Impact of Pulp Mill Project in Laos: Regional and National Level Economic Modelling Analysis

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Abstract: Timber production and processing have the potential to significantly contribute to the economic development in “low-income” countries such as Lao PDR, which have suitable land and access to markets. Processing investment can include smaller-scale furniture or veneer manufacturing or large-scale, capital-intensive industries, such as pulp and paper production. A 300,000 tonne/yr bleached hardwood kraft pulp mill has recently been constructed in Savannakhet Province, Lao PDR and began operation in 2018. The pulp mill represents a potentially significant contribution to both regional and national economies and has changed the plantation wood market environment in Laos. To date, there has not been an investigation of the full economic impact of a pulp mill, and the potential flow-on benefits to the regional and national economy. This paper examines the impact of this mill on provincial and national economies using an input-output modelling approach. Input-output models provide a framework for analysis of the inter-relationships between sectors within an economy. The modelled scenario was a dramatic change in the wood industry sector exports due to the products from this pulp mill. Regional level analysis revealed that the gross outputs for all sectors of the economy are likely to increase by 39% (an equivalent of US\$ 294 million), largely due to the impact of the pulp mill on demand from wood industry sector and other related sectors. The greatest beneficiaries from the mill are industries in other countries which purchase and use the pulp. At the national level, the gross production output of the national economy would increase by 2.3% (US\$ 351 million). Currently, the log raw material for the mill is mostly coming from plantations in neighbouring Vietnam and Thailand. There is considerable potential for timber plantations on degraded land in Laos, that would greatly enhance the economic contribution of the mill to the local community. Increasing sustainable timber production from plantations in Laos needs enforcement of forestry and other laws, and supporting policies, guidelines and codes of practices relating to planted forests to ensure that forest processing industries are environmentally responsible and consistent with international best-practice standards.

Keywords: forestry, input-output model, Laos, regional economy, wood industry

1. Introduction

Pulp and paper plants have been in operation around the world since the late 1800s but there has been limited recent analysis of the specific economic contribution of individual plants to regional or national economies. In many developed countries, pulp and paper mills are being closed due to downturn in demand for newsprint and other traditional paper products, and competition from lower cost suppliers. Alternatively, pulp and paper mills are being transformed into “biorefineries”. Recent social and economic analysis of the sector has focused more on the impacts of these closures (Brandeis and Guo 2016), or on the potential economic benefits of transforming to a “bioeconomy” (Pereira et al. 2018).

While many new mills have been constructed in emerging economies like China, Brazil, or Indonesia, there have been few published studies on the impacts of a specific mill in a low-income country like Laos. Laos has implemented policies to expand the forest sector because of their contribution to economic development, particularly for poor rural people.

Timber production and processing have the potential to significantly contribute to economic development in low-income countries with suitable land and access to markets, such as Lao PDR. Lao PDR has over 6 million hectares of degraded forest land that could potentially be used for a combined production and conservation purposes (World Bank 2018). The timber harvesting and processing sectors have been significant contributors to economic activity and national income, largely through the exploitation of natural forests for domestic furniture production and log export (World Bank 2018). Natural forest harvest has not been sustainable and the government of Lao PDR has recently curtailed timber harvest and banned the export of unprocessed wood from natural forests. The

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government has also actively promoted foreign investment in wood products and processing sector (Smith et al. 2016). The Lao 2020 Forest Sector Strategy aims to increase forest cover on degraded land to enhance rural livelihoods and safeguard environmental values such as water resources. In part, this goal was to be achieved through planting 500,000 ha of high-value or fast-growing trees by smallholders and corporate investors, although markets for products for these plantations have been unclear (Phimmavong et al. 2019a).

More recently, a large-scale pulp mill was commissioned in Sepon District, Savannakhet Province, Southern Laos. Sun Paper Holdings (Lao) has established a “swing” pulp mill, capable of producing 300,000 tonne/year bleached hardwood kraft (BHK) pulp or 250,000 tonnes/year of dissolving pulp (DP). The pulp mill uses modern technology from Europe and represents a potentially significant contribution to both regional and national economies. It has changed the plantation wood market environment in Laos (Phimmavong et al. 2019a). The direct contribution to the regional economy includes direct investment, wages for employees in construction and operation, and payments for procuring wood and other inputs and services. However, these direct revenues are only part of the contribution the pulp mill project makes to the economy.

Previous economic analysis of the forest industry in Laos has focused on investment analysis, and simple estimation of production, consumption, and trade. There has been little examination of the interaction of the wood industry sector with the rest of the domestic economy. The pulp mill represents a potentially significant contribution to both regional and national economies with potential flow-on benefits to the regional and national economies. The intent of this paper is to assess the impact of this pulp mill. To achieve this goal, we modelled the effects of the pulp mill project on 20 economic sectors in the provincial economy and in the national economy. To set the scene, the following section discusses the pulp mill development and its potential impact to Laos^{*1}. The design and methods used in input-output modelling are described, and the results of analysis are discussed in the context of the literature and the implications for Lao forest sector policy.

2. Company and Mill Development

Sun Paper Ltd Sun Paper Holdings (Lao) is part of the Sun Paper Group, China’s largest privately owned and managed paper business. The company has been active in Laos since the late 2000s and in 2010 were granted a concession to grow tree plantations for pulpwood in the eastern part of Savannakhet Province. The pulp mill project has been proposed since 2010. Construction began in 2016 and a 300,000 tonne/yr bleached hardwood kraft (BHK) pulp mill commenced operation in 2017. This involved an initial investment of about US\$ 432 million for equipment, roading, buildings for workers and office, modern nursery and other infrastructure. The Provincial Department of Finance received tax revenue from initial construction of about \$ 5.2 million which was forwarded to the national Ministry of Finance. In addition, the project has provided employment to thousands of people both in construction and plantation establishment (Chareun and Associates 2011; Phimmavong et al. 2019b). At the time of writing this paper, the wood pulp and waste paper commodity export has just become the fourth biggest export revenue (US\$ 251 million) in Laos after electricity, gold ore, and copper^{*2}.

With a production capacity of 800 to 1,000 tonne/day BHK pulp consuming between 3,300 – 4,200 green metric tonne (gmt) of wood chips daily or up to 1.5 million gmt annually, the mill requires a plantation base of 60,000 – 75,000 ha of managed *Eucalyptus* or *Acacia* plantations to supply wood fibre sustainably. Approximately 60,000 hectares of new plantations will be needed to establish to feed the new pulp mill at full capacity (Barr and Cossalter 2004). The pulp is made by a chemical process which separates the cellulose from the lignin, hemicelluloses and extractives in the wood. The cellulose is used for pulp and the remainder used as fuel for the generation of electricity.

At present, approximately 300,000 gmt per year is potentially available in Laos and the remaining resources are being imported from Thailand (*Eucalyptus*) and Vietnam (*Acacia*). The mill is paying between 300,000 to 350,000 kip (US\$ 36.00 to 42.00)^{*3} per gmt (with bark) at the mill gate in Laos for domestically grown eucalypt logs. The mill gate price for *Acacia* woodchips from Vietnam is

^{*1}Data for section were mainly obtained from authors’ personal communication with the pulp mill manager on November 7th 2018 and two main reports (Chareun and Associates 2011; Phimmavong et al. 2019b)

^{*2}Vientiane Times on January 30, 2020.

^{*3}Exchange Rate: 1 US\$ = 8,376 kip (<https://www.xe.com>, accessed 14 June 2018)

US\$ 123.66/BDT (approximately US\$ 62.00/gmt) and for eucalypt woodchips from Thailand is US\$ 156.94/tonnes at 38% moisture content (US\$ 78.00/gmt). This includes chipping costs. The mill generates regional income of US\$ 39.2 million per year (900 million kip to 328.5 billion) for wood purchases. A greater proportion could go to Lao plantation growers if plantations are developed in Laos. The proportion depends on harvest and transport costs, traders' fees and government charges on harvesting and transport. Assuming an import price of BHK pulp in China of US\$ 800 or US\$ 950 for dissolving pulp (excluding Chinese taxes), Sun Paper will generate about US\$ 216 million (1.8 billion kip) from export earnings.

3. Input-output Analysis and Methods

I/O analysis has a long presence in the economics literature and it is perhaps the most crucial instrument to evaluate the impact of development on local and regional economies (Richardson 1972). While I/O approach has its origin in a well-known *Tableau Économique* of a French economist, Francois Quesnay dating back to 1758, the great achievement of I/O was when Wassily Leontief developed the first input-output model for the United States economy (Leontief 1936).

The basis of I/O analysis is the input-output table which quantifies inter-industry linkages between different sectors within an economy. The basis of the input-output system is transactions table, which is essentially an extended version of the national accounts in which inter-industry transactions—that is flows of goods and services between industries or sectors within an economy. While each row of the table shows the flow of sales by each industry to each other industry, to final demand and itself, each column gives the flow of input by each industry to each other industry, to primary inputs (i.e. imports, wages, and other value added). Each row of I/O table shows the flow of sales by each industry to each other industry, to final demand and itself, and each column gives the flow of input by each industry to each other industry, to primary inputs (i.e. imports, wages, and other value added). Once an I/O table is constructed, one can generate the multiplier effect from the Leontief inverse, which is used to measure the full impact on the economy of exogenous disturbances (Ferguson 1972; Richardson 1972, p.30). The I/O table is not only used for data organization, multiplier analysis, and macro models, but also as the main database for economy-wide models in general, and for computable general equilibrium (CGE) models (Phimmavong 2012; Phimmavong and Keenan 2020).

I/O analysis has been widely used to assess the impact of the forestry and forest-based industries on regional and national economies. For example, Ferguson (1972) evaluated the total effect of a wood chip project on the regional economy in Western Australia. In the United States, Weber (2002) carried out input-output analyses for Benton County to find out consequences of strengthening and diversifying the economy. In Northern Victoria, Australia, Todd et al. (1997) developed a regional input-output table using the Generation of Regional Input-Output Table (GRIT) hybrid technique to assess the impact of farm forestry development on local industries and employment. Phimmavong (2012) developed an integrated macro-micro economic model to assess the impacts of plantation development policies on the economy in Lao PDR. First, the Lao dynamic computable general equilibrium model was built according to the key characteristics of the Lao economy. Then, he sets out a macro-micro economic framework by connecting the Lao DCGE model to a Lao Household Microsimulation Model (Lao MSM) in a top-down manner.

To examine the effects of this pulp mill project, 20 economic sectors in the provincial economy and in the national economy are used in the current analysis. More precisely, we calculated the total income multipliers and type multipliers for the highly aggregated Savannakhet regional economy in the following sectors: (1) forestry, (2) agriculture, mining, food and textiles, (3) wood & paper products, (4) manufactured goods, (5) electricity, construction and transportation, and (6) services. The impact of a pulp mill project on gross production output and gross domestic products (GDP) was then estimated by using a 20-sector input-output table constructed by the Asian Development Bank.

3.1. Models for examining the full impact of the wood industry sector at regional and national level

For the current analysis, Savannakhet Province was considered as one region in which the pulp mill has been introduced into a regional economy while Laos will be considered as the national unit

for the analysis. Thus, both Savannakhet Province and national economy can be represented by two level input-output tables, which contain different 20 sectors in the economy. According to the central principle of I/O theory, the total output and input of different sectors of the economic system can be represented by different demand-supply balance equations for the regional and national production. The following equation illustrates the relationship for a six-sector economy.

$$[1] \quad \begin{cases} z_{11} + z_{12} + \cdots + z_{16} + y_1 = x_1 \\ z_{21} + z_{22} + \cdots + z_{26} + y_2 = x_2 \\ z_{31} + z_{32} + \cdots + z_{36} + y_3 = x_3 \\ z_{41} + z_{42} + \cdots + z_{46} + y_4 = x_4 \\ z_{51} + z_{52} + \cdots + z_{56} + y_5 = x_5 \\ z_{61} + z_{62} + \cdots + z_{66} + y_6 = x_6 \end{cases}$$

where x_i is the total output supply of the i th sector, z_{ij} stands for sales of commodity i to the j th sector, and y_i is the final demand for the i th sector, representing the sum of the sales to households, both private and public investment expenditure and export.

Eq.[1] is a descriptive model. If we want to express it in analytical form, intermediate inputs are assumed to be a fixed proportion of the output of the purchasing sector. As a result, any increase in the output of the i th sector will finally lead to an increase in the input of the j th sector. This relationship is expressed by:

$$[2] \quad z_{ij} = a_{ij}x_j$$

assuming a proportional relationship between the input and output. Thus, by substituting Eq.[2] to Eq.[1], the following input-output system is obtained:

$$[3] \quad \begin{cases} x_1 = a_{11}x_1 + a_{12}x_2 + \cdots + a_{16}x_6 + y_1 \\ x_2 = a_{21}x_1 + a_{22}x_2 + \cdots + a_{26}x_6 + y_2 \\ x_3 = a_{31}x_1 + a_{32}x_2 + \cdots + a_{36}x_6 + y_3 \\ x_4 = a_{41}x_1 + a_{42}x_2 + \cdots + a_{46}x_6 + y_4 \\ x_5 = a_{51}x_1 + a_{52}x_2 + \cdots + a_{56}x_6 + y_5 \\ x_6 = a_{61}x_1 + a_{62}x_2 + \cdots + a_{66}x_6 + y_6 \end{cases}$$

Using the matrix algebra, we have the following:

$$[4] \quad \mathbf{x} = \mathbf{Ax} + \mathbf{y}, \quad \mathbf{x} = \begin{pmatrix} x_1 \\ \vdots \\ x_6 \end{pmatrix}, \quad \mathbf{y} = \begin{pmatrix} y_1 \\ \vdots \\ y_6 \end{pmatrix}, \quad \mathbf{A} = \begin{pmatrix} a_{11} & \cdots & a_{16} \\ \vdots & \ddots & \vdots \\ a_{61} & \cdots & a_{66} \end{pmatrix}$$

Or we can arrange it to:

$$[5] \quad \mathbf{x} - \mathbf{Ax} = \mathbf{y} \quad \text{or} \quad (\mathbf{I} - \mathbf{A}) \cdot \mathbf{x} = \mathbf{y}$$

where $\mathbf{I}$ is the (6×6) identity matrix. This further results in the following well-known Leontief Inverse (Leontief 1936), given that the inverse is non-singular.

$$[6] \quad \mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{y}$$

This model is a solution to the problem of assessing the total impact of specified changes in final demand and exports. In addition, by manipulating the input-output table, we can determine the different type of multiplier effect. However, this formula is valid under certain assumptions (Richardson 1972, p.27). Note that 1) No joint products exist, since each commodity is supplied

by a single industry and via one method of production; 2) The linear input functions assumption means constant returns to scale and no substitution between inputs; 3) Additivity exists, i.e. the total effect of production is the sum of the separate effects, which rules out external economies and diseconomies; 4) The system is in equilibrium at given prices; and 5) In static versions of the input-output model, no capacity constraints exist so that the supply of each good is perfectly elastic, thereby ignoring problems of the capital.

3.2. Data for the analysis

The input-output table for the regional analysis shows the transactions of different sectors in Lao kip terms at basic values for 2002–2003 for the Savannakhet Province (SVK), Laos. This provincial input-output table was developed by Asra et al. (2006). They divided the SVK economy into 20 sectors: three agricultural sectors (crop; livestock, poultry and fishery; forestry and logging), 10 industrial sectors, and 7 service sectors. In our analysis, the wood & paper products; printing/publishing (in short “wood industry sector”) is used as the unit of the analysis. It consists of industries manufacturing pulp but not paper or paperboard. For the impact analysis, we used a 20 economic sector for both regional and national analysis, while for simplicity tables were aggregated to visualize an input-output relationship in a highly aggregate six-sector for Savannakhet economy, one of which is the wood industry sector (Table 1).

Table 1. Aggregated input-output transactions table for Savannakhet, 2003 (million kips).

	Producing Sector	Purchasing Sector					HCE	Export	OFD	Gross Output	
		1	2	3	4	5	6				
1	agriculture, minning, food and textiles	1,399,236	17	34	327	2,451	9,124	1,608,949	311,402	498,264	3,829,804
2	forestry and logging	789	2,155	22,524	20	6,866	65	7,510	1,674	24,205	65,808
3	wood & paper products; printing/publishing	2,907	251	2,967	72	36,045	10,676	11,763	36,903	4,603	106,187
4	manufactured goods	7,877	123	483	6,167	27,667	39,007	20,993	0	21,504	123,822
5	electricity, construction and transportation	24,507	80	363	1,785	2,564	24,404	21,910	1,869	787,641	865,123
6	services	219,847	1,494	8,254	9,091	94,717	90,664	669,779	85,603	123,785	1,303,234
	Compensation of employees	614,507	23,904	15,703	15,923	157,768	302,272	0		0	1,130,077
	Other Primary Inputs	1,232,186	33,903	40,377	37,870	264,051	518,163	0		115,000	2,241,550
	Imports	327,949	3,881	15,482	52,567	272,994	308,858	417,949		-1,399,678	0
	Gross Input	3,829,804	65,808	106,187	123,822	865,123	1,303,234	2,758,853	437,451	175,324	9,665,606

Note: HCE= Household consumption expenditure; OFD= Other final demand

Source: Authors' calculation from Asra et al. (2006)

Based on the input-output convention, the table is divided into four main quadrants. Quadrant I is the “intermediate” quadrant, which illustrates flows of goods and services sold and purchased by intermediate sectors. By looking across any row of the table, i.e. the agriculture, mining, food and textiles sector sells 1,399,236 million kip of its outputs to firms in the same sector (the agriculture, mining, food and textiles sector), 17 million kip to the forestry and logging sector, 34 million kip to the wood industry sector, 327 million kip to the manufactured goods sector, 2,451 million kip to the electricity, water supply, construction and transportation sector, and 9,124 million kip to the service sector.

From Table 1, looking down the first column, the intermediate sector at the top (i.e., the agriculture, mining, food and textiles sectors) will purchase about 1,399,236 million kip of inputs from the sector; 789 million kip from the forestry and logging sectors; 2,907 million kip from the wood industry sector; 7,877 million kip from the manufactured goods sector; 24,507 million kip from the electricity, water supply, construction and transportation sector; and 219,847 million kip from the service sector. Quadrant II or “final demand” quadrant, displays flows of goods and services exchanged by intermediate sectors and final demand. Final demand represents household consumption (households), capital formation, government expenditure, and export. Quadrant III or “primary” quadrant records values of inputs and outputs exchanged by intermediate sectors and primary inputs. The primary inputs consist of payments to household as wages, other value added (OVA),

and imports. Value added input denotes labour cost, taxes, depreciation cost. “Value added” is the contribution of an enterprise to the gross national product.

For each sector or industry total output is identical to total input, i.e. the sum of the elements in any row equals to the sum of the elements in the corresponding column. For the table as a whole total intermediate sales are identical to total intermediate purchases, and total final demand is identical to total primary input.

Table 2. Aggregated input-output transactions table for Lao economy, 2017 (current prices, US\$ million).

		Purchasing Sector									Gross Output
Producing Sector		1	2	3	4	5	6	HCE	Export	OFD	
1	agriculture, minning, food and textiles	110	474	81	20	56	3	1,714	581	0	3,038
2	forestry and logging	23	531	1	196	347	16	1,077	2,445	0	4,636
3	wood & paper products; printingpublishing	1	4	15	7	15	19	19	207	0	286
4	manufactured goods & trade	19	106	3	68	332	79	201	1,722	23	2,553
5	electricity, water supply, construction and transportation	78	451	27	103	1,665	760	2,018	903	1,919	7,923
6	services	6	30	4	15	325	417	2,714	288	2,123	5,922
GVA Gross value added		2,726	2,656	136	1,901	4,007	4,424	1,008	0	343	17,201
Imports		75	384	19	243	1,178	20	2,188	0	1,987	6,280
Gross Input		3,038	4,636	286	2,553	7,923	5,922	10,940	6,146	6,395	47,839

Source: Authors’ calculation based on data from Asian Development Bank*⁴.

The development of the pulp mill would contribute to the national economy by increasing production, income, and employment (Table 2). Income multipliers are explained in Table 3. Each unit of output in the forestry and logging sector generates 0.36 units of household income to its employees, 0.60 units in total household income to the region and hence a flow-on of 0.24 units. The wood industry sector generates an additional 0.34 units in total household income to the region. The analysis also indicated an income multiplier of 1.20 for the forestry sector. That is, each \$100 of additional sales generates additional regional income of \$120. The income multiplier for wood industry sector was much higher (1.68).

4. Results

4.1. Regional level economic modelling: the impact of the pulp mill

At the provincial level, the establishment of a 300,000 tonne/yr bleached hardwood kraft pulp mill is projected to have a substantial impact on the gross production of the Savannakhet economy (Table 4). Higher export demand for wood products will result in a significant expansion in the wood industry sector and sectors related to wood industries. The output growth in the wood industry sector results in significant increases in gross output of the wood industry sector which is a gain of about US\$ 222.5 million.

The sectors selling goods to the wood industry and those consuming mill products are likely to receive the most benefit from the pulp mill. The analysis shows that the sector benefiting the most from this pulp mill is the forestry sector, with an increase in production level of about 7-fold (US\$ 222.5 million) compared to the baseline (623%), followed by the wholesale and retail trade (US\$ 12 million), personal, social & community services sector (US\$ 6 million and banking, insurance, business services sector (US\$ 2 million). Overall, the gross outputs for all sectors increased by 39% or US\$ 294 million. This is because the new export from the wood sector grows almost nineteen-fold,

*⁴Based on data from ADB, available at <https://data.adb.org/dataset/lao-pdr-input-output-economic-indicators> (Accessed 29 January 2020)

Table 3. Comparison of total income multipliers and type multipliers for the highly aggregated Savannakhet regional economy.

Sector	Initial stimulus	First round income effect ¹	Industrial support income effects ²	Consumption induced income ³	Total	Flow-on ⁴	Type IA or IF/I multiplier
agriculture, minning, food and textiles	0.16	0.07	0.05	0.08	0.36	0.20	1.46
forestry and logging	0.36	0.07	0.05	0.12	0.60	0.24	1.20
wood & paper products; printingpublishing	0.15	0.10	0.01	0.08	0.34	0.19	1.68
manufactured goods	0.13	0.03	0.00	0.05	0.21	0.08	1.21
electricity, construction and transportation	0.18	0.04	0.01	0.07	0.30	0.12	1.22
services	0.23	0.03	0.01	0.08	0.34	0.11	1.11

Source: Authors' calculation from the input-output table 2003 by Asian Development Bank

1:First round income effect refers to the first round purchases by the sector providing the additional dollar of output, 2:Industrial support income effects denote the second round and subsequent round effects as successive waves of growths in output occurring in the economy as a result of the original dollar increase in sales to final demand, 3:Consumption induced income effects refer to the effects on the economy induced by increase in household income related to the original dollar stimulus in output, 4:Flow-on refers to the impacts occurring in all sectors of the economy because of the initial impact of a dollar increase in sales on each of the sector i (total impact less stimulus)

becoming the second largest sector in the provincial gross output. The forestry and logging sectors also increased very rapidly in total value. There were some changes in the value of other modelled sectors. A pulp mill project, being an export earner, will therefore aid both regional and national trade balance significantly. Furthermore, linkages and impacts on other sectors are relatively small -for mining and quarrying (US\$ 6,170), food, beverage and tobacco (US\$ 49,584), chemical products and petroleum sector (US\$ 44,000), given the weak relationship shown in the input-output table.

Overall, the pulp mill project is likely to have a large impact on the Savannakhet economy. GDP tends to increase dramatically by 39%, compared to the baseline scenario, an economic gain of US\$ 152 million injection into the regional economy. However, most of this gain is currently generated through importing wood raw materials and exporting manufactured pulp. As a foreign-owned company, profits also accrue to international shareholders. The actually benefit flowing through the Provincial economy is relatively modest.

4.2. National level economic modelling: the impact of the pulp mill at the national economy

As expected, the mill construction and operation initially affect the wood industry sector and wood related industry sectors. The analysis shows that change in the gross output for all economic sectors at the national level are smaller compared to regional level because, most other provinces are relatively unaffected by the new mill. For example, machinery and labour were largely supplied from China or overseas suppliers (Table 5).

Currently, imports of wood fibre from Vietnam and Thailand account for 90% of the total wood input to processing but the direct impact of this wood supply on the Lao economy is generally low with the total content of imports amounting to \$ 6.00 for each \$ 100.00 of sales from the forestry sector. This impact would increase if the wood supply was generated in Laos.

The increase in employment at the pulp mill, in a region where unemployment and underemployment are high, can generate significant medium and long-term social benefits, that are not necessarily picked up by I/O modelling due to employment data constraint.

Under full operation of the pulp mill, gross outputs for all sectors of the economy are estimated to increase by 2.3%, which is equivalent to approximately US\$ 352 million. Much of its expansion is the impact of the expansion of the wood sector and wood-related sectors. The sectors buying goods more intensively from the wood sector gain the most from this policy change. This effect is obvious

given the presence of relationship of their dependency in the initial input-output table. The analysis also shows that the sector benefiting the most from this change, besides the wood industry sector, are the agriculture, hunting, forestry, and fishing sector, with an increase in production level of about 3.6% (US\$ 79 million), followed by the trade sector (US\$ 12 million), financial intermediation sectors (US\$ 3.3 million), and transportation sector (US\$ 3.1 million). GDP tends to increase slightly by 2.3% in equivalent to US\$ 217 million, compared to the baseline scenario.

Table 4. Impact on the GDP and quantities of production in all economic sectors in Savannakhet Province, Laos (change over baseline).

No.	Economic sector	US\$ million	Percentage change
1	crops	0.0	0.1
2	livestock and poultry	0.1	0.1
3	forestry and logging	48.9	623.0
4	mining and quarrying	0.0	0.0
5	food, beverage and tobacco	0.0	0.0
6	textiles, garments & leather products	0.1	1.7
7	wood & paper products; printing/publishing	222.5	1,755.5
8	chemical products; petroleum	0.0	39.2
9	non-metallic mineral products	0.1	13.9
10	metal products, machinery, equipment, spare parts	0.7	8.6
11	other manufactured goods	0.8	15.1
12	electricity and water supply	0.9	17.1
13	construction	0.3	0.3
14	transportation	0.0	6.0
15	post and telecommunication	0.0	6.5
16	wholesale and retail trade	11.9	20.0
17	banking, insurance, business services	1.9	27.5
18	real estate & ownership of dwellings	0.1	0.8
19	public administration	0.0	0.0
20	personal, social & community services	5.8	9.3
	Gross Production	294.5	39.2
	GDP	152.4	39.2

Source: Calculated from the input-output table 2003 by Asian Development Bank

Table 5. Impact on the GDP and quantities of production in all sectors in Laos (change over baseline).

No.	Economic sector	US\$ million	Percentage change
1	agriculture, hunting, forestry, and fishing	78.6	3.6
2	mining and quarrying	0.2	0.0
3	food, beverages, and tobacco	1.3	0.1
4	textiles, garments and leather products	1.3	0.4
5	wood, pulp, paper and paper products of wood and cork	242.5	85.7
6	chemical, rubber, plastic, petroleum products	2.0	1.1
7	other nonmetallic minerals	0.0	0.0
8	metal products, machinery, equipment & spare parts	0.2	0.2
9	other manufacturing	0.2	0.1
10	electricity, gas, and water supply	2.2	0.3
11	construction	0.2	0.0
12	motor vehicles and motorcycles	2.0	0.8
13	trade	11.6	0.8
14	hotels and restaurants	0.2	0.0
15	transportation	3.1	0.8
16	post and telecommunications	0.4	0.2
17	financial intermediation	3.3	0.9
18	real estate & ownership of dwellings	2.1	0.2
19	public administration	0.0	0.0
20	other services	0.0	0.0
	Gross Production	351.5	2.3
	GDP	216.8	2.3

Source: Calculated from the input-output table 2017 by Asian Development Bank

5. Discussion

This article has presented a technique of examining the impact of the pulp mill project on the regional and national economy of Laos using an input-output modelling approach. The main contribution of this method is that given the social and political context in Lao PDR, the paper represents a novel application of existing economic modelling theory. It does not attempt to establish new theories or methodologies. Laos has implemented policies to expand plantations and this has brought about a recent dramatic increase in large-scale projects by some of the largest global forestry companies with few local production factor inputs except for land (Phimmavong 2009). Previous economic analysis of the wood industry sector in Laos has only paid attention to investment analysis, and simple economic estimation such as production, consumption, and trade, but interactions between the wood industry sector and the rest of the domestic economy have not been explored.

In general, these results indicate that the pulp mill project in Laos can bring about different economic consequences between the regional and national economy, especially in regards to output, and GDP at the regional level and Laos. The economic impact of the pulp mill project seems to be significant, especially at the regional level and much smaller at the national level. It should be noted that regional and national impact could be more significant if wood raw material is produced within the province or elsewhere in Laos. Therefore, the increase in the level of production output ranges from 2.3% at the national level to 39% at the regional level, compared to the baseline scenario.

The wood industry sector experienced the greatest change from this project, an average increase of over US\$ 222.5 and US\$ 242.5 million to regional and national economies respectively. Impacts on other sectors are very minor - mostly for transporting wood from Vietnam. For instance, the increase in the level of production for the transportation sector in Savannakhet Province was only about US\$ 47,000. The sector benefiting the least from this pulp mill project is the crops sector, with a production level of about US\$ 30,000 above the baseline, followed by the livestock and poultry sector (US\$ 70,000), post and telecommunication sector (US\$ 70,000), real estate & ownership of dwellings (US\$ 94,000), and construction sector (US\$ 252,000), mostly due to increased consumption through increased wage labour.

As mentioned earlier, the projected impacts of the pulp mill at both provincial and national scale, might be much larger if more of the wood raw material is grown in Lao PDR by local farmers or companies. The pulp mill project manager has indicated that it has already secured a *Eucalyptus* plantation area of 25,400 ha, which consists of 1) 3,500 ha of concession land, 2) other areas under lease and outgrower contracts from villagers (6,450 ha), and 3) the purchase of the Birla Lao plantations of 15,407 ha in another part of the province. The company is planning to expand this plantation area to 70,000 ha. The region around the mill was heavily impacted by bombing during the Indochina war. Plantation establishment or outgrower schemes need to include clearance of unexploded ordinances (UXOs) before commencement of plantation activities.

There has been surprisingly little economy-wide impact analysis of a pulp mill, with which to compare this analysis. Phimmavong (2012) developed a Lao dynamic computable general equilibrium model according to the key characteristics of the Lao economy and connect this model to a Lao Household Microsimulation Model (Lao MSM) to assess the forest plantation development in Laos. The analysis indicates 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. Williams (Williams et al. 2008) developed an economic input-output model integrated with Monte Carlo simulation to examine the economic impact of two wind energy projects in northern Arizona, USA. The results show that the impact of the wind energy project is likely to generate more economic contributions to the region with a more developed economy because of the less induced economic benefit and fewer workforce and equipment and supplies in the rural economy. This is similar analysis in Laos if much of the workforce, transportation, equipment, and suppliers are bought in Laos, the economic impact from this pulp mill will be much larger.

A more recent analysis by Henderson et al. (2017) examine the potential economic impact of the wood pellet market in the U.S. South by using an input-output analysis examining the direct effects of the construction and operation of wood pellet mill. Their analysis indicates that there are variations in economic benefits captured by different states. The regions with larger scale and more diverse economies tends to gain economic values than those with smaller and less diverse economy. This is because these regions have to heavily depend on some goods and services imported from

other province and from the rest of the world and this reduced the economic impact of the region. This is similar to our analysis, in that the greatest beneficiaries from the mill are industries in other countries which purchase and use the pulp. At national level, economic impacts of the pulp mill are relatively small because economic activity in most other provinces is relatively unaffected by the new mill.

In an analysis assessing the economic impact of small-scale wood pellet production for power generation in Alabama in the USA, Kebede et al. (2013) found that wood pellet production is likely to create significant economic impact, especially wood pellet industry and forests-related services. The other sectors with close relation to wood pellet production industries are those sectors that experience increase demand for services needed by the wood pellet industry: the food and beverage services sector, health service, wholesale and the like. This is very similar economic outcome to this analysis. Alavalapati et al. (1999) developed a two sector CGE model to examine the economic impact of changes in the forestry sector in the Foothills region in Alberta. They concluded that a decrease in the annual allowable cut and in the price of the forest products will produce a dramatic negative impact on the forestry sector and the other sectors of the economy. Consequently, the income of local communities witnessed a reduction in response to the reduction of the supply of timbers from the forestry sector and decrease in factor market.

Economic analyses in North Carolina found that the production of the wood chip provided a better economy wide impact on the economy because of the strong integration between the forestry sectors to other sectors of the economy and then bring about the higher integration among timber markets in the state (Schaberg et al. 2005). A significant increase in timber markets were response to increased pulpwood harvests and better prices. This is quite different from this study since the plantation development in Laos can only supply little fibre to the pulp mill and much of the fibre, equipment, supplies and workers are imported from foreign countries.

While the pulp mill can have significant positive benefits to the economy, it can also have serious environmental externalities that represent a cost to society. A high quantity of chemicals is used in the pulping and bleaching processes. A sizeable amount of water is used in the pulp mill's operation. In China, several mills in which it has been uneconomic to install effluent treatment plants have been closed down because release of untreated effluent into rivers has impacted on water quality for downstream users and aquatic ecosystems (Williams 2014). Similar problems could occur with this mill. Concerns have recently been raised by the local television news media and people in Sepon District regarding the potential for pollution of local rivers and impacts on water used by the local people, and bad odours for the local population. Native timbers have been used in energy production of the mill. The pulp and paper industry has had a history of environmental challenges. While many of these have been addressed through developing new technologies, it is important that the government effectively monitors outputs from the mill and, where necessary, introduces new laws and regulations in order to prevent any adverse impact from the pulp mill on the local people or their environment.

6. Conclusions

This paper is the first attempt to analyse the impact of a pulp mill project using input-output modelling approach at the regional and national level. Here we have tried to quantify these effects by using input-output data from Asian Development Bank and by looking at the economy situation before-and-after the establishment of the fully operation of a 300,000 tonne/yr bleached hardwood kraft pulp mill. Even though this paper does not attempt to establish new theories or methodologies, the main contribution of this method is a novel application of existing economic modelling theory given the social and political context in Lao PDR. The development is projected to have a substantial positive effect on the local economy at the regional level, but a relatively small impact at the national level. The gross production output of the regional economy would increase by US\$ 294.5 million compared to US\$ 351.5 million at the national economy. This pulp mill will add US\$ 152.4 million and US\$ 216.8 million to GDP of the Savannakhet economy and national economy respectively. Almost all of this impact is in the wood and forestry sectors, with limited linkages with other sectors. This is because the mill is capital intensive and most of the economic benefit will go to foreign product purchasers or investors. Laos will benefit through increased terms of trade and export income, employment in mill operation and wood procurement and transport. The modelling

shows that the wood industry sector has relatively weak linkages with other sectors of the economy. Impacts on the other sectors are relatively small - much of it for transporting wood from Vietnam or Thailand. The high proportion of export income to import expenditure will assist the regional balance of the trade, significantly but a slight impact at the national level. In the short-term most of the wood is being purchased from Vietnam and Thailand.

The pulp mill will change the plantation wood market in Laos and projected impacts at provincial and national scales might be much larger if more of the fibre supply was grown in Lao PDR by smallholder growers or companies. To promote sustainable wood pulp production in Laos, the Government of Laos should require more investment in local commercial tree growing and ensure investors in large-scale processing facilities comply with national environmental laws and standards. Companies need to engage transparently and proactively with local communities and undertake Environmental and Social Impact Assessments to identify and mitigate, or avoid any environmental issues from plantation areas with increased activities, transport of wood, or the mill operation. Plantation development models that are integrated with local land uses and support smallholder participation through outgrower schemes or other models are more likely to be supported by local communities and have fewer social and environmental impacts and provide the most benefits.

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