



RESEARCH REPORT

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Trade Liberalization, Pollution and Poverty: Evidence from Lao PDR

Dr. Phouphet Kyophilavong

Faculty of Economics and Business Management, National University of Laos,
P.O. BOX 7322, Vientiane, Lao PDR.

Tel: +(856) 21-770067 Mobile: +(856) 20-55527321

E-mail: Phouphet20007@hotmail.com

As is the case in many developing countries, the Lao People's Democratic Republic (Laos), is adopting a policy of trade liberalization in an attempt to grow its economy. However, the impact of this approach is not clear, as there have been few studies on trade liberalization in countries such as Laos, which have a predominantly poor, rural population. To give policy makers the information they need, a new EEPSEA study has looked at the impact of Laos' trade liberalization policies on its economy, the livelihood of its people and its environment. The study is the work of Dr. Phouphet Kyophilavong from the National University of Laos. The results show that trade liberalization in Laos will have a positive effect on growth, but that this effect will be relatively small. From an environmental point of view, it shows that trade liberalization will decrease CO₂ emissions but will also increase the rate of resource depletion in some sectors. In terms of socio-economic impact, it shows that households in Vientiane, the capital of Lao PDR, and non-poor households in other urban areas will benefit from trade liberalization, but that many poor and rural households will suffer a drop in income. In light of these findings, the study recommends that the Laos government should find a way to protect those who will lose out. It also suggests that the government should strengthen rules and regulations to protect the environment.

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Phouphet Kyophilavong

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Comments should be sent to: Dr. Phouphet Kyophilavong, Faculty of Economics and Business Management, National University of Laos, P.O. BOX 7322, Vientiane, Lao PDR.

Tel: +(856) 21-770067

Mobile: +(856) 20-55527321

E-mail: Phouphet20007@hotmail.com

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The conclusions and recommendations in this report are mine alone and do not necessarily reflect the views of EEPSEA. I am also responsible for any errors in this report.

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TRADE LIBERALIZATION, POLLUTION AND POVERTY: EVIDENCE FROM LAO PDR

Phouphet Kyophilavong

EXECUTIVE SUMMARY

Various empirical studies have confirmed that trade liberalization stimulates economic growth. In order to strengthen economic development and emerge from Least Developed Country (LDC) status by the year 2020, the Government of Lao (GoL) PDR is eager to capitalize on trade liberalization agreements such as the ASEAN Free Trade Area (AFTA) and future membership of trade organizations such as the World Trade Organization (WTO). However, the exact impact of trade liberalization is debatable, especially in LDCs such as Lao PDR, which face various economic and social constraints. Due to a lack of research on this issue, the impact of trade liberalization on pollution and poverty is unclear from a quantitative perspective. The main objective of this study is to use a Computable General Equilibrium (CGE) model to analyze the impact of trade liberalization on pollution and poverty. In particular, this study uses two approaches: a Global CGE model – GTAP model – to assess the impact of trade liberalization on CO₂ emissions, and a micro-simulation to assess the impact of trade liberalization on poverty. The results from the GTAP model show that trade liberalization has a positive effect on growth, but this effect is relatively small. Surprisingly, trade liberalization decreases CO₂ emissions but the change is small due mainly to declining output in some sectors as a result of trade liberalization. However, trade liberalization increases the rate of resource depletion in some sectors because the demand for products increases. The micro-simulation using a household survey indicates that the change in household welfare due to tariff reduction is heterogeneous. The winners from the tariff cut are urban households, households in Vientiane, the capital of Lao PDR, and non-poor households in urban areas. The losers from this policy change are households that do not belong to the above categories; these households suffer a drop in income and their poverty rate increases.

1.0 INTRODUCTION

1.1 Statement of Problem

According to empirical studies, trade is important to stimulate economic growth and structural change, which can lead to higher incomes and reallocation of production and consumption (Winter, 2004; Dollar, 1992; Frankel and Rose, 1999). However, there are still some questions as to whether or not trade liberalization¹ is good for poor households and for pollution abatement. Currently, the Lao People's Democratic Republic (hereafter Laos) is a Least Developed Country (LDC) in economic transition and there is a large development gap between Laos and other

¹ The definition of trade liberalization is explained in Santos-Paulino (2005) as the removal of or reduction in trade practices that thwart the free flow of goods and services from one nation to another. This includes dismantling of tariffs (such as duties, surcharges and export subsidies) as well as non-tariff barriers (such as licensing regulations, quotas and arbitrary standards).

countries. The Government of Laos' (GoL) national development goal is to graduate from LDC status by the year 2020, while balancing economic, social and environmental issues (GoL, 2004; 2006). To this end, the Government is liberalizing trade in order to increase economic growth and reduce poverty. Laos joined the ASEAN Free Trade Area (AFTA) in 1998 and will join the World Trade Organization (WTO) in the next few years.

According to free trade agreements, Laos must reduce its tariffs. By doing so, the Government expects to gain key benefits such as an increase in exports, and increased foreign direct investment (FDI). With reduced tariffs, the price of imported goods will be reduced and therefore imports will increase.

Trade liberalization will increase the trade deficit for two reasons. First, Laos does not produce a diverse range of goods. Besides minerals and electricity, Laos exports a few other commodities such as clothes, coffee and a few crops (Pholsena et al., 2007). Second, some of Laos' exported goods are not competitive in the world market but are propped up by preferential treatment. For instance, Lao labor productivity in the garment sector is lower than in neighboring countries (Kyophilavong, 2008); garments are exported mainly to the EU and the US, which use the Generalized System of Preferences (GSP). Additionally, some of Laos' agricultural products are given unilateral preferential treatment by the original ASEAN members (Pholsena et al., 2007).

Laos has achieved economic growth in the past decade and poverty fell from 45% to 39% between 1992-93 and 1997-98. However, poverty is still high and inequality has increased (NSC, 2003). A number of interrelated factors determine whether trade liberalization has positive or negative consequences on poverty. One aspect of this involves the effect of trade liberalization on household income, and takes place in the factor market. A second dimension affects household expenditure patterns, which take place in the commodity market. The specific effects of trade liberalization vary from country to country, and so the exact impact of trade liberalization on poverty and income distribution in the context of Laos is not clear.

Trade liberalization can also have either a positive or negative impact on the environment. As in other LDCs, environmental regulation is weak in Laos (ADB, GEF and UNEP, 2006) so trade liberalization may increase pollution and natural resource degradation, leading to increased poverty and inequality. Trade liberalization can affect the environment through increased or decreased emissions of harmful substances into the air, water or land, including the disposal of solid waste. According to Copeland and Taylor (2003) and OECD (1994) the environmental effects of trade liberalization can be sorted into the five following categories: scale effects, structural effects, technology effects, direct effects and regulation effects (Table 1). Rafaelita et al. (2002) showed that trade liberalization had a positive impact on pollution in the Philippines. However, it is still not clear whether trade liberalization has a negative or positive impact on pollution in general². Given the fact that research on these issues

² IISD, SIDA and IUCN (2007) used a rapid assessment method to study the impact of trade liberalization on eight sectors pertaining to the environment, including hydropower, mining, construction materials, wood and wood products, garments, tourism, organic agricultural products, and silk handicrafts. The study focused on the impact of trade and investment on the environment through trade investment drivers, environmental impacts, and mitigating factors. The study concluded that the electricity, mining, and wood products sectors, which are all exports, share an increased burden on the natural resource base in Laos. Whether or not these sectors can be sustainable will depend on the development and implementation of an effective institutional and regulatory structure in Laos. On the

is so limited, the impact of trade liberalization on pollution and poverty is still not clear. Therefore, it is vital to analyze this issue in order to form appropriate policies to gain the maximum benefits from trade liberalization.

Table 1. Links between trade and the environment

Category	Driving forces	Pressures	Impacts	Mediating factors
Scale effects Ve(-) and Ve(+)	Ve (-): Increased access to foreign markets thanks to reductions in tariffs and non- tariff barriers to trade	Ve(-): increased scale of production	Ve(-): Increased consumption of natural resources; increased production- related pollution (air, water, soil)	Ve(-) : if the environmental regulatory regime is adequate, there is little negative effect. If not then there are negative effects
	Ve (+): Lower domestic tariffs and non-tariff barriers on goods and services	Ve(+): increased efficiency of production	Ve(+): reduced consumption of natural resources; reduced production- related pollution (air, water, soil)	Ve(+): use of environmentally- sound technologies enhances environment benefits
Structural effects Ve(-) and Ve(+)	Ve (-): greater openness to and attractiveness for FDI due to better access to foreign markets	Ve(-): higher polluting firms migrate from higher-standard countries to lower-standard countries	Ve(-): increased consumption of natural resources; increased production- related pollution (air, water, soil)	Ve(-): this pollution will not occur if a strong environmental regulatory regime is in place
	Ve (+): increased foreign market access from reductions in tariffs, NTBs and subsidies	Ve(+): new investment brings in cleaner technology, adherence to higher standards	Ve(+): reduced consumption of natural resources; reduced production- related pollution (air, water, soil)	Ve(+): national certification of process and production methods enhance effects
Technology effects Ve(+)	Ve (+): greater openness to and attractiveness for FDI due to better access to foreign markets	Ve(+): new investment brings in cleaner technology, adherence to higher standards	Ve(+): reduced consumption of raw materials and energy inputs; reduced production- related pollution (air, water, soil)	Ve(+): if the environmental regulatory regime is strong, it increases the likelihood that imports of new technology will be the best available
	Ve (+): lower	Ve(+): increase	Ve(+): reduced	Ve(+): if the

other hand, ecotourism, organic agriculture, and silk handicrafts can potentially be developed as “green” niches. It should be noted that this study is descriptive in nature because the rapid assessment method lacks quantitative evidence to support it.

	domestic tariffs and non-tariff barriers	in imports of cleaner technologies and intermediate goods	consumption of raw materials and energy inputs; reduced production-related pollution (air, water, soil)	environmental regulatory regime is strong, it increases the demand for clean imports
Direct effects Ve(-)	Ve(-): liberalization of trade and investment creates increased trade flows and economic activity	Ve(-): increased trade-related transportation activities	Ve(-): increased air pollution, particularly along major transportation corridors; habitat loss from increased transportation infrastructure; climate change impacts	Ve(-): this effect will always occur, but will be less intense in direct proportion to the stringency of transportation-related emissions regulations
Regulatory effects Ve(-) and Ve(+)	Ve(-): standard international investment agreements	Ve(-): provisions on indirect expropriation constrains the ability of regulatory authorities to regulate	Ve(-): weaker enforcement of environmental laws; reluctance to draft new environmental laws (regulatory chill) in order not to lose FDI	Ve(-): if private investors successfully argue that regulation amounts to indirect expropriation, there will be a regulatory chill
	Ve(+): rising income from trade and investment liberalization	Ve(+): increased public awareness and demand for higher environmental quality	Ve(+): stronger enforcement of environmental laws; pressure to draft new environmental laws; requirements to meet export standards	Ve(+): this effect is stronger if the decision-making process and institutional structures are transparent and inclusive of stakeholders

Sources: IISD/UNEP 2005; Copeland Taylor 2003; OECD 1994

1.2 Research Questions and Hypothesis

In order to benefit from trade liberalization, it is important that policy makers ask the following questions:

1. How does trade liberalization affect macroeconomic performance?
2. Which sectors does trade liberalization impact, either positively or negatively?
3. Does trade liberalization increase pollution and resource depletion?

4. How are poor and non-poor households helped by trade liberalization?

The author has developed the following hypotheses regarding the impact of trade liberalization on poverty and pollution: Trade liberalization has a positive impact on growth.

According to Winter (2004), who summarized previous studies on the relationship between trade and growth, trade improves growth due mainly to increased productivity, including improved policies and institutions. Laos has some specific characteristics that should be taken into account. Despite having abundant resources such as land, water, forests and minerals, Laos has supply-side constraints, lacks capital, and skilled labor and technology. By liberalizing trade, Laos will import more intermediate and investment goods for domestic use and will export products, which will increase growth. In addition, as trade liberalization increases competitiveness and efficiency in resource allocation, it leads to more effective resource allocation. Because Laos is a Socialist country, some enterprises are highly protected, particularly in sectors with state-owned enterprises. As a result, trade liberalization should increase resource allocation efficiency, and so have a positive impact on growth in the context of Laos.

1.2.1 Trade liberalization will increase pollution and resource depletion

According to empirical studies from Yang (2001), trade liberalization leads to increased total carbon dioxide emissions. Given that Laos has weak environmental regulations and tends to be lax on enforcement, the production of pollution-intensive goods might increase with trade liberalization³. In addition, because Laos has abundant natural resources such as minerals, forests, and water, these might be depleted more rapidly as trade liberalization increases. However, there is disagreement on the above assumptions and so this study proposes to test them.

1.2.2 Trade liberalization has a positive impact on urban households rather than on rural households, which leads to wider inequality

In other words, poor households will not gain much benefit from trade liberalization. Urban households seem to experience greater income gains from trade liberalization than rural households so urban households will benefit more than rural households from the falling prices granted by trade liberalization. According to empirical studies from Cororaton et al. (2005), Li and Zhai (2000) and Fujii and Roland-Holst (2007), rural areas do not benefit as much as urban areas from trade liberalization. Around 80% of Laos' population lives in rural areas and the roads connecting them to urban centers are poor. Additionally, urban dwellers have more opportunities than rural people to increase their income from factor products. Therefore, simply lowering the price of goods at the border will not benefit the rural poor.

1.3 Objectives

Based on the issues and hypothesis presented above, the main objective of this research report is to investigate the impact of trade liberalization on Laos. The report has four specific objectives:

- To assess the impact of trade liberalization on macroeconomic indicators.

³ It is important to note that trade liberalization and weak environmental regulation might not necessarily increase pollution if the expansion of output is from cleaner industries. As a result, trade liberalization will not increase pollution.

- To assess the impact of trade liberalization on carbon dioxide emissions.
- To assess the impact of trade liberalization on resource depletion.
- To assess the impact of trade liberalization on poverty.

1.4 Scope of the Study

There are various dimensions to both poverty and pollution, and trade liberalization impacts poverty and pollution through different routes. This study will focus on:

- The impact of trade liberalization through reduced tariff rates. It does not take into account other routes such as foreign direct investment, business environment improvement, etc.
- This study focuses on CO₂ emissions from 57 sectors based on the GTAP data base (version 7). This study does not take into account the impact of trade liberalization on other forms of air pollution, water pollution, soil erosion and solid waste.
- The poverty measurement focuses on headcount poverty and the inequality measurement uses the GINI coefficient.

2.0 TRADE, THE ENVIRONMENT AND POVERTY IN LAOS

2.1 Macroeconomic Conditions

Since introducing the New Economic Mechanism (NEM) in 1986⁴, Laos has been in transition from a centrally-planned economy to a more market-oriented economy. As a result, except during the Asian Financial Crisis of the 1990s, Laos has achieved high rates of economic growth with low inflation. The average rate of economic growth was about 6.53% from 2001 to 2006, which increased from 6.18% during 1996-2000⁵. The average inflation rate was maintained at one digit from 2001 to 2006, which is a significant decline from the average rate of 57% from 1996 to 2000. The exchange rate was also stable from 2001 to 2006 (Table 2). Of the nation's total GDP of USD 4,053 million in 2007, the agricultural sector accounted for 40.3%, industry for 34.1% and the service sector for 25.6% (World Bank, 2008). However, since 2003, industry has grown more than 10%, which has caused the agricultural share of GDP to decline.

Even though Laos has maintained high economic growth with low inflation and a stable exchange rate, it still has serious macroeconomic issues to overcome. Firstly, Laos is facing chronic twin deficits in both Government spending and international trade. The average ratio of budget deficit to GDP was 4.4% during 2001-2006. The average ratio of current account balance deficit to GDP was 9.24% during

⁴ After establishing the Lao People's Democratic Republic in 1975, the Lao Government adopted a planned economy, following the models of other Socialist countries.

⁵ The engine of growth during this period was capital inflows of Foreign Direct Investment (FDI) in the mining and hydropower sectors and mining production and exports. For a more detailed discussion of the impact of FDI in the mining and hydropower sectors on the Lao economy see Kyophilavong and Toyoda (2008).

the same period⁶. These deficits are mainly financed by Official Development Assistance (ODA), Foreign Direct Investment (FDI), and remittances. Firstly, the fiscal issue is particularly serious in Laos. If the budget deficit continues to expand, it might cause acceleration in the inflation rate and the devaluation of the kip (the Lao currency), which could lead to economic instability similar to the Asian Financial Crisis⁷ (Okonjo et al., 1999). Secondly, there is a huge gap between savings and investment. The savings rate is low because average incomes are low – GDP per capita was about USD 580 in 2007 (World Bank, 2009) – and because the financial sector is underdeveloped. The banking sector is occupied by state commercial banks, which are unable to perform a full range of banking functions⁸. Thirdly, Laos faces a high burden from external debts; external debt accumulation was more than 60% of GDP in 2007. If Laos becomes too dependent upon foreign finance, particularly to meet its debt obligations, this could cause a foreign debt crisis that might lead to macroeconomic instability.

Table 2. Macroeconomic indicators

Macroeconomic indicators	2001-2006	1996-2000	1990-1995
Population (million people)*	5.46	4.86	4.4
Population growth (%)	2.12	2.06	2.52
GDP (current million USD)**	2,416	1,618	1,276
GDP growth (%)	6.53	6.18	6.46
GDP per capita (constant 2000 USD)**	379	307	248
GDP per capita growth (%)	4.04	3.68	3.80
Reserve money (M2) (million USD)*	450,981	270,728	148,280
Money supply (M2) (%)*	21.14	65.99	30.92
Inflation-CPI (%)	9.73	57.00	15.27
Trade deficit (million USD)***	-219.91	-263.21	-174.92
Trade deficit/GDP (%)	-9.24	-16.06	-13.14
Foreign reserve (million USD)***	220	127	48
External debt (million USD)*	2,640	2,410	1,965
External debt/GDP (%)	115	152	161
Budget deficit (including grants) (million USD)	-104	-58	-100
Budget deficit/GDP (%)	-4.42	-3.60	-7.61
Budget deficit (excluding grants) (million USD)	-149	-121	-145
Budget deficit/GDP (%)	-6.29	-7.58	-11.21
Exchange rate (kip/USD) official rate ***	10,163	4,094	727

Sources: *Asian Development Bank (ADB), *Key Indicators for Asia and the Pacific 2008*, **World Bank *World Development Indicators* CD-ROM (2005), ***International Monetary Fund, *International Financial Statistics* CD-ROM, August 2008

⁶ It is important to note that trade data used for this analysis is based on data from international organizations. The Lao Government claimed that the trade deficit became a surplus in 2006.

⁷ As Laos has limited revenues, an increase in budget deficit puts pressure on increasing the money supply – the monetary authority might print money to cover the budget deficit. This circumstance did not happen in the past. See more details in Kyophilavong (2010).

⁸ More details about financial issues and monetary and exchange rate policies in Laos are discussed in Kyophilavong (2008).

2.2 Trade Reforms and Structure

Trade liberalization has been identified as a key component for achieving the Lao national goal of emerging from LDC status by 2020 (GoL, 2004; 2006). Trade liberalization has been one of the pillars of economic reform in Laos (Martin, 2001). In 2004, Laos was granted Normal Trade Relations (NTR) status by the United States. Laos also has plans to join the World Trade Organization (WTO) within the next few years. These actions show that Laos is keen to participate more fully in the global economy. By becoming a WTO member and establishing stronger ties with the US economy, Laos will face a number of new challenges and opportunities. Trade agreements/preferences are shown in Appendix 1.

Trade trends indicate that Laos has been facing a chronic trade deficit since introducing the New Market Mechanism (NEM) in 1986, although the situation has recently changed. Laos imports various goods from other countries, from basic consumer goods to investment goods and fuel, and most of these imports come from Thailand. The average growth in imports from 1990 to 1996 was 22.9%.

Laos' main export commodities are wood products, electricity and clothing, and since 2005 mineral and electricity exports have increased sharply. From 1990 to 1996, export growth averaged 20%. At this time, Laos' main export markets were Vietnam and Thailand. From 1995 to 1997 imports were double the dollar value of exports, leading to a large trade deficit. With the Asian financial crisis, export growth decreased sharply, with annual growth averaging 2% from 1997 to 2004. The export share to Thailand was also sharply reduced. After the Asian financial crisis of 1997 Laos' balance of trade narrowed.

As mentioned above, the trade deficit became a trade surplus in 2005 due to an increase in the export of electricity and minerals such as gold and copper, coupled with high mineral prices. However, when an economy depends on booming sectors, the competitiveness of non-booming sectors can decrease, which can lead to long-term risks for economic development.

2.3 The Environmental Situation

Laos is characterized by abundant natural resources including forests, minerals, water, and biodiversity. In order to maintain sustainable environmental management, several laws and regulations have been passed, such as the Water and Water Resources Law (1996), the Forestry Law (1996), the Land Law (1997), the Agriculture Law (1998), and the Environmental Protection Law (1999). For a detailed list of environmental and socio-economic laws and regulations, see Appendix 2.

The Water Resources and Environmental Agency (WREA)⁹, which comes under the jurisdiction of the Prime Minister's Office, is primarily responsible for issues related to the environment and the conservation of natural resources. Unfortunately, some of these natural resources have been damaged by development projects¹⁰ coupled with a lack of regulation, a lack of law enforcement, and weak institutional capacity (Liemphrachanch, 2005). For instance, while Laos still has a high proportion of forest cover, accounting for about 45% of the country's total land area (Phimmavong, et al., 2009), forest areas have declined (Shaw et al., 2007). In

⁹ WREA was previously called the Science, Technology and Environment Agency (STEA), the main government agency responsible for managing and controlling the environment and natural resources.

¹⁰ Development projects refer to road, hydropower and mining project development. In addition, the increasing population is an important factor in natural resources depletion.

addition, threats to land resources, water resources, and biodiversity have increased (WB and STEA, 2008).

Various studies show that poor people's economic dependence on natural resources make them vulnerable to environmental degradation (Cavendish, 1999; Cavendish, 2000; Reddy and Chakravarty, 1999). Laos is no exception to this reality; about 80% of the country's inhabitants are farmers who depend on natural resources. Other studies point out that environmental disasters and damage may have a regressive impact on poor people because they lack the capacity to cope with their effects. In Laos, there is a strong correspondence between poverty rankings and environment rankings in terms of deforestation, erosion potential, indoor air pollution, contaminated water, and outdoor air pollution, particularly for the lowest- and highest-income provinces (Susmita et al., 2003).

Trade liberalization may lead to strengthened regulations, strengthened law enforcement and improved technology, which would have a positive impact on the environment. On the other hand, as Laos is a LDC with weak institutions and environmental enforcement, trade liberalization could contribute to further environmental destruction. To date, the impact of trade liberalization is not well understood in the Lao context.

2.4 Poverty

In order to eradicate poverty by 2020, the Government has implemented the National Growth and Poverty Eradication Strategy (NGPES), an overall development and poverty alleviation framework (GoL, 2004).

Analysis of three Lao Expenditure and Consumption Surveys (LECS) from WB and DOS (2009) showed that the incidence of poverty has fallen since LECS 1, though it fell slowly during 1997-98. The incidence of poverty fell from 46% in LECS 1 to 39% in LECS 2, and from 33.5% in LECS 3 to 28% in LECS 4. Inequality has also changed since LECS; it increased between LECS 1 and LECS 2, but declined by LECS 3 (see Appendix 3).

Poverty can contribute significantly to the degradation of environmental and natural resources. The link between poverty and the environment is significant in the case of Laos (Dasgupta et al., 2003). For example, the National Park Areas (NPAs) can play a vital role in sustaining and improving rural livelihoods. Emerton et al. (2002) estimated the economic value of Nam Et-Phou Loei National Biodiversity Conservation Area to be worth more than USD 1.12 million a year overall, or USD 313 per household. This study also revealed that poorer households depend more than richer households on forest products to generate income; the loss of natural resources and biodiversity has a more severe impact on poor households.

Trade liberalization increases employment opportunities and reduces the price of consumer goods, which could lead to a reduction in poverty and inequality. On the other hand, liberalization may mainly benefit the non-poor. It is not clear what impact trade liberalization will have on inequality and poverty in the Lao context.

3.0 SURVEY OF LITERATURE

3.1 Studies Conducted in other Developing Countries

3.1.1 Trade liberalization and poverty

Various studies have used a CGE model to examine the impact of trade liberalization in developing countries. Cororaton et al. (2005) used a CGE model to investigate the impact of Doha scenarios and trade reforms on poverty in the Philippines. This research found that poverty increased slightly with the implementation of the Doha scenario, especially in rural areas and among the unemployed, self-employed and rural population with low education levels. Using a CGE model, Li and Zhai (2000) studied the impact of WTO accession on China's economy. The results of the simulation showed that China would gain significantly in economic efficiency from becoming a WTO member, but that the gains would not be evenly distributed among sectors or income groups.

Ianchovichina and Martin (2001) used a CGE model to analyze China's WTO accession, concentrating on the changes in China's trade regime. They found that with such policy measures Chinese households would gain about 2.2% of their income (compared to not joining the WTO). Fujii and Roland-Holst (2007) combined an integrated microsimulation-CGE model with a small area estimation to evaluate the spatial incidence of poverty from Vietnam's accession to the WTO. Full liberalization would benefit the poor on a national basis, but the northwestern area of Vietnam would probably lag behind.

Chaipan et al. (2006) used a Global CGE model to assess the impact of a Free Trade Agreement (FTA) on poverty and income distribution in Thailand. Simulation results indicated that FTA strategies and the formation of a FTA in East Asia would stimulate growth and investment and improve Thailand's welfare. However, the impacts on income distribution varied with the integration scenarios, production and trade patterns, and the extent of trade liberalization in Thailand's FTA partners.

In summary, poor households in some countries gain benefits from trade liberalization but some do not, depending on the characteristics of individual countries, trade structures and kinds of trade liberalization.

3.1.2 Trade liberalization and pollution

The link between trade and pollution is complex. Trade liberalization affects pollution in three ways; scale effects, structural effects, and technology effects (Beghin, et al., 2002; Perroni and Wigle, 1994). Scale effects refer to changes in aggregate outputs. Structural effects refer to a change in the commodity composition (the composite effect). Technical effects refer to a change in the adoption of input mix in less or more polluting factors.

Many studies have investigated the connections between trade liberalization and the environment. One important study by Coxhead and Jayasuriya (2003) examined natural resource use and explained the impact of agricultural and environmental policies on the economies and environments of Asian countries. The authors used a general equilibrium model for Asian countries that considered environmental issues, and they modified the standard model into a two-region model (uplands and lowlands) to reflect the conditions in Asian countries. Their findings showed that free trade may have an impact on increasing deforestation and land

degradation, especially in the uplands. Hao (2001) examined the environmental effects associated with WTO accession; the empirical results showed that total carbon dioxide emissions increased as a result of trade liberalization. Beghin et al. (2002) used the CGE model to examine the links between trade integration, pollution, and public health in Chile. The scenario induced a substantial worsening of pollution, partly because it facilitated access to cheaper and dirtier energy, and had a significant negative effect on urban morbidity and mortality.

Corong (2007) used a CGE model to identify the links between tariff reductions, carbon emissions and poverty for the Philippines. The results showed that tariff reductions reduced the cost of imported fossil fuels, resulting in a marginal increase in carbon emissions. The national poverty headcount also fell as a result of tariff reductions. In Indonesia Yusuf (2007) used a CGE model to evaluate a carbon tax and energy price reforms on income distribution. The results showed that in contrast to most studies from developed countries, the distributive effect of a carbon tax is not necessarily regressive; there is not necessarily a conflict between the environment and poverty. Using a CGE model, Rafaelita et al. (2002) assessed the effects of trade reform on pollution in the Philippines, focusing on industrial sectors and their pollution. The empirical results showed that trade reform increased output and income, but the overall impact on pollution was relatively small. This study indicated that production technology is a major factor that can check the pollution problems associated with industrialization. Strutt and Anderson (2005) used a GTAP model to analyze the impact of trade liberalization on poverty in GMS, but this study did not include Laos.

In summary, the impact of trade liberalization on pollution is complex and differs between countries. Trade liberalization has positive and negative impacts in different countries, depending on various factors such as scale effects, structural effects, technology effects, and regulation effects.

3.2 Studies Conducted in Laos

Few studies have been carried out on the impact of trade liberalization on the Lao economy. In a descriptive analysis, Anderson (1998) examined the implications of WTO accession for agriculture and rural development. This study found that the net benefits are overwhelmingly positive, as economic growth would be boosted and sustained at a higher level. Agriculture would expand, along with associated agribusinesses and other service activities, which would boost income-earning opportunities for farm households in rural areas; poverty would be alleviated and there would be more equitable income distribution. This study also contends that contrary to common perceptions, Government revenue from trade taxes may actually increase, particularly if non-tariff trade barriers are tariff. Akkharath (2003) provided a descriptive study of WTO accession. The study results showed that WTO membership would bring both challenges and opportunities. Laos would gain benefits, including expanded access to international markets for its goods and rights under international law to equal treatment with all other exporters. WTO accession would encourage trade and investment and benefit the resolution of transit disputes related to Laos' land-locked geography.

While many studies conducted in other developing countries have used a CGE model, there are very few studies with CGE model building for the Lao economy. Fukase and Martin (1999) built a simple CGE model to analyze the economic effect of joining the AFTA; the simulation results showed that AFTA accession is economically beneficial. Using a CGE modeling approach, Warr and Menon (2006)

studied the effect of rural road improvements in Laos on poverty. The simulation results showed that there is considerable scope for reducing poverty in Laos by reducing rural transport costs through improving the quality of rural roads. Warr (2006) built a two-sector, multi-household CGE model to analyze the impact of the hydropower dam Nam Theun 2 (NT2) on the Lao economy and poverty. This model follows a 1-2-3 model structure which includes the production of two types of goods, exports and non-trade goods. The distinctive feature of this model is its disaggregation of households. The simulation results showed that the project had significant effects on poverty. If poor households do not share directly in the proceeds of the project, poverty is likely to rise.

Kyophilavong (2006) analyzed the potential impact of AFTA using a CGE model. The simulation results showed that Laos gains substantial benefits from AFTA, especially in non-agriculture sectors. However, this model was two-sector, quite small, and did not analyze the impact of AFTA on poverty and income distribution.

There are very few quantitative studies on trade and poverty in Laos. Moreover, there are no studies that use a CGE model analysis to examine the relationship between trade liberalization, the environment, and poverty. However, the newest version of the GTAP 7 data base includes Laos' input-output table, which might provide a significant contribution to empirical studies of international trade (Narayann and Walsmsley, 2008).

4.0 METHODOLOGY

4.1 Research Framework

The research framework of this study is shown in Figure 1. There are three models used in this study; the GTAP model, the Single Country CGE model, and micro-simulation. Firstly, the GTAP model is used to analyze the impact of trade liberalization on macro-economic variables, emissions and natural resources. Secondly, the results of the GTAP model (prices, wages and outputs) are used in micro-simulation to analyze the impact of trade liberalization on poverty. Here, it is important to note that there are other approaches to assessing the impact of trade liberalization on poverty. The first one is to link the GTAP model with the single country model (with multi-household). The import and export prices from the GTAP model can be used to shock to the single country model. This approach can estimate the change in household welfare as a result of trade liberalization. The second approach links the three models (GTAP model and micro-simulation). The import and export price changes from the GTAP model can be used to shock into the single country CGE model, then used to shock in the micro-simulation model.

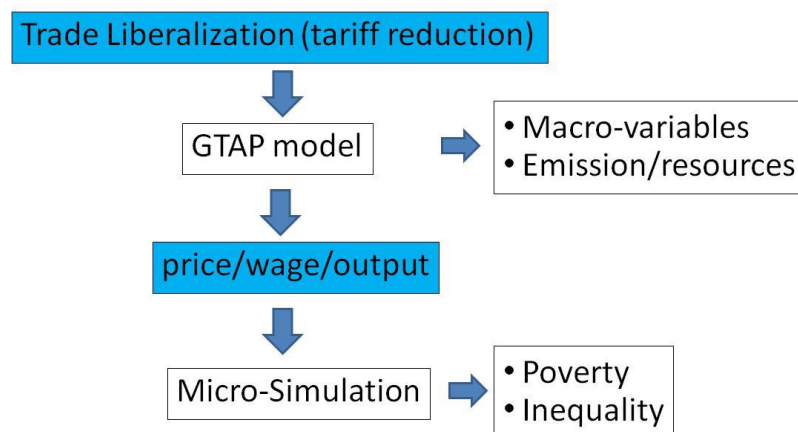


Figure 1. The research framework of this study

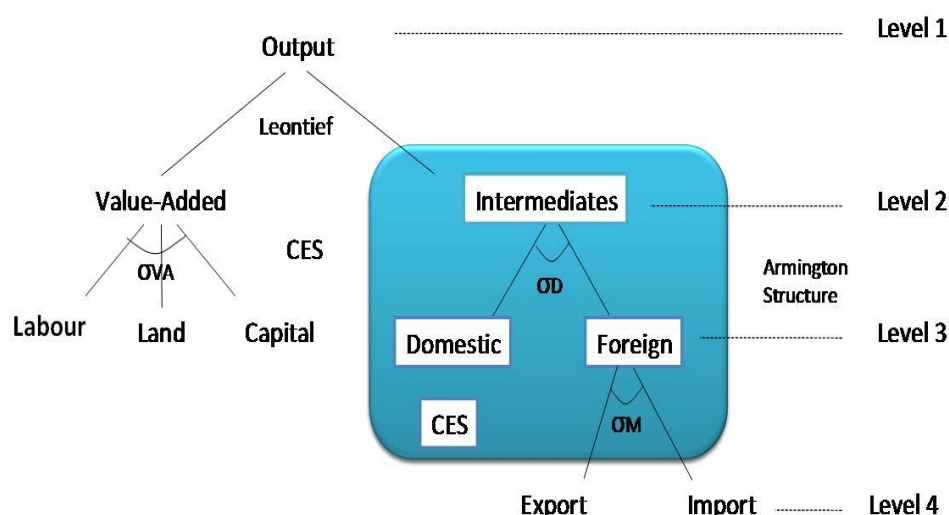
4.2. GTAP Model and Data Base

The Global Trade Analysis Project (GTAP) model, a multi-region computable equilibrium (CGE) model, is one of the most popular models for analyzing the impact of trade policies. There are various advantages to the GTAP model. Firstly, since it is a multi-regional model of world production and trade, it can take into account the overall trade implications of Laos' WTO accession as well as third-party countries. Secondly, it contains a data base for different sectors and thus can explore the trade implications for various sectors of interest¹¹.

The GTAP model assumes perfectly competitive markets, where the zero profit condition holds, and that all the markets are cleared. The regional household allocates expenditure across three categories: private household, government, and savings. It derives income from the 'sale' of primary factors to the producers, which combine them with domestically produced and imported intermediate composites to produce final goods. These final goods are in turn sold both domestically to private households and the Government, and exported to the rest of the world. Both the Government and private households also import consumer goods from the rest of the world. A global bank intermediates between global savings and regional investments by assembling a portfolio of regional investment goods and selling shares in this portfolio to regional households in order to meet their savings demands. Finally, a global transport sector assembles regional exports of trade, transport and insurance services and produces composite goods used to move merchandise trade among regions (Hertel and Tsigas, 1997). The flowchart of the GTAP model and production structure in the GTAP model is illustrated in Figure 2.

The latest version of the GTAP data base, version 7, is used for this study. To facilitate our analysis, I have aggregated regions into 10 regions. All 57 sectors remain (Appendix 4). The breakdown of regions is shown in Appendix 5.

¹¹ For more details, see Hertel (ed), 1997. A graphic presentation of the GTAP model, with particular emphasis on the accounting relationships, is given by Brockmeier (1996).



Source: Hertel (ed.), 1997.

Figure 2. Production structure in the GTAP model

4.3 Measuring Welfare Impacts

As mentioned in the research framework, the measurement of welfare changes due to trade liberalization uses the top-down approach linked to the GTAP model and micro-simulation. There are two steps to estimating the effect of trade liberalization on household welfare. Firstly, we estimate producer and consumer price changes, and factor production price changes from the GTAP model. Secondly, the price and output changes from the GTAP model are used for micro-simulation (Figure 3). Household welfare change is calculated using the formula in Chen and Ravallion (2004) and Ravallion and Lokshin (2008). Household welfare is affected by four factors; changes in revenue, changes in expenditure, changes in inputs, and changes in wages (see equation below). The results of the GTAP model indicate that the four factors are influenced by changes in consumer and producer prices, and wages. The changes in the price and production of particular food and non-food items alter household welfare, which is based on a share of revenue from these items. Changes in international demand for particular goods affect household incomes, which depend on a proportion of their marketed production of goods. Wage changes influence household income according to the share of waged income received. Price changes also affect household consumption, with an increase in prices decreasing household welfare. The welfare impacts from trade liberalization in the monetary value of the change in utility for household i can be expressed as follows¹²:

¹² The measurement of welfare impacts from trade liberalization has data constraints because initial data of price and wage levels are not included. However, this problem can be overcome by calculating a first-order approximation of the welfare impact in a neighborhood of the household's optimum (Chen and Ravallion, 2004; Ravallion and Lokshin, 2008).

$$g_i = \sum_{j=1}^{57} \left[p_{ij}^s q_{ij}^s \frac{dp_{ij}^s}{p_{ij}^s} - p_{ij}^d (q_{ij}^d + z_{ij}) \frac{dp_{ij}^d}{p_{ij}^d} \right] + \sum_{k=1}^2 \left(w_k L_{ik}^s \frac{dw_k}{w_k} \right)$$

= (change in revenue) - (change in expenditure) - (change in input) + (change in wage)

g_i = The monetary value of the change in utility for household i

$p_{ij}^s q_{ij}^s$ = The revenue (selling value) from household production activities in sector j

p_{ij}^s = Supply price from household i in production activities in sector j

q_{ij}^s = Quantity supplied from household i in production activities in sector j

$p_{ij}^d (q_{ij}^s + z_{ij})$ = The (negative) weight for demand price changes

p_{ij}^d = Demand price from household i in production activities in sector j

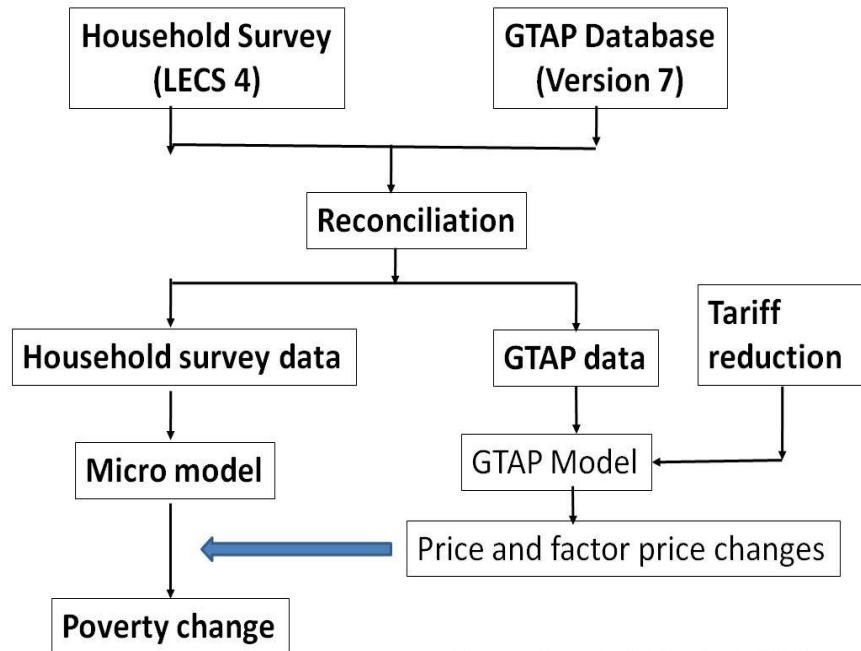
q_{ij}^d = Quality demanded from household i production activities in sector j

z_{ij} = Commodities used as production inputs, of which z_{ij} is used for production goods in sector j

$w_k L_{ik}^s$ = The weight for changes in the wage rate for activity k

w_k = Wage rate to activity k

L_{ik}^s = Household's "external" labor supply to activity k



Source: authors adopted from Ivanic (2006)

Figure 3. Methodology framework, poverty analysis

4.4 Data Matching

There are 57 sectors of production and consumption in the GTAP data base. There are 356 categories for consumption and 117 categories for production in the third Lao Expenditure and Consumption Survey (LECS 3) from 2002/2003. Therefore,

in order to link the results from the GTAP model to the micro-simulation model, it is important to reconcile the data. The reconciliation of data from LECS 3 with the GTAP data base was achieved in the following way¹³.

4.4.1 Consumption and production

We used GTAP data base version 7, which consists of 57 sectors; factor products included land, capital, skilled labor and un-skilled labor. We matched consumption and production from LECS 3 to the GTAP data base. In LECS 3 there are 357 categories for consumption and 117 categories for production. Since the agricultural section in LECS 3 does not contain the value of sales and the cost of the agricultural products, we cannot use the information in this section. However, the dairy section of LECS 3 records the monthly transactions of agricultural income and costs. So, we have obtained information on agricultural income by using the dairy section of LECS 3 but it is possible that this income has been underestimated because the reference period is monthly.

4.4.2 Labor

There are two types of labor in the Lao GTAP model: skilled labor and un-skilled labor. Skilled labor has been defined by whether wage earners have completed at least primary education. Unskilled labor has been defined by whether wage earners have not completed primary education. Since each entry on wage incomes in LECS 3 has an ID for each person but does not include information on the industry, the industry in which a person is engaged for the greatest number of days and hours has been chosen as the industry supplying the waged income.

4.4.3 Household income

Change in per capita income is used as the welfare indicator in this study. Household income includes agriculture, non-agriculture business, waged income, and expenditure on own-produced agricultural products. Own-produced consumption represents a large portion of household consumption and to neglect this area of income would be to underestimate household income. New income in the simulation is calculated by adding the estimated gain to income in the baseline (as in Chen and Ravallion, 2004).

4.4.4 Poverty line income

An official estimation of the income that constitutes the poverty line is not established in Laos. Estimation of the poverty line in Laos is mostly gauged from expenditure. Official per capita expenditure in LECS 3 established levels of poverty. The poverty line was obtained by taking the mean per capita expenditure for poor households, based on their expenditure. The means were taken separately in four regions, both urban and rural, because poverty expenditure in LECS 3 is organized in the same way. Therefore, the poverty rates in this study match those using the expenditure poverty rates in LECS 3.

4.5 Analyzing Impacts on Pollution

Due to the lack of data on pollution, this study will focus on carbon emissions as a proxy for environmental pollution. The calculation of CO₂ coefficients for each sector (57 sectors in total) follows Lee (2008). Combustion-based CO₂ emissions

¹³It is important to note that this study reconciled sectors of consumption, production, wages and income, it did not reconcile their value.

were calculated from GTAP energy volume data. The tier 1 method of the revised 1996 IPCC guideline (IPCC/OECD/IEA, 1997) was adopted. The impact of trade policy changes on the environment can be explained by the scale, composite and technology effects discussed by Strutt and Anderson, 2000; Beghin, et al., 1997; Grossman and Krueger, 1992; 1995; and Copeland and Taylor, 1994. However, this study does not focus on decomposition analysis of CO₂ emissions.

5.0 SIMULATION DESIGN AND RESULTS

5.1 Simulation Design

Laos will gain various benefits from trade liberalization, such as joining the WTO. Firstly, WTO accession will give Laos opportunities to improve its trade and investment environment. Secondly, WTO members would be more secure and less discriminatory in terms of market access for Lao exports. Thirdly, WTO accession will increase FDI in Laos (Anderson, 1998). However, trade liberalization also has costs, such as the loss of preferential tariffs, loss of textile and clothing quotas, and losses in revenue¹⁴.

Though WTO accession involves various costs and benefits, we will focus on tariff reductions. The base case scenario represents Laos without WTO accession, which is referred to as no shock in the model. The simulation scenario represents Laos' accession to the WTO through reduced tariff rates. Because the final tariff commitment of WTO accession is not available, I have assumed that with WTO accession Laos' final tariff rate commitment in agriculture, non-agriculture and services will be the same as in the Common Effective Preferential Tariff (CEPT) Scheme for AFTA. The simulation scenario cuts the tariff rate to Laos by 2.5% in all sectors except the service sector from nine regions, including Southeast Asia.

The initial tariff rate is shown in Appendix 6. Comparing the tariff rate with the nine regions¹⁵, Laos has a small percentage of *ad valorem* rate in import tax. This shows that the impact of tariff rate reduction on the Lao economy might be small.

In addition, Laos produces about 1.7 million tonnes of CO₂ emissions per year (base year 2004). Compared with other regions, Laos creates a small amount of CO₂ emissions (CAIT, 2011). Electricity, households and transportation produced the most CO₂ emissions (Appendix 7). Around 40% of CO₂ emissions are from petroleum products, 32% from coal and 26% from natural gas.

5.2 Simulation Results

These results focus on the impact of trade liberalization on Laos, neglecting its impact on other regions. The results are divided into the impact of trade liberalization on the national economy, CO₂ emissions, resource depletion¹⁶ and welfare effects.

¹⁴ Due to the limitations of the model (static GTAP model), the dynamic impact such, as improvement in the investment climate and increased foreign direct investment (FDI), is neglected.

¹⁵ The nine regions include: Australia/New Zealand, East Asia, Southeast Asia, South Asia, North America, Latin America, the European Union, Sub-saharan Africa, and the rest of the world.

¹⁶ The impact of trade liberalization on resource depletion refers to changes in primary product (Strutt and Anderson, 2000; Mukhopadhyay and Thomassin, 2010). In many other cases resource depletion also means the declining stock of reserves, which is a function of available reserves.

5.2.1 Impact on national economy

Trade liberalization increases equivalent variation (EV) and real GDP but reduces the terms of trade and the trade balance. EV increases by USD 1.67 million and real GDP increases by 0.53%; the terms of trade decline 0.90% and the trade balance declines by 43.08%. The increased EV¹⁷ in simulation 2 comes primarily from the allocative efficiency effect, which is evident in processed food, light manufacturing and grains and crops (Table 4). It is clear that the effects of trade liberalization are slight because Laos already has low tariffs from joining AFTA and the economy of scale in Laos is relatively small.

Table 3. Impact on macroeconomic variables

Macroeconomic variables	Simulation 1
EV (million USD)	1.67
Real GDP (%)	0.53
Term of trade (%)	-0.93
Trade balance (million USD)	-43.08
Import volumes (%)	7.74
Export volumes (%)	5.29

Source: author's GTAP model results

5.2.2 Impact on CO₂ emissions

Surprisingly, trade liberalization leads to a decrease in CO₂ emissions of 8,300 tonnes, but this is a small decrease (Table 4). The main decline in CO₂ emissions is due to changing output, which is small in some sectors, and more intensive in other sectors. Therefore, trade liberalization does not lead to an increase in CO₂ emissions. This empirical result contradicts other studies (Corong, 2007; Mukhopadhyay and Thomassin, 2010; Yang, 2001; Strut and Anderson, 2000). However it is important to note that there are various dimensions to the impact of trade liberalization on the environment and this study focuses only on CO₂ emissions, which might underestimate the impact of trade liberalization on the environment. In addition, this study focuses on tariff reduction due to trade liberalization, which neglects other impacts such as an improvement in trade facilitation, an improvement in the business climate, and advances in technology.

The top 10 sectors for a decline in CO₂ emissions are shown in Table 5. Trade liberalization leads to a decline CO₂ emissions from transport, petroleum, coal products, electricity, chemicals, rubber, plastic products, paper products, publishing, gas manufacture, distribution, ferrous metals, beverages and tobacco products, food products, and fishing.

However, CO₂ emissions increase in some sectors due to trade liberalization (Table 6). The top 10 sectors with increasing CO₂ emission due to trade liberalization are air transportation, mineral products, recreational and other services, construction, machinery and equipment, water transport, oil, minerals, coal, and manufacturing.

¹⁷ There are basically four major sources of welfare change: the allocative efficiency effect, the endowment effect, the technology effect and the terms of trade effect (Huff and Hertel, 2000; Hanslow, 2000; Adams, 2005).

Table 4. Impact on CO₂ emissions (1,000 tonnes)

Sector	Before trade liberalization		After trade liberalization		Net change in emissions
	Emissions	Share	Emissions	Share	
Grain and crops	7.9	0.48	7.7	0.5	-0.2
Livestock and meat products	4.8	0.29	4.7	0.3	-0.1
Mining and extraction	50.6	3.09	50.8	3.1	0.2
Food processing	23.2	1.42	22.3	1.4	-0.9
Textiles and clothing	8.3	0.51	8.2	0.5	-0.1
Light manufacturing	34.5	2.11	32.6	2	-1.9
Heavy manufacturing	197.8	12.09	197.5	12.1	-0.3
Utilities and construction	691.8	42.28	690.8	42.4	-1
Transport and communication	315.9	19.31	316.9	19.5	1
Services	301.3	18.42	296.2	18.2	-5.1
Total	1636.1	100	1627.8	100	-8.4

Source: author's estimation from GTAP model

Table 5. Top 10 sectors for decreasing CO₂ emissions (1,000 tonnes)

Rank	Sector	Before trade liberalization	After trade liberalization	Net change
1	Air transportation	65.4	68.89	3.49
2	Mineral products	70.8	73.45	2.65
3	Recreational and other services	44.1	46.32	2.22
4	Construction	11.3	12.27	0.97
5	Machinery and equipment	7.4	8.11	0.71
6	Water transport	32.2	32.75	0.55
7	Oil	15	15.29	0.29
8	Minerals	9.4	9.68	0.28
9	Coal	6.1	6.25	0.15
10	Manufacturing	4.4	4.46	0.06

Source: author's estimation from GTAP model

Table 6. Top 10 sectors with increasing CO₂ emissions (1,000 tonnes)

Rank	Sector	Before trade liberalization	After trade liberalization	Net change
1	Air transportation	65.4	68.89	3.49
2	Mineral products	70.8	73.45	2.65
3	Recreational and other services	44.1	46.32	2.22
4	Construction	11.3	12.27	0.97
5	Machinery and equipment	7.4	8.11	0.71
6	Water transport	32.2	32.75	0.55
7	Oil	15	15.29	0.29
8	Minerals	9.4	9.68	0.28
9	Coal	6.1	6.25	0.15
10	Manufacturing	4.4	4.46	0.06

Source: author's estimation from GTAP model

5.2.3 Impact on resource depletion

The impact of trade liberalization on natural resource depletion refers to changes in primary production¹⁸. Trade liberalization has both positive and negative impacts on the resource sector, which are shown in Table 7. Trade liberalization leads to a decline in forestry and fishery, but it also leads to an increase in the use of coal, gas and minerals. This shows that trade liberalization will increase resource depletion, especially in coal, oil, gas and minerals.

Table 7. Impact on resource sector output levels

Code	Commodity	Percentage change (%)
frs	Forestry	-2.35
fsh	Fishing	-0.03
coa	Coal	0.99
oil	Oil	1.88
gas	Gas	2.21
omn	Minerals	1.94

Source: author's estimation from GTAP model

5.2.4 Impact on welfare

Using the simulated price and output changes based on the GTAP model, the predictions regarding changes in welfare and poverty were created using the Lao household survey (LECS 3). Table 8 summarizes the results of the micro-simulation. The first panel in the table shows the median change in welfare for households with the tariff reduction in terms of rural and urban regions, and poverty in the baseline economy. The second column indicates the median revenue of households (net income from agricultural non-farm household business – expenditure) and this column implies whether households are buyers or sellers in the economy¹⁹. As seen in the table, all of the numbers are negative, and this means that on average households

¹⁸ In many other cases resource depletion also means the declining stock of reserves, which is a function of available reserves.

¹⁹ Wage income is not included in the numbers in this column.

in Laos are net buyers rather than sellers. The third and fourth columns indicate the estimated per capita welfare changes and the percentage of the welfare change in income, respectively. The former implies the absolute size of the welfare change, and the latter implies the relative size. As seen in the table, the welfare change across the entire country is negative by 761.3 kips, -0.65% of the income²⁰. However, the direction of the welfare change in rural areas is the opposite of that in urban areas (-872.3 kips in rural areas and 617.1 in urban areas). The direction of the relative welfare change is the same as that of the absolute sizes in rural and urban areas. These results mean that welfare changes for households due to tariff reduction are heterogeneous. In the panel, welfare changes are estimated over regions and poverty status in the baseline economy. As seen in the panel, households in Vientiane benefit from the tariff cut but households in the rest of the regions are worse off. In addition, non-poor households in urban areas benefit from the policy change, but the rest of the households become worse off, and poor households in rural areas suffer the most. Therefore, welfare change due to tariff reduction across the entire economy is negative, but this differs according to region (whether rural or urban) and poverty status. The second panel in the table shows the change in economic inequality due to tariff reduction using the Gini index. I found that there was almost no change in inequality due to tariff reduction (as seen in the panel). The Gini index increased slightly from the baseline to simulation, but this was negligible.

The last panel in Table 8 shows the impacts of tariff reduction on poverty. The poverty rate in the entire country increases slightly due to tariff reduction but the changes are heterogeneous across rural and urban regions. As seen in the table, the poverty headcount rate increases by 0.4% from 34.4%. However, the poverty rate increases by 0.7% in rural areas and decreases by 0.3% in urban areas. Finally, poverty rates decrease in Vientiane and also drop in the rest of the regions. These changes in poverty rate are consistent with those in welfare changes, as discussed in the previous paragraph. This is because the change in household welfare is measured by the change in household income.

As discussed in this section, the impacts of the tariff reduction on welfare are positive for urban households, households in Vientiane, and the urban non-poor, but are negative for all other households. The sizes of these welfare changes are not large but trade liberalization creates both winners and losers within the country. The impacts of trade liberalization on inequality are negligible but the impacts on poverty are heterogeneous across rural and urban regions, as is the case for changes in welfare.

There are three main reasons for differences in welfare changes between urban and rural areas as a result of trade liberalization: changes in wages, changes in the prices of consumer goods, and changes in revenue from the sale of agricultural products.

The first source of the difference is due to increases in wages. Urban areas will gain more waged income from trade liberalization in some sectors, such as garment-making and manufacturing, rather than rural areas because most factories and industries in Laos are concentrated in urban areas. Even agricultural wage income is higher in urban areas than in rural areas, so the benefit from trade liberalization in rural areas is limited. Therefore, urban areas will gain a higher benefit in term of wage

²⁰ The direction of the welfare change in the entire country in this micro-estimation is opposite to that in the macro-simulation from the GTAP model. This sounds strange, but the former uses the change in income as a welfare indicator, and the latter uses the equivalent variation.

income than rural areas. The second difference is due to lower prices for consumer goods. Trade liberalization leads to lower domestic prices in some sectors, such as motor vehicles and parts, machinery and equipment, and these commodities are mostly consumed by urban households. Therefore, urban households will gain greater benefits from trade liberalization in terms of lower prices rather than rural households. The third difference is due to changes in income from the sale of agricultural products. The agriculture sector is mainly located in rural areas. Rural areas have poor infrastructure and poor agricultural land compared to urban areas. Rural areas might benefit from an increase in revenue from the sale of their agriculture products due to increases in crop prices brought about by trade liberalization. However, returns from agricultural sales in rural areas are not very significant because the value of sales in rural areas is not as large as the value of wage income. Therefore, households (possibly poorer) in rural areas cannot take advantage of the benefits of trade liberalization. Urban households will gain more benefits than rural households from trade liberalization.

Table 8. Summary of statistics on aggregate welfare impacts

1. Median welfare change			
	Revenue per capita (kip)	Change per capita (kip)	Percentage in income
National	-37,917	-761.3	-0.649
Rural	-30,875	-872.3	-0.767
Urban	-90,044	617.1	0.242
Region			
Vientiane (capital)	-108,500	1717	0.554
North	-28,100	-941.3	-0.794
Central	-40,500	-722	-0.638
South	-37,670	-761.3	-0.672
Poverty estimated by expenditure			
Non-poor	-61,500	-649.9	-0.405
Poor	-16,214	-855.2	-0.938
Rural non-poor	-50,750	-851.6	-0.572
Rural poor	-14,750	-895.8	-0.97
Urban non-poor	-115,625	1311.9	0.421
Urban poor	-37,238	-382.8	-0.42
2. Gini index as percentage			
	Baseline	Simulated	Change
Total	43.25	43.54	0.3
Rural	38.25	38.53	0.28
Urban	39.54	39.7	0.16
Region			
Vientiane (capital)	37.41	37.54	0.13
North	39.73	40.01	0.28
Central	41.41	41.71	0.29
South	40.71	41	0.29
3. Poverty impacts (headcount index, percentage)			
	Baseline	Simulated	Change
National	34.4	34.8	0.4
Rural	32.8	33.5	0.7
Urban	39.6	39.2	-0.3
Region:			
Vientiane (capital)	46.1	45.4	-0.6
North	33.5	34.3	0.7
Central	34.5	34.8	0.3
South	29	29.7	0.7

Sources: author's computations based on the GTAP

6.0 CONCLUSIONS AND RECOMMENDATIONS

The main objective of this study is to assess the impact of trade liberalization on poverty and pollution by using a multi-region, multi-sector CGE model (GTAP) and micro-simulation. The following conclusions can be drawn.

Trade liberalization has a positive impact on growth, but its impact is relatively small. Surprisingly, trade liberalization also decreases CO₂ emissions but its percentage change is very small. In addition, trade liberalization increases resource depletion in sectors such as coal, gas and minerals. The micro-simulation using the household survey (LECS 3) indicates that the change in household welfare due to tariff reduction is not homogenous but heterogeneous. The winners from the tariff cut are households in urban areas, Vientiane, and non-poor households in urban areas. The losers from this policy change are households that do not belong to the above categories – their household income drops and the rate of poverty increases.

As trade liberalization will have winners and losers, Government should find a way to protect those who will lose out. Even though trade liberalization will not increase CO₂ emissions, there are various ways in which trade liberalization will have an effect on the environment and the Government should not overlook this issue and should strengthen rules and regulations to protect the environment.

However, this study is characterized by several weaknesses. Firstly, trade liberalization though membership of the WTO confers various benefits, but this simulation focuses only on tariff cuts, and so might underestimate the impact of WTO accession. Secondly, this study focuses only on the impact of WTO accession on CO₂ emissions, without considering other forms of air, water, and soil pollution. Moreover, this top-down approach has several weaknesses. Firstly, there is no behavior response that links the macro and micro accounting model, which is major criticism of this approach (Bourguignon, Bussolo and Silav, 2008). Secondly, this study focuses on the short-term welfare impact of trade policy changes. This approach does not capture the dynamic effect trade policy changes might bring to the labor market and technical innovation (Ravallion and Lokshin, 2008). Thirdly, this approach does not capture feedback from externalities of trade policy changes on productivity and utilities. For instance, increased pollution from trade policy changes has an inverse impact on the productivity of firms and decreasing household utilities (Xie and Saltzman, 2000).

REFERENCES

- Adams, P.D. 2005. Interpretation of results from CGE models such as GTAP. *Journal of Policy Modeling*. Vol. 27. 941-959.
- ADB, GEF and UNEP. 2006. Lao PDR National Environmental Performance Assessment EPA Report. Science Technology and Environmental Agency. Lao PDR and Project Secretariat UNEP Regional Resource Center for Asia and The Pacific.
- Anderson, A. 1998. Lao PDR and WTO Accession: Implications for Agriculture and Rural Development. School of Economics and Centre for International Economic Studies. University of Adelaide. Australia.
- Akkharath, I. 2003. The agricultural development policy and WTO accession of Lao PDR. World Trade Organization.
- Beghin, J.; S. Dessus; D. Roland-Holst; and D. Van der Mensbrugghe. 1997. The Trade and Environmental Nexus In Mexican Agriculture; A General Equilibrium Analysis. *Agricultural Economics*. 17. 2-3. 115-131.
- Beghin J.C.; B.J. Bowland; S. Dessus; D.R. Holst; and D. Ven Der Mensbrugghe. 2002. Trade Integration, Environmental Degradation and Public Health in Chile: Assessing the Linkages. *Environment and Development Economics*. 7: 241–267. Cambridge University Press. UK.
- Bourguignon, F.; M. Bussolo; and L.A.P. Silav. 2008. Introduction: Evaluating the Impact of Macroeconomic Policies on Poverty and Income Distribution. *In The impact of Macroeconomic Policies on Poverty and Income Distribution: Macro-Micro Evaluation Techniques and Tools*. Bourguignon, Bussolo, and Silav. (eds.). The World Bank. Washington. DC. USA.
- Brockmeier, M. 1996. A graphical exposition of the GTAP model. *GTAP technical paper*. Purdue University: Center for Global Trade Analysis.
- CAIT. 2011. Climate Analysis Indicators Tool. World Resources Institute. Available at: <http://cait.wri.org>
- Cavendish, W. 1999. Poverty, Inequality and Environmental Resources; Quantitative Analysis of Rural Households. Working Paper Series 99-9. Centre for The Study of African Economies. University of Oxford. UK.
- Cavendish, W. 2000. Empirical Regularities in the Poverty-Environment Relationship of African Rural Households. *World Development*. 28 (1); 1979-2003.
- Chaipan C.; T.D. Hguen; and M. Ezaki. 2006. Regional Economic Integration and its Impacts on Growth, Poverty and Income Distribution; The Case of Thailand. Discussion Paper No. 147. Graduate School of International Development. Nagoya University. Japan.
- Chen, S. and M. Ravallion. 2004. Welfare impacts of China's access to the World Trade Organization. *The World Economic Review*. Vol. 18. No. 1. p 29-57.
- Copeland, B. and S. Taylor. 2003. Trade and The Environment; Theory and Evidence. Princeton University Press. USA.
- Copeland, B.R. and S.M. Taylor. 1994. North-South Trade and the Environment. *Quarterly Journal of Economics*. 109; 755- 787.

- Corong, E.L. 2007. Tariff Reduction, Carbon Emissions and Poverty: An Economy-wide Assessment of The Philippines. Research Report, The Economy and Environment Program for South East Asia (EEPSEA).
- Cororaton C.; J. Cockburn; and E. Corong. 2005. Doha Scenarios: Trade Reforms and Poverty in The Philippines; A CGE Analysis. PEP-MPIA Working Paper No. 2005-03.
- Coxhead. I. and S. Jayasuriya. 2003. The Open Economy and The Environment; Development, Trade and Resources in Asia. Edward Elgar Publishing. UK.
- Dasgupta, S.; U. Deichmann; C. Meisner; and D. Wheeler. 2003. The Poverty/Environment Nexus in Cambodia and Lao People's Democratic Republic. World Bank Policy Research Working Paper 2960. The World Bank. Washington DC. USA.
- Department of Agricultural Economics, Purdue University. NSC. 2003. The Households of Lao PDR: Social and Economic Indicators, Lao Expenditure and Consumption Survey 1997/98. Vientiane. Laos.
- Dollar, D. 1992. Outward-Oriented Developing Economies Really Do Grow More Rapidly: Evidence From 95 LDCs, 1976-1985. Economic Development and Culture Change. Vol. 40(3). 523-44.
- Emerton, L. et al. 2002. Nam Et-Phou Loei National Biodiversity Conservation Area. Lao PDR: A Case Study of Economic and Development Linkages. IUCN The World Conservation Union. Lao PDR.
- Frankel, J. and A.K. Rose. 1999. Does Trade Cause Growth? American Economic Review. Vol. 89(3) June. 379-99.
- Fujii, T. and D. Roland-Holst. 2007. How Does Vietnam's Accession to The World Trade Organization Change the Spatial Incidence of Poverty? Research Paper No. 2007/12. World Institute for Development Economics Research. United Nations University.
- Fukase, E. and W. Martin. 1999. Economic Effect of Joining The ASEAN Free Trade Area (AFTA): The Case of The Lao People's Democratic Republic. World Bank. Washington DC. USA.
- GoL. 2004. The National Growth and Poverty Eradication Strategy (NGPES). Committee of Planning and Investment. Vientiane. Laos.
- GoL, 2006. Sixth National Socio Economic Development Plan (NEDP) for 2006-2010. Committee of Planning and Investment. Vientiane. Laos.
- Grossman, G.E. and A.B. Krueger. 1992. Environmental Impact of a NAFTA. CEPR Discussion Paper Series. No. 644. April.
- Grossman, G.M. and B.A. Krueger. 1995. Economic Growth and the Environment. Quarterly Journal of Economics. May, 1995. 110(2). 353-77.
- Hanslow, K.J. 2000. A General Welfare Decomposition for CGE Models. GTAP Technical Paper No. 19.
- Hertel, T. W. (ed). 1997. Global Trade Analysis: Modeling and Applications. Cambridge University Press.
- Ianchovichina, E. and M. Will. 2001. Trade liberalization in China's accession to the World Trade Organization, Policy Research Working Paper Series 2623, The

World Bank.

- IISD; SIDA; and IUCN. 2007. Rapid Trade and Environment Assessment (RTEA) National Report for Lao PDR. International Institute for Sustainable Development.
- IPCC/OECD/IEA. 1999. Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. Intergovernment Panel on Climate Change (IPCC), Paris, Organization for Economic Co-operation and Development (OECD), International Energy Agency (IEA).
- Kyophilavong Phouphet. 2006. Can Laos Gain Benefit by Joining AFTA? How Much? A CGE Model Approach. Academic Journal of National University of Laos. Vol. 1. No. 1.
- Kyophilavong, P. 2008. SMEs Development in Lao PDR. *In* Hank Lim (ed). Asian SMEs and Globalization. ERIA Research Project Report 2007. Economic Research Institute for ASEAN and East Asia (ERIA).
- Kyophilavong, P. 2010. Lao People's Democratic Republic: Dealing with Multi Currencies. *In* Capannelli, G. and J. Menon. Dealing with Multiple Currencies in Transitional Economies. Asian Development Bank.
- Lee, H.L. 2008. The Combustion-Based CO₂ Emission Data for GTAP Version 7 Data Base. Department of Economics. National Chengchi University. Taiwan.
- Li, S. and F. Zhai. 2000. The Impact of Accession to WTO on China's Economy. Development Research Center. P. R. China.
- Magnus, A.; E. Anders; and A. Kokko. 2005. Determinants of Poverty in Lao PDR. Working Paper. Stockholm School of Asian Studies. Stockholm School of Economics. Mimeo.
- Martin, W. 2001. Trade Policy Reform in the East Asian Transition Economies. Policy Research. Working Paper 2535. The World Bank.
- Mukhopadhyay, K. and P.J. Thomassin. 2010. Economic and Environmental Impact of Free Trade in East and South East Asia. Springer. London.
- Narayann, B.G. and T. Walsmsley. 2008. Global Trade, Assistance, and Production: the GTAP 7 Data Base. Center for Global Trade Analysis.
- OECD. 1994. The Environmental Effects of Trade. Organisation for Economic Cooperation and Development. Paris.
- Perroni, C. and R.M. Wigle. 1994. International Trade and Environment Quality: How Important Are the Linkages? Canadian Journal of Economics. 27.551-567.
- Phimmavong, S.; B. Ozarska; S. Midgley; and R. Keenan. 2009. Forest and Plantation Development in Laos: History, Development and Impact for Rural Communities. International Forestry Review. Vol. 11(4). 501-513.
- Pholsena, K.; G. Isacson; L. Douangboupha; B. Vilavong; and S. Phounesavath. 2007. Addressing the Impact of the Phasing Out of Textiles and Clothing Quotas in Lao PDR (4). National Statistic Centre. Vientiane. Laos.
- Rafaelita, M. Aldaba; and B. Cororaton Caesar. 2002. Trade Liberalization and Pollution: Evidence from the Philippines. Research Report, The Economy and Environment Program for South East Asia (EEPSEA).

- Ravallion, M. and M. Lokshin. 2008. Winners and Losers from Trade Reform in Morocco. *In The impact of Macroeconomic Policies on Poverty and Income Distribution: Macro-Micro Evaluation Techniques and Tools*, Bourguignon, Bussolo, and Silav, eds. The World Bank. Washington DC. USA.
- Richter, K.; R. Van Der Weide; and Phonesaly Souksavath. 2005. Lao PDR Poverty Trends 1992/93-2002/3. National Statistics Centre, Vientiane, and World Bank.
- Santos-Paulino, A.U. 2005. Trade Liberalisation and Economic Performance: Theory and Evidence for Developing Countries. *The World Economy*. Vol. 28(6). 783-821.
- Shaw, S.; A. Cosbey; H. Baumuller; IUCN Laos; T. Callender; and L. Sylavong. 2007. Rapid Trade and Environment Assessment (RTEA): National Report for Lao PDR. International Institute for Sustainable Development (IISD), SIDA and IUCN.
- Strut, A. and K. Anderson. 2000. Will Trade Liberalization Harm the Environment? The Case of Indonesia to 2020. *Environmental and Resource Economics* 17. 203-232.
- Strutt, A. and K. Anderson. 2005. Trade Liberalization and Poverty Alleviation in the GMS. *Journal of GMS Development Studies*. Vol.2 (1): 1-20.
- Susmita, D.; D. Uwe; M. Craig; W. David. 2005. Where is the Poverty-Environment Nexus? Evidence from Cambodia, Lao PDR, and Vietnam. *World Development*. Vol. 33(4). 617-638.
- Warr, P, 2006. The Gregory Thesis Visits the Tropics. *The Economic Record*. Vol. 82. No. 257. 177-194.
- Warr, P.; J. Menon; and A.A. Yusuf. 2010. Regional Economic Impact of Large Projects: A General Equilibrium Application to Cross-Border Infrastructure. *Asian Development Review*. 2010. Vol. 27. No. 1. 104-134.
- WB and STEA. 2008. Lao PDR Environmental Monitor. The World Bank and Science Technology and Environment Agency. Vientiane. The World Bank.
- Winter, L.A. 2004. Trade Liberalization and Economic Performance: an Overview. *The Economic Journal*. 114. F4-F21.
- Winter, L.A.; N. McCulloch; and A. McKay. 2004. Trade Liberalization and Poverty: The Evidence so far. *Journal of Economic Literature*. Vol. XLII. 72-115.
- World Bank. 2009. Lao PDR: Recent Economic Developments. World Bank Vientiane Office. Laos.
- Xie; and S.J. Saltzman. 2000. Environmental Policy Analysis: An Environmental Computable General-Equilibrium Approach for Developing Countries. *Journal of Policy Modeling*. 22(4). 453-489.
- Yang. 2001. Trade Liberalization and Pollution: A General Equilibrium Analysis of Carbon Dioxide Emission in Taiwan. *Economic Modeling*. 18, 2001. 435-454.
- Yusuf, A. A. 2007. Distribution Impact of Environment Policies: The Case of Carbon Tax and Energy Price Reform in Indonesia. Research Report. The Economy and Environment Program for South East Asia (EEPSEA).

APPENDICES

Appendix 1. Trade agreements and preferences

Trade agreement/preference	Type of agreement	Entry into force	Fully effective	Membership
Normal trade relations with the USA	Normal trade relations status	Feb 2005	MFN tariff treatment	Exports from Laos PDR receive the same MFN treatment as WTO members
EU GSP	GSP quota-free preferences	1995	As an LDC	LDCs
EU Everything But Arms initiative	Duty-free, quota-free access	Jun 2005	As an LDC	LDCs
Australia GSP	Preferences	Jul 2003	As an LDC	LDCs
New Zealand GSP	Duty-free, quota-free access	Jul 2001	As an LDC	LDCs
Japan GSP	Duty-free, quota-free access	Apr 2001	As an LDC	LDCs
WTO	Multilateral trade agreement	In the process of accession	To be determined in the accession negotiations	151 WTO member countries

Sources: IISD, SIDA, IUCN (2007)

Appendix 2. Key environmental and socio-economic laws and regulations

Laws and regulations	Year	Key provisions
New Economic Mechanism	1986	Begins restructuring toward a market-oriented economy
Tropical Forest Action Plan	1991	Forest management plan for the country, emphasizing community involvement and alternatives to shifting cultivation
Science, Technology and Environment Agency (STEA)	1993	Established under the Prime Minister's Office as the principle government agency for formulating and guiding environmental policy
Forestry Law	1996	Classification of land, management and planning, biodiversity conservation
Water and Water Resource Law	1996	Regulates the management and sustainable use of water and water resources
Land Law	1997	Allocation of land to individuals and companies
Mining Law	1997	Regulations concerning development of land for mining operations
Environmental Protection Law	1999	Advocates public participation and the use of EIAs in project planning
Industrial Law	1999	Establishes the requirement for environmental assessments in industries and development projects
Environmental Impact Assessment Regulation	2000	Decree to undertake EIAs for approval of development projects
National Protected Areas Regulations	2001	Clarifies the concept of National Protected Areas
National Environment Committee (NEC)	2002	Coordinating body mandated to provide advice on environment-related matters and to coordinate environmental management and monitoring
National Growth and Poverty Eradication Strategy (NGPES)	2004	Five-year strategic plan for national growth and poverty reduction
National Biodiversity Strategy and Action Plan (NBSAP)	2004	Plan for biodiversity conservation
Law on the Promotion of Foreign Investment	2004	Framework for foreign investment
Environment Protection Fund	2005	Decree to finance projects to conserve or protect the environment or to strengthen environmental management
National Socio-Economic Development Plan (NSEDPA)	2006-2010	Five-year plan to reform the economy
Water Resources and Environment Agency (WREA)	2007	Responsible for managing water and environmental resources to ensure sustainable development

Sources: IISD, SIDA, IUCN (2007)

Appendix 3. Poverty and inequality in Laos

Poverty in Laos	LECS 1 1992/93	LECS 2 1997/98	LECS 3 2002/03	Change 92/93 to	Change 97/98 to
Northern region	51.6	47.3	37.9	-4.3	-9.4
Central region	45	39.4	35.4	-5.6	-4
Southern region	45.7	39.8	32.6	-5.9	-7.2
Vientiane	33.6	13.5	16.7	-20	3.2
Lao PDR	46	39.1	33.5	-6.9	-5.6

Sources: Richter and Phonesaly (2005)

Inequality in Laos	1992/3	1997/8	2002/3	2007/8
Lao PDR	30.5	34.9	32.6	35.4
Area				
Urban	30.9	39.7	34.8	36.3
Rural	39	32.1	30.3	33.4
Rural area, with road	29.3	32.1	30.3	33.2
Rural area, without road	27.5	30.9	29.4	33.3
Region				
Vientiane M	29.7	36.9	36	38
North	26.9	34.5	30.7	35.2
Central	31.5	32.5	31	34
South	32.3	32.4	31.4	32.2

Sources: World Bank and DOS (2009)

Appendix 4. The 57 sectors examined in the model

No.	Code	Description	No.	Code	Description
1	PDR	Paddy rice	29	LEA	Leather products
2	WHT	Wheat	30	LUM	Wood products
3	GRO	Cereals, grains	31	PPP	Paper products, publishing
4	V_F	Vegetables, fruit, nuts	32	P_C	Petroleum, coal products
5	OSD	Oil seeds	33	CRP	Chemicals, rubber, plastic products
6	C_B	Sugar cane, sugar beet	34	NMM	Mineral products
7	PFB	Plant-based fibers	35	I_S	Ferrous metals
8	OCR	Crops	36	NFM	Metals
9	CTL	Bovine cattle, sheep and goats, horses	37	FMP	Metal products
10	OAP	Animal products	38	MVH	Motor vehicles and parts
11	RMK	Raw milk	39	OTN	Transport equipment
12	WOL	Wool, silk-worm cocoons	40	ELE	Electronic equipment
13	FRS	Forestry	41	OME	Machinery and equipment
14	FSH	Fishing	42	OMF	Manufactures
15	COC	Coal	43	ELY	Electricity
16	OIL	Oil	44	GDT	Gas manufacture, distribution
17	GAS	Gas	45	WTR	Water
18	OMN	Minerals	46	CNS	Construction
19	CMT	Bovine meat products	47	TRD	Trade
20	OMT	Meat products	48	OTP	Transport
21	VOL	Vegetable oils and fats	49	WTP	Water transport
22	MIL	Dairy products	50	ATP	Air transport
23	PCR	Processed rice	51	CMN	Communication
24	SGR	Sugar	52	OFI	Financial services
25	OFD	Food products	53	ISR	Insurance
26	B_T	Beverages and tobacco products	54	OBS	Business services
27	TEX	Textiles	55	ROS	Recreational and other services
28	WAP	Wearing apparel	56	OSG	Public administration, defense, education, health
			57	DWE	Dwellings

Source: GTAP, data base 7

Appendix 5. The regions in the model

No.	Region code	Comprising	Region description
1	Oceania	AUS (Australia), NZL (New Zealand), ROC (Rest of Oceania), CHN (China), HKG (Hong Kong), JPN (Japan), KOR (Korea), TWN (Taiwan), XEA (rest of East Asia)	Australia, New Zealand
2	East Asia	KHM (Cambodia), IDN (Indonesia), MMR (Myanmar), MYS (Malaysia), PHL (Philippines), SGP (Singapore), THA (Thailand), VNM (Vietnam), XSE (rest of Southeast Asia)	East Asia
3	SE Asia	BGD (Bangladesh), IND (India), PAK (Pakistan), LKA (Sri Lanka), XSA (rest of South Asia)	Southeast Asia
4	South Asia	CAN (Canada), USA (United States Of America), MEX (Mexico), XNA (rest of North America)	South Asia
5	North America	ARG (Argentina), BOL (Bolivia), BRA (Brazil), CHL (Chile), COL (Colombia), ECU (Ecuador), PRY (Paraguay), PER (Peru), URY (Uruguay), VEN (Venezuela), RSM (Rest of South America), CRI (Costa Rica), GTM (Guatemala), NIC (Nicaragua), PAN (Panama), RCA (rest of Central America), XCB (Caribbean)	North America
6	Latin America	AUT (Austria), BEL (Belgium), CYP (Cyprus), CZE (Czech Republic), MLT (Malta), NLD (Netherlands), POL (Poland), PRT (Portugal), SVK (Slovakia), DNK (Denmark), EST (Estonia), FIN (Finland), FRA (France), DEU (Germany), GRC (Greece), HUN (Hungary), IRL (Ireland), ITA (Italy), LVA (Latvia), LTU (Lithuania), LUX (Luxembourg), MLT (Malta), NLD (Netherlands), POL (Poland), PRT (Portugal), SVK (Slovakia), SVN (Slovenia), ESP (Spain), SWE (Sweden), GBR (United Kingdom)	Latin America
7	EU25	NGA (Nigeria), SEN (Senegal), XWF (rest of Western Africa), XCF (rest of Central Africa), XAC (rest of South Central Africa), ETH (Ethiopia), MDG (Madagascar), MWI (Malawi), MUS (Mauritius), MOZ (Mozambique), TZA (Tanzania), UGA (Uganda)	European Union 25
8	SSA	ZMB (Zambia), ZWE (Zimbabwe), XEC (rest of Eastern Africa), BWA (Botswana), ZAF (South Africa), XSC (rest of South Africa Customs Union)	Sub-saharan Africa
9	LAOS	LAO (Lao People's Democratic Republic)	Laos
10	Rest of world	SWL (Switzerland), NOR (Norway), XEF (rest of EFTA), ALB (Albania), BGR (Bulgaria), BLR (Belarus), CRO (Croatia), ROU (Romania), RUS (Russian Federation), UKR (Ukraine), XEE (rest of Eastern Europe), XER (rest of Europe), KAZ (Kazakhstan), KGZ (Kyrgyzstan), XSU (rest of former Soviet Union), ARM (Armenia), AZE (Azerbaijan), GEO (Georgia), IRN (Iran, Islamic Republic of), TUR (Turkey), XWS (rest of Western Asia), EGY (Egypt), MAR (Morocco), TUN (Tunisia), XNF (rest of North Africa)	Rest of world

Source: author, compiled from GTAP database

Appendix 6. Percentage of *ad valorem* rate (import tax)

No.	Code	1. Oceania	2. East Asia	3. South-east Asia	4. South Asia	5. North America	6. Latin America	7. EU25	8. SSA	9. Rest of world	10. Laos
1	PDR	472.3	557.3	595.2	387.5	522.7	124.7	55.5	4.1	531.7	58
2	WHT	75.6	44	180.2	30.1	101.2	62.8	39.3	3.9	70.5	0
3	GRO	106.6	90.3	54.2	84.5	109.7	86.8	62.7	56.3	110	38.6
4	V-F	94.5	165.8	140.2	73.6	102.1	117.7	104.4	142.5	79.2	57.6
5	OSD	41.7	180.3	90.3	189.4	39	59.5	56.2	219.6	59.3	22.3
6	C-B	9.9	4	5.1	4.2	14	17.9	19.7	2.9	14.2	0
7	PFB	15.4	20.3	21.3	25.5	16.4	24.8	21.5	27.9	27.5	0.8
8	OCR	76.3	132.2	106.3	94.3	197.2	134.3	119.4	99	141.6	41.5
9	CTL	19.5	18.9	48.1	14.1	51.1	31	44.7	19.3	10.6	5
10	OAP	32.3	51.2	35.5	47.6	53.3	41.8	50.3	17.7	29.3	14.1
11	RMK	0	0	0	0	0	0	0	0	0	0
12	WOL	61.7	32.2	10.4	30.4	60.3	54.3	59.2	24.4	21.9	0
13	FRS	29.4	51	27.4	63.3	32.2	25.7	32.1	37.9	23.8	35
14	FSH	49.5	52.8	63	57	90.5	54.6	72.1	87.3	64.8	7
15	COC	35.7	34.2	40.8	17.6	34.6	23.5	15.5	49.7	30.5	0
16	OIL	35.2	3.2	17.8	0.1	11.8	24	1.2	12.6	19	0
17	GAS	0	1.5	10.4	14.1	0.7	9.1	0.9	0.1	10.6	0
18	OMN	17.3	29.8	25.5	25.7	20.5	11.5	31.4	20	24.9	2.2
19	CMT	138.2	51.4	88.2	334.6	142.9	192.1	92.7	140	52.5	0
20	OMT	138	133.1	160.9	123.6	206.8	122.8	212.4	64.6	86.2	1.1
21	VOL	68.8	123.5	141.6	46.1	89.4	77.1	119	144	145.1	3.3
22	MIL	189.6	119.2	181.4	147.7	172.8	143	149.5	136.1	177.4	11.5
23	PCR	387.1	605.6	315.1	468.4	508	142.3	167.2	101.7	615.8	85.7
24	SGR	413.8	167.5	284.5	260.2	166.3	371.3	137.7	306.5	259.3	0
25	OFD	135.4	158.4	111.4	97.4	138.6	88.4	146.4	113	123.3	23
26	B-T	322.1	334.7	354	335.8	286.5	375.3	246.9	301.7	303.3	53.9
27	TEX	88.6	135	107.1	109.2	76.6	108.5	95.8	65.1	110.1	61.3
28	WAP	118.4	165.7	143.8	139.3	125.9	102.9	135.4	71.1	130.4	50
29	LEA	66.6	142.5	119.5	74.1	100	62.6	102.2	65.8	91.2	38.3
30	LUM	68.5	117.5	81.5	72.1	67.4	53.3	105.6	59.3	82.5	44.8
31	PPP	47.1	78.2	61.2	57.5	44.1	40.3	59.2	38.4	57.2	9.3
32	P-C	54.1	48.2	61	34	47.5	81.5	75.9	59.6	54.3	4.1
33	CRP	58	77.1	65.8	59.2	55.7	56	56.4	59.6	50.1	50.7
34	NMM	73.5	93.3	77.2	83.7	63.2	69.3	80.5	57	74.5	25.4
35	I-S	44.6	70.2	58.1	59.5	46.7	48.4	64.4	52.5	57	20.3
36	NFM	37.6	51.1	35.6	45.3	33.9	32.1	46.2	32.9	41	4.9
37	FMP	73.3	90.7	76.3	88.2	70.8	54.7	78.5	83.4	76.8	18.4
38	MVH	116.1	174.6	120.8	122.2	141.2	126.4	158.8	66	143.9	36.2
39	OTN	42.1	98.8	47	62.8	25.9	35.6	45.9	32.5	32.4	4.9
40	ELE	38.8	38.3	35.4	54.2	25	17.8	36.3	46.1	46.8	14.3
41	OME	48.5	63.5	60.4	52.7	44.8	47.2	52.7	51.9	51.7	16.3
42	OMF	94	88	70.4	56.1	71.3	43.1	85.5	63.1	58.2	21
43	ELY	0	1.3	0	0	0.3	0	0.9	1.6	1	0
44	GDT	0	0	0	0	0	0	0	0	0	0
45	WTR	0	0	0	0	0	0	0	0	0	0
46	CNS	0	0	0	0	0	0	0	0	0	0
47	TRD	0	0	0	0	0	0	0	0	0	0
48	OTP	0	0	0	0	0	0	0	0	0	0
49	WTP	0	0	0	0	0	0	0	0	0	0
50	ATP	0	0	0	0	0	0	0	0	0	0
51	CMN	0	0	0	0	0	0	0	0	0	0
52	OFI	0	0	0	0	0	0	0	0	0	0
53	ISR	0	0	0	0	0	0	0	0	0	0
54	OBS	0	0	0	0	0	0	0	0	0	0
55	ROS	0	0	0	0	0	0	0	0	0	0
56	OSG	0	0	0	0	0	0	0	0	0	0
57	DWE	0	0	0	0	0	0	0	0	0	0

Appendix 7. CO₂ emissions by sector (1,000 tonnes)

No.	Code	Sector	Coal	Crude oil	Natural gas	Petrol	Electricity	Gas distribution	Total
1	PDR	Paddy rice	0.1	0	0	3	0	0.1	3.2
2	WHT	Wheat	0	0	0	0	0	0	0
3	GRO	Cereal, grains	0	0	0	0	0	0	0
4	V_F	Vegetables, fruit, nuts	3	0	0	0.9	0	0	3.9
5	OSD	Oil seeds	0	0	0	0	0	0	0
6	C_B	Sugar cane, sugar beet	0	0	0	0.1	0	0	0.1
7	PFB	Plant-based fibers	0	0	0	0	0	0	0
8	OCR	Crops	0	0	0	0.4	0	0	0.4
9	CTL	Bovine cattle	0.1	0	0	0.8	0	0.5	1.4
10	OAP	Animal products	0.3	0	0	1.9	0	0.6	2.8
11	RMK	Raw milk	0	0	0	0	0	0	0
12	WOL	Wool, silk-worm cocoons	0	0	0	0	0	0	0
13	FRS	Forestry	0.8	0	0	5.8	0	0.1	6.7
14	FSH	Fishing	0.1	0	0	13.1	0	0.2	13.4
15	COC	Coal	5.7	0	0	0.4	0	0	6.1
16	OIL	Oil	0	1.4	0.1	0.9	0	12.7	15.1
17	GAS	Gas	0	0	0	0	0	0	0
18	OMN	Minerals	1.5	0	0	5.7	0	2.2	9.4
19	CMT	Bovine meat products	0.2	0	0	0	0	0	0.2
20	OMT	Meat products	0.2	0	0	0	0	0	0.2
21	VOL	Vegetable oils and fats	0	0	0	0.1	0	0.1	0.2
22	MIL	Dairy products	0	0	0	0	0	0.1	0.1
23	PCR	Processed rice	0.7	0	0	2.2	0	0.8	3.7
24	SGR	Sugar	0	0	0	0	0	0	0
25	OFD	Food products	3.6	0	0	3.1	0	4.4	11.1
26	B_T	Beverages and tobacco products	1.5	0	0	2.8	0	3.8	8.1
27	TEX	Textiles	1.9	0	0	1.4	0	1.2	4.5
28	WAP	Wearing apparel	1.5	0	0	1.2	0	1	3.7
29	LEA	Leather products	0.2	0	0	0.1	0	0.1	0.4
30	LUM	Wood products	0.7	0	0	1.2	0	0.8	2.7
31	PPP	Paper products, publishing	4.1	0	0	2.9	0	4.4	11.4
32	P_C	Petroleum, coal products	0	0	4.2	0	0	50.9	55.1

33	CRP	Chemicals, rubber, plastic products	3.7	1	0.1	25.6	0	15.5	45.9
34	NMM	Mineral products	42.6	0	0	16.5	0	11.7	70.8
35	I_S	Ferrous metals	4.7	0	0	6.9	0	5	16.6
36	NFM	Metals	1.2	0	0	1.4	0	1.8	4.4
37	FMP	Metal product	1.6	0.1	0	1.8	0	3.1	6.6
38	MVH	Motor vehicles and parts	0.6	0	0	0.7	0	1.8	3.1
39	OTN	Transport equipment	0.3	0	0	0.3	0	0.7	1.3
40	ELE	Electronic equipment	0.1	0	0	1.3	0	0.6	2
41	OME	Machinery and equipment	1.2	0	0	2.7	0	3.4	7.3
42	OMF	Manufacturing	0.9	0.1	0	2.1	0	1.2	4.3
43	ELY	Electricity	432.5	3.7	5.5	62	0	149.5	653.2
44	GDT	Gas manufacturing, distribution	3.3	0.5	0	1.4	0	19.8	25
45	WTR	Water	1.7	0	0	0.2	0	0.3	2.2
46	CNS	Construction	1.8	0	0	8.5	0	0.9	11.2
47	TRD	Trade	1.8	0.1	0	12.3	0	13.3	27.5
48	OTP	Transport	1.4	0	0.1	175	0	13.1	189.6
49	WTP	Water transport	0.1	0	0	31.2	0	1	32.3
50	ATP	Air transport	0	0	0	62.8	0	2.6	65.4
51	CMN	Communications	0.1	0	0	0.4	0	0.8	1.3
52	OFI	Financial services	0	0	0	0	0	0.2	0.2
53	ISR	Insurance	0	0	0	0	0	0	0
54	OBS	Business services	0.1	0	0	0	0	0.4	0.5
55	ROS	Recreation and other services	2.4	0.1	0	30.4	0	11.1	44
56	OSG	Public administration, defense, education, health	1.7	0	0	6.3	0	15	23
57	DWE	Dwellings	0	0	0	0	0	0	0
58	CGD S		0	0	0	0	0	0	0
59	HH	Household	20.9	0	0.1	187	0	93.4	301.4
60	GOV T	Government	0	0	0	0	0	0	0
Total			551.1	7.3	10.1	685.3	0	450.4	1704.2

Source: Lee (2008)



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