Impact of Forest Plantation Development in Laos: A Dynamic General Equilibrium Analysis

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Abstract: Over the past decade, the world has observed a major growth in the development of forest plantations. Despite the considerable number of studies that have been undertaken to examine the impact of forest plantation development, there has been relatively little investigation of the economic impact of plantations. Lao People's Democratic Republic (hereafter Lao PDR or Laos) has implemented policies to expand plantations based on their contribution to economic development. This paper examines the economy-wide impact of forest plantation development in Laos using a recursive dynamic computable general equilibrium model. Analysis focused on the Government of Laos' forest policies to promote the development of forest plantation by the year 2020. Simulation results show that this forestry policy is likely to have a positive impact on the Lao economy by increasing the production of forestry and forestry related industries and by stimulating exports and household income. Impacts are more significant for the forestry and forest-related sectors. Despite prompting a relatively higher growth in the production of various other industries, some undesirable impacts are also likely on sectors that do not have strong interactions with the forestry sector. The results also indicate that the government tax revenue is likely to experience some growth.

Keywords: Dynamic CGE model, economics, forest policy, Laos

1. Introduction

Over the past decade, the world has observed a major growth in the development of forest plantations¹ (FAO 2006, 2010; Keenan et al. 2015). There has been considerable investigation of the economic impact of plantations at regional scales but relatively little analysis of the potential impact of plantation development at the national level. Lao People's Democratic Republic (hereafter Lao PDR or Laos) has implemented policies to expand plantations because of their potential contribution to national and regional economic development, particularly for poor rural people. Because of these policies, there has been a recent dramatic increase in large-scale projects by some of the largest global forestry companies. Previous economic analysis of the forest plantation industry in Laos has only paid attention to investment analysis (Manivong and Cramb 2008; Maraseni et al. 2018; Phimmavong 2004; Xayvongsa 2001), and simple economic estimation such as production, consumption, and trade (Buongiorno et al. 2003; Phengsopha 2011), but how the forestry industry interacts with the rest of the domestic economy has been either overlooked or poorly accounted for.

The aim of this paper is to quantify the likely economy-wide impacts of forest plantation development on the forestry sector and the Lao economy. Analysis focused on the Government of Laos' forest policies to double the 2003 forest cover by the year 2020, partly through the development of plantations for timber production.

This research study will contribute to current literature in various ways. It is the first comprehensive study of the impact of forest plantation development in developing countries, focusing on the economy-wide effects on the Lao economy. Even though the computable general equilibrium (CGE) modelling approach has been widely applied for the analysis of taxation, trade, finance, environmental policies, energy, and various issues, it has not yet been used as a tool for assessing the impact of forest plantation development on the macro-economy. It is expected that the CGE model will become a very useful decision-making tool in support of sustainable forest plantation development, regional planning, and monitoring.

Significantly, for Laos, the model can also be used as a framework to answer a number of other questions relating to Lao trade, taxation, and environmental issues. For example, it could be used to investigate the impact of economic policies or external shocks such as those resulting from Laos joining the ASEA Free Trade Area (AFTA), and China-ASEAN FTA (CAFTA).

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This article is organised as follows. After a brief discussion of the methodological framework employed to examine possible effects of forest plantation development, the results of the CGE analysis are presented. Finally, the conclusion and policy recommendations are provided.

2. A Dynamic CGE Model for Laos

2.1. Introduction

Lao Dynamic CGE model (LaoDCGE) is the first dynamic multi-sector general equilibrium model for Lao PDR\(^2\). It is based on the 2003 Lao social accounting matrix (SAM). In many aspects, this model is similar to those employed in Cockburn et al. (2008) and Decaluwé et al. (2010)\(^3\). It can be viewed as a neoclassical structuralist model, as pioneered by Dervis et al. (1982). From both a methodological and a theoretical perspective, the model is a recursive dynamic computable general equilibrium model, which has appeared frequently in the literature over the past decade.

The recursive dynamic CGE model considers both the medium- and long-run general equilibrium effects. The behaviour of economic agents and their interdependences is comprehensively modelled in a system of simultaneous linear and non-linear equations. The latter are specified according to an adaptive dynamic decision-making mechanism, which incorporates sequential dynamics into the framework of the static CGE modelling. Technically, the sequential dynamics adapt by the evolution of the capital stock in the Lao economy between periods. Capital stock is updated endogenously with a capital accumulation equation, which encompasses investment and depreciation. By contrast, labour supply or population is updated exogenously between annual periods.

Producers maximise profits subject to a given production technology and a representative household maximises utility subject to a budget constraint in a recursive dynamic model. The model assumes the government does not have an explicit objective function, so system constrains must be imposed to ensure equilibrium (Adelman and Robinson, 1989; Robinson, 2006). The choice of appropriate system constraints, or closure rules, requires a theoretical perspective and depends on particular characteristics of the Lao economy. Closures are particularly important because they determine how the model adjusts to shocks or policy changes.

In LaoDCGE model, the economy is disaggregated into 20 economic activities or sectors, each producing a single commodity. These include three agricultural sectors (crop, livestock, and forestry), 17 industrial and service sectors. Four factors of production are distinguished: capital, unskilled labour, skilled labour, and land. There is only one representative household who maximises a Cobb-Douglas utility from consuming the 20 consumer goods.

The LaoDCGE model adopts a multi-level production function (Figure 1). On the production side, mixtures of value added and total intermediate consumption are selected subject to the Leontief production technology respectively (Leontief 1936). Value added for each individual sector except for the public sector is represented by a constant elasticity of substitution\(^4\) (CES) production function of composite labour and composite capital (Arrow et al. 1961).

Regarding the substitution possibilities between the domestic and foreign markets, the model distinguishes the Armington CES production function and the constant elasticity of transformation (CET) production function. The latter is designed to determine the optimal allocation of goods on the domestic and foreign markets (export). The former enables imperfect substitution between domestically produced and imported goods in the intermediate input mix (Armington 1969).

The elasticities play an important role in the successfully implementation of CGE models. Due to the limitation of time and resources available for this study, all elasticities used in the LaoDCGE model were taken from Warr (2007, 2008) who developed a static 20 sector-CGE model and estimated elasticities of substitution for Laos.

In going from a static to a dynamic CGE model that simulates changes over time, investment, capital accumulation, and population growth need to be incorporated into the modelling framework. One of the most important features of recursive dynamic CGE models is the specification of capital accumulation and allocation across periods. As discussed in the earliest section of this chapter, capital stock is updated endogenously with a capital accumulation equation, which encompasses investment and depreciation\(^5\)

\[ KD_{k,j,t+1} = KD_{k,j,t} (1 - \lambda_{k,j}) + IND_{k,j,t}, \]
where the capital stock in individual sector \( j \) in year \( t+1 \) \((K_{D,k,j,t+1})\) is equivalent to the capital stock in the previous year \((K_{D,k,j,t})\) taking account of the quantity of new investment in a certain time \( t \) \((IND_{k,j,t})\) as well as the annual rate of depreciation \((\lambda_{k,j})\).

Furthermore, labour supply \((LS_{l,t})\) is exogenously fixed and updated between periods and it is simply assumed to grow the population growth path. The population growth rate \((n_t)\) obtained from the United Nations forecast is about 1.5% p.a.\(^6\)

\[
LS_{l,t+1} = LS_{l,t}(1 + n_t)
\]

In addition, the minimum household consumption \((C_{MIN}^{t+1})\), public savings \((SG_t)\), public investment\(^7\) \((IND_{k,pub,t})\), and changes in inventories \((VSTK_t)\) are also exogenously fixed and assumed to rise equally along the population growth. Decaluwé et al. (2010) pointed out the following reasons for this assumption. First, it allows the model to be in a balanced growth path so that the consistency of the model can be tested as to whether the economy follows a balanced growth path when these exogenous variables have a constant growth and relative prices remain stable. Finally, the balanced growth check enables us to know whether the model has the dynamical analogies of the homogeneity test in static models, or the money-neutrality test (Decaluwé et al., 2010).

The elasticities play an important role in the successfully implementation of CGE models. Due to the limitation of time and resources available for this study, all elasticities used in the LaoDCGE model were taken from Warr (2007, 2008) who developed a static 20 sector-CGE model and estimated elasticities of substitution for Laos. The elasticities of substitution between imports and home goods equal two for all imported commodities while all elasticities of transformation in CET function are 20. Substitution elasticities between primary factors (labour, capital and land) are 0.5 for all sectors except for the crop sector (0.25).

Nevertheless, all values for each type of elasticities, except CES in primary factors for the crop sector, are almost the same reflecting the empirical observation of low elasticities of supply response in the crop sector.

Figure 1. Nested production structure for Lao dynamic CGE model.
The database used was the 2003 Lao SAM, derived from the Savannakhet (SVK) input-output table. The SVK input-output table was the only available input-output table in Laos and was produced by Asra et al. (2006) at the ADB. The SVK table was converted into a national table by using a row and column sum (RAS) method. The value added totals of the SVK table were mathematically adjusted to equalise those of the national accounts (Warr 2007). Thus, the resulting national input-output table has similar Leontief coefficients to the SVK table but has an industry structure similar to that shown in the 2003 National Accounts.

2.2. System constraints and macroeconomic balances

The LaoDCGE model adopts different sets of closures for the current account, the government balance, and the savings/investment account (as shown in Table 1).

Labour is assumed to be fully employed and mobile across sectors in all periods. Real wages are allowed to vary across sectors and are market-clearing variables amending endogenously to reach the equilibrium condition where labour demand equals supply. Labour supply is exogenously fixed and updated between periods according to population growth estimates. Two types of labour: skilled and unskilled are distinguished in the LaoDCGE model and both types of labour are assumed to be fully mobile across all sectors of the economy and wages differed by sectors in terms of base levels. The agricultural sector, which employs a large proportion of the Lao population, relies intensively on unskilled labour (Phimmavong 2012). Because of the adoption of a wage differential in the analysis, relative changes in wages are the same across all sectors, albeit they differ in levels. The wage differential is used to reflect the differences in wage levels across sectors that can be observed in the economy.

As mentioned earlier, labour is classified into unskilled and skilled labour. The present study used an “education” variable to define whether the workforces were skilled or unskilled workers. Workers, who completed secondary school or higher, were defined as skilled labour, while the rest of education types were classified as unskilled labour. The forestry sector relies intensively on unskilled labour besides skilled labour (Phimmavong 2012). This is one of the main reasons why both skilled and unskilled workers can move to the forestry sector if required. Furthermore, shortages of labour and skills remains the constraints facing the private sector in the Lao PDR. Unskilled workers are thus assumed to be trained to become skilled workers and can be fully mobile across all sectors of the economy.

Furthermore, the present study does not assume that it is rural workers who move to the forestry sector, but it can very well be urban workers, since the model does not distinguish rural and urban workers.

The model assumes that land is only used by the agriculture and mining sectors but is immobile across these sectors. In simulating the plantation development policy, land supply is exogenously increased to the forestry sector for the policy shock (i.e. it is brought into production from the degraded land pool and does not come through substitution of agricultural production. The sector-specific rental rates of land adjust endogenously to clear the land markets in all periods. This assumption reflects the prevailing competition for land acquisition within these primary sectors in the Lao economy. According to the Lao forest laws and regulations, agricultural uses of forestlands are prohibited. In some places, the forestland is not suited to other agricultural lands. Similarly, this also applies to the crop and livestock sectors where use of forest lands by these sectors is not allowed. Despite these laws and regulations, there is some interchangeability of land between crop and livestock sectors, because in reality there is competition between these uses in some areas. Nevertheless, for the purposes of the analysis, land is simply assumed to be immobile between different agricultural uses and forest plantations.

Capital is assumed to be sector-specific in the first year so that sector-specific returns adjust to clear the capital market. In subsequent years, capital can be reallocated across sectors through new investments while returns are flexible. As mentioned earlier, the capital stock in each sector is endogenously adjusted for investment and depreciation per annum and then updated automatically between periods. It is important to distinguish “rate of return on capital” and rental rate of capital (Decaluwé et al. 2010: 110). The latter refers to the price gained from the use of one unit of capital in a certain economic activity in a particular period. In the LaoDCGE model formulation, it is used in equation for household capital income. In contrast, a rate of return refers to return on investment or earning rate on investment relative to the value of the asset invested.
The choice of the current account and the government account closures are dependent on the economic condition, the policies of the government, and the policy changes to be examined. The current government expenditures are exogenously fixed for both short and long runs in real terms so that public savings adjust to compensate variations in government revenue.

The current account balance is exogenously fixed in nominal terms. The real exchange rate\textsuperscript{10} is the market clearing variable, adjusting endogenously to ensure the equilibrium of the balance of payments. This closure is suitable for Lao economy since the Lao exchange rate regime is relatively flexible. As noted in the previous section, because the Lao economy is relatively small, compared to other countries in the region or in the globe, world prices of imports and exports are exogenously fixed.

Much debate still surrounds the choice of closure for the savings-investment account. Based on the savings-driven closure (or neoclassical closure), investment is endogenous and adjusts to achieve the savings-investment balance. Under this closure, an increase in government deficit induces a crowding-out of private investment. In contrast, for the investment driven closure or Keynesian approach, savings are endogenous and adjust to maintain a fixed level of investment.

In the present study, a neoclassical approach was used to help establish adjustment mechanism for the savings-investment account. Investment is therefore the market clearing variable used to achieve the savings-investment balance. Investment consists of gross fixed capital formation and changes in inventories. While the former is an endogenous variable, the latter, which may be either positive or negative, has to be fixed in volume because it is difficult to create negative changes in inventories endogenously (Decaluwé et al. 2010).

In addition, it should be noted that the simulation results are based on relative prices that move to clear demand and supply markets in the economy while a price index is set as numeraire. The model cannot determine absolute price level, which is therefore fixed exogenously. Inflation effect plays no role in the computable general equilibrium modelling since monetary variables are not specified in CGE models.

The nominal exchange rate is selected as the numeraire for all periods.\textsuperscript{11} The LaoDCGE model comprises 1,223 independent equations and the same number of endogenous variables. It is homogenous of degree zero in prices in the way that a doubling of all prices would have no impact on resource allocation.

### Table 1. Closure rules for Lao dynamic CGE model.

| Closure rules | 2003 | 2004-2020 |
|---------------|------|-----------|
| Capital       | Flexible sector-specific returns; sector-specific factor; Fixed supply | Flexible sector-specific returns; Mobile factor; Flexible supply |
| Labour        | Mobile factors; Flexible wage; Fixed supply | Mobile factors; Flexible wage; Flexible supply |
| Land          | Flexible rental rate; immobile factor; Flexible supply | Flexible rental rate; immobile factor; Flexible supply |
| Saving-Investment | Flexible investment; Fixed savings rates; | Flexible investment; Fixed savings rates; |
| Government account | Fixed real government expenditures; Flexible public savings | Fixed real government expenditures; Flexible public savings |
| Current account | Fixed current account balance | Fixed current account balance |
| Numeraire price | flexible domestic price index; flexible producer price index; fixed nominal exchange rate (\textsuperscript{\textasciicircum}numeraire) | flexible domestic price index; flexible producer price index; fixed nominal exchange rate index (\textsuperscript{\textasciicircum}numeraire) |
2.3. Policy scenario

The policy scenario for this analysis is based on the Government of Laos’ forest policies concerning the development of forest plantation by the year 2020. Specifically, the aim of the present study is to quantify the impact of the establishment of 371,000 hectares of new tree plantations between 2004 and 2020. To do this, the land supply for the plantation sector is exogenously increased over the forecasting period (Figure 2). The policy scenario for this analysis involves the establishment of new tree plantations between 2004 and 2020 (blue colour), together with accumulated area of plantation establishment in Laos (green colour). To do this, the land supply for the plantation sector is exogenously increased over the forecasting period (Figure 2).

Figure 2 shows the establishment of new tree plantations between 2004 and 2020, together with accumulated area of plantation establishment in Laos. Two main periods: the plantation boom period (2004-2011) and the stabilisation plantation period (2012-2020) can be distinguished. The information on areas of plantations during the plantation boom period was obtained from the Department of Forestry within the Ministry of Agriculture and Forestry of Laos (MAF). The stabilisation plantation period during 2012 and 2020 was estimated based on an assumption of the average growth and the target plan of the Government of Laos over the forecasting period. Nevertheless, the actual potential planting sites during this period may vary and depend on land allocation and unexploded ordinance (UXO) issues. As shown in Figure 2, marked fluctuations in annual planting occurred during 2004-2011, varying between 14,000 ha and 40,000 ha per year in this period.

By 2017, an estimated 478,600 ha of tree plantations had been established, with the major proportion of these being for rubber production. Plantations were established for timber production, mainly Eucalyptus by overseas companies in central and southern Laos. The Lao Government has recently expanded the plantation target from 500,000 ha to about 1.2 million hectares, or about 700,000 hectares of new plantations, by 2030 (Phimmavong et al. 2019).
3. Simulation Results

3.1. Impact on the forestry sector

Tables 2 and 3 below summarize the impact of the plantation development policy on the forestry sector. As expected, the policy change initially affects the forestry sector through the reduced price of land (due to the increasing land supply to this sector). Land price decreases significantly compared to the business as usual (BaU) scenario, by 21 per cent in 2004 to almost 100 per cent by the end of the projection period. In a competitive market, the progressive increase in supply would be expected to result in a lower price. This is followed by increases in the forestry sector’s competitiveness, and leads to an expansion of this sector, partly at the expense of other sectors. The forestry production is projected to rise rapidly compared to the BaU scenario by 2.3 per cent in 2004 to almost 26 per cent in 2020.

In addition, this policy change induces a large increase in investment. Investment demand increases significantly compared to the BaU path from about 3.2 per cent in 2004 to 33.1 per cent in 2020.

The decreases in prices of domestic production in this sector can be explained by the cheaper cost of land inputs. These decreases in domestic producer prices and the expansion of the forestry production consequently make exports more competitive and provoke a major boost in forestry exports. Forestry exports increases considerably from about 6.1 per cent in 2004 compared to the BaU path, to nearly 70 per cent by 2020.

Higher forestry outputs will also result in a significant expansion in domestically produced commodities (domestic goods), quantity demanded of composite commodities (composite goods), and intermediate consumption. The growth rate of domestic and composite goods climbs noticeably against the BaU path between approximately 2.2 and 24.8 per cent per year during the projection period. The output growth in the forestry sector results in significant increases in intermediate and factor demand. For instance, by 2020, the surge in forestry sectoral output increases the percentage change in the demand for unskilled labour by 7.9 per cent, skilled labour by 7.7 per cent, capital by 6.6 per cent, intermediate demand by 10.9 per cent, and land by 281.8 per cent in this sector, compared with the BaU scenario.

This policy outcome can be understood as follows. The production function is dependent on labour, land, capital, and intermediate inputs such that increases in production output require additional factor inputs. For instance, if we look at the relationship of production and the labour market, an increase in land supply or capital stock shifts the production function of the forestry sector upward, pushing the marginal product of labour higher.

Labour demand in this sector will also increase because the forestry sector will need units of labour until the point where the marginal product of labour is equivalent to the real wage. At the same time, the real wage shifts to the equilibrium condition where labour demand equals supply. Furthermore, simulation results reveal that the wage rates for both unskilled and skilled workers grow for all periods of the simulation. The wage rate of unskilled workers increases from just below 0.6 per cent above the BaU path in 2004 to 7.9 per cent by the end of the projection period, while that for skilled workers, the increase is from 0.6 per cent in 2004 to 7.7 per cent in 2020. It should be noted that labour is fully employed and mobile across sectors of the economy in all periods.

The overall results show that the plantation development policy has a significant positive impact on the forestry sector by stimulating production, investment, domestic demand, intermediate consumption, and factor demand. The forestry sector faces a significant decrease in land prices due to increased availability of land supply.

3.2. Impact on other sectors

The plantation development policy not only makes a direct contribution to the forestry sector by generating additional employment, and tax revenue, but also an indirect effect on other economic sectors. This is best explained by reference to the Lao SAM table. On the consumption side, the forestry sector sells its outputs (goods) to a number of intermediate sectors including (as percentages of total sales): the wood industry (33 per cent), electricity sector (5 per cent), and forestry sector (1 per cent) as well as the final demand to households (57 per cent), and investment (5 per cent). On the production side, the sector purchases a mixture of intermediate inputs, for example (as
Table 2. Effects on the forestry sector 2004-11: percentage change from BaU path (%/year).

|                          | 2004  | 2005  | 2006  | 2007  | 2008  | 2009  | 2010  | 2011  |
|--------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Rental rate of land      | -21.2 | -33.7 | -54.3 | -63.7 | -73.4 | -79.1 | -83.0 | -86.2 |
| Investment in land       | -29.7 | -45.5 | -68.6 | -77.6 | -85.9 | -90.1 | -92.7 | -94.6 |
| Value added price        | -3.2  | -5.4  | -9.4  | -11.7 | -14.4 | -16.3 | -17.9 | -19.4 |
| Export price             | -2.9  | -4.9  | -8.6  | -10.6 | -13.1 | -14.8 | -16.3 | -17.7 |
| Domestic price           | -3.1  | -5.2  | -9.1  | -11.2 | -13.8 | -15.7 | -17.2 | -18.7 |
| Composite price          | -3.1  | -5.2  | -9.1  | -11.2 | -13.8 | -15.7 | -17.2 | -18.7 |
| Producer price           | -3.1  | -5.2  | -9.1  | -11.2 | -13.8 | -15.7 | -17.2 | -18.7 |
| Wage (Unskilled)         | 0.1   | 0.2   | 0.4   | 0.6   | 0.8   | 0.9   | 1.0   | 1.2   |
| Wage (Skilled)           | 0.2   | 0.3   | 0.6   | 0.8   | 1.0   | 1.2   | 1.3   | 1.5   |
| Investment demand        | 3.2   | 5.5   | 10.1  | 12.8  | 16.3  | 18.9  | 21.2  | 23.4  |
| Exports                  | 6.1   | 10.5  | 19.6  | 25.2  | 32.4  | 37.9  | 42.8  | 47.7  |
| Intermediate demand      | 0.5   | 1.0   | 1.9   | 2.8   | 3.7   | 4.6   | 5.5   | 6.3   |
| Private consumption      | 3.3   | 5.7   | 10.4  | 13.2  | 16.8  | 19.4  | 21.8  | 24.1  |
| Domestic goods           | 2.2   | 3.9   | 7.1   | 9.1   | 11.6  | 13.6  | 15.4  | 17.1  |
| Composite goods          | 2.2   | 3.9   | 7.1   | 9.1   | 11.6  | 13.6  | 15.4  | 17.1  |
| Production               | 2.3   | 4.1   | 7.4   | 9.6   | 12.2  | 14.3  | 16.2  | 17.9  |
| Land demand              | 13.4  | 24.3  | 51.2  | 70.9  | 101.5 | 128.5 | 155.4 | 185.0 |
| Composite capital        | 3.8   | 6.6   | 12.3  | 15.9  | 20.4  | 24.0  | 27.2  | 30.3  |
| Labour (Unskilled)       | 0.6   | 1.1   | 2.0   | 2.7   | 3.4   | 4.1   | 4.7   | 5.2   |
| Labour (Skilled)         | 0.6   | 1.0   | 1.9   | 2.6   | 3.3   | 4.0   | 4.5   | 5.1   |
| Capital                  | 0.0   | 0.1   | 0.3   | 0.6   | 1.0   | 1.5   | 2.0   | 2.6   |

...percentages of their gross production costs): the petroleum (1.2 per cent), forestry (0.9 per cent), wood industry (0.5 per cent), other services sector (0.5 per cent), the machinery sector (0.3 per cent), unskilled labour (19.8 per cent), skilled labour (22.8 per cent), capital (36.2 per cent), land (16.2 per cent) and activity tax (2 per cent). For these reasons, the shock of increasing land inputs in the forestry sector not only affects its production output, but also various plantation-related sectors.

3.2.1. Effects on production and factor allocation

The surge in forestry sector output associated with reduction in local prices in the forestry-related industries will tend to increase their competitiveness, which leads to an expansion of these sectors, partly at the expense of other sectors.

The sectors buying goods more intensively from the forestry sector gain the most from this policy change. This effect is obvious given the presence of relationship of their dependency in the initial SAM table. The analysis shows that the sector benefiting the most from this policy change is the wood industry sector, with a production level of about 12.2 per cent above the BaU scenario in 2020, followed by the trade sector (0.8 per cent), communication sector (0.7 per cent), other services sector (0.5 per cent), and electricity and water sector (0.3 per cent). The following figures (Figures 3-7) summarise the impacts on the quantities of production and its factor allocation for some sectors, which are measured in real terms between 2004 and 2020. The results reveal that increases in sectoral outputs will accompany expansion in primary factor demand in their corresponding sectors, in part because of the increasing demand of inputs and materials for new investment to enhance the production of domestic commodities. On one hand, sectors that have strong interactions with the forestry sector enjoy increases in their production and in their demand for unskilled and skilled labour (Figures 3 and 4). As illustrated in Figure 3, the surge in wood industry sectoral output (9.7 per cent) will cause shifts in demand for capital by 9.4 per cent, skilled labour by 10.6 per cent, unskilled labour by 10.8 per cent, compared to the BaU path by 2020. On the other hand, sectors that do not have strong interactions with the forestry sector face decreases in their production and in their demand for unskilled and skilled labour (Figures 5 and 6). For instance, the contraction in petroleum sectoral output (0.23 per cent) will cause decline in unskilled and skilled labour by approximately 0.92 per cent, and 1.15 per cent respectively, compared to the BaU path in 2020 (as illustrated in Figure 5).
Figure 3. Impact on the quantities of production and factor allocation in the wood industry sector (percentage change over BaU path).

Figure 4. Impact on the quantities of production and factor allocation in the trade sector (percentage change over BaU path).
Figure 5. Impact on the quantities of production and factor allocation in the petroleum sector (percentage change over BaU path).

Figure 6. Impact on the quantities of production and factor allocation in the machinery sector (percentage change over BaU path).
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Table 3. Effects on the forestry sector 2012-20: percentage change from BaU path (%/year).

|                          | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|--------------------------|------|------|------|------|------|------|------|------|------|
| Rental rate of land      | -86.6| -88.3| -89.3| -90.2| -91.0| -91.2| -91.5| -91.7| -91.9|
| Investment in land       | -94.9| -95.8| -96.3| -96.7| -97.1| -97.2| -97.3| -97.4| -97.5|
| Value added price        | -20.0| -21.0| -21.9| -22.7| -23.4| -23.9| -24.4| -24.9| -25.4|
| Export price             | -18.2| -19.2| -20.0| -20.7| -21.4| -21.9| -22.3| -22.8| -23.2|
| Domestic price           | -19.2| -20.2| -21.0| -21.8| -22.5| -23.0| -23.5| -23.9| -24.4|
| Composite price          | -19.2| -20.2| -21.0| -21.8| -22.5| -23.0| -23.5| -23.9| -24.4|
| Producer price           | -19.2| -20.2| -21.0| -21.8| -22.5| -23.0| -23.5| -23.9| -24.4|
| Wage (Unskilled)         | 1.2  | 1.3  | 1.4  | 1.5  | 1.6  | 1.6  | 1.7  | 1.8  | 1.8  |
| Wage (Skilled)           | 1.6  | 1.7  | 1.8  | 1.9  | 2.0  | 2.1  | 2.2  | 2.2  | 2.3  |
| Investment demand        | 24.3 | 25.9 | 27.2 | 28.5 | 29.7 | 30.6 | 31.4 | 32.2 | 33.1 |
| Exports                  | 49.6 | 53.2 | 56.2 | 59.1 | 61.9 | 63.9 | 65.8 | 67.7 | 69.6 |
| Intermediate demand      | 6.9  | 7.6  | 8.2  | 8.7  | 9.3  | 9.7  | 10.1 | 10.5 | 10.9 |
| Private consumption      | 25.0 | 26.7 | 28.1 | 29.4 | 30.7 | 31.6 | 32.5 | 33.3 | 34.2 |
| Domestic goods           | 17.8 | 19.1 | 20.2 | 21.1 | 22.1 | 22.8 | 23.5 | 24.1 | 24.8 |
| Composite goods          | 17.8 | 19.1 | 20.2 | 21.1 | 22.1 | 22.8 | 23.5 | 24.1 | 24.8 |
| Production               | 18.8 | 20.1 | 21.2 | 22.2 | 23.2 | 24.0 | 24.7 | 25.4 | 26.0 |
| Land demand              | 190.7| 211.4| 228.1| 243.1| 259.0| 265.4| 270.8| 276.3| 281.8|
| Composite capital        | 31.6 | 33.9 | 35.8 | 37.6 | 39.3 | 40.5 | 41.6 | 42.7 | 43.8 |
| Labour (Unskilled)       | 5.6  | 6.0  | 6.4  | 6.7  | 7.0  | 7.3  | 7.5  | 7.7  | 7.9  |
| Labour (Skilled)         | 5.4  | 5.8  | 6.1  | 6.5  | 6.8  | 7.0  | 7.2  | 7.5  | 7.7  |
| Capital                  | 3.1  | 3.6  | 4.1  | 4.6  | 5.1  | 5.5  | 5.9  | 6.3  | 6.6  |

The plantation development policy is likely to have an impact on factor prices that will differ between capital, skilled and unskilled labour. Consequently, some sectors will benefit more than others depending on their factor intensities. For example, if capital costs increase while wages decrease, then the policy change will tend to benefit labour-intensive sectors more than capital-intensive sectors.

From the analysis, generally, both capital costs and wages increase, but the latter increases faster than the former. As a result, the plantation policy is likely to benefit capital-intensive sectors rather than labour-intensive sectors. We observe increases in production of many capital-intensive sectors such as mineral products, electricity, communication, trade, banking, and other services sectors, as a result of plantation development policy.

Furthermore, it is important to recall that the production function is dependent on the composite factors of labour and capital, that is the production output rises in response to increases in labour or capital. From the analysis, producers can increase output by using more capital and labour. For example (Figure 4), compared to the BaU path by 2020, production of the trade sector will increase by 0.8%, which is slower than the growth in the capital (0.95%), together with the increases in unskilled labour demand (0.58) and skilled labour demand (0.34%).

In addition, a producer may increase output by using more capital but less labour (Figure 7). For instance, compared to the BaU path by 2020, production of the electricity sector increases by 0.19%, which is slower than the growth in the capital (0.36%) due to the fall in unskilled labour demand (-0.11) and skilled labour demand (-0.29%). Additional increased capital input can more than offset the reduction in labour input. These similar allocation effects also occur in the banking sectors.

In computable general equilibrium (CGE) analysis, the choice of parameter values may have different effects on the results the model produces. In this analysis, some key parameters cannot be econometrically estimated due to the lack of data, it is therefore important to conduct sensitivity analyses in order to test the impact of uncertainty relating to different levels of elasticities of substitution.

The labour-capital elasticity denotes a relative variation in the capital intensity in consequence of a relative change in the proportion of the wage rate and the rental rate of capital for a certain output level. It measures how easily capital and labour can substitute for each other without a decrease in

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marginal productivity of each input. With higher labour-capital elasticities, labour and capital are easily substituted for each other. More precisely, producers with high labour-capital elasticity can produce at the high level of capital intensity deprived of diminishing returns to capital.

For the present study, two sensitivity tests were conducted on the production and factor allocation of the wood industry sector of the model results (Appendix A). The test varies a 50% interval for the substitution parameters. In the initial and second experiments, the elasticities of substitution between capital and labour were uniformly varied by +- 50%.

For the first test, using 50% higher elasticity values in the production function caused a decrease of production of only 0.17% by 2004 from the original simulation result. By 2020, production is slightly increased by 0.82%, compared to the original result. Furthermore, the analysis resulted in no changes for capital by 2004 from the original simulation result while it is increased by 1.2% by 2020 compared to the original result. Unskilled labour in this test rose from 1.25 per cent in 2004 to 13.5 per cent by the end of the projection period while skilled labour in this test grew from 1.22 per cent to 13.1 per cent. Compared to the results of original scenario, these are small deviations. The higher elasticity of substitution between capital and labour causes a narrower gap between capital and labour wages. In the original scenario, the gap between growth rates in capital and labour wages are between 0.21 and 0.62 percentage points while that of this test ranges from 0.14 to 0.29 percentage points over the projected period. In addition, the higher elasticity of substitution between capital and labour leads to a weaker growth of labour income, but higher growth of capital income. In the original scenario, labour income increased from 0.16 per cent above the BaU path in 2004 to 1.6 per cent by the end of the project period. In this test, labour income increased more slowly from 0.09 per cent above the BaU path in 2004 to 0.93 per cent by the end of the project period.

3.2.2. Effects on households

The analysis reveals that this policy is likely to increase household income (Figure 8). After deducting income taxes and social contributions to the government, households only realize a small increase in “disposable income” (0.97 per cent) relative to the BaU value at the end of the projection. Overall, labour income is likely to grow faster than other sources of income in both short and long runs because of rising wage prices in all economic sectors. The results reveal that wage rates for unskilled and skilled labour climb faster than capital prices. The increase in household income is accompanied by increase in consumption budget, savings, and total absorption through expan-
sion in consumption and investment. Household savings increases perfectly in line with household disposable income because it is specified as a fixed fraction of disposable income.

Figure 8. Impacts on households: percentage change over BAU path.

3.2.3. Effects on the government budget

The government budgets are tied to the performance of all economic units. This is because the government revenues are generated by different types of taxes levied on economic sectors, households, tariffs levied on production and imported goods and services. For instance, when we want to quantify a government revenue imposed on household income, it is simply obtained by summing up household income tax collected from households while total government income is sum of total revenue from household income taxes, taxes on products and imports, production taxes and government transfer income.

The plantation development policy is projected to increase government revenues (Figure 9). This increase is driven by the above mentioned increase in the economic agents’ income, which amounts to an increase in the tax base.

The government earns income through tax collections from economic activities and households, tariffs levied on production and imported goods and services. Because of increases in imports, total revenue on import duties grows steadily from about 0.07 per cent in 2004 to 0.86 per cent by the end of the projection. Similarly, household income tax increases to 0.78 per cent above the BaU path by the end of the projection period.

There is only a small increase in the growth of government revenue. This is because the total tax revenue collected from land rent, particularly from the forestry sector, is extremely low, compared to regional and international land tax rates. The total land tax revenue from all sectors was 27 billion Kip, representing just only 0.1 per cent of the 2003 GDP (Keith et al. 2006).

3.3. Impact on gross domestic product

The following tables summarize the impacts on some key aggregate indicators between 2004 and 2020. The policy change is likely to have a small but positive impact on the Lao economy. Real GDP tends to increase slightly from just only 0.06 per cent in 2004 to 0.91 per cent in 2020, compared to the BaU scenario (Tables 4 and 5 below). Three main factors have contributed to this. Firstly, the expansion of the forestry sector made a small contribution to the national economy, representing 4 per cent of GDP in 2003.

Secondly, the interactions between the forestry sector and the rest of the economy (except for
the wood industry sector) are relatively small, as shown in the Lao SAM table used in the analysis. Thirdly, most forestry goods are currently exported as raw materials to neighboring countries. These factors directly and indirectly affect the performance of the Lao economy.

**Table 4. Effects on Lao economy 2004-11: percentage change from BaU path.**

| Year | GDP at market price | Private consumption | Gross fixed capital formation | Exports | Imports | Real exchange rate | Domestic good | Composite good | Production | Intermediate demand |
|------|---------------------|---------------------|-----------------------------|---------|---------|-------------------|---------------|---------------|-----------|-------------------|
| 2004 | 0.06                | 0.09                | 0.03                        | 0.11    | 0.04    | 0.09              | 0.04          | 0.04          | 0.05      | 0.01              |
| 2005 | 0.12                | 0.16                | 0.05                        | 0.23    | 0.09    | 0.15              | 0.08          | 0.08          | 0.10      | 0.03              |
| 2006 | 0.22                | 0.29                | 0.10                        | 0.43    | 0.17    | 0.26              | 0.14          | 0.15          | 0.18      | 0.07              |
| 2007 | 0.29                | 0.38                | 0.15                        | 0.62    | 0.24    | 0.31              | 0.19          | 0.14          | 0.25      | 0.10              |
| 2008 | 0.38                | 0.48                | 0.21                        | 0.84    | 0.32    | 0.38              | 0.24          | 0.20          | 0.33      | 0.14              |
| 2009 | 0.46                | 0.56                | 0.26                        | 1.05    | 0.40    | 0.42              | 0.28          | 0.26          | 0.33      | 0.18              |
| 2010 | 0.53                | 0.62                | 0.31                        | 1.25    | 0.48    | 0.45              | 0.32          | 0.31          | 0.39      | 0.23              |
| 2011 | 0.60                | 0.69                | 0.36                        | 1.45    | 0.55    | 0.48              | 0.36          | 0.40          | 0.51      | 0.27              |

Simulation results also show that the aggregate value of intermediate demand is likely to increase in both the short to long run. All production of the domestic commodities, composite good supply, and domestic sales will also enjoy a growth.

The aggregate value of international trade (i.e. exports plus imports) is projected to grow from about 54 per cent of GDP in 2004 to 55 per cent in 2020. As exports increase, driven by the increased competitiveness of the forestry-related sectors, the exchange rate appreciates, leading in turn to an increase in imports, so that foreign savings remain fixed (as per the closure rule adopted here).

By comparing the results calculated by the simulation analysis with actual economic situation of the Lao economy based on the Lao SAM 2003 and United Nation Statistics Division, we found that investment for all sectors grew rapidly between 2003 and 2017 and accounted for 29% of GDP in 2017. The sum of exports and imports, a common indicator of trade openness, increased from about 54% of GDP in 2003 to 76% in 2018. Imports grew faster than exports resulting in a widening trade deficit. However, the increase in exports, driven by the mining sector and hydropower projects, largely explains the appreciation of the exchange rate and strong economic growth. The exchange rate of the national Lao currency (Kip) against the US dollar reflects a constant appreciation from 10,434 Kip/USD in 2003 to 8,466 Kip/USD in 2008 (International Monetary Fund, 2009). The current exchange rate is at 8,714 Kip/USD.
Table 5. Effects on Lao economy 2012-20: percentage change from BaU path.

|                      | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|----------------------|------|------|------|------|------|------|------|------|------|
| GDP at market price  | 0.64 | 0.69 | 0.73 | 0.77 | 0.81 | 0.84 | 0.86 | 0.89 | 0.91 |
| Private consumption  | 0.72 | 0.76 | 0.80 | 0.84 | 0.88 | 0.91 | 0.94 | 0.96 | 0.99 |
| Gross fixed capital formation | 0.39 | 0.43 | 0.46 | 0.49 | 0.52 | 0.55 | 0.57 | 0.59 | 0.61 |
| Exports              | 1.61 | 1.77 | 1.91 | 2.05 | 2.18 | 2.30 | 2.41 | 2.51 | 2.61 |
| Imports              | 0.61 | 0.67 | 0.72 | 0.77 | 0.82 | 0.86 | 0.90 | 0.94 | 0.97 |
| Real exchange rate   | 0.47 | 0.48 | 0.49 | 0.49 | 0.50 | 0.49 | 0.49 | 0.48 | 0.48 |
| Domestic good        | 0.38 | 0.41 | 0.44 | 0.47 | 0.50 | 0.52 | 0.54 | 0.57 | 0.59 |
| Composite good       | 0.42 | 0.46 | 0.49 | 0.53 | 0.56 | 0.58 | 0.61 | 0.64 | 0.66 |
| Production           | 0.55 | 0.60 | 0.65 | 0.69 | 0.73 | 0.77 | 0.81 | 0.84 | 0.87 |
| Intermediate demand  | 0.31 | 0.34 | 0.38 | 0.42 | 0.45 | 0.48 | 0.51 | 0.54 | 0.57 |

4. Conclusion

The dynamic general equilibrium model was used to examine impacts of forest plantation development on the macro-economy of Laos. Analysis focused on the Government of Laos’ forest policy to double the 2003 forest cover by the year 2020, partly through the development of plantations for timber production. This analysis shows that the plantation development policy is likely to have a small positive impact on the Lao economy by increasing the production of several economic sectors and by stimulating exports and household income. Impacts are more significant for the forestry and the wood industry sector. Land price will decrease significantly because of the increasing land supply. This will consequently lead to a rapid increase in the forestry sector’s competitiveness, and bring about an expansion of this sector, partly at the expense of other sectors. Furthermore, higher production in forestry and the wood industry sectors will result in a significant increase in domestically produced commodities, intermediate consumption, and exports in these sectors.

Despite prompting a relatively higher growth in the production of various other industries, some undesirable impacts are also likely on sectors that do not have strong interactions with the forestry sector. The results also indicate that the government tax revenue is likely to experience some growth. Furthermore, this policy will increase the relative prices of several sectors that have weak relationship with the forestry sector, but on the other hand, the forestry and forestry related sectors would enjoy decreases in their prices of production, domestic sales, intermediate inputs, and exports.

The strength of this model is the comprehensive general equilibrium framework, which provides understanding of the complex interdependencies and feedback effects between policy interventions and the economic activity in different sectors.

However, while important in understanding the general equilibrium effects, this modeling technique did not capture the impact of the shock at an individual household level.

In order to maximize the benefits from this policy and minimize any adverse impacts, there is a need to enforce forestry and other laws and implement supporting policies to ensure that plantation investments are consistent with international standards, guidelines and codes of practices relating to the creation of planted forests.

Endnote:

1. The total area of the plantations has accelerated dramatically between 1990 and 2015 from 128 million hectares to 278 million hectares.
2. This is a first attempt to develop a dynamic general equilibrium model for Laos.
3. The presentation of the LaoDCGE model follows Decaluwé et al. (2010) in which variable names and parameters used in the construction of the LaoDCGE model are the same. However, some parameters and variables are complemented or deleted where they are specifically adapted to the Lao economy
4. CES substitution parameter is not restrictive like the Leontief one, and can have a value of other than 1.
5. In this analysis, the depreciation rate was assumed to be 3% p.a. in all sectors though it can differ by sector and type of capital.
6. UN website: available at http://esa.un.org/wpp/Excel—Data/population.htm (accessed on 07/06/2012)
7. Following previous work by Decaluwé et al. (2010), only investment in public administration sector is exogenously fixed.
8. Warr (2006, 2008) also used this method in his CGE analysis for Laos.
9. The labour closure rule follows the World Bank reports that unemployment is virtually non-existent in Laos. Source: World Bank: http://data.worldbank.org/country/lao—pdr
Real exchange rate is the proportion of the nominal exchange rate multiplied by the world export prices, divided by the domestic price index.

Several groups of CGE researchers also selected nominal exchange rate as numeraire, and the current account balance is held fixed so that real exchange rate adjusts endogenously to ensure the equilibrium of the balance of payments. Amongst these works are those of Decaluwé et al. (2010), Cororaton et al. (2006), Annabi et al. (2005), and Cockburn (2001).

GDP at market prices

Based on data from IMF, available at https://data.imf.org/?sk=E86E9088-3830-4CA3-B240-1B0EC5E15221 (August 19, 2019).

The exchange rate (selling rate) on Wednesday, August 21, 2019 at BANQUE POUR LE COMMERCE EXTERIEUR LAO

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### Appendix A (Sensitivity tests for production and factor allocation in the wood industry sector: percentage change from BaU path)

#### 50% higher substitution elasticities

| Year | Labour (Unskilled) | Labour (Skilled) | Production | Capital | Labour (Unskilled) | Labour (Skilled) | Production | Capital | Labour (Unskilled) | Labour (Skilled) | Production | Capital |
|------|-------------------|------------------|------------|---------|-------------------|------------------|------------|---------|-------------------|------------------|------------|---------|
| 2004 | 1.25              | 1.22             | 0.35       | -       | 1.8               | 1.8              | 0.52       | 0.0     | 1.3               | 1.2              | 0.4        | 0.0     |
| 2005 | 2.16              | 2.10             | 0.96       | 0.49    | 3.0               | 2.9              | 1.09       | 0.3     | 2.2               | 2.1              | 1.0        | 0.5     |
| 2006 | 3.53              | 3.43             | 1.81       | 1.17    | 5.2               | 5.1              | 2.06       | 0.9     | 3.5               | 3.4              | 1.8        | 1.2     |
| 2007 | 4.51              | 4.38             | 2.79       | 2.16    | 6.3               | 6.2              | 3.00       | 1.7     | 4.5               | 4.4              | 2.8        | 2.2     |
| 2008 | 5.63              | 5.46             | 3.80       | 3.13    | 7.8               | 7.6              | 4.05       | 2.6     | 5.6               | 5.5              | 3.8        | 3.1     |
| 2009 | 6.44              | 6.27             | 4.80       | 4.21    | 8.8               | 8.6              | 5.06       | 3.7     | 6.4               | 6.3              | 4.8        | 4.2     |
| 2010 | 7.51              | 7.26             | 5.74       | 5.14    | 9.6               | 9.4              | 6.02       | 4.7     | 7.5               | 7.3              | 5.7        | 5.1     |
| 2011 | 8.09              | 7.89             | 6.69       | 6.21    | 10.4              | 10.2             | 6.94       | 5.6     | 8.1               | 7.9              | 6.7        | 6.2     |
| 2012 | 8.99              | 8.70             | 7.47       | 6.97    | 10.6              | 10.4             | 7.69       | 6.6     | 9.0               | 8.7              | 7.5        | 7.0     |
| 2013 | 10.20             | 9.80             | 8.4        | 7.93    | 11.1              | 10.9             | 8.42       | 7.4     | 10.2              | 9.8              | 8.5        | 7.9     |
| 2014 | 9.78              | 9.57             | 9.20       | 9.03    | 11.6              | 11.4             | 9.09       | 8.2     | 9.8               | 9.6              | 9.2        | 9.0     |
| 2015 | 10.60             | 10.28            | 9.74       | 9.51    | 12.0              | 11.8             | 9.72       | 8.9     | 10.6              | 10.3             | 9.7        | 9.5     |
| 2016 | 11.45             | 11.07            | 10.40      | 10.11   | 12.4              | 12.2             | 10.31      | 9.5     | 11.4              | 11.1             | 10.4       | 10.1    |
| 2017 | 11.80             | 11.49            | 11.05      | 10.86   | 12.7              | 12.5             | 10.83      | 10.1    | 11.8              | 11.5             | 11.1       | 10.9    |
| 2018 | 12.71             | 12.28            | 11.65      | 11.39   | 13.0              | 12.7             | 11.31      | 10.7    | 12.7              | 12.3             | 11.7       | 11.4    |
| 2019 | 13.39             | 12.97            | 12.42      | 12.18   | 13.3              | 13.0             | 11.75      | 11.2    | 13.4              | 13.0             | 12.4       | 12.2    |
| 2020 | 13.53             | 13.13            | 13.00      | 12.90   | 13.6              | 13.3             | 12.17      | 11.7    | 13.5              | 13.1             | 13.0       | 12.9    |