos, are hard to prevent because of Laos' weak enforcement of environmental regulations. In dam construction projects, the implicit connection between armies and logging companies implies arrangements by higher powers that support these projects. It also reflects the sophisticated transnational cooperation between the ruling elite groups in exploiting natural resources of the region. Measuring the impact of illegal or unofficial natural resource exploitation is complicated by crime and corruption. Cross-border leakage, therefore, becomes difficult to demonstrate and address.

2.3 Vietnam

2.3.1 Deforestation and reforestation

In Vietnam, rapid deforestation took place during and after the war period (1954-1975). From 14,300 thousand ha (43% of the total surface), the country's forest area dropped to the lowest point in 1990, covering only 27% (9,175 thousand ha) of the national land area (FAO, 2009 p. 16). Before 1975, deforestation was mainly caused by war; afterwards, logging, population growth, conversion from forest land to agriculture, and forest mismanagement were the main causes (Ecofys, 2012). Agriculture intensification happened in Vietnam in the end of 1990s, mainly for perennial crops such as coffee and rubber in the highlands. The New Economic Zone programme was also implemented in the same period, causing Kinh people to migrate to the uplands, where they converted forest land into farmland. Hills became bare due to agricultural expansion and unsustainable logging by state forestry enterprises (SFEs).

In the early 1980s, state control of forests was strong, with about four hundreds SFEs. These SFEs were given many privileges, in addition to high logging quotas. As there was no effective system to monitor and enforce their activities, these state companies played a controversial role in the last two decades of the 20^{th} century. They cut down trees intensively without replanting them; or, if they did replant, they often used poor-quality seedlings and did not maintain them well (McElwee, 2012). In the 2000s, these companies were placed under a privatization process, in which about 250 units remained operating with low budgets and under-qualified staff. The survival of these semi-private, semi-state-owned companies cost a significant amount of capital. The national reforestation programme, which later came to be officially known as the "National Program to Rehabilitate and Develop 5 Million Hectares of Forests" (Nguyen, 2003) (Five Million Hectare Programme) was vital for their survival.

After several decades of net deforestation, Vietnam, along with China and India, passed the stabilizing loops stage in the 1990s, and has experienced reforestation since (Mather, 2007). According to Mather, afforestation and forestation (A/F) of not-in-use land are two key drivers of forest transition in these countries. Even though both forestation and afforestation refer to an increase in forest cover, only the latter term refers to tree planting (Rudel et al., 2005). In 1992, Vietnam initiated the 327 Reforestation Programme under Decree 327-QD signed by the Prime Minister. Its main objective was to increase the number of protected and specified forests areas. The result is quite positive, with a rapid increase in forest cover during the 2000s (FAO, 2009 p. 16). In 2006 and 2007, the state adopted the ambitious Five Million Hectare Programme, also known as the 661 Programme which is claimed to help the country become self-sufficient in timber resources. Under the 661 Programme, bare hills are transformed into forests. This program supports the two drivers of forest transition – A/F to develop. A/F can occur both in forested areas and abandoned agriculture land. As a result of A/F, tree planting leads to the expansion of forest cover on empty lands.

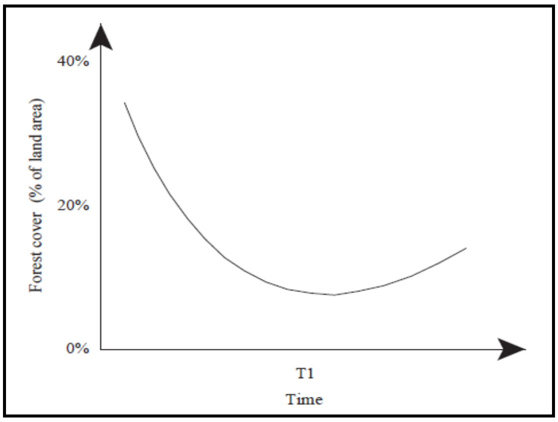

Figure 2.1 - The forest transition pattern.

Source: Rudel et al., 2005 p. 26

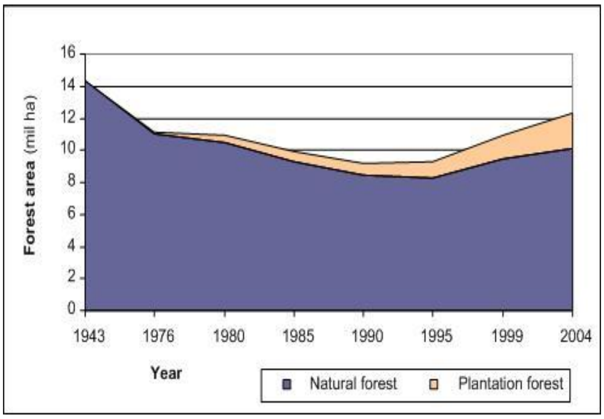

Figure 2.2 - Changes in forest area in Vietnam.

Source : Nguyen, 2008a p.21

At the turning point in 1991-1993, Vietnam's forests accounted for about 25-31% of the country's total land area (Meyfroidt & Lambin, 2008a), which is in accordance with the 27% forest cover in 1990 reported by FAO (2009, p. 16). This is the time when the Vietnamese government realized the importance of forest management. They applied various laws, regulations, and programs to protect standing forests, plant trees on bare hills in order to increase the total forest cover area. One other political response to the high deforestation rate before 1990 was that the government reopened a national campaign for small upland farmers' resettlement in the north-western region in the 1990s. Most of these upland residents cultivate swidden crops. By arranging living space for these people, the government hoped to limit slash-and-burn cultivation practices[6]. After the turning point, net reforestation has continued for almost 20 years (see appendix I). Forest land has recovered at the rate of +2.54% per year during the period 1990-2005.[7]

Decentralization of forest management and the construction of new forest plantations are supposed to be the main causes of reforestation in Vietnam. After the implementation of the Forest Protection and Development Law in 1991, forest lands were redistributed to households and small forest managers. These individuals' rights to collect forest products not only concern timber, but also NTFP. In Dak Lak Province, for example, each participant is allocated 10m^3 timber for housing purposes, and a 6% share of the logged value if his/her forest area is used for commercial logging (Nguyen, 2008b p. 194). The distribution program in this province has two advantages: giving local people the right to use natural forest resources, and sharing land use and timber benefits among

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[6] The resettlement program started in 1968 but had not been forced forward and implemented until 1990.

[7] Source: http://rainforests.mongabay.com/deforestation/archive/Viet_Nam.htm. Localised on 24 March 2013.

local forest managers. However, the main problem of this program is that people were given the total right over NTFP in their forests, but not for timber logging. They have to apply for logging permits, which are not usually easy to get. According to Nguyen (ibid.), there are three challenges in applying the Forest Protection and Development Law on a local institutional level: the distance to the provincial capital, complicated procedures, and a lack of information. As a result of these challenges, the costs of implementation have increased, not only for policy makers but also for those whom the policy wants to regulate. Many households, therefore, prefer not to be part of the devolution process, and instead carry on logging without a permit. This makes the problem of illegal logging even more serious. People, with or without certified forest rights, have no incentive to obey the forest management laws. Nguyen's field study in Dak Lak shows that timber was collected more by households who do not have the legal right to do so than by those who do. Moreover, it is common to convert natural forests into plantation when there are no clearly defined boundaries between different kinds of forests.

Vietnam may have experienced significant forest transition (see figure 2.1 and 2.2), but that does not mean the new forests are of high quality. The plantation of fast-growing species such as eucalyptus, acacia, and pine on bare hills in Vietnam has led to rapid land degradation and biodiversity loss. According to Barney (2005), these species may account for 54% of the total plantation area in the country (p. 11). The negative impact of programs that encourage the cultivation of exotic tree species at the expense of the natural regeneration of existing forests has been discussed in several studies (To, 2008; McElwee, 2009). Most of the planted forests can only supply small logs which diameter is less than 30mm. As a result, wood harvested from these forests fails to meet the high-quality requirements for producing furniture and handicrafts, which are the two key export commodities of the Vietnamese wood industry. Most wood harvested from planted forests can only be used for producing pulp, paper, and woodchips (Waggener, 2001).

2.3.2 Logging, timber trade, and leakage in Vietnam

The developments in Vietnam's forests also have international consequences. In particular, Vietnam is displacing deforestation to other countries. The country protects its domestic forests, while at the same time it is developing a booming furniture industry by using imported timber.

The high demand for timber materials in Vietnam started at the end of the 1990s, when the New Enterprise Law encouraged people to open new businesses. Wood production and timber trade were no longer restricted to state-owned companies or state-run forestry enterprises. Moreover, Decision no. 46/2001/QD-TTg of the Prime Minister regarding the management of import and export in the period 2001-2005 reinforced this trend by letting the export of wood easier than before. According to this decision, timber materials and wood products can be imported and exported duty- and tax-free (Article no. 4[8]). One exception is wood exploited from domestic natural forests, which can be subject to an export tax of 5-10%. The Vietnamese government has also simplified import and export procedures, making it easier for trading companies to trade timber materials and wood products. These good conditions have facilitated the industry's growth and increased the demand for timber materials. As a result, the domestic wood supply from natural and planted forests cannot meet this demand and the Vietnamese wood industry relies heavily on import.

The country's wood industry is growing rapidly with high export turnover and many big markets (see figure 2.3 and appendix II), despite several partial logging bans which have restricted forest access for timber extraction. According to a recent classification, Vietnam has three kinds of forests: Special Use Forests, Protection Forests and Production Forest (Barney, 2005 p. 2). Notably, timber exploitation was banned in 1992 in almost all natural forests classified as special use forests (Brown & Durst, 2003). Later, this logging ban was partly lifted, and since 2000 cutting has been allowed in natural forests, up to a maximum of 300,000m^3 (ibid., p. 16). Logging, or harvesting wood from forests, is officially allowed in natural and planted forests in the classified production forests (Barney, 2005). In her study of 'legal' and 'illegal' logging in Vietnam, McElwee (2004) is concerned about the sometimes indistinguishable boundary between them. Illegal logging does not only involve thousands of small loggers, but also many big traders, who have large amounts of money and close connections with politicians. Their activities are often covered up by forest management authorities. These actors largely

[8] Decision no. 46/2001/QD-TTg of Prime Minister was issued on 4 April 2001. It stipulates that all kinds of wood and wood products can be exported, except for sawn wood and round wood produced from domestic natural forests. The decision also abolishes quotas of wood from natural forests in order to produce wood products for export. Source: http://www.business.gov.vn/assets/45689cd95ae34335abc1913c8c1d1856.pdf. Localised on 28 April 2013.

control the timber trade, the profits of which "have led to vulnerability of the systems at all levels to corruption, tax evasions, and systematic cover-ups of deforestation" (ibid., p. 123). Even when wood prices are low, illegal logging and trade can still bring significant profits because of the large scale on which they occur.

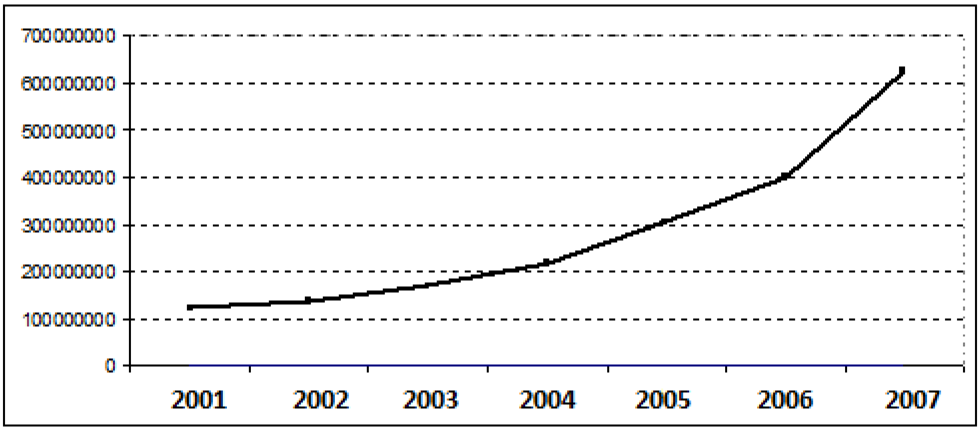

Figure 2.3 - Total wood export revenue of Vietnam.

Source: Information Centre for Agriculture and Rural Development

The Vietnamese processing industry is thirsty for materials. Because of its increasing demand, the gap between domestic supply and demand is widened. Strict policies in forest protection, therefore, make the local wood industry highly dependent on imported timber. As the fourth-largest wood processing country in the world, Vietnam has imported intensively from different sources – from nearby countries in Southeast Asia to far-away continents like Africa, Australia and America (Dawson, 2008). In Southeast Asia, the main countries that export timber to Vietnam are Indonesia, Malaysia, Laos and Cambodia.

Recent studies have pointed out that attempts to avoid deforestation and encourage reforestation in Vietnam might have induced leakage to a larger region. Firstly, using a model of wood production and trading – i.e., looking at the import of wood into Vietnam and the export of wood products out of Vietnam – Meyfroidt and Lambin (2009) found a 39% displacement of the Vietnam's forest regrowth in the period 1987-2006 into Laos and Cambodia. And illegal timber accounted for half of the imported wood in Vietnam during this time. Based on several years of field research, the authors have analyzed data on illegal wood extraction and timber import, from which they then inferred patterns for the rest of this twenty-year period (see appendix III). Their research suggests that strict protection policies limit timber harvest from natural forests in Vietnam.

As a result of increasing domestic demand, which is much more than the planted forests' capacity, the Vietnamese wood industry puts pressure on forests abroad (in particular, in Laos and Cambodia) and thus induces leakage.

Secondly, Forest Trend (2010) has revealed that many Vietnamese wood processing companies have set up their factories in the borderland, and import illegal timber from Laos and Cambodia. These companies employ Vietnamese local people in the border provinces, such as Gia Lai and Kontum, and give them opportunities to generate extra income outside of the forests. Jobs at timber processing factories are likely to reduce pressure on local forests and lead to land use change by pulling labour out of farms and agriculture land. When it comes to the production of high-value species, most of the wood used by these companies is imported illegally. The trade involves institutions at different levels in the two countries. In order to obtain quota for logging, carry out logging, and transport logs through border checkpoints, Vietnamese companies use large amounts of money to bribe officials, sometimes up to 16% of the total wood price (p. 5). While state officials, provincial state representatives and local authorities benefit financially from cutting down forests, local people in Laos and Cambodia are often excluded from these benefits.

Thirdly, reports by environmental investigators and observers also claim that Vietnam has imported a large amount of wood from Laos and Cambodia through border checkpoints. In recent years, cross-border illegal timber trade from neighbouring countries into Vietnam via border checkpoints has been reported regularly. These reports include the ones by the Environmental Investigation Agency (EIA) in 2008 (Borderlines), Chatham in 2009, EIA in 2011 (Crossroads), and EIA in 2012 (Checkpoints). These reports also clarify that supply in Vietnam is severely affected by forests protection. Domestic companies have filled the gap between demand and supply by importing nearly 80% of the needed wood. If the imported wood comes from Indochina, it is likely to be illegal trade. An investigation by EIA (2012, p. 8) revealed that imported wood from Laos only needs a phytosanitary certificate to cross the border into Vietnam. At the Vietnamese border, custom officers will need this certificate, together with an import declaration and a commercial invoice, to issue a Vietnamese Certificate of Origin (C/O). The certificate is only supplied by the Vietnamese competent authorities, so the wood is considered as Vietnamese. Consequently, the official origins of most timber imported from Laos are false.

Measuring the leakage in the region is challenging due to data limitations. Forest cover and forest loss data in Laos and Cambodia are not categorized. Data of timber trade within the three countries issued by the GSO and Vietnamese Customs only show the tip of the iceberg. In addition, when timber arrives in Vietnam, it is distributed to thousands of small processing companies, whose output cannot be traced. Nevertheless, evidence of timber trade and leakage in this section points to the border region of Indochina, where trade and production of wood inevitably affect the region's forest cover and land use.

2.3.3 The borderland and trade

At the end of the 19th century, the French divided their colonial possessions in Indochina into three countries: Vietnam, Laos, and Cambodia. Today's borders between the three countries, which are hereafter referred to as the borderland, were established and developed based on this colonial division (Pangsapa & Smith, 2008).

Grundy-warr (1993) argues that national sovereignty requires a state to have armed forces at border areas in order to prevent any conflicts with its neighbour(s). This requirement imposes "regulations and restrictions on borderland inhabitants" (p. 45). In the case of Vietnam, the government has officially had border defence forces at the borders with Laos, Cambodia, and China since 1958.[9] The state reinforced its control over these areas after 1975 by allocating the army's economic units to upland districts. Border defence forces built offices called "border checkpoints" at each place where they wanted to control.

The establishment of border checkpoints and regulations on practices at border checkpoints are based on three official agreements between Vietnam and its neighbouring countries. The first is the "Agreement of border checkpoints and management regulation of border checkpoints on Vietnam – China mainland between governments of the Socialist Republic of Vietnam and the People's Republic of China", dated 18 November 2009. The second is the "Agreement on national border regulation between the Socialist Republic of Vietnam and Lao People's Democratic Republic", dated 1 March 1990. The

[9] The information is provided by the current Vietnamese government, which was the government in the North of Vietnam in 1958. The government in the South of Vietnam lost the Vietnam war in 1975. Therefore, this information may only tells a part of the story. Source: http://www.qdnd.vn/qkqd/vi-vn/111/343/nguoi-linh-quan-ham-xanh-viet-tiep-trang-su-hao-hung/176933.html. For English, see: http://www.qdnd.vn/qdndsite/en-US/72/72/Default.aspx. Localised on 14 March 2013.

third is the “Agreement on border regulation Vietnam – Cambodia”, dated 20 July 1983. According to these agreements, there are three types of mainland border checkpoints between these countries:

- International checkpoints
- National checkpoints
- Sub-border checkpoints (for small-scale local trade)

In addition, there are small opening points where citizens of two countries can trade small amount of commodities, less than the taxable quantity, without applying for exporting or importing licenses. These points are sometimes upgraded to sub-border checkpoints and national checkpoints. In most cases, these checkpoints had markets nearby, allowing Vietnamese border residents to trade with their neighbours. Residents of both sides of the borderline make transactions based on market rules, in which trade is facilitated by gaps between supply and demand. According to the market rules, when one commodity is rare within one territory, such as timber, high demand will drive up the price. The new price will bring about more supply from the other side of the border.

Trading needs between residents of the borderland leads to the construction of markets and road networks. The state controls border trade by sending customs officers to collect taxes (Schoenberger & Turner, 2008). Together with the border defence force, they set up official local border checkpoints. It is difficult to say which one comes first, the market or the border checkpoint. Provincial authorities acknowledge these markets as official border checkpoints (sub-border checkpoints in the case of Vietnam) by signing a memorandum of understanding (MOU) with the neighbouring provincial authority. If trade increases, and the province wants the border checkpoint to be on a higher institutional level (i.e., turn it into a “national” or “international” border checkpoint), they will do so by applying for official permission from the national government.

According to Ribot (1998; see also Ribot and Peluso 2009), residents of borderlands have access to both forest resources and markets. Therefore, activities along the border have the characteristics of natural resource exploitation. Turner (2010) even suggests that borderland residents exploit their access to markets and border crossings in order to benefit from their livelihoods and trade networks across the border. Lao residents, for instance, have the opportunity to extract timber in their own country, and sell it to neighbouring countries with a high timber demand – not only Vietnam, but also China and Thailand (Singh, 2012). In the case of Vietnamese residents, high profits from the timber trade may give them the incentive to put efforts and utilize labour in the trade.

Therefore, people refrain from other activities, such as timber extracting, NTFP collecting, and tree planting in Vietnamese territory, in order to be fully involved in cross-border trade. As a result, the trade may have reduced pressure on Vietnamese forests.

Borderland residents have certain privileges that the residents of other areas do not have, which may exclude the latter from cross-border trade. Singh (2012) states that "central authorities may also be less legible to borderlanders" (p. 18). One of those privileges is the regulation by the Vietnamese state that border residents do not need to have an official passport to cross the border and travel further inland on the other side, to the nearest market. This law encourages border residents to work as small traders (Schoenberger & Turner, 2008), who may then act as a link, or a transporter in the illegal logging chain of influential traders. Big local traders often take advantage of these crossing points, and use small transporters to collect rare, high-value log species. If logs are in large quantity, these traders can cut the logs into small pieces and hire local border residents to bring them across the border by using all available transport means, ranging from baskets, buffaloes and cows to bicycles and motorbikes. As a result, buoyant timber transport and different forms of smuggling are nearly impossible to control.

Contrary to the trading method employing local people described above, Walker (1999) has described a new method, in which the improvement in transport routes and infrastructure conditions has changed the power structures in the borderlands of Laos, Thailand, China, and Myanmar. Powerful traders and transporters, who are often outsiders (or, in the case of Laos, foreigners), can trade larger volumes of commodities thanks to economies of scale with cheap big trucks, and threaten the local Laos traders and transporters using boats. These actors can "exert great influence over market prices and commodity volumes" (Porter, 1995 p. 82), and leave local populations little space to compete. Therefore, local people hardly play a role in the border trade, which is controlled by "external metropoles" (Smith, 1976 p. 338).

The existence of external influential traders and local trading networks challenges the state in controlling everyday activities at borderlands (Morehouse, Pavlakovich-Kochi & Wastl-Walter, 2004). Several laws and regulations have been issued in order to manage trading activities at the Vietnamese borderland. However, institutions overlap between different state offices sometimes creates difficulties for import companies in Vietnam, such as overlapping regulations on trade quantity by the Provincial People Committee and by the Ministry of Industry and Trade. Regulations for trading quantities are not only different for different types of checkpoints, but also differ among provinces. In Nghe An province, for example, only 4,000 m^3 of permitted wood is traded in one day, while at the Nam Na checkpoint in Dak Nong Province the permitted amount is 10,000m^3.

Transporting large timber volumes from the borderlands is expensive, since it requires big trucks or cars. In order to reduce transportation distance and costs, timber trading companies usually want to trade timber at the most convenient border checkpoints. However, Vietnamese laws and border regulations stipulate that timber trade is only allowed at border checkpoints that have all three forces: customs, quarantine, and border defence.[10] Several wood companies would like to import timber from Laos through small open border points in the Central Highlands, in order to reduce transportation costs and avoid international attention. However, they are unable to do so, since most of these small open places do not provide quarantine services.[11] One well-known case is a company named Vietnam Agriculture Forestry Investment & Development Limited Company ("TNHH Đầu tư phát triển Nông lâm nghiệp Việt Nam"), who was unable to import 10.000m^3 of wood from Cambodia through a sub-border checkpoint in Dak Nong in 2012. Their desired wood quantity could not get through the checkpoint because different authority levels in Vietnam require different import license papers.[12]

State control is weak and not well organized in the remote borderlands, except for areas with international and national crossings. Most of these checkpoints belong to border economical zones, where trade is much larger. Traders have to pay tax and can do business in every kind of product, as long as trading commodities do not belong to the prohibited trade list.[13] At small local crossings, however, the types of commodities that can be traded are limited. Wood and wood products can be traded here only if the

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[10] Circular no. 13/2009/TT-BCT of the Ministry of Industry and Trade, dated 3 June 2006, regulating import and export at sub-border checkpoints and border open points outside border-gate economic zones. Source: http://thuvienphapluat.vn/archive/Thong-tu/Thong-tu-13-2009-TT-BCT-quy-dinh-xuat-nhap-khau-hang-hoa-qua-cua-khau-phu-loi-mo-bien-gioi-ngoai-khu-kinh-te-cua-khau-vb89256t23.aspx. Localised on 14 March 2013.

[11] According to the official letter of the Ministry of Finance and General Custom no. 5893/TCHQ-GSQL to the Vietnamese Wood and Forest Products Association, regarding the import of wood from Cambodia through small border points at border posts no. 717 and 729 of Gia Lai Province and border posts no. 751 and 753 of Đắk Nông Province. Import is not allowed here because these places do not have enough control forces, especially the quarantine. Source: http://thuvienphapluat.vn/archive/Cong-van-5893-TCHQ-GSQL-nhap-khau-go-tu-Campuchia-qua-cua-khau-phu-loi-mo-vb150237.aspx. Localised on 14 March 2013.

[12] Source: http://vietnamnet.vn/vn/kinh-te/101732/ap-quy-dinh-khac-nhau--nhap-khau-go-be-tac.html. Localised on 14 March 2013.

[13] The prohibited trade list is stipulated in Decision 238-TM/XNK dated 24 March 1994 by the Ministry of Trade. Source: http://thuvienphapluat.vn/archive/Quyet-dinh/Quyet-dinh-238-TM-XNK-Danh-muc-hang-hoa-cam-xuat-khau-cam-nhap-khau-vb38751t17.aspx. Localised on 14 March 2013.

aforementioned three authority forces are present at border checkpoints. When checkpoints only serve small-scale trade between border residents, it does not pay off to establish customs, or sanitary and phytosanitary forces at remote crossing points. As a result, these places only have border defence forces, who sometimes also work as rangers to control illegal logging and trade across the border.

The border defence forces are managed by Vietnam People's Army, who play an important role in the Vietnamese economy. After 1986 (the year of "Đổi mới", or national reforms), the Vietnam People's Army was placed under a new mission: assuring national defence in combination with developing the economy (Thayer, 2009). As a result of this new mission, the army has developed many economic units, and has become active in many different sectors in the Vietnamese economy. The army's economic units enjoy not only tax exemption, but also other priorities. Under the governance of the Communist Party, state-owned companies managed by the army have enjoyed a lot of privileges from the state, especially in the forestry industry. During my research, the army's activities came up in many business channels, working networks, and economic fields. Many of these companies were loggers (before 1990), wood processors, and exporters. The army also controls border checkpoints, as one of its tasks is to protect the Vietnamese borders. In addition to acting as security keeper and ranger, the army also acts as an agent of deforestation and an illegal timber trader. It has been suggested that some members of the border defence force are also active as poachers. These people tend to accept large bribes, and ignore environmental rules issued by their government (McElwee, 2004). Moreover, the close political relationship between the two communist parties in Vietnam and Laos also assures these companies easy access to Laos' forests. In 2010, Vietnam People's Army launched a project called Border Patrol Route ("Đường tuần tra biên giới"),[14] which may lead to further deforestation in Indochina. The project entails larger access for the Vietnamese army and its economic units into the neighbouring countries' territories and forests.

[14] Source : http://www.qdnd.vn/qdndsite/en-us/75/72/182/155/160/137077/Default.aspx. According to the project's official website, the Border Patrol Route is 14,251 Km long. At : http://duongtuantrabiengioi.vn/Voc-dang-cua-con-duong_N141.aspx. Localised on 24 March 2013.

2.4 Forest cover change in Laos and Cambodia

2.4.1 Laos

After a rapid decline in natural forest cover mainly due to dam construction and unsustainable logging (from 70% in the 1940s to 47% in 1989, and then to 41% in 1999), Laos launched a ban on logging in 1991, then on the log export in 1999, and finally a reduction in sawn timber export in 2001 (EIA, 2008 p. 4). However, due to the large discrepancy between the written laws and the actual law enforcement, these regulations have failed to save Laos' forests and their biodiversity rich areas. Despite the new laws, during the period 1990-2010 Laos continued to experience net deforestation, with an average forest loss of 0.43% per year (see figure 2.4). Because the plantation forests are of poor quality and made up with exotic species, these types of forests do not recover. In the 1990s, the forestry sector accounted for about 4.5% of the GDP. Laos' wood processing industry has increased in size, with an annual growth of 24% (FAO, 2010b p. 4, 8, 16). The industry, however, is criticized for being a disguise to obtain logging quota and export raw wood to Vietnam, Thailand, and China (EIA, 2008; 2012).

The construction of dams for generating electricity is the main cause of natural forest depletion in Laos. As of September 2010, the country had 79 hydropower projects, of which fourteen were under construction.[15] Most of these projects are located in dense forests and rich habitat areas. Accordingly, project contractors need to cut down trees for land clearance. They can do it themselves, or subcontract to logging companies who have equipment and trucks. Some of these subcontractors are from Vietnam and Thailand. Significantly, Thailand and Vietnam are also the two main foreign investors in the hydroelectricity industry in Laos. Indeed, Vietnam has currently become the biggest foreign investor, especially active in mining, electricity generation, and the agricultural sector.[16]

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[15] Source http://www.internationalrivers.org/files/attached-files/laohydro2010_sept_final.pdf. Localised on 08 April 2013

[16] Source http://www.vir.com.vn/news/top-news/vietnam-becomes-biggest-foreign-investor-in-laos.html. Localised on 08 April 2013.

Unsustainable logging is another cause of forest loss in Laos. The country is located in a region where timber is in high demand. Thailand, Vietnam and even China are all in need of raw materials for their domestic wood processing industries. In order to cut down forest trees in Laos, logging companies have to obtain a logging quota. The Provincial Wood Trade Committee distributes logging quota base on three standards: sawmills' capacity, political awareness and community development (Southavilay & Cástren, 1999 p. 11). The second standard in particular can be interpreted in various ways; normally, it rewards political allies, such as the Vietnam People's Army. In order to export wood, trading companies in Laos, , have to obtain export quota and contracts with importers. These importers usually have connections with subcontractors or investors in Laos' hydroelectricity.

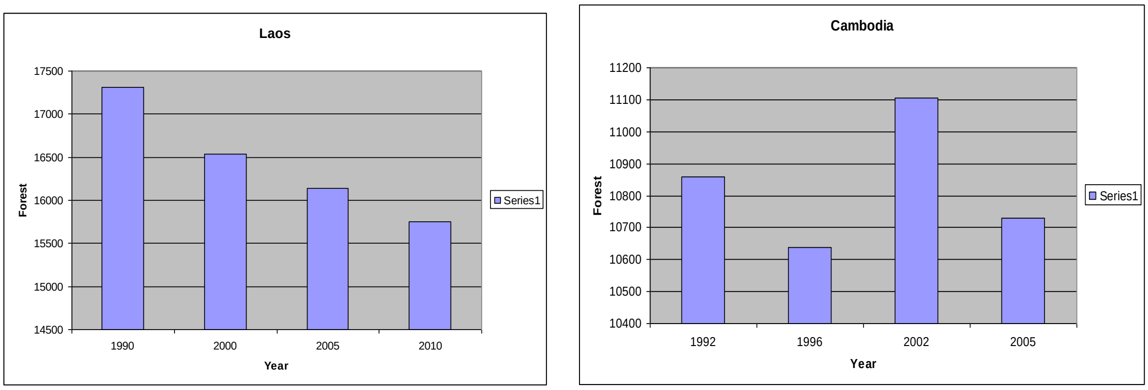

Figure 2.4 - Forest cover change in Laos and Cambodia (unit:1000 ha).
Source: FAO 2010a, FAO 2010b

2.4.2 Cambodia

During the period 1990-2010, Cambodia's forests decreased at a rate of 1.1% per year (Butler, 2013a). Civil wars, intensive illegal logging, and population growth are the main causes of forest cover loss in the country. From 1970 to 1998, Cambodia exported most of its logs and timber to Vietnam, Thailand, and Japan. The rapid disappearance of primary rainforests due to illegal logging (from 70% of the total forest cover in 1970 to merely 3.1% in 2007) has aroused international attention, even leading to the IMF and World Bank's disruption in giving loans and direct aid in the 1990s (Butler, 2013b). In 1993, the country adopted a new forest policy, which encouraged private investment in plantations (FAO, 2010a p. 16) and classified forests into three different types: protected, potential, and producing forests (Sasaki, 2006 p. 398). In addition to forest classification, Cambodia has issued three export bans of unprocessed wood since 1996 in order to protect its forest resource, and encourage the domestic wood processing industry's development (De Lopez, 2002).

In spite of the government's efforts in forest conservation and plantation, however, Cambodia was too late to save its primary forests. During the period 2000-2005, an average area of 218,800 ha was removed annually from the national forest cover area (FAO, 2010a). Domestic laws and regulations regarding logging and export ban have been violated for wood demand in foreign markets, such as in Thailand and Vietnam (Cástren, 1999; De Lopez, 2002).

2.5 Hypotheses

As suggested in the literature discussion, there are potentially strong links between forest conservation policies in Vietnam and deforestation and degradation in the neighbouring countries (i.e. international or cross-border leakage). Measuring leakage by estimating the amount of wood going in and out of the country is difficult due to a lack of data. Correlation between border checkpoint density, wood production, and other socio-economics factors with forest cover change can indirectly point to the existence of leakage. Forest cover change in Vietnam is observed in two kinds of data: deforestation and reforestation. I will further explain how to construct these two dependent variables in section 3.1. In order to observe the relationships between dependent variables and explanatory factors, the following hypotheses will be tested.

> **Hypothesis 1**: *The more border checkpoints a province has with Laos or Cambodia, the less deforestation and the less reforestation it experiences.*

By only looking at provinces that share a border with Laos and Cambodia, I want to compare the effects of border checkpoints on forest cover change in these provinces. Border checkpoint density is a proxy of access to the border. Traders may have more access to resources at the other side of the border if a border province has more border checkpoints. Thanks to these open border points, the costs of transportation are also reduced if they do not need to travel far to go to the neighbouring countries. In such cases, deforestation inside the country will be reduced if cutting down trees gives less profit than trading timber from outside. Therefore, a negative correlation is expected between checkpoint density and deforestation. In addition, if the resources at the other side of the border are available with cheaper prices and costs, local people will have less incentive to plant trees than to trade. As a result, reforestation is expected to have a negative correlation with border checkpoint density.

> **Hypothesis 2**: *High transparency leads to less deforestation and more reforestation at the borderland.*

From 2005, the Vietnam Chamber of Commerce and Industry (VCCI) has developed the Provincial Competitiveness Index (PCI), in cooperation with the U.S. Agency for International Development-supported Vietnam Competitiveness Initiative (USAID/VNCI). The index ranks governance performance of 64 provinces in Vietnam. As one of the subcategories of the PCI index, the transparency index represents the quality of the communication between the central government, local authorities, and investors. On the PCI's website, this variable is specified as follows: "A measure of whether firms have access to the proper planning and legal documents necessary to run their business, whether those documents are equitably available, whether new policies and laws are communicated to firms and predictably implemented, and the business utility of the provincial web page." (PCI Vietnam, n.d.).

'Transparency' refers to how effectively a legal system is translated and implemented in each provinces, one of the basic management unit by the central government. The system shows how easily an enterprise can achieve correct information from local authorities. In other words, the transparency index shows how good the provincial information environment is and how well laws and regulations of the central government are implemented at the provincial level. Institutions can influence deforestation in negative ways, in positive ways, or in both negative and positive ways at the same time. As discussed in section 2.1, policy failure causes deforestation. Good institutions can enforce forestry laws and regulations, and help to protect standing forests. When the pay-off from forest protection and plantation is high, local authorities make efforts to manage their forests well. Benefits from some international climate change mitigation projects such as REDD+ and PES reinforce this pay-off. In addition, a good information environment can also lower transaction costs. As a result, high transparency is expected to have a negative correlation with deforestation and a positive association with reforestation.

Hypothesis 3: *High wood production leads to more deforestation and more reforestation.*

Logging is a major cause of deforestation and forest degradation in South East Asia (Kaimowitz & Angelsen, 1998). Unsustainable logging will have a negative effect on forests. After 1991, when the Forest Protection Law was implemented, logging was banned in classified forests in Vietnam. Since then, wood production, or legal logging, has only been permitted in production forests. Unsustainable logging in production forests may lead to an increase in deforestation. However, if the wood processing industry has a high timber demand, reforestation programs will be set up. Planted forests are expected to increase. Therefore, high wood production may also lead to an increase in reforestation.

Hypothesis 4: *High population density leads to more deforestation and more reforestation at the borderland.*

Population growth has been identified as one of the indirect causes of deforestation (Kaimowitz & Angelsen, 1998; Rudel et al., 2005). As discussed in section 2.1, population growth affects deforestation and reforestation in different ways. It can undermine reforestation policies of a country and accelerate deforestation due to rapid land conversion for food production. But this effect on forest cover change is not consistent at the global level. High population density in one area can also raise the demand for timber products and encourage tree plantation. Thus, the high demand encourages governments and authorities to carry out conservation program and reforestation measures. I would like to test this by examining the partial effects of population density on forest cover change in Vietnam. These coefficients are expected to be positive with both deforestation and reforestation.

Furthermore, some other drivers of deforestation and reforestation, such as border-gate economic zones, industrial parks, and road networks, agriculture, and income growth, are included in the model in order to observe their full effects in Vietnam. Their effects can also support the main hypothesis testing variables. These factors establish a set of explanatory variables for the two dependent variables – deforestation and reforestation.

3. DATA AND METHOD

3.1 Data and variable specification

3.1.1 General data issues

In order to test my hypotheses, I use a panel data set at the provincial level for the period 2005-2011. The panel data has 60 units, representative for 60 provinces in Vietnam. There were 64 provincial units in Vietnam in 2005. In August 2008, the Vietnamese government decided to merge two units (Hanoi City and Ha Tay province) into one unit. Since then, official data in Vietnam report statistical information for 63 provinces. Accordingly, I have merged data for Ha Tay province from before 2008 with Hanoi's data. In addition, the three provinces Hung Yen, Can Tho and Vinh Long do not have data for both natural and planted forests. Areas of natural and planted forests are used to calculate deforestation and reforestation, which are the main targets for analyzing forest cover change in Vietnam. Therefore, the three provinces have been taken out of the data set.

In the dataset, the main interest variable – border checkpoints – does not include checkpoints at airports or seaports. Firstly, air transport is not a common method for timber trade. Secondly, because most of the borderline between Vietnam, Laos and Cambodia is on the mainland, trade between the three countries is not frequently recorded at seaports. These checkpoints also have a relative small impact on forest cover change in the Vietnamese borderland. The reason is that most airports and seaports are located in coastal provinces, where there are not so many forests left. Finally, local people whose livelihood depends on forests do not often participate directly in trade at airports and seaports. As a result, I do not expect to see much effect of border access to forest cover change in Vietnam by including border checkpoints at these places. In sum, the thesis only takes into consideration border checkpoints on the mainland between Vietnam, Laos, and Cambodia.

Small open points managed by border defence forces only are also excluded from the border checkpoint variable. These places have trading activities with rather small value. Furthermore, tracing the correct time of opening of these small points is difficult.

Vietnam's regulations allow only taxable transactions through border checkpoints that have all three control forces: customs, quarantine, and border defence.[17] Most of these small open points do not have all these three forces, and are therefore omitted.

Among 63 provincial units in Vietnam, 19 provinces border Laos and Cambodia and seven provinces border China. A dummy variable will represent for Vietnamese provinces which share a border with Laos and Cambodia and have at least one border checkpoint. There are some exceptions such that Điện Biên province which borders both China and Laos, and Kon Tum province which borders both Laos and Cambodia. The main objective of my econometric analysis is to see whether access to the border with Laos and Cambodia is correlated with forest cover change in Vietnam. If a Vietnamese province sharing a border with (one of) these two countries experiences less deforestation, I expect that leakage may occur. In that case, I will be able to demonstrate regional leakage due to cross-border timber trade.

3.1.2 Variable specification

a) Deforestation

Deforestation is a relative term, which is divided by provincial land area. The relative term makes it easier to compare deforestation trends in different regions. An absolute term of deforestation cannot reveal the partial effects of explanatory variables at a provincial level, because different provinces have different sizes. One province could experience more deforestation than another simply because it is larger in area. Therefore, a relative term can reveal precisely the impact of explanatory factors on forest cover change. Statistical data on forest cover in Vietnam are classified into two types: natural forest area and plantation area. I calculate deforestation by subtracting the natural forest area in the previous year from the natural forest area in this year. Then the natural forest difference is divided by land area. Therefore, the deforestation rate shows a decline of forest area over land area.

[17] According to Circular no. 13/2009/TT-BCT of the Ministry of Industry and Trade regulating import and export through sub-border checkpoints and border open points outside border economical zones.

$$D_t = \frac{NF_t - NF_{t-1}}{L_i} \text{ if } NF_t \leq NF_{t-1} \quad (1)$$

Where:

Dt: deforestation at the period t;

NF: natural forest area;

Li: provincial land area.

b) Reforestation

The reforestation area is calculated by combining the difference between this period and the previous period in natural forest area and planted forest area. The reforestation variable is relative and divided by provincial land area for the same reasons as deforestation explained above. Therefore, the reforestation rate shows a gain of forest area over land area.

$$R_t = \frac{(NF_t - NF_{t-1}) + (PF_t - PF_{t-1})}{L_i} \text{ if } R_t \geq 0 \quad (2)$$

Where:

R_t : reforestation in the period t;

PF: Planted forest area.

c) Border checkpoint density

In order to see the impact of border access on forest cover change in provinces that share a border with Laos or Cambodia (or both), I use the border checkpoint density variable.

$$\text{Border checkpoint density} = \frac{\text{Number of border checkpoints in a province}}{\text{Border length of province (Km)}} \quad (3)$$

This variable gives an average number of border checkpoints per kilometre of border. As discussed in 3.1.1, I omit small border points, and only include three types of checkpoints: international, national and sub-border checkpoints.

Table 3.1 - Variables and data sources.

Variable	Unit	Source
Deforestation		Vietnam Forest Management - Rangers [http://www.kiemlam.org.vn/]
Reforestation		Vietnam Forest Management - Rangers [http://www.kiemlam.org.vn/]
Border dummy		Vietnam Sovereign Boundaries [http://biengioilanhtho.gov.vn]
Border checkpoint density	Unit/Km	Vietnam Sovereign Boundaries [http://biengioilanhtho.gov.vn]
Transparency	PCI index	The Vietnam Provincial Competitive Index [http://pcivietnam.org]
Wood production	Thousand m^3	General Statistics Office of Vietnam [http://gso.gov.vn]
Population density	Thousand persons/ha	General Statistics Office of Vietnam [http://gso.gov.vn]
Agriculture output	Billion VND	General Statistics Office of Vietnam [http://gso.gov.vn]
Income	Thousand VND	General Statistics Office of Vietnam [http://gso.gov.vn]
Road density	Thousand persons	General Statistics Office of Vietnam [http://gso.gov.vn]
Border-gate economic zone	Unit	Decision no. 52/2008/QD-TTg[18]
Industrial park	Unit	Industrial Parks and Investment Information Consulting Portal [http://viipip.com]
Provincial area	Ha	Government Web Portal – Socialist Republic of Vietnam [http://gis.chinhphu.vn]

a) Income

Data of GDP per capita at the provincial level are not registered in the Vietnamese statistics system. However, the average monthly income of residents in a province can be obtained from the Household Living Standard Survey. The General Statistics Office of

[18] Decision no. 52/2008/QD-TTg dated 25 April 2008 of Prime Minister approving the scheme on the master plan on Vietnam's border-gate economic zone development up to 2020.
Source: http://lawfirm.vn/?a=doc&id=1503. Localised on 13 April 2013.

Vietnam carries out this survey every two years. In order to determine the annual income variable in the period 2005-2011, monthly incomes are multiplied by twelve months. Data from 2004, 2006, 2008, and 2010 are duplicated for 2005, 2007, 2009, and 2011. For a complete summary of data, data sources, and the utilized variables, see

3.1.3 Limitation in data

Different offices and organizations have several approaches to collecting forest cover data. In Vietnam, provincial data of natural and planted forests are collected every five years by the Forest Inventory and Planning Institute (FIPI), which belongs to the General Department of Forestry. Based on this five-year survey, the Forest Protection Department or "Kiểm Lâm Việt Nam" (FPD) has developed a system that is updated annually. For this purpose, local rangers and officers of the FPD collect data on local forest plots that are burnt, cleared, and planted. This bottom-up process of collecting data may be sensitive in the sense that local authorities may interfere, and compromise the neutrality of the data.

Governments and states, especially those who are subject to supervision of land use change policies, are very careful in recording forest data. Because of this, FAO collected forest loss data before 1995, but total forest cover has since replaced that category and become an official unit for classification (Lang, 2001). Laos, Cambodia and Vietnam are now under pressure of international organizations such as the World Bank to protect their natural environment. Baseline data in Laos and Cambodia are inadequate due to poor governance of the environment (Pangsapa & Smith, 2008). Among the three countries, Vietnam has been most successful in updating data on forest cover and forest loss. Forest loss data in Vietnam are classified into two types: cleared and burnt forest area. Forest cover includes changes in natural and planted forests. Nevertheless, the methods of collecting these types of data, especially those on forest cover, are questionable. To (2008) and McElwee (2009) have shown that data on forest cover in Vietnam ignore the biodiversity characteristics of planted and reforested areas. In addition, environmental observers often report the country as a hot spot when it comes to the loss of rare species and biodiversity. Vietnam is also a well-known destination for the illegal trade in forest animals.

3.2 Method

In this section, I will discuss the estimation method used for testing the hypotheses. Potential problems such as unobserved effects, endogeneity, and heterogeneity are discussed in order to avoid estimation bias. The method relies heavily on Wooldridge (2002, 2005, & 2011).

3.2.1 Choice of estimation method

In this study, deforestation (*Dt*) and reforestation (*Rt*) take the form of limited dependent variables, which are distributed along a restricted value range. Both deforestation and reforestation are defined as positive. *Dt* is set as zero if $NF_t \geq NF_{t-1}$. *Rt* is set as zero if $R_t \leq 0$. Therefore, these two dependent variables have a positive value, but pile up at zero (Wooldridge, 2011, p. 587). Estimation regression uses a Tobit model for corner responses in order to have a more efficient estimation than a linear model.

The dependent variable Y_{it} is observed by a latent variable Y_{it}^{*} in the following Tobit model for panel data.

$$Y_{it}^{*} = \beta_0 + \mathbf{x}_{it}\boldsymbol{\beta} + u_{it},\ u_{it}|\mathbf{x}_{it} \sim \text{Normal}(0, \sigma^2) \qquad (4)$$

$$Y_{it} = \max(0, Y_{it}^{*})$$

$$t = 1, 2, \ldots, T;\ i = 1, 2, \ldots, N \qquad \textit{(Wooldridge, 2002 p. 538)}$$

Where:

β_0: constant term that measures the common trend of deforestation and reforestation in every province;

$\mathbf{x}_{it}$: a vector of independent variables that are expected to affect deforestation and reforestation in province i;

$\boldsymbol{\beta}$: a vector of estimated parameters;

u_{it}: error term.

In the panel data, the Tobit model is often estimated with a random effect (Tobit RE). Panel data models face the challenge of unobserved effects in which outside factors are correlated with independent variables. If these outside factors are not captured and modelled, predicted results are likely to be inconsistent. Inconsistent estimation fails to predict the error term correctly, which can cause bias. Consider the following unobserved effects of the Tobit model (Wooldridge, 2002, p. 540):

$$Y_{it} = \max(0, \mathbf{x}_{it}\boldsymbol{\beta} + c_i + u_{it}) \quad t = 1, 2, \ldots, T \qquad (4)$$

$$u_{it}|\mathbf{x}_{it}, c_i \sim \text{Normal}(0, \sigma^2)$$

The unobserved effect c_i is assumed to be uncorrelated to the explanatory variables. In other words, the independent variables $\mathbf{x}_{it}$ have to be strictly exogenous, and conditional on c_i. Therefore, random effect estimation for panel data assumes the unobserved effect and explanatory variables to be uncorrelated. This assumption will rule out several potential endogenous independent variables, which will be further clarified in 3.2.4. In order to keep these variables in separate models but still have a consistent estimation, a Chamberlain-like model is applied to deal with unobserved effects. This model allows $\mathbf{x}_{it}$ to be correlated to c_i, and assumes:

$$c_i|\mathbf{x}_i \sim \text{Normal}(\psi + \bar{x}_i\zeta, \sigma_a^2) \qquad (5)$$

$$c_i = \psi + \bar{x}_i\zeta + a_i \qquad \textit{(Wooldridge, 2002 p. 540-541)}$$

Where σ_a^2 is a variant of a_i – an error term in the estimation of c_i on $\bar{x}_i$. Based on this assumption, the random effect Tobit model now has a new set of time-invariant independent variables for each period. The time-constant variable can also solve the unobserved heterogeneity problem. The variable of industrial park for every province, which is invariant according to time, serves as a treatment for unobserved heterogeneity in light of this method.

3.2.2 Pre-estimation issues

a) Causality

The presence of border checkpoints and their quantity in each border province are believed to affect forest cover change. The reason is that they are the exits for leakage, trade and activities displacement from Vietnam to Laos and Cambodia. Because of these exits, Vietnamese borderland forests are expected to experience less pressure, due to ineffective direct deforestation drivers – in particular, agriculture conversion and unsustainable logging. Scatter diagrams between dependent and explanatory variables show their correlation, and partly a causal relationship (see figure 3.1 and 3.2).

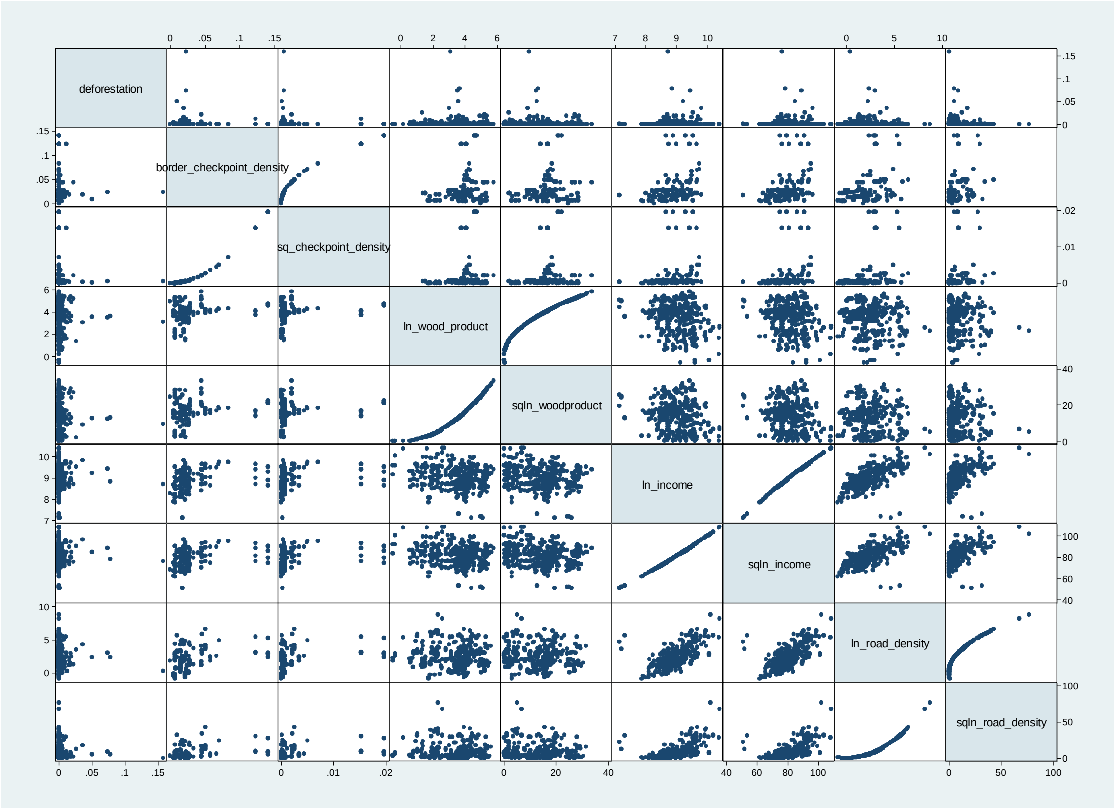

Figure 3.1 - Scatter diagram of deforestation and explanatory variables.

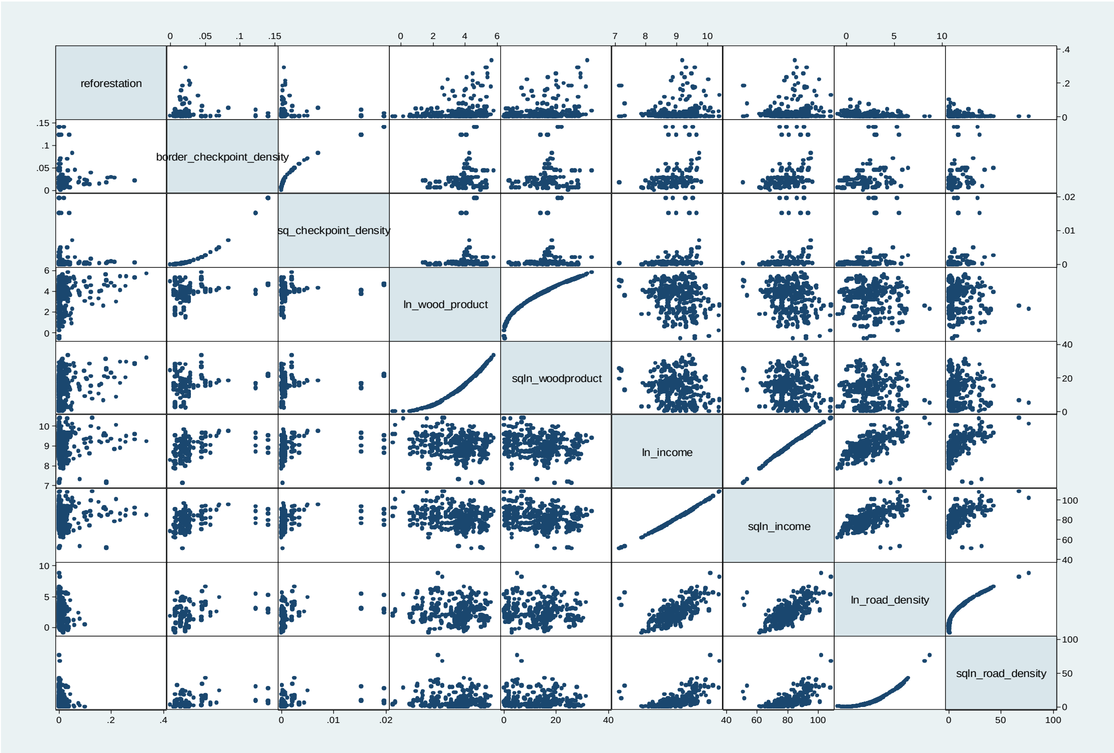

Figure 3.2 - Scatter diagram of reforestation and explanatory variables.

b) Omitted variables

Omitted variables in panel data estimation can cause unobserved heterogeneity, where the omitted factor correlates with the error term. As a result, the model's disturbance term is unequally distributed. Omitted variables are difficult to handle because of many direct and indirect causes of deforestation (Barbier & Burgess, 2002). In this econometric analysis, only a limited range of factors are quantified and tested, such as border checkpoints, transparency index, population density, wood production, income, etc. These factors, which are relevant for the forest cover change in Vietnam, have been discussed in part two. Other possible causes of deforestation and reforestation in Vietnam which are unable to quantify will also be discussed after the econometric analysis.

c) Multicollinearity

The multicollinearity problem arises when the predictor variables are highly correlated with each other. Assumption of no perfect linear relationship among independent variables in the regression models can be one way to deal with the problem. Even though violating this assumption does not affect the models' predictive power, individual effects of explanatory variables could be misled. In some cases, estimated parameters and standard errors are imprecise (Grewal, Cote & Baumgartner, 2004). A correlation matrix can detect whether the assumption is violated. The matrix (table 3.2) shows high correlations between agriculture output and population density (corr = 0.707). In order to avoid multicollinearity, agriculture output and border-gate economic zone variables are left out in several models.

Table 3.2 - Correlation matrix of utilized variable.

	Checkpoint density	Transparency	Wood production	Population density	Annual income	Predicted income	Agriculture output	Industrial parks	Road density	Border-gate economic zone
Checkpoint density	1									
Transparency	0.082	1								
Wood production	0.285	0.1309	1							
Population density	0.5817	0.1525	0.1323	1						
Annual income	0.2786	0.2192	-0.1644	0.2989	1					
Predicted income	0.0102	0.232	0.0674	0.0597	0.2561	1				
Agriculture output	0.5999	0.1029	0.3456	0.707	0.3764	0.0797	1			
Industrial parks	0.3444	0.0573	-0.2333	0.5249	0.3684	0.0462	0.3079	1		
Road density	0.3593	0.2097	0.1489	0.619	0.5711	0.2296	0.5524	0.3915	1	
Border-gate economic zone	-0.1129	-0.0897	-0.4267	0.1388	0.1494	-0.028	0.0509	-0.049	0.0683	1

d) Endogeneity

The endogeneity problem is referred to in statistics as "inconvenient truth". It arises when the disturbance term of the model is correlated with a dependent variable, causing estimation bias. This can happen if the model has omitted variables (1), measurement errors (2), and/or simultaneity (3). The omitted variable problem has been discussed in part b of this section. Measurement errors are often caused by unobserved heterogeneity, which is also discussed in section 3.2.1. Simultaneity refers to the problem of counter causality. Border checkpoints and other factors may cause deforestation. But forest deforestation or reforestation may have an opposite effect on the opening of more border checkpoints, due to infrastructure design of cleared land. The following variables are suspected to be endogenous, and therefore, are controlled for endogeneity in estimation.

Border dummy variable

There are three economic centres in Vietnam: Hanoi in the north, Danang in the middle, and Ho Chi Minh City in the south. Most economic activities and wealth are concentrated in these centres, which are also densely populated. The borderland with Laos and Cambodia (defined as 1 for border dummy variable) is far away from these three centres and may have less population, a lower GDP per capita, and less infrastructure. In order to control this difference, I use several models which have data only from these border provinces. In particular, models with border checkpoint density control the potential endogeneity with regard to this border dummy.

Income variable

Income is potentially endogenous because Vietnam has an agricultural economy with a rural population accounting for more than 70% of the total population (2009 – The World Bank).[19] This characteristic makes income potentially endogenous and correlated with agriculture output. Furthermore, income can be correlated with other unobserved factors such as industrial technology, foreign investment, and business development. In order to control for endogeneity, the instrument method is a candidate. However, there is little empirical evidence to support the instrument method in Tobit models for panel data.

[19] Source: http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/EASTASIAPACIFICEXT/VIETNAMEXTN/0,,contentMDK:20534368~isCURL:Y~pagePK:141137~piPK:141127~theSitePK:387565,00.html Localised on 13 May 2013.

Therefore, I use the year dummy variable (2006) in a regression with income, and obtain a predicted value (yhat) to mitigate for potential endogeneity. The reason why 2006 is chosen is that a New Enterprise Law was issued in Vietnam in 2005 and had full legal force on 1st July 2006. The law is an improvement of the Enterprise Law 1999, which has promoted the private sector development and fostered income growth (Klump, 2007). The predicted income is obtained from a regression in which income is the dependent variable and year dummy is the independent variable. Table 3.3 shows the results of the Smith-Blundell test for the exogeneity of the main estimation models. The test's null hypothesis states that the explanatory variables are weakly exogenous (Smith & Blundell, 1986). And a rejection of the null hypothesis means that the instruments should be used for the suspected endogenous variable[20]. In this test, income is the suspected endogenous variable and the year dummy variable is used as an instrument. The test shows that there is no problem with endogeneity in my deforestation models. However, the three models of reforestation (II, IV and V) have a high test statistic value and the null hypothesis of the Smith-Blundell test is rejected. Therefore, the predicted income should be used in order to have a more consistent estimation.

Table 3.3 - Smith-Blundell test of exogeneity.

	Deforestation		Reforestation	
	F-value	p-value	F-value	p-value
Model I	2.6906	0.1041	0.5204	0.4724
Model II	0.4587	0.5003	7.5368	0.0076
Model IV	0.4671	0.4965	10.452	0.0018
Model V	0.3742	0.5426	9.1841	0.0034
Model VI	0.6594	0.4194	0.6594	0.4194

Agriculture output

Agriculture output may be endogenous because land is needed to carry out farming activities. Land clearance for agriculture is also decided by other factors such as population growth, environment protection, and economic development policies. As I have mentioned above, this variable can correlate highly with income. Checking for the

[20] Interpretation of the Smith-Blundell test is obtained from http://fmwww.bc.edu/repec/bocode/t/tobexog.hlp. The post is written by Christopher F. Baum from Boston College, the U.S.. Localised on 13 May, 2013.

correlation between agriculture output and income does not expose the multicollinearity problem (see table 3.2). However, for a cautious approach, the potential endogeneity problem will be controlled by using the same method discussed in part c for the agriculture output variable.

e) Descriptive statistics

The econometric analysis is based on a Tobit estimation of panel data with 60 units over the period 2005-2011. Table 3.4 summarizes number of observation, mean value, and standard deviation of the two dependent variables (deforestation and reforestation), and key explanatory variables in this thesis.

Table 3.4 - Descriptive statistics.

Variables	Obs.	Mean	Std. Dev.	Min	Max
Deforestation	427	0.0022382	0.010155	0	0.15813
Reforestation	427	0.0201147	0.047721	0	0.334286
Number of checkpoints	175	4.622857	2.911638	0	20
Border dummy	420	0.3142857	0.464784	0	1
Checkpoint density	175	0.032527	0.03284	0	0.14
Transparency	398	5.651243	1.074342	2.154291	8.854357
Production of wood	420	59.66676	60.18559	0.6	326.5
Population density	420	0.0043371	0.005254	0.000384	0.035837
Income (annual)	420	9576.311	5113.738	1269.96	32844
Agriculture output	420	2459.398	1848.927	188.4	8356.3
Number of industrial parks	412	5.162621	7.014775	1	36
Road density	360	70.99361	399.8533	0.4	6466
Number of border-gate economic zones	148	1.283784	0.628577	1	3

3.2.3 Econometric model specification and assumption

a) Model specification

Taking into account the unobserved heterogeneity and pre-estimation problems, the study's econometric analysis will be based on seven models. These models are built with the purpose of identifying drivers of deforestation and reforestation at the borderland of Vietnam. The models are estimated in two separate ways, in which deforestation and reforestation act as dependent variable. Estimation results of the seven models will be reported with three methods: pooled Tobit (1), pooled Tobit with robust standard error (2), and random effect Tobit (3).

The approach of each model is justified by testing whether there are relationships between socio-economic explanatory variables and forest cover change (see table 3.5). First, drivers of deforestation and reforestation except border checkpoint density are investigated at a large scale, including the regions outside the borderland. Second, the same factors are observed at the border region. Third, simple correlations of the border checkpoint density variable with deforestation and reforestation are observed. The later models are the third model which have more controlled factors; some of which will be treated for multicollinearity and endogeneity. Especially, the sixth and seventh models have a wood production’s quadratic term, which observes how sensitive the forest cover change is when the amount of produced wood get large. The main purpose of these different approaches (see appendix IV) is to observe correlation robustness of the dependent variables with their explanatory factors, which may reveal causality.

Table 3.5 - Overview of models and predicted signs.

	Model I	Model II	Model III	Model IV	Model V	Model VI	Model VII	Expected signs	
								Deforestation	Reforestation
Checkpoint density			x	x	x	x	x	-	-
Transparency	x	x		x	x	x	x	-	+
Wood production	x	x		x	x	x	x	+	+
Quadratic wood production						x	x	-/+	-/+
Population density	x	x		x	x	x	x	+	+
Industrial parks	x	x		x	x	x	x	-/+	-/+
Road density	x	x		x	x	x	x	-/+	-/+
Border-gate economic zone		x		x	x	x	x	-/+	-/+
Annual income	x	x		x	x	x		-/+	-/+
Predicted income							x	-/+	-/+
Agriculture output	x	x		x				+	_

b) Assumption

According to Wooldridge (2011, p. 588), the latent variable Y^* satisfies the linear model assumption, even though Tobit is a non-linear model. In addition, error terms of the latent variable estimation must be homoscedastic and normally distributed. Homoscedasticity requires the variance of error terms to be independent with explanatory variables.

The validity of the Tobit estimation relies strongly on the normality distribution of the disturbance (or error) term. Three methods of Tobit estimation are applied in order to have efficient results. Each method relaxes assumptions of the previous one in term of solving the unobserved effects and heteroskedasticity. The pooled Tobit assumes no heterogeneity, and explanatory variables are strict exogenous. The error term (u_{it}) is independent across provinces and over time for the same province. The estimation with Tobit - robust standard errors is reported in appendix VI in order to observe heteroskedasticity. Finally, the Tobit - random effects estimation in appendix VII captures unobserved individual effects. Unobserved effects are assumed to be random and independent over time for the same province.

c) Turning point calculation

Estimating a turning point can reveal the counter-effect of some independent variables on the forest cover change. Because most independent variables have a logarithm form, parameters of the following functions will be estimated in Stata in order to calculate the turning point.

1st degree polynomial function is:

$$Y = a + b_1 \ln x \qquad (6)$$

2nd degree polynomial function is:

$$Y = a + b_1 \ln x + b_2 \left(\ln x\right)^2 \qquad (7)$$

Where:

Y: Deforestation or reforestation

Taking derivative of equation (7) for x gives:

$$\frac{\partial Y}{\partial x} = \frac{b_1}{x} + \frac{2b_2(\ln x)}{x} = 0 \ (x \neq 0)$$

$$\Rightarrow \ \ln x = \frac{-b_1}{2b_2} \qquad (8)$$

$$\Rightarrow \ x = (e)^{\frac{-b_1}{2b_2}}$$

In the case of linear model, and quadratic equation is expressed as:

$$Y = a + b_1 x + b_2 x^2 \qquad (9)$$

The turning point is estimated at $x = \frac{-b_1}{2b_2}$ (10) (Plassmann and Khanna, 2007)

4. RESULT AND DISCUSSION

4.1 Bivariate relationship between deforestation/reforestation and exogenous variables

Statistical confidence in the relationships between deforestation or reforestation with border checkpoint density and some other explanatory variables is presented in figure 4.1-4.4. [21] The shaded area in figure 4.1 is narrow when the border checkpoint density's mean ranges from 0.015 to 0.05, equivalent to an average of three to ten[22] checkpoints in a province. The dataset has few observations for provinces which have fewer than three border checkpoints or more than ten. Therefore, it gives little support for the correlation between border checkpoint density and border provinces' deforestation or reforestation in these cases, in which factors other than cross-border trade have a stronger partial effect. However, within the range from three to ten border checkpoints, both deforestation and reforestation show a decreasing trend. Hypothesis one, which states that a higher number of border checkpoints is associated with less deforestation and the less reforestation, is supported.

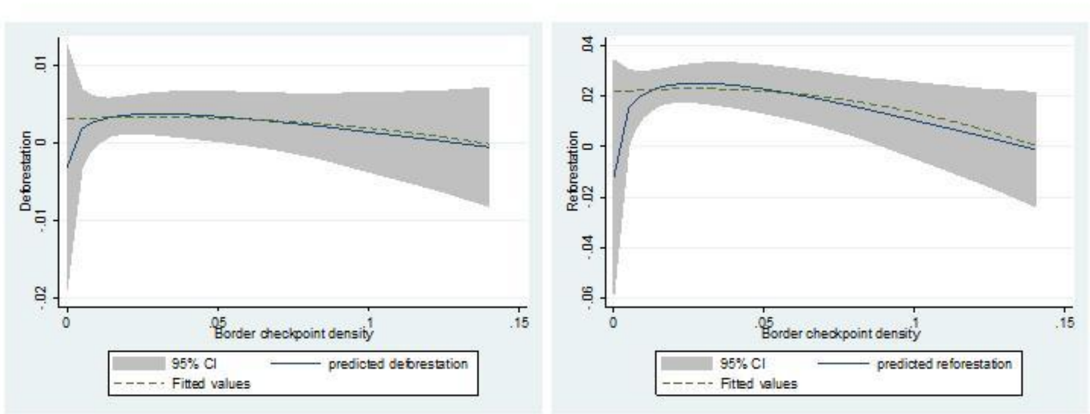

Figure 4.1 - Forest cover and border checkpoint density.

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[21] Graphs were generated in Stata-11 software using the commands: **twoway (fpfitci deforestation *the_exogenous_variable*) qfit deforestation *the_exogenous_variable*** or **twoway (fpfitci reforestation *the_exogenous_variable*) qfit reforestation *the_exogenous_variable***

[22] The average number of checkpoints per province is calculated from equation (3) by multiplying the mean of border checkpoint density with the mean of border length.

In general, the relationship between deforestation and transparency as showed in figure 4.2 is statistically stronger than other relationships. Meanwhile, the relationship between reforestation and wood production is significant (figure 4.3); more wood production encourages more reforestation. Hypothesis three regarding reforestation and wood production is statistically supported by observing only the correlation between these two variables. Figure 4.4 presents a rather unclear relationship between forest cover change and population density.

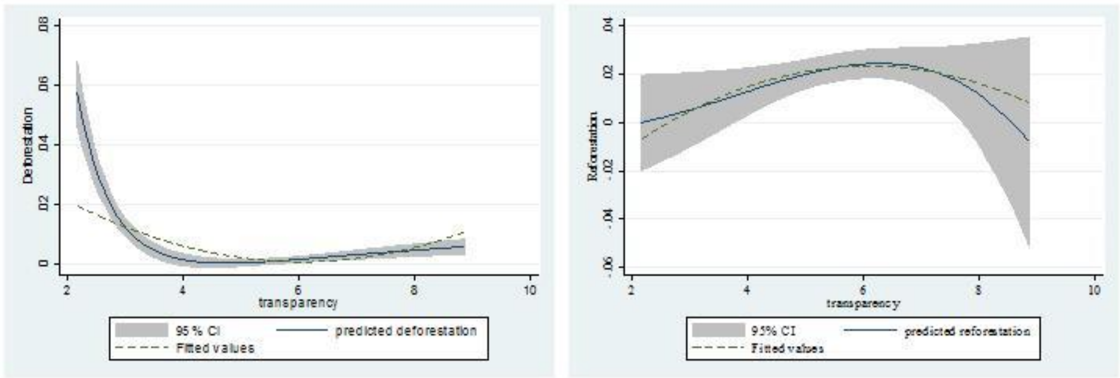

Figure 4.2 - Forest cover and transparency.

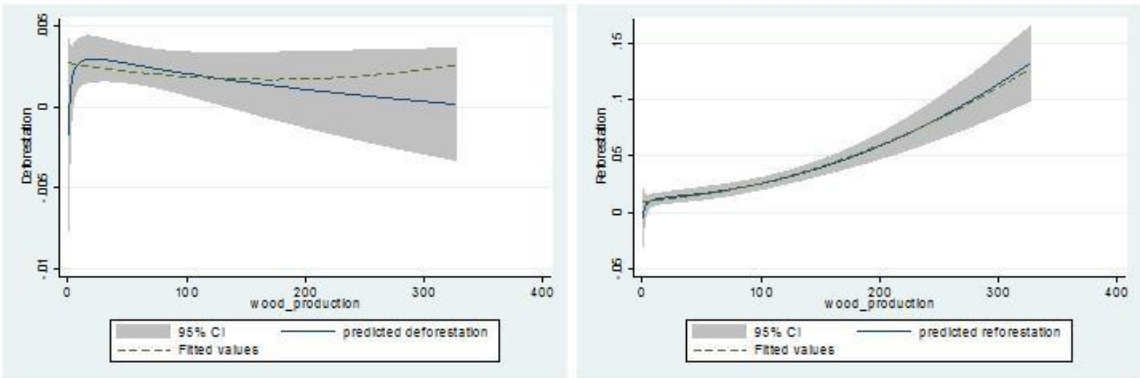

Figure 4.3 - Forest cover and wood production.

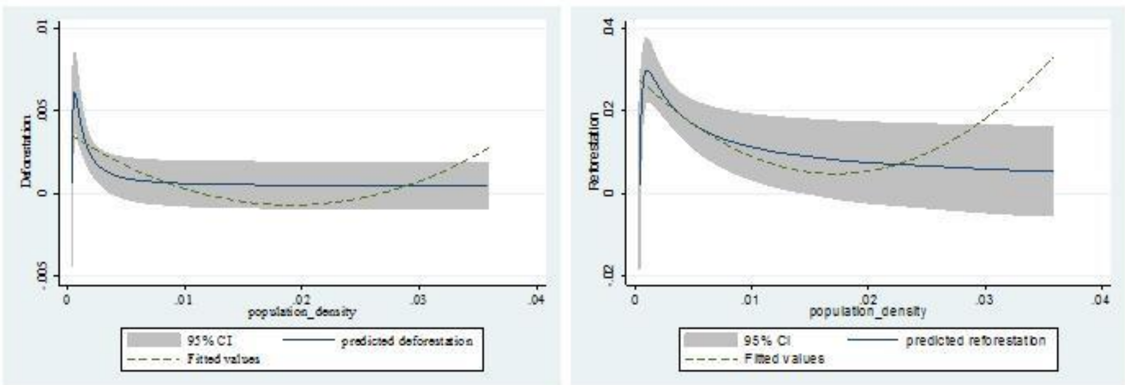

Figure 4.4 - Forest cover and population density.

Kernel density estimation in figure 4.5 shows that the distribution of the logarithm of deforestation and reforestation in the borderland is different from other regions.[23] The right graph shows that reforestation of border provinces is distributed more to the right. This implies a lower reforestation rate for these provinces. The left graph is unclear about whether border provinces have more or less deforestation. Nevertheless, mean comparisons of deforestation and reforestation between these two geographical regions by a t-test in appendix V confirm that the borderland has higher deforestation and lower reforestation rates than other regions do.

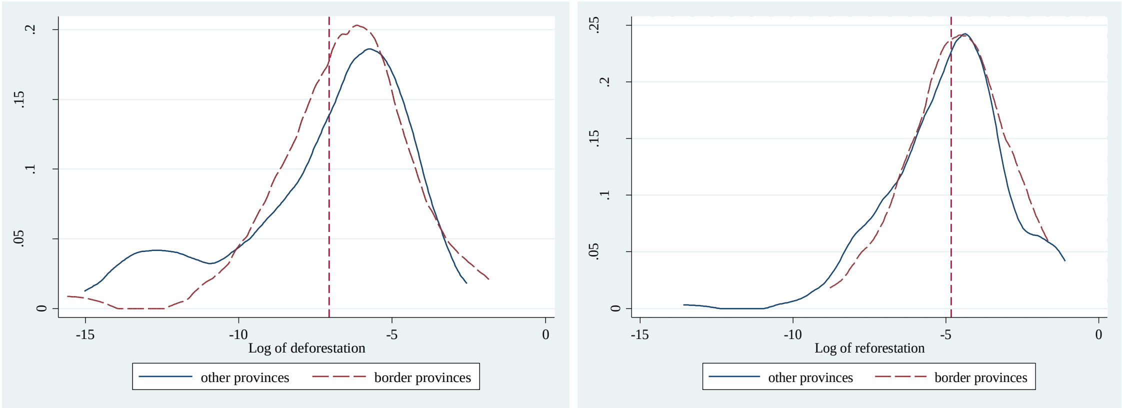

Figure 4.5: Distribution of logarithm deforestation and reforestation by region

The bivariate graphs in this section show only the correlation between forest cover change and one of the independent variables, without taking into account the effect of other explanatory factors. Therefore, no conclusion should be drawn before estimating multiple models in the next part.

4.2 Multiple regression models

Deforestation and reforestation estimations are reported and discussed using the pooled Tobit. Appendix VI and VII shows the estimations for the Tobit robust standard errors and Tobit RE.

[23] Figure 4.5 was generated in Stata-11 software using the commands: **twoway (kdensity ln_deforestation if borderpoint==0) (kdensity ln_deforestation if borderpoint==1), xli(`r(mean)', lpa(dash))** or **twoway (kdensity ln_reforestation if borderpoint==0) (kdensity ln_reforestation if borderpoint==1), xli(`r(mean)', lpa(dash)).**

4.2.1 Deforestation

The estimation of the explanatory variables' effects on deforestation is presented in table 4.1. The first two models show the effects of other factors than border checkpoints at the national and local level. The effects of transparency and population density are significant and robust. In order to see the effects of some factors more clearly, the quadratic terms of some variables are introduced in appendix VIII and IX. Even though border checkpoint density shows the expected negative signs, its effect is not significant. However, when the quadratic checkpoint density is introduced, the effect becomes significant.

The signs of transparency are different in the borderland models and the model control for other regions (model I). The coefficient's sign between transparency and deforestation changes from negative to positive in models II-VII as border checkpoint density and border-gate economic zones are controlled for scale sensitivity. While more transparency is associated with less deforestation at the national level, it is the opposite at the borderland. At the national level, a one-point increase in the transparency index can reduce the rate of deforestation by 0.003. But in the border region, it has an opposite effect: the same increase in the transparency index here is associated with an increase of 0.004 in the deforestation rate (model IV). An increase of 0.004 in deforestation rate means that the share of forest area over the provincial land area is decreasing by 0.004. The inconsistency between the local and the national level implies that economic institutions in favour of attracting new investors have contributed to land clearance and more deforestation at the borderland.

Deforestation is sensitive to the quantity of wood production. The correlation between logging and deforestation at the border region is negative, significant, and robust. Hypothesis three is rejected, meaning that more wood production (1% increase) is associated with less deforestation (-0.005).

Population density is associated with less deforestation. The hypothesis that population density has a negative effect on forests due to agriculture expansion and overexploitation of the forest's resources for food is rejected. It is likely that population density influences deforestation in a way different from agriculture activities. Trade and distance to markets often influence farming and cultivation. When agriculture output is taken out of the estimation, the effect of population changes slightly; its coefficient with deforestation changes from (-0.008) to (-0.007). In appendix VIII, quadratic population density is significant, but there is no turning point.

Table 4.1 - Deforestation estimation.

Deforestation Pooled Tobit estimation	Model I	Model II	Model III	Model IV	Model V	Model VI	Model VII
Checkpoint density			-0.121	-0.031	-0.014	-0.022	-0.018
			(0.09)	(0.06)	(0.05)	(0.05)	(0.05)
Transparency	-0.003***	0.004**		0.004**	0.004**	0.004**	0.004**
	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)	(0.00)
Log of wood production	0.000	-0.005*		-0.005*	-0.005*	-0.023*	-0.025**
	(0.00)	(0.00)		(0.00)	(0.00)	(0.01)	(0.01)
Quadratic wood production						0.003	0.003
						(0.00)	(0.00)
Log of population density	-0.003**	-0.008**		-0.008**	-0.007**	-0.006*	-0.006*
	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)	(0.00)
Log of industrial parks	-0.001	-0.002		-0.002	-0.002	-0.002	-0.002
	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)	(0.00)
Log of road density	-0.001	0.001		0.001	0.001	0.001	0.001
	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)	(0.00)
Border-gate economic zone	0.006	0.006		0.006	0.007	0.008	0.008
	(0.01)	(0.01)		(0.01)	(0.01)	(0.01)	(0.01)
Log of income	0.007**	0.001		0.001	0.002	0.002	
	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)	
Log of predicted income							0.010
							(0.01)
Log of agriculture output	-0.002	0.001		0.002			
	(0.00)	(0.00)		(0.00)			
Constant	-0.060*	-0.086**	-0.011***	-0.089**	-0.079*	-0.041	-0.114
	(0.03)	(0.04)	(0.00)	(0.04)	(0.04)	(0.05)	(0.11)
Sigma	0.017****	0.011****	0.026****	0.011****	0.011****	0.011****	0.011****
Constant	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Number of observations	333	83	175	83	83	83	83
LR chi2	28.45	18.08	2.03	18.38	36.82	45.78	55.73
Prob > chi2	0.000	0.021	0.155	0.031	0.022	0.017	0.014
Pseudo R2	-0.047	-0.099	-0.012	-0.101	-0.170	-0.220	-0.260
Uncensored observations	154	39	62	39	50	50	50
Left-censored observations	179	44	113	44	33	33	33
Right-censored observations	0	0	0	0	0	0	0
Log likelihood	312.624	99.689	84.548	99.838	121.745	126.224	131.197
Turning point						**46.216**	**64.5**

Note: ****, ***, **, * indicate significance levels at 0.1%, 1%, 5%, 10% respectively

Road density, which is used as a proxy of access to road facilitates, is associated with more deforestation. Even though the effect of road density is not significant in table 4.1, it is significant in the quadratic model in appendix VIII. Road access has a positive but diminishing impact on deforestation. Building roads provides access to the remote borderland and its resources, which causes a decline of forest area over land area by 0.014. But when more people have access to road facilities, other activities than natural resource exploitation, such as trade, can develop and the deforestation rate is reduced by 0.002. Deforestation reaches a turning point when the road density is 33,115 persons per year.

4.2.2 Reforestation

The estimation results for reforestation in table 4.2 are much clearer than for deforestation. Border checkpoint density has a negative correlation with reforestation: i.e., there is less reforestation at the border area. The effect is significant and robust at a level of 5 % or better. An increase of one unit/km in the border checkpoint density corresponds to at least 0.202 less reforestation. It means that the gain of forest area over the provincial land area is decreased by 0.202 if a province opens more border checkpoints. Therefore, hypothesis one regarding reforestation at the border region cannot be rejected.

Transparency has a significant negative association with reforestation, which is contrary to hypothesis two. The significance of transparency is robust at a level of 0.1% in the borderland models. This correlation implies that provincial authorities who give transparent information on central-government laws and regulations might have upset the reforestation process at the borderland. At the national level (model I), despite having the same sign as other models, the coefficient of transparency with reforestation is not significant. Reinforcing the effect of transparency, industrial parks also has a negative correlation with reforestation, suggesting a link between investment and industrial development in the region. Industrial parks undermine the reforestation process, and its effect is significant in models I, II, and IV. The reforestation rate decreases by 0.006 if the number of industrial parks increases by one percent. At a national scale, the effect of opening industrial parks is less apparent than in the borderland (0.003).

Table 4.2 - Reforestation estimation.

Reforestation Pooled Tobit estimation	Model I	Model II	Model III	Model IV	Model V	Model VI	Model VII
Checkpoint density			-0.429***	-0.202**	-0.284***	-0.269***	-0.292****
			(0.14)	(0.08)	(0.08)	(0.08)	(0.08)
Transparency	-0.001	-0.009****		-0.010****	-0.009****	-0.010****	-0.008****
	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)	(0.00)
Log of wood production	0.003****	0.001		0.004	0.003	0.072**	0.070***
	(0.00)	(0.00)		(0.00)	(0.00)	(0.03)	(0.02)
Quadratic wood production						-0.009**	-0.009***
						(0.00)	(0.00)
Log of population density	0.000	0.014***		0.015***	0.009**	0.007*	0.007*
	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)	(0.00)
Log of industrial parks	-0.003**	-0.008**		-0.006*	-0.005	-0.005	-0.005
	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)	(0.00)
Log of road density	0.000	0.003		0.002	0.001	0.003	0.003**
	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)	(0.00)
Border-gate economic zone		-0.013		-0.013	-0.012	-0.016*	-0.013*
		(0.01)		(0.01)	(0.01)	(0.01)	(0.01)
Log of income	0.000	0.002		0.003	-0.003	-0.001	
	(0.00)	(0.01)		(0.01)	(0.01)	(0.01)	
Log of predicted income							-0.044***
							(0.01)
Log of agriculture output	-0.006****	-0.015****		-0.011***			
	(0.00)	(0.00)		(0.00)			
Constant	0.042	0.251****	0.024****	0.215****	0.151**	0.003	0.377***
	(0.03)	(0.06)	(0.01)	(0.06)	(0.06)	(0.08)	(0.13)
Sigma	0.015****	0.015****	0.051****	0.015****	0.016****	0.015****	0.014****
Constant	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Number of observations	333	83	175	83	83	83	83
LR chi2	64.11	37.57	18.38	44.12	36.82	45.78	55.73
Prob > chi2	0.000	0.000	0.002	0.000	0.000	0.000	0.000
Pseudo R2	-0.066	-0.181	-0.101	-0.213	-0.178	-0.221	-0.269
Uncensored observations	211	50	39	50	50	50	50
Left-censored observations	122	33	44	33	33	33	33
Right-censored observations	0	0	0	0	0	0	0
Log likelihood	512.643	122.117	99.838	125.392	121.745	126.224	131.197
Turning point						**54.598**	**48.857**

Note: ****, ***, **, * indicate significance levels at 0.1%, 1%, 5%, 10% respectively

In the coefficient with reforestation, wood production has a significant impact at the national level (Model I), and the local level in the border region (models VI and VII). This supports hypothesis three, which states that more wood production is associated with more reforestation. In order to observe the effects of this factor more clearly, a quadratic term of wood production logarithm has been added in the last two estimation models. Reforestation reaches a turning point when wood production is about 54,598m^3 in model VI, and 48,857m^3 in model VII. Combined with its effect on deforestation, the coefficients of wood production imply that if there is more produced wood, the pressure on forests may decrease and create good conditions for reforestation.

Population density has a positive significant correlation with reforestation. And the significance of population density is robust in the models that control for different factors at the borderland. Hypothesis three, which states that high population density leads to more reforestation, cannot be rejected. When agriculture output is taken out, population density's coefficient with reforestation changes from (0.015) to (0.009). The effect of income is opposite to that of population density. After treated, the effect of income becomes significant; income is negatively correlated with reforestation. And an increase in income will lead to a turning point in reforestation, as demonstrated by the quadratic income model in appendix IX.

In sum, by testing my hypotheses, I have shown how the partial effects of economic development policies, transparency, logging, population, and infrastructure systems on the provincial level affect forest cover change over time. Hypothesis one is of my main interest of testing for forest cover change and leakage at the border region. If border checkpoint density has significant correlations with both deforestation and reforestation, border access and trade have a certain impact on changing the forest cover in Vietnam. Moreover, deforestation can be demonstrated on a larger scale, including the territory of Vietnam's neighboring countries. The econometric estimation shows that border checkpoint density does have negative correlation with deforestation and reforestation, but the correlation is significant only in the reforestation models. Hypothesis one is partly supported. Regarding deforestation models, the explanatory variables may not have fully captured all of the potential factors that can affect the reduction of natural forests due to unobserved heterogeneity. I will further discuss about this hypothesis and leakage at the border region in the section 4.3.1.

Regarding transparency at the borderland, a high transparency index turns out to represent pro-investment policies by provincial authorities. VCCI measures the index to assess how successful a province attracts investment capital into the its region. Investment projects, mainly focused on extracting natural resources, compete for land with forests and agriculture. Provincial authorities establish many industrial parks in order to compete with their neighbouring provinces for investment capital and regional economic development. Therefore, provinces with more institutional arrangements for economic development are associated with more deforestation and less reforestation. Hypothesis two is rejected.

Population growth is one of the indirect causes of deforestation. However, the partial effect of population density on deforestation in Vietnam is rather unexpected; higher population density areas are associated with less deforestation. Nevertheless, high population density does lead to more reforestation. Hypothesis three is partly rejected. It is possible that population growth creates good conditions for agriculture intensification, leading to the abandonment of marginal agriculture lands and reforestation in less suitable plots (Meyfroidt & Lambin, 2008a).

There is competition between agriculture activities and forests for land. More agricultural output is associated with less land for reforestation. At the same time, agricultural output has a positive correlation with deforestation, suggesting that farming activities can accelerate the deforestation process. The effect of average income becomes significant after the year dummy variable is used to control for endogeneity. Higher income is associated with more deforestation and less reforestation. Following the environmental Kuznets and forest transition curves, it may be argued that the Vietnamese borderland is still in the first period of forest transition, where higher income accelerates the rate of deforestation.

4.3 Discussion

4.3.1 Leakage and the role of trade at the borderland

Figure 4.5 shows a systematic difference in log deforestation and reforestation of regions bordering with Laos and Cambodia from regions that do not share borders with these. After the reforms in 1986, local economies have changed. No longer controlled by a central planning state, provinces compete with each other in order to attract foreign investment in their regions and to stimulate local economic growth. Since 1992, the Free Trade Area in ASEAN countries (AFTA) has brought about many good conditions for trade. Tax duties are set at zero, and trade procedures and import-export licenses are unbundled among member countries. As a consequence, Vietnamese border provinces have established new border checkpoints and open border-gate economic zones in order to support trading activities with neighbouring countries.

The allocation of border checkpoints is highly dependent on the geographic characteristics of the borderland. Transport routes usually avoid perilous areas. For this reason, most border checkpoints are located on accessible roads. In order to promote local trade and local economies, border provincial authorities make plans with their foreign neighbour provinces to develop the regional economy. The authorities of two neighbouring provinces take into account the density of available border checkpoints, volume of passengers, traffic, amount of commodities, border length, border population etc., before they decide to open new economic zones and border checkpoints.[24] These border checkpoints are often established near available army checkpoints of the Vietnamese People's Army. Before an official approval for a new border checkpoint is granted, the army checkpoint acts as a passing point for border residents. Sometimes, local residents of two neighbouring provinces can bring small amounts of goods to the other side of the border. They can even make small transactions with each other at these army checkpoints.[25] When the army checkpoint is upgraded to the status of sub-border and then national border checkpoint, trade in larger amounts gradually develops. When it comes to timber trade, border residents and logging companies make connections with suppliers at the other side of the border to import and transport cheaper logs to Vietnam (Waggener, 2001).

The econometric estimation of reforestation supports hypothesis one, which states that "the more border checkpoints a province has with Laos and Cambodia, the less reforestation it experiences". In particular, border checkpoint density has discouraged the reforestation process in the Vietnamese borderland. Even though the effect of border checkpoint density is not significant in the deforestation models, it shows the expected negative signs. There is evidence of leakage in the region.

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[24] According to Circular no. 04/2012/TT-BNG of Ministry of Foreign Affairs regarding "Procedure guidance to open and upgrade new and official border checkpoints, border roads in land between Vietnam and China", issued on 6 September, 2012.

[25] Personal communication with Mr. Pháp, former head of Tay Giang checkpoint, Quang Nam province, dated 8 April 2013.

Leakage from Vietnam to Laos and Cambodia most likely falls into the *primary leakage*. At first, leakage takes the form of *activity shifting* when Vietnamese companies operate abroad. Considering Vietnamese logging companies as targeted agents for emission reduction projects, their activities would be affected by policies of forest protection in Vietnam. These companies will expand their operations to foreign territory, as they have done in Laos and Cambodia (Forest Trend, 2010; IEA, 2011). Most Vietnamese companies in these two countries employ both energy and plantation projects. They carry out mining, build dams, and plant rubber and coffee in order to obtain logging quota in allocated land, which usually consists of dense forests. Some of these companies are active in logging and wood processing in Vietnam. They can open processing factories in Laos and Cambodia. According to Forest Trend's investigation, these logging or wood processing companies do not employ local people, due to language barriers and working customs. Local people in Laos, especially ethnic minorities, do not usually have many job opportunities, and continue to depend on forests for their living. As a result, both Vietnamese companies and local Laotians put pressure on Laos' forests. Later leakage may take the form of *outsourcing* when timber traders and wood processing companies transport the quota wood into Vietnamese territories. The traded wood is then processed by Vietnamese companies in border provinces such as Gia Lai, Kon Tum, Dak Lak.

There are two possible explanations for the insignificant partial effect of border checkpoint density on deforestation:

(1) Deforestation data in my thesis are generated from the official data on natural forest area loss, which are produced by the national statistics system and may not be fully accurate. Official deforestation data may not reflect the actual experiences of people living near the forests. Therefore, deforestation models built from this dataset may not completely capture well the deforestation process and local activities in the Vietnamese borderland. In fact, according to Lang (2001), forest communities and indigenous people are often excluded from the official use of forests, and therefore their activities are not well recorded by national data. More specific and better data collection of deforestation on local levels in future studies may improve the tests of hypotheses and advance this study with regard to the border checkpoint density variable.

(2) The trade of logs from Laos and Cambodia to Vietnam and the development of the Vietnamese wood processing industry do not have a strong regional impact on the deforestation rate in the borderland. The local population whose lives depend on forests,

do not participate in the trade and the production. Wood is, in fact, imported from these two countries, but then transported further inland, supporting the economic development of the coastal area. And the timber trade is often controlled by large companies, who are able to influence Cambodian, Laos' and Vietnamese political systems.

Therefore, I still have good reasons to believe that trading activities in the borderland of Vietnam, Laos, and Cambodia have some impact on the forest cover change in this area. In particular, the opening of more and more border checkpoints in the Vietnamese border provinces give less incentives to tree plantation than to timber trade across border. Because actors in power manage a great part of the timber trade from which local people get no benefit, the local people continue to depend on forests for living and natural forests may be even cleared more in the borderland. When these places applied plantation forest programs in special use, protection, and production forests, leakage travelled further and crossed Vietnam's boundary. In some aspects, the Indochina border region shows similar characteristics as the borderland between Thailand, Laos, and Myanmar. These characteristics include, but are not limited to, exploiting the natural resources of, and exporting deforestation to each other's frontier areas (Pangsapa & Smith, 2008). In addition, dam construction and the army's sensitive role in exploiting natural resources requires cautious analyses, which will be further discussed in 4.3.4.

4.3.2 Logging and wood production

The negative and significant correlation between deforestation and wood production at the border region is unexpected. Higher wood production is often associated with a higher rate of deforestation; but in this case, it is the opposite. Therefore, the estimated result suggests two possibilities. Firstly, deforestation may have been exported to the neighbouring countries, causing leakage to happen on a transnational level. Secondly, a high timber demand may have encouraged tree planting and the protection of remaining forests. This possibility is in line with the forest scarcity path, as suggested by forest transition theory.

Vietnam had banned logging in natural and reservation forests, but changed this regulation in 2000. Once again, logging in natural forests was allowed, but with a limited quota. Logging companies now have to apply for logging quota in natural forests that are allowed to be cut down. This means that domestic logging is allowed in so-called production forests, which, confusingly, include both natural and planted forests. The problem is that there is no clear boundary between natural and production forests. In addition to the limitations of collecting data on forest cover and forest loss in Vietnam, the unclear distinctions between natural and production forests may lead to distorted data and statistical reports, and create space for wood that is unlicensed and of unclear origin, or even illegal. The Central Highlands in Vietnam have the highest rate of forest cover (54%), followed by the North Central (50.7%) and Northeast regions (47.9%) (FAO, 2009). Most of the country's borders lie within these regions. By contrast, provinces that are not in the borderland are comparatively deforested due to infrastructure construction and economic development. As a result, these regions have no or few standing forests. The possible inclusion of illegal imported wood into the official data of wood production could explain why more wood production does not lead to more, but to less deforestation in the borderland.

In a discussion of the logging ban in natural forests in Vietnam, Waggener (2001) has pointed out that non-licensed logging still happens in these forests, in addition to harvest from plantation areas. Due to a shortage of materials for the wood processing industry, about 300,000 m^3 of imported wood was planned to come to Vietnam every year from Malaysia, Laos, Cambodia, Myanmar, and Russia. However, Waggener also acknowledges the local role of building direct contact with foreign timber suppliers. Even though the Government decides on the flow of imports, some provinces close to Laos and Cambodia have used their own contacts to import more timber. This implies that local authorities, logging and trading companies in these provinces can operate outside the central governments' control (Barney, 2005). These actors may find ways to import more logs from Laos and Cambodia than the amount allocated by the state. At border checkpoints, these actors may even spoil the border custom's trade record system in order to document less imported wood. And inside the country, the undocumented surplus of imported timber may be inserted into the official data of national wood production or even used to fulfill ambitious targets of reforestation programs.

Regarding replantation program by the SFEs in Vietnam, the research by McElwee (2011) has revealed that these companies only put efforts in the seedling period of plantation. The state subsidy under the Five Million Hectare Programme did not provide these SFEs incentives to take care of their planting forests' future. The company's responsibility ended at the moment state representatives came to count the number of seeded plants. The state did not have the capacity to control and monitor these

SFEs' operations. Fire and slash-and-burn cultivation practices are often used as a scapegoat to disguise the bad management of these companies (ibid.). Statistical analysis in this study shows that the effect of wood production in Vietnam on reforestation is more significant in a large area, which includes other areas that do not border with Laos and Cambodia. This supports the explanation that the wood imported from Laos and Cambodia is transported further and has impact on land use change and economic development of other areas than the border provinces. The test also calls into question the reforestation policy in Vietnam, in which more trees may have been replanted in other areas than the borderland. Moreover, when the amount of produced wood becomes larger and larger, both deforestation and reforestation may reach turning points. After these turning points, more logging will be associated with more deforestation and less reforestation, implying the necessity of logging control policies. Without proper management from forestry authorities, demand-driven wood production may be sensitive to national deforestation. Production is driven by market forces, and an increasing domestic demand for wood material can lead to unsustainable forest management. In response, one of the common measures to deal with the situation is issuing logging bans.

The logging ban on natural and watershed forests has worked well in Vietnam. However, it leads to a shortage of raw materials for the booming wood industry. In order to get enough wood, Vietnam imports wood materials from other countries in addition to replanting trees at national scale. The country has a good reputation for increasing forest cover thanks to plantation and protection of conserved forest lands, but the imported amount of wood materials was not taken into account. This is because the (potentially unsustainable) logging is happening elsewhere, away from the mitigation project's location. In the case of Vietnam, wood extraction from plantation and natural forests has a positive impact on forest cover change, which means that logging and wood production from these forests do not lead to deforestation. On the contrary, the present level of logging and wood production is associated with more reforestation. If forest product scarcity is assumed to be at work in Vietnam, it might have encouraged plantation in the less favourable farming areas which are released due to agriculture intensification (Meyfroidt & Lambin, 2008a). However, as showed in the statistical analysis, if wood production exceeds the sustainable amount, or the domestic demand is too high, logging will have a negative impact on the reforestation process. In such case, if local and legal sources fail to meet this demand, illegal timber import will enter the market in order to fill the market gap.

4.3.3 Population

Population growth can accelerate deforestation for food production. However, Angelsen (2010) points out that this is not always the case, and the effect is ambiguous. Population increase can lead to both deforestation and reforestation, depending on each region's circumstances. Empirical tests of the effects of population in the models of Meyfroidt and Lambin (2008a) show that rural population density decreases forest cover growth in natural and planted forests. But contrary to their empirical test, they argue for a third forest transition path, where population growth compromises with reforestation. The economic development path of forest transition is partly at work in Vietnam because depopulation has never happened in the mountainous areas. Meyfroidt and Lambin suggest instead that population growth in the Vietnamese uplands intensifies agriculture activities, which leads to the abandonment of marginal lands for reforestation. In other words, the increase in population density in the mountainous areas in the 1990s due to migrants moving to the uplands has stimulated the third forest transition path, where population in less favourable areas does not decrease. Indeed, estimation result of this thesis shows a positive correlation between reforestation and population density. The partial effect of population on reforestation supports partly the third hypothesis, which states that high population density leads to more reforestation. But densely populated areas does not experience more deforestation and the test does not support the argument that high population density leads to rapid agriculture conversion for food or infrastructure development for economic growth. In sum, the Vietnamese border provinces with high population density experience less deforestation and more reforestation.

4.3.4 Institutions

In South East Asia, the Asian Free Trade Area has deregulated trade, and created a free trade zone among its members. More companies are encouraged to invest in the borderlands, where they can enjoy favourable tax conditions, cheap labour, and flexible regulations by native authorities (Pangsapa & Smith, 2008). In Vietnam, more investment means more industrial parks, and more advanced infrastructure systems (such as border-gate economic zones) that support investors' business and production. Expectations tend to be high when it comes to employment opportunities, which can lead to labour being taken away from farms, and the slowing down of forest land conversion to agriculture land. After a while, however, many of these expectations turn out to be unjustified, as most economic strategic development areas are underinvested and ill-equipped. Some economic zones, and even industrial parks, were abandoned shortly after being opened. Land seizing due to investment speculation, in addition to infrastructure development, accelerates deforestation and undermines reforestation processes by competing for land with forests. Therefore, institutions established for the purpose of economic development can lead to unsustainable land management.

When it comes to logging, forest management policies in Laos, Cambodia, and Vietnam are not very different from each other. Subject to national agendas of decentralization, institutions in these three countries cannot respond quickly to "rent seeking" behaviour of elite groups, local people, and other influential actors. In periphery areas, such as the Vietnamese borderland, institutions are weak and laws are hardly enforced. As a result, it is very difficult to control the activities of these rent-seeking actors. In their search for profit gained from selling timber resources, these actors employ various strategies to bypass laws and regulations.

However, in the rent seeking process, local people have little space to compete with other more powerful groups. Regulations that shape the trading environment in the Vietnamese borderland are influenced by powerful actors such as big traders, transporters, and investors (Walker, 1999). These powerful groups form alliances with the army's economic units and control both logging and trading networks at the borderland. Therefore, local populations hardly take part in the economic development brought about by resource exploitation and trade. As a result, they have to depend on forests for a living – the same forests that are also subject to the competing agendas of logging and conservation carried out by powerful actors. In all likelihood, the remote peripheries of Indochina will still be subject to further deforestation in the future, which is brought about by cross-border cooperation in economic development.

4.3.5 Other factors

As expected from the environmental Kuznets curve, the relationship between income per capita and deforestation is not straightforward. Some countries may experience a turning point at the peak of deforestation, when national income reaches a sufficiently high level. Beyond this point, higher income will be associated with less deforestation. The turning point of the environmental Kuznets curve is compatible with forest transition theory, which assumes that reforestation will appear along with income growth. Therefore, a high-income society will experience forest transition (Angelsen & Rudel, 2013). In Vietnam, if the forest transition path is at work, high income will be associated with a slowing down of deforestation and an increase in reforestation. The result of quadratic income shows that the borderland of Vietnam is still in the stage two of forest transition (reinforcing slope) and will soon reach the turning point. In addition, Vietnam may need more time to reach the national baseline level for compensation by REDD+, which is identified between the baseline two and three (Angelsen et al., 2012). The bell shape of the income-reforestation coefficient has a turning point when income per capita reaches 5.248 million VND (≈ 250USD[26]) (see appendix IX). This amount is low. But Vietnam is a low middle income country, where in 2006 about 21.4% of the population were living on less than 1.25 USD a day.[27] Pressure on forests will be reduced mainly by reducing the dependence of rural areas on fuel wood for energy (Sunderlin & Ba, 2005).

Meyfroidt and Lambin (2008a) note that agriculture intensification due to population growth and policy reforms has encouraged cultivation activities in the most suitable plots, and the abandonment of marginal ones for reforestation. Agriculture output is therefore expected to have a negative correlation with reforestation and a positive one with deforestation. Some researchers (Sunderlin, 2006; To, 2008) have argued that conflicts between households in remote areas with little governmental control on reforestation and conservation are difficult to solve, especially in regions characterised by shifts in cultivation practices. However, Meyfroidt and Lambin (2008a) suggest that farming activities, in order to meet the food demand of a growing population, can create space for negotiation and relax these conflicts. Forest land conversion to agriculture land is expected to happen in the midlands of Vietnam, but this is not clearly supported by the empirical tests of this study.

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[26] The exchange rate is obtained from http://www.vietcombank.com.vn/en/exchange%20rate.asp on 01 August 2013. 1USD = 21,130VND.

[27] Source: The World Bank at http://data.worldbank.org/indicator/SI.POV.DDAY/countries/1W-VN?display=graph. "Poverty headcount ratio at $1.25 a day (PPP) (Population below $1.25 a day) is the percentage of the population living on less than $1.25 a day at 2005 international prices". This percentage is 16.9% in 2008 for Vietnam. Localised on 31 May 2013.

Finally, infrastructure construction, especially the building of roads, is one of the drivers of deforestation. However, this effect may be reserved in the future, when large areas have been cleared for constructing more roads and develop more infrastructure (Angelsen, 2010). When there are more roads, access to remote areas becomes easier. The infrastructure development in the midlands of Vietnam may support plantation plans and forestry intensification as suggested by Meyfroidt and Lambin (2008b). This explains the positive significant correlation of road density and reforestation in the last model (model VII – reforestation) and negative significant association between quadratic road density with deforestation (appendix VIII).

5. CONCLUSION

The borderland of Vietnam constitutes a region with special geographical characteristics, including dense forests, rich biodiversity, and difficult access. The quantitative analysis in this thesis shows that the opening of more and more border checkpoints by the Vietnamese border provinces' authorities has discouraged the reforestation process in the border region; the impact of border checkpoint density on reforestation is statistical significant. The Vietnamese provinces that have more border checkpoints with Laos and Cambodia have less reforested area. This association is also significant after controlling for other factors that differ systematically between the the borderland and other regions. Transnational leakage happens partly because of the ambitious Vietnamese forest conservation and reforestation programs. At the same time, the country's wood industry also has a high timber demand that cannot be met by the domestic supply.

However, this study finds little empirical evidence of the impact of border checkpoint density on deforestation in the region due to data limitation. Because the imported wood is transported to locations further inland, cross-border trade does not have such a strong effect on the deforestation rate as other factors, such as population, foreign investment, and infrastructure development. In the national statistics system, most deforestation data are classified. In order to improve the hypothesis testing, and to clarify the link between border checkpoint density and deforestation, data should be collected independently in the future.

Forests in the Vietnamese borderland are rich in natural resources, and may become targets for exploitation. In the region's remote areas, the weak state, ineffective security, and illegal trade are often identified as common problems. Local people tend to exploit their forests in unsustainable ways. Control networks of the state, such as rangers or army forces, are thinly allocated in these areas. Moreover, these networks usually lack people, and are isolated from the central authorities, which make it easier for them to ignore law violations. Illegal small-scale domestic logging still happens at the borderland, where cooperation between rangers and poachers is a well-known problem. Failure to enforce laws and regulations has turned rangers into poachers at times; accordingly, they fail to protect the standing forest. As a result, the forest quality tends to be low, and forest degradation continues to happen in the region, as well as biodiversity loss.

Forests are vital not only for the livelihood of people in the uplands, but also for those in the lowlands. Upland forest loss often accompanies big floods due to unsustainable forest management, which have destroyed parts of the lowlands several times during the past few years. The national government has now realized the importance of these upland forests, and turned them into conservation areas. As intensive logging is now illegal within the Vietnamese territory, logging companies and poachers are looking for other ways to obtain their resources, often turning to their neighbours' rich forests. Projects focused on forest conservation, avoiding deforestation, and forest plantation carried out by the Vietnamese government and relevant organizations have thus induced cross-border leakage, which affects the forests of Laos and Cambodia. This happens because of activity shifts in logging and timber production, as well as increased log trade across the border. The leakage facilitates plantation programs in Vietnam, while forests in Laos and Cambodia have been a source of supply for the booming furniture industry in Vietnam. Imported wood from Laos and Cambodia, however, is transported further than the borderland, and has impact on the land use change of other areas. This impact of imported wood on other areas' economic development needs to be addressed in a future study.

Paradoxically, efforts to protect the environment in one area may lead to the exposure of other unprotected areas. REDD+ programs in Vietnam should address seriously the leakage problem in the country's forestry sector. Vietnam gets credits for forest conservation and reforestation, yet at the same time it exports deforestation to neighbouring countries in order to develop the domestic wood processing industry. In order to gain better knowledge of the current situation, more accurate data are needed to correctly calculate the leakage amount from Vietnam to its neighbouring countries. In other words, efforts to reforest in Vietnam have led to transnational leakage in the region. Forest loss is reduced in one country but moved elsewhere, not contributing to a solution to the global deforestation problem. Thus, the transnational aspects of environmental problems should be recognized. As environmental issues do not usually respect national borders, solutions should also be carried out internationally.

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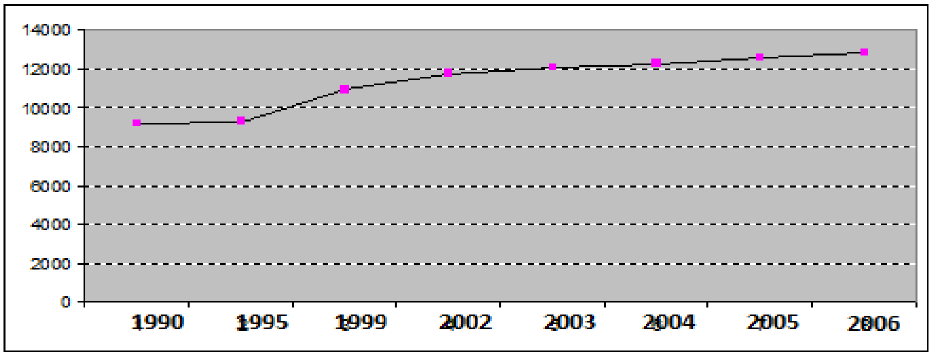
APPENDICES

Appendix I - Forest cover change in Vietnam reported by FAO.



Year	1990	1995	1999	2002	2003	2004	2005	2006
Forest cover (Unit: 1000ha)	9175	9305	10916	11785	12095	12306	12616	12874

Figure A.1 - Forest cover change in Vietnam (1990 – 2006).

Source: FAO 2009, FAO 2010c

Appendix II - Vietnam's wood export turnover by top five markets.

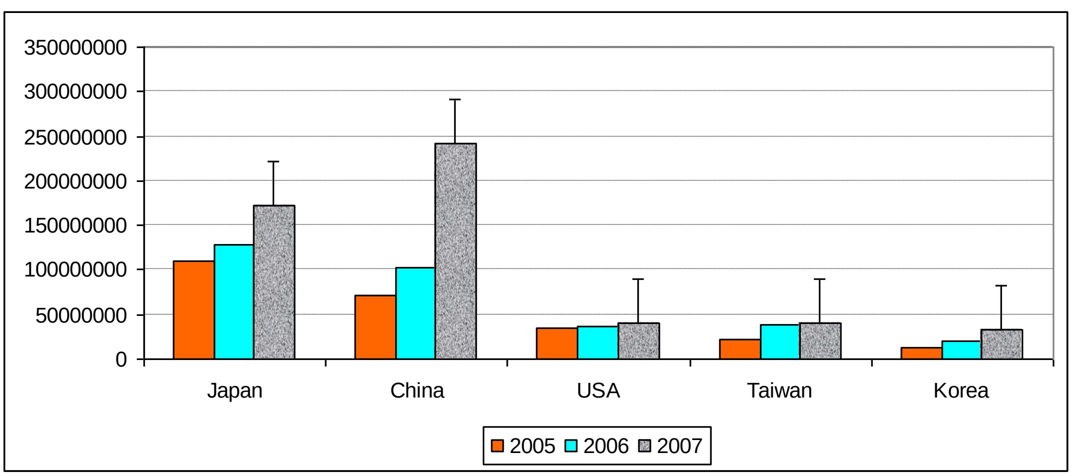


Figure A.2 - Vietnam's wood export turnover by top five markets. (Unit: USD).

Source: Information Centre for Agriculture and Rural Development (http://agro.gov.vn)

Appendix III - Illegal wood imported to Vietnam from Laos and Cambodia.

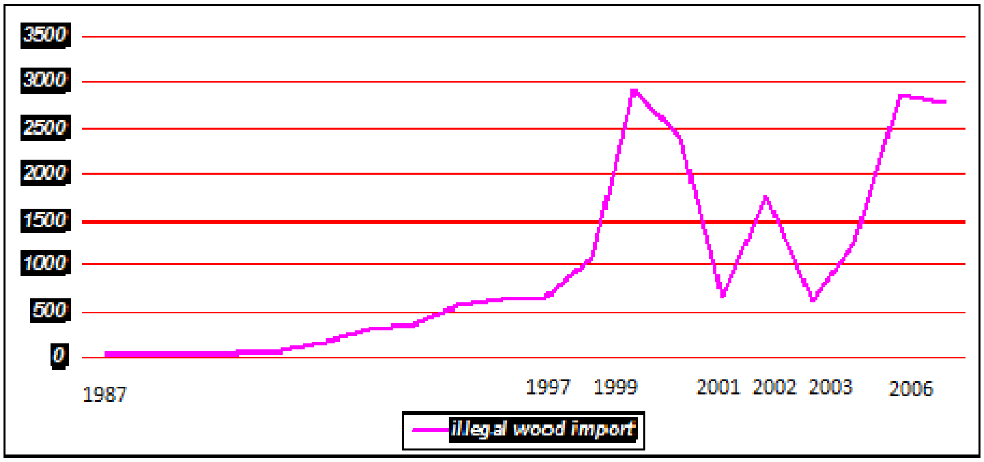


Figure A.3 - Consolidated illegal wood import from Laos and Cambodia to Vietnam in the period 1987-2007 (Unit: thousand m^3).

Source: Meyfroidt & Lambin (2009) - Supporting Information

Appendix IV - Model specification.

Model I: *Reforestation/deforestation = f(transparency, wood production, population density, industrial parks, road density, income, agriculture output)*

Model II: *Reforestation/deforestation = f(transparency, wood production, population density, industrial parks, road density, border-gate economic zone, income, agriculture output) if border dummy==1*

Model III: *Reforestation/deforestation = f(border checkpoint density) if border dummy==1*

Model IV: *Reforestation/deforestation = f(border checkpoint density + other factors) if border dummy==1*

Model V: *Model IV is controlled for multicollinearity; agriculture output is left out*

Model VI: *Model V but a quadratic term of wood production is added*

Model VII: *Model VI is controlled for multicollinearity and endogeneity; agriculture is left out and income is treated by a year dummy variable*

Appendix V - Bivariate mean comparisons between the borderland and other regions.

1) Deforestation

```
. ttest deforestation, by (borderpoint)

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
       0 |     288    .0016616    .0003405    .0057787    .0009914    .0023318
       1 |     132    .0036149    .0014015    .0161024    .0008423    .0063874
---------+--------------------------------------------------------------------
combined |     420    .0022755    .0004994    .0102354    .0012938    .0032572
---------+--------------------------------------------------------------------
    diff |           -.0019532    .0010729               -.0040622    .0001557
------------------------------------------------------------------------------
    diff = mean(0) - mean(1)                                      t =  -1.8206
Ho: diff = 0                                     degrees of freedom =      418

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0347         Pr(|T| > |t|) = 0.0694          Pr(T > t) = 0.9653
```

Notes: The t-test compares mean of deforestation rate between the borderland and other regions. The test shows that other regions have a lower rate of deforestation than the borderland does; this is statistically significant. (the borderland = 1)

2) Reforestation

```
. ttest reforestation, by (borderpoint)

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
       0 |     288    .0216818    .0030891    .0524238    .0156016     .027762
       1 |     132    .0177623    .0032005    .0367705     .011431    .0240936
---------+--------------------------------------------------------------------
combined |     420      .02045    .0023444    .0480468    .0158416    .0250583
---------+--------------------------------------------------------------------
    diff |            .0039195    .0050526               -.0060121    .0138511
------------------------------------------------------------------------------
    diff = mean(0) - mean(1)                                      t =   0.7757
Ho: diff = 0                                     degrees of freedom =      418

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.7808         Pr(|T| > |t|) = 0.4383          Pr(T > t) = 0.2192
```

Notes: The t-test compares mean of reforestation rate between the borderland and other regions. The test shows that other regions have a higher rate of reforestation than the borderland does; even though this is not statistically significant. (the borderland = 1)

Appendix VI_a - Deforestation - Estimation results for Tobit – Robust standard error.

Deforestation Tobit - Robust SE	Model I	Model II	Model III	Model IV	Model V	Model VI	Model VII
Checkpoint density			-0.121	-0.031	-0.014	-0.022	-0.018
			(0.08)	(0.06)	(0.05)	(0.06)	(0.05)
Transparency	-0.003	0.004**		0.004**	0.004*	0.004**	0.004*
	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)	(0.00)
Log of wood production	0.000	-0.005*		-0.005	-0.005	-0.023**	-0.025***
	(0.00)	(0.00)		(0.00)	(0.00)	(0.01)	(0.01)
Quadratic wood production						0.003*	0.003*
						(0.00)	(0.00)
Log of population density	-0.003*	-0.008**		-0.008**	-0.007*	-0.006	-0.006
	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)	(0.00)
Log of industrial parks	-0.001	-0.002		-0.002	-0.002	-0.002	-0.002
	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)	(0.00)
Log of road density	-0.001	0.001		0.001	0.001	0.001	0.001
	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)	(0.00)
Border-gate economic zone		0.006		0.006	0.006	0.007	0.008
		(0.00)		(0.00)	(0.00)	(0.00)	(0.01)
Log of income	0.007**	0.001		0.001	0.002	0.002	
	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)	
Log of predicted income							0.010
							(0.01)
Log of agriculture output	-0.002	0.001		0.002			
	(0.00)	(0.00)		(0.00)			
Constant	-0.060*	-0.086**	-0.011**	-0.089**	-0.079*	-0.041	-0.114
	(0.03)	(0.04)	(0.00)	(0.04)	(0.04)	(0.05)	(0.09)
lnsigma	-4.055****	-4.539****	-3.634****	-4.537****	-4.535****	-4.540****	-4.538****
Constant	(0.26)	(0.23)	(0.35)	(0.23)	(0.23)	(0.24)	(0.24)
Number of observations	333	83	175	83	83	83	83
Wald chi2	10.080	9.700	2.260	10.250	7.440	13.610	14.400
Prob > chi2	0.148	0.286	0.132	0.330	0.490	0.137	0.109
Uncensored observations	154	39	62	39	50	50	50
Left-censored observations	179	44	113	44	33	33	33
Right-censored observations	0	0	0	0	0	0	0
Log pseudolikelihood	312.624	99.689	84.548	99.838	99.578	100.737	101.003
Turning point						46.216	64.5

Note: ****, ***, **, * indicate significance levels at 0.1%, 1%, 5%, 10% respectively

Appendix VI_b - Reforestation - Estimation results for Tobit – Robust standard error.

Reforestation Tobit - Robust SE	Model I	Model II	Model III	Model IV	Model V	Model VI	Model VII
Checkpoint density			-0.429***	-0.202**	-0.284***	-0.269***	-0.292****
			(0.13)	(0.08)	(0.10)	(0.09)	(0.08)
Transparency	-0.001	-0.009**		-0.010**	-0.009**	-0.010**	-0.008***
	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)	(0.00)
Log of wood production	0.003****	0.001		0.004	0.003	0.072***	0.070****
	(0.00)	(0.00)		(0.00)	(0.00)	(0.02)	(0.02)
Quadratic wood production						-0.009***	-0.009***
						(0.00)	(0.00)
Log of population density	0.000	0.014**		0.015**	0.009**	0.007	0.007*
	(0.00)	(0.01)		(0.01)	(0.00)	(0.00)	(0.00)
Log of industrial parks	-0.003***	-0.008**		-0.006*	-0.005	-0.005*	-0.005*
	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)	(0.00)
Log of road density	0.000	0.003*		0.002	0.001	0.003*	0.003**
	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)	(0.00)
Border-gate economic zone		-0.013		-0.013	-0.012	-0.016*	-0.013*
		(0.01)		(0.01)	(0.01)	(0.01)	(0.01)
Log of income	0.000	0.002		0.003	-0.003	-0.001	
	(0.00)	(0.01)		(0.01)	(0.00)	(0.00)	
Log of predicted income							-0.044**
							(0.02)
Log of agriculture output	-0.006****	-0.015***		-0.011**			
	(0.00)	(0.01)		(0.01)			
Constant	0.042	0.251***	0.024****	0.215***	0.151**	0.003	0.377**
	(0.03)	(0.08)	(0.01)	(0.07)	(0.06)	(0.06)	(0.19)
lnsigma	-4.227****	-4.171****	-2.975****	-4.201****	-4.157****	-4.197****	-4.288****
Constant	(0.14)	(0.18)	(0.15)	(0.18)	(0.20)	(0.20)	(0.16)
Number of observations	333	83	175	83	83	83	83
Wald chi2	60.650	16.220	10.760	16.900	16.030	19.110	22.460
Prob > chi2	0.000	0.039	0.001	0.050	0.042	0.024	0.008
Uncensored observations	211	50	129	50	50	50	50
Left-censored observations	122	33	46	33	33	33	33
Right-censored observations	0	0	0	0	0	0	0
Log pseudolikelihood	512.643	122.117	168.184	125.392	121.745	126.224	131.197
Turning point						54.598	48.857

Note: ****, ***, **, * indicate significance levels at 0.1%, 1%, 5%, 10% respectively

Appendix VII_a - Deforestation - Estimation results for Tobit – Random Effect.

Deforestation RE Tobit estimation	Model I	Model II	Model III	Model IV	Model V	Model VI	Model VII
Checkpoint density			-0.133	-0.028	-0.017	-0.022	-0.018
			(0.13)	(0.06)	(0.06)	(0.05)	(0.05)
Transparency	-0.002	0.004**		0.004**	0.004**	0.004**	0.004**
	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)	(0.00)
Log of wood production	0.000	-0.005**		-0.004	-0.004	-0.023*	-0.025**
	(0.00)	(0.00)		(0.00)	(0.00)	(0.01)	(0.01)
Quadratic wood production						0.003	0.003
						(0.00)	(0.00)
Log of population density	-0.004*	-0.008**		-0.008**	-0.007**	-0.006*	-0.006**
	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)	(0.00)
Log of industrial parks	-0.001	-0.002		-0.002	-0.002	-0.002	-0.002
	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)	(0.00)
Log of road density	0.000	0.001		0.001	0.001	0.001	0.001
	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)	(0.00)
Border-gate economic zone		0.006		0.007	0.007	0.007	0.008
		(0.01)		(0.01)	(0.01)	(0.01)	(0.01)
Log of income	0.004	0.001		0.001	0.002	0.002	
	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)	
Log of predicted income							0.010
							(0.01)
Log of agriculture output	-0.002	0.001		0.001			
	(0.00)	(0.00)		(0.00)			
Constant	-0.039	-0.086**	-0.012**	-0.090*	-0.081*	-0.041	-0.114
	(0.04)	(0.04)	(0.01)	(0.05)	(0.04)	(0.05)	(0.11)
Sigma_u	0.009****	0	0.016****	0.003	0.004*	0.000**	0.000**
Constant	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)
Sigma_e	0.015****	0.011****	0.023****	0.010****	0.010****	0.011****	0.011****
Constant	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)
Number of observations	333.000	83.000	175.000	83.000	83.000	83.000	83.000
Wald chi2	12.3	17.19	0.99	14.21	13.83	18.58	18.76
Prob > chi2	0.091	0.028	0.32	0.115	0.086	0.029	0.027
Rho	0.268	9.14E-11	0.326	0.104	0.118	2E-10	4.85E-14
Uncensored observations	154	39	62	39	39	39	39
Left-censored observations	179	44	113	44	44	44	44
Right-censored observations	0	0	0	0	0	0	0
Log likelihood	323.945	101.77	93.322	100.271	100.172	104.124	101.003
Turning point						**46.216**	**64.5**

Note: ****, ***, **, * indicate significance levels at 0.1%, 1%, 5%, 10% respectively

Appendix VII_b - Reforestation - Estimation results for Tobit – Random Effect.

Reforestation RE Tobit estimation	Model I	Model II	Model III	Model IV	Model V	Model VI	Model VII
Checkpoint density			-0.419***	-0.202**	-0.283***	-0.269***	-0.289****
			(0.16)	(0.08)	(0.09)	(0.08)	(0.08)
Transparency	-0.001	-0.009****		-0.010****	-0.009****	-0.010****	-0.008****
	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)	(0.00)
Log of wood production	0.003***	0		0.004	0.003	0.072***	0.069***
	(0.00)	(0.00)		(0.00)	(0.00)	(0.03)	(0.02)
Quadratic wood production						-0.009***	-0.009***
						(0.00)	(0.00)
Log of population density	0.000	0.014***		0.015***	0.009**	0.007*	0.007*
	(0.00)	(0.01)		(0.00)	(0.00)	(0.00)	(0.00)
Log of industrial parks	-0.003**	-0.009**		-0.006*	-0.005	-0.005	-0.005
	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)	(0.00)
Log of road density	0.000	0.003		0.002	0.001	0.003	0.003**
	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)	(0.00)
Border-gate economic zone		-0.013		-0.013	-0.012	-0.016*	-0.013
		(0.01)		(0.01)	(0.01)	(0.01)	(0.01)
Log of income	0.001	0.002		0.003	-0.002	-0.001	
	(0.00)	(0.01)		(0.01)	(0.01)	(0.01)	
Log of predicted income							-0.044****
							(0.01)
Log of agriculture output	-0.006****	-0.015****		-0.011***			
	(0.00)	(0.00)		(0.00)			
Constant	0.034	0.250****	0.024****	0.215****	0.146**	0.003	0.379***
	(0.03)	(0.07)	(0.01)	(0.06)	(0.06)	(0.08)	(0.13)
Sigma_u	0.006****	0.002	0.01	0	0.002	0	0.002
Constant	(0.00)	(0.01)	(0.01)	(0.00)	(0.01)	(0.001	(0.00)
Sigma_e	0.014****	0.015****	0.050****	0.015****	0.016****	0.015****	0.014****
Constant	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Number of observations	333.000	83.000	175.000	83.000	83.000	83.000	83.000
Wald chi2	38.13	32.71	7.28	38.74	30.58	37	49.04
Prob > chi2	0	0	0.007	0	0	0	0
Rho	0.171	0.022	0.037	1.86E-32	0.022	1.98E-12	0.024
Uncensored observations	211	50	129	50	50	50	50
Left-censored observations	122	33	46	33	33	33	33
Right-censored observations	0	0	0	0	0	0	0
Log likelihood	518.948	122.141	168.465	125.392	121.767	126.224	131.236
Turning point						**48.857**	**46.216**

Note: ****, ***, **, * indicate significance levels at 0.1%, 1%, 5%, 10% respectively

Appendix VIII - Quadratic models for deforestation.

Deforestation Pooled Tobit estimation	Model V	Checkpoint density	Population density	Road density	Income
Checkpoint density	-0.014	0.372	0.010	-0.024	-0.018
	(0.05)	(0.23)	(0.05)	(0.05)	(0.05)
Quadratic checkpoint density		-2.612*			
		(1.55)			
Transparency	0.004**	0.004**	0.004**	0.003	0.004*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Log of wood production	-0.005*	-0.006**	-0.005*	-0.004	-0.005*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Log of population density	-0.007**	-0.006*	-0.076**	-0.010***	-0.005*
	(0.00)	(0.00)	(0.04)	(0.00)	(0.00)
Quadratic population density			-0.005*		
			(0.00)		
Log of industrial parks	-0.002	-0.002	-0.003	-0.002	-0.001
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Log of road density	0.001		0.001	0.014***	
	(0.00)		(0.00)	(0.00)	
Quadratic road density				-0.002***	
				(0.00)	
Border-gate economic zone	0.007	0	0.006	0.004	0.006
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Log of income	0.002	-0.001	0.003	0.000	0.015
	(0.00)	(0.00)	(0.00)	(0.00)	(0.06)
Quadratic income					-0.001
					(0.00)
Constant	-0.079*	-0.035	-0.304**	-0.087**	-0.11
	(0.04)	(0.04)	(0.13)	(0.04)	(0.27)
Sigma	0.011****	0.011****	0.011****	0.010****	0.012****
Constant	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Number of observations	83	98	83	83	98
Prob > chi2	0.022	0.023	0.009	0.001	0.064
Turning point		**0.142**		**33.115**	**1808.042**

Note: ****, ***, **, * indicate significance levels at 0.1%, 1%, 5%, 10% respe
Models with quadratic border checkpoint density and quadratic income are estimated without road density variable

Appendix IX - Quadratic models for reforestation.

Reforestation Pooled Tobit estimation	Model V	Checkpoint density	Population density	Road density	Income
Checkpoint density	-0.284***	-1.517**	-0.256***	-0.283***	-0.640****
	(0.08)	(0.75)	(0.08)	(0.08)	(0.17)
Quadratic checkpoint density		5.712			
		(4.70)			
Transparency	-0.009****	-0.008	-0.009****	-0.010****	-0.011*
	(0.00)	(0.01)	(0.00)	(0.00)	(0.01)
Log of wood production	0.003	0.025**	0.002	0.003	0.017*
	(0.00)	(0.01)	(0.00)	(0.00)	(0.01)
Log of population density	0.009**	0.020**	-0.063	0.008*	0.017**
	(0.00)	(0.01)	(0.04)	(0.00)	(0.01)
Quadratic population density			-0.006*		
			(0.00)		
Log of industrial parks	-0.005	0.001	-0.005	-0.005	-0.006
	(0.00)	(0.01)	(0.00)	(0.00)	(0.01)
Log of road density	0.001		0.001	0.006	
	(0.00)		(0.00)	(0.01)	
Quadratic road density				-0.001	
				(0.00)	
Border-gate economic zone	-0.012	0.003	-0.014	-0.013	-0.018
	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)
Log of income	-0.003	0.007	-0.002	0.007	-0.651****
	(0.01)	(0.01)	(0.01)	(0.01)	(0.18)
Quadratic income	sqln_income				0.038****
					(0.01)
Constant	0.151**	0.056	-0.082	0.146**	2.944****
	(0.06)	(0.12)	(0.14)	(0.06)	(0.81)
Sigma	0.016****	0.042****	0.015****	0.015****	0.040****
Constant	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Number of observations	83	98	83	83	98
Prob > chi2	0.000	0.007	0.000	0.000	0.000
Turning point		**0.133**		**20.085**	**5248.982**

Note: ****, ***, **, * indicate significance levels at 0.1%, 1%, 5%, 10% respe
Models with quadratic border checkpoint density and quadratic income are estimated without road density variable