

Foreign Capital Inflows in the Natural Resources Sector: Impacts on the Lao Economy*

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Abstract

Foreign capital inflows are important sources of investment finance for low income developing countries like Laos. On the other hand, massive foreign capital inflows also may have adverse economic effects. This syndrome is called ‘Dutch Disease’. It refers to the phenomena that, firstly, capital inflows give rise to appreciation of the real exchange rate which causes adverse effects for traded goods production and employment. Despite the positive and negative impact of the foreign capital inflows on the Lao economy, there are very few studies on this issue. Therefore, this paper attempts to investigate the effects of foreign capital inflows on Lao economy using a simple macroeconomic model. The results show that the foreign capital inflows by resource sectors stimulate the economic growth meanwhile it also has impact on increasing price and appreciating real exchange rate, which lead to declining export. However, for a rather short period of three years of our simulation, the latter effect is not so strong. We anyhow conclude that foreign capital inflows have two-side effects, positive and negative impact on Lao economy, and we can see Dutch Disease syndrome in Lao economy in the long run. Therefore, the government should pay more attention to macroeconomic management to avoid Dutch Disease in near future.

Keywords: Resource sectors, macroeconomic model, growth, and real exchange rate and Laos.

JEL Classification: Q33;E600

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1. Introduction

Foreign capital inflows are important sources of investment finance for low income developing countries like Laos. As Laos has for a long time faced trade and budget deficits, foreign sources of income such as Foreign Direct Investment (FDI) and Official Development Assistant (ODA) are very important for the country's economic development. On the other hand, massive foreign capital inflows also may have adverse economic effects. This may happen, firstly, if capital inflows are directed to some special sector like mining, and secondly, if a significant increase in government budget revenue occurs due to a sudden increase of production in the special sector. This syndrome is called 'Dutch Disease'. It refers to the phenomena that, firstly, capital inflows give rise to appreciation of the real exchange rate which causes adverse effects for traded goods production and employment (Gregory, 1976; Corden and Neary, 1982), and secondly, a possible government allocation of the sudden increase in revenues to institutional or permanent items like social securities and/or salaries of public employees.

Laos is a Least Developed Country (LDC³) with GDP per capita of US\$580 in 2007. The 34 percent of population live below the poverty line (NSC, 2003). It is basically an agricultural country; of the nation's total GDP of US\$ 2.8 billion in 2005, the agricultural sector covers 44%, the industry sector 30% and the services 26% (World Bank, 2008). However, after introducing a market mechanism, called New Economic Mechanism⁴ (NEM), in 1986, and joining ASEAN Free Trade Area (AFTA) in 1997, the Lao economy has been gaining momentum opportunities and the incidence of poverty has declined. One of the most important factors of high economic growth is foreign capital inflows.

³ According to UNDP (2007/2008), in term of human development index, Laos was ranked as 130th out of 177 countries.

⁴ After the 1975 communist revolution the Lao PDR set up a centrally-planned economy. Under this type of economy system, domestic price, foreign trade and trade among provinces were strictly controlled by the State. Since 1986, Laos has implemented various reforms under NEM, which includes vital components; (a) promotion of private production through improved incentives; (b) institutional infrastructure to improve market economy operation; (c) the strengthening of Lao comparative advantages through trade liberalization and future specialization; and (d) the establishment of price stability through macroeconomic policy measures (Ljunggren, 1993).

ODA inflows have increased since introducing NEM: ODA inflows are to develop mainly infrastructure, human resources and public health care. The average ratio of ODA to GDP is about 13% during 2000-2005. The ODA inflows apparently have no significant adverse effects on Lao economic development. Therefore, we hereafter do not treat ODA inflows in this analysis.

FDI inflows have gradually increased, particularly since the government induced the Foreign Investments Promotion Law in 1988. Since 2002, FDI has flowed in to Laos rapidly especially in resource sectors (i.e., mining and hydropower sectors). Recently, Laos is ranked as one of the resources-rich countries in Asia⁵. There are more than 570 mineral deposits identified, including gold, copper, zinc and lead (World Bank, 2004). In addition, Laos is also traditionally known as a high potential hydropower producer, about 26,000 MW (excluding mainstream Mekong), only 9% of its capacity being used in 2004 (Pholsena and Phonekeo, 2004).

Figure 1 shows that FDI has suddenly increased since 2004 (correctly speaking since 2002). This is mainly because foreign mining companies began to increase production in the mining sector. In 2007, the actual FDI inflows are estimated as about US\$950 million, which shows an increase by 60% from 2006. About 90% of FDI values are related to the resource industry. The economic growth was about 7.5% in 2007, of which 2.5% was from the resource sector (World Bank, 2008).

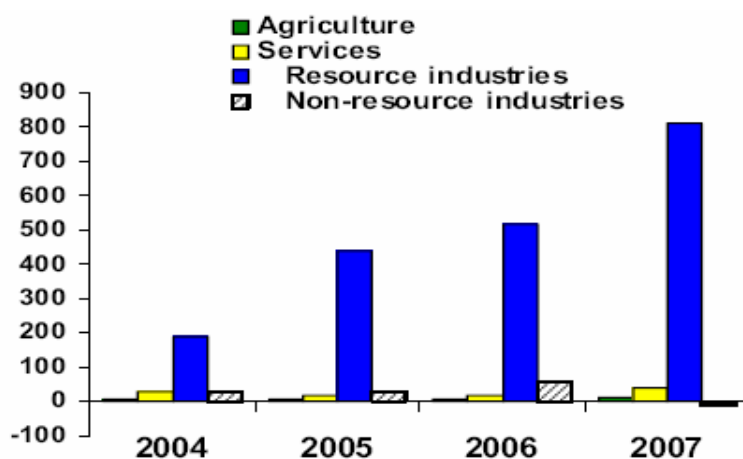


Figure 1. FDI by sector (mil. US\$)

Source: World Bank (2008).

⁵ See the comparison of Lao resource sectors with other countries in [appendix 1](#).

We are interested in determining the future possible consequences of this sudden increase in FDI in the resource sector. Despite potentially significant positive or negative impacts of foreign capital inflows on the Lao economy, there has been little research done on this issue in Laos⁶. Therefore, the impact of foreign capital inflows has not been well understood. Our main objective in this study is to quantify possible impacts of foreign capital inflows on the Lao economy using a macro-econometric approach.

Our paper is organized as follows. Section 2 describes the current macroeconomic conditions of Laos. Section 3 overviews on the recent development of capital inflows and real exchange rate. Section 4 describes our macroeconomic model for the Lao economy. Section 5 presents the impacts of foreign capital inflows on the Lao economy. The last section is devoted to conclusions and limitations of this paper.

2. Macroeconomic Conditions

The national development goal is to liberate the country from the group of least developed countries (LDC) by the year 2020 (GoL, 2004). To achieve the national goal, government announced the National Growth and Poverty Eradication Strategy (NGPES). As infrastructure development, human resources and productivity is poor, promotion of FDI and ODA is one of the main priorities for the Government of Laos.

Since the NEM was introduced in 1986, Laos has been in transition from a centrally planned economy to a more market-oriented economy. As a result, with the exception of a period of negative growth following the Asia financial crisis of 1997, Laos had generally been achieving high rates of economy growth with low inflation. Average economic growth was about 7 % during 2000-2007. Inflation has been maintained below double digits since 2005, about 4.5 % in 2007 (World Bank, 2008). Since 2005 the exchange rate has appreciated, 9,670 kip per US\$ in 2007 compared to 10,655 kip per US\$ in 2005. Laos is an agriculture-based economy, in total GDP of 2.8 US\$ billion, agriculture sector covered 44% of GDP, industry sector was 30% and services

⁶ As one of a few exceptions, Warr (2006) used CGE model – 1-2-3 model framework with multi-households to investigate Dutch Disease in Laos.

was 26% in 2005 (World Bank, 2008). However, since 2003, industry sector have grown more than 10% which has caused agriculture share of GDP declined.

Even though Laos has been maintaining high economic growth with low inflation and a stable exchange rate, there are still serious macroeconomic issues to overcome. Laos is basically facing chronic twin deficits in both government spending and international trade deficit. Deficit financing is mainly depended on foreign sources. Budget deficit to GDP was 2.5% in 2007 (fiscal year) compared to 4.4% in 2005 (fiscal year) (World Bank, 2008). Current account balance deficit to GDP was 17.8% in 2005 compared to 17.4% in 2007 (IMF, 2008). Particularly, the fiscal issue is very serious in Laos. If the budget deficit continues to expand, it will cause an accelerating inflation rate and devaluation of the kip (Lao currency), and could lead to economic instability as during the Asian financial crisis (Okonjo-Iweala et al, 1999). The more details of macroeconomic indicators see Appendix 2

3. Foreign Capital Inflows and Real Exchange Rate

Because we could not access data on the relative price between traded and non-traded goods, we calculate the real exchange rate, derived by nominal exchange rate, domestic price and foreign price as follows.

$$RRATEU = RATEU * PW / PL$$

where RATEU denotes the nominal exchange rate, measured in (kip/US\$), PW denotes foreign price (measure in foreign currency). We use consumer price of United State as proxy for PW. PL refers to domestic price (measured in domestic currency), and we use consumer price as its proxy. The result of real exchange rate calculation is shown in table1.

We divide data from 1989 to 2006 in to three period followed Warr (2006). Period 1: from 1989- 1994 is called “post-reform adjustment”, period 2: 1995-1999 is called “hyperinflation and exchange rate depreciation, and period 3: 2000-2006 is called “sustained growth and foreign capital inflows”. Period 1 (1989-1994) was period of beginning economic reforms in

Table 1 Changes of real exchange rate and foreign capital inflows

Foreign capitals	(average change, % per year)		
	1990-1994	1995-1999	2000-2006
Real exchange rate	-5.4	9.2	-3.1
FDI inflows	106.7	61.6	118.6
ODA inflows	26.0	81.3	16.7
Total (FDI+ODA) inflows	36.7	67.4	46.3

Source: authors' calculation from IMF (2008), International Financial Statistics

Laos. Since NEM was introduced in 1986, Laos has continued to open its doors for foreign trade and investments by relaxing severe quantitative restrictions on import and export and inducing several laws. The first investment law was adopted in 1988. Thereafter, foreign capital inflows in terms of FDI and ODA increased sharply. As a result, during this period, the real exchange rate appreciated by about 5.4%. Period 2 (1995-1999) was a period of macroeconomic turmoil in Laos and other Asia countries. Due to the ripple effect from the Asia crisis spreading from Thailand in 1997, Laos experienced macroeconomic instability, hyperinflation, and nominal exchange rate chaos. Real exchange rate depreciation in this period was mainly caused by high depreciation of the nominal exchange rate. During the Asian financial crisis the Lao currency, kip, was the most affected of the Asian currencies. Period 3 (2000-2006) is categorized as the high growth period with huge foreign capital inflows. The Bank of Laos adopted a monetary policy framework in an IMF-supported program in 2001. Price and the nominal exchange rate stabilized. In addition, a new investment law was adopted in 2004. Coupled with mineral and oil price increased, and rich natural resources in Laos, the massive FDI of mining and hydroelectricity sectors has flowed to Laos. There are several mining and hydropower project under-way. For one of the biggest projects in hydroelectric power development in Laos, called “Nam Theun 2⁷”, total investments is about US\$ 1.03 billion (about 35% of GDP in 2005). In the mining sector, the most successful project is called “Sepon Mining Project⁸” in the south of Laos. This project has been operated by Oxiana Resources Ltd of Australia.

⁷ More details of project see Nam Theun 2 Power Co.Ltd (<http://www.namtheun2.com/>)

⁸ More details of project see Sepon Gold Mine (<http://www.ozminerals.com/Operations/Mining-Operations/Sepon-Gold.html>)

The real exchange rate appreciated by about 3.1 % per year due to massive inflows of foreign capital during this period. As work continues on these projects foreign capital inflows will continue to increase. This will lead to more real exchange rate appreciation which may cause some adverse effects on traditional non-resource manufacturing and also on the agriculture sector.

4. Macroeconomic Model of Laos

There have been various studies done on the impact of resource boom/foreign capital inflows into developing countries using different approaches. Computable General Equilibrium (CGE) approach is popular among them. Devaranjan et al (1993) developed 1-2-3 model to estimate the change in the equilibrium real exchange rate in terms of trade shock and changes in foreign capital inflows. This model is popular and is used to analyze the effects of Dutch Disease. The results are consistent with those of multi-sector computable general equilibrium models. Benjamin (1990) added the investments dimension by incorporating two-period optimization in a multi-sectors CGE model for Cameroon. This model is used to test the impact of foreign-capital inflows, tariff policy, and policy toward public firms. Levy (2007) used a CGE model to study the impact of using Chad's annual oil revenue for public investments, which focused on development of road and irrigation infrastructure. The results showed that Dutch Disease is not an unavoidable consequence of oil booms in Chad. Benjamin et al (1989) used a CGE model to look at the impact of an oil boom on Cameroon's economy. The results showed that one of the standard Dutch Disease results can be reversed, the agricultural sector is most likely to be hurt, but not all the traded good sectors will contract, whereas some of the manufacturing sectors will benefit. In addition, Usui (1996) also used macroeconomic model to analyze the effect of two policy adjustment, namely exchange rate devaluation and the accumulation of budget surpluses to the oil export boom in Indonesia.

Due to the lack of input-output tables or Social Accounting Matrix (SAM⁹) in Laos, the CGE model approach could not be used. Therefore, in order to analyze the impact of foreign capital inflows on Lao economy, we used a macroeconomic model approach. This model is based on LAOMACROMODEL-2 (Kyophilavong and Toyoda 2004;

⁹ Warr (2006) used Savannakhet Input-Output table to estimated national Input- Output table for his database of CGE model.

Toyoda and Kyophilavong 2005; 2007). We modified the model in order to meet our research objectives. Firstly, we extend estimation periods from 2000 to 2006. Secondly, we induced real exchange rate function into the model, and added foreign capital inflows in nominal exchange rate function. Thirdly, we attached indirect tax and direct tax function into one, tax function and omitted gross national income and domestic income.

The key distinguishing features of the model are as follows. (1) For building this model, the most important hypothesis is time series data and the market economy mechanism. Laos continues to induce a market economy into its communist system. Even though the economic structure is different from the usual one of capitalist countries, we assume that the Lao economy has basically the same structure as capitalism countries. (2) Current Laos is facing supply side issues because capital and skilled labor are scarce. On the other hand, it is also facing demand side issues such as: possible high inflation and the devaluation of kip as during the Asian crisis. Therefore, we consider both demand and supply side issues in order to construct the Lao model. The ratio of supply side GDP and demand side GDP determine general price function. On the other hand, demand and supply are adjusted by general price mechanism. (3) Lao is an agricultural economy. From this point we divide the supply side GDP into agricultural GDP and non-agricultural GDP to analyze the structural change in the agricultural sector. (4) We have 20 equations, which are divided into 9 behavioral equations¹⁰, 9 identities, and 2 statistical equations (appendix 3 and 4). The flowchart of model see Figure 1.

The data used in this model are largely sourced from the International Monetary fund (IMF), World Bank (WB) and Asian Development Bank (ADB). Due to the lack of necessary data for building this model, the authors did some modification and adjustment of data set by using various assumptions. For details of modifications of data, see in Kyophilavong and Toyoda (2004), and Kyophilavong (2004). In order to test the reliability of the model, we conduct final test. The results are summarized in appendix 5.

¹⁰ We used the two-stage OLS (Ordinary Least Square) method to estimated equations. In order to avoid multicollinearity in the independent variables, the correlation matrix method was employed. We chose variables which had correlations of less than 50%. The Breusch-Pagan test was used to check whether the model has any heteroskedasticity or not (Wago and Ban 1995).

5. Impacts of Foreign Capital Inflows

There are mainly two kinds of foreign capital inflows in Laos, FDI and ODA. In this paper, we focus on the impact of FDI on the Lao economy. There are two reasons why we concentrate on FDI. Firstly, the trend of FDI in mining and hydropower sector is profoundly increasing as we have seen in Section 1. In addition, ODA seems to be declining. Secondly, FDI contributes more directly to production rather than ODA and may cause Dutch Disease.

There are mainly two routes of impacts of investment inflows on Lao economy. First, foreign investment inflows lead to increased domestic investments (eq 1, 2). Increasing domestic investments result in an increase in potential production (eq 3-5), then potential production has an impact on lowering domestic price (eq 6, 7). The first route of the effects of foreign investment inflows is shown in equation 1-6 (appendix 3).

On the other hand, foreign capital inflows also have adverse effects on the economy through appreciation of the real exchange rate, which leads to declining exports. We follow Athukorala and Rajapatirana (2003) and Lartey (2007) in order to make exchange rate function. Here, we use general price as proxy of excess money growth. Laos is a transitional economy and government expenditure is basically financed by money supply growth (Kyophilavong, 2008). In this model, foreign capital inflows determine the nominal exchange rate (eq 7), then the nominal exchange rate determines the real exchange rate (eq 8). Changes to the real exchange rate has effects on exports and imports, and finally on gross domestic product (eq 9-11).

Our simulation exercise was done as follows. First, we conduct a base-line simulation without giving any shocks on the model for the simulation period (1989~2006). We call it the base case (B). In order to analyze the impacts of foreign capital inflows on the Lao economy, we make the assumption that FDI increased by 50 % from the based year during three simulation periods¹¹, which is called shock case (C). By increasing FDI inflows, we can see the effects on such macroeconomic variables as inflation, the real exchange rate, gross domestic product, and exports and imports. We chose the period of 1994 to 1996 for simulation because it was stable period before the external shock of the Asian financial crisis.

¹¹ It is important to note that we use nominal FDI as shock variables in this simulation

The difference between base case (B) and shock case (C) refers to impacts of foreign capital inflows¹².

Table 2 shows the simulation result of the effects of foreign capital inflows to the Lao economy. Foreign capital inflows have a positive impact on growth; average GDP increases by 2 %. The increase in GDP in the first year of simulation is 2.1 %, 1.3 % in the second year of simulation, and 2.5 % in the last year of simulation. It shows that the foreign capital inflows play a very important role for economic growth. The main channel through which FDI encourages economic growth is via increases in investment in capital stock and then production.

The authors found that increasing foreign capital inflows results in a decrease in general price (PL), but its impact is small. For the first year of simulation, the price decreases by 1.2 %, 0.4 % in the second year, and 1 % in the last year. The decrease in price is due to the fact that an increase in potential product is smaller than an increase due to demand side of GDP coupled with the one due to money supply increase.

Several empirical studies have shown that foreign capital inflows can have adverse negative impacts on the domestic economy due to appreciation of the real exchange rate damaging production of tradable goods. Without any exception, this study shows the same result. Foreign capital inflows lead to an appreciation of real exchange rate, the average of real exchange rate appreciation is 3 %; the appreciation in first year of simulation is 2.2 %, 3 % in the second year and 4.5 % in the third year. Appreciation of the real exchange rate causes a decline in non-primary exports. However, the impact is not so strong. According to our simulation it is about 4 %.

Due to specification limitations of our export function, we could not identify how the impacts of foreign capital inflows affect on the booming sector, the non-resource manufacturing sector and the agricultural sector in detail. The appreciation of the real exchange might be caused through two channels, firstly through an increase in nominal exchange rate and secondly through an increase in the general price, then leading to appreciation of real exchange rate. We need to improve our specification of these channels in more detail. Also, we need to specify our equations to investigate possible movements of production factors, capital stock and labor, from

¹² The impact of capital inflows = $(B - C) * 100 / C$; B: Base case; C: Shock case.

the non-resource sector to the resource sector, which will cause adverse effects on production and exports in non-resource sectors.

Table 2. Impact of foreign capital inflows

Variables		Period 1	Period 2	Period 3	Average
GDP	Gross domestic product	2.07	1.27	2.52	1.96
PL	General price	1.20	0.42	0.94	0.85
RRATEU	Real exchange rate	-2.15	-2.93	-4.49	-3.19
RATEU	Nominal exchange rate	-0.98	-2.53	-3.59	-2.36
EX	Export	-3.49	-3.86	-4.68	-4.01
IM	Import	2.52	1.66	3.01	2.40
CP	Private consumption	1.67	1.58	2.47	1.91
DI	Domestic investment	4.18	-0.41	4.06	2.61
TAX	Tax	1.74	1.55	2.42	1.90
WAGE	Wage	1.97	1.13	2.41	1.84

Source: authors estimated from model.

6. Conclusions

This paper attempts to analyze the possible impacts of foreign capital inflows on the Lao economy using a simple macroeconomic model. According to the model foreign capital inflows clearly increase economic growth. On the other hand, foreign capital inflows increase general prices and appreciate the real exchange rate, which show unfavorable signs on economic development through a decline in exports. However, for a rather short period of three years of our simulation, the latter effect is not so strong. Considering the right signs of positive direction of GDP and negative direction of export, we foresee a possible stagnation path if the resource boom stops in the long run. We anyhow conclude that foreign capital inflows have two-side effects, positive and negative impact on Lao economy, and we can see Dutch Disease syndrome in Lao economy in the long run. Therefore, the government should pay more attention to macroeconomic management to avoid Dutch Disease in near future.

However, this model has some limitations, mainly due to data availability. There are no details on distinction between booming sector and non-booming sector. So we cannot identify clearly which sector will gain and which sector will lose from foreign capital inflows. In addition, we neglected the impact of expending windfall from the resource sector on the Lao economy. We also need to specify various aspects in more detail, including sectoral movements of production factors and analysis of government allocation of an increase of tax revenues from the resource (booming) sector.

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Appendix 1: Comparison Laos resource sectors with other countries

Country	Resource export		Resource fiscal revenue		Per capita GDP (in US dollars)	Commodity
	In percent of total export	In percent of GDP	In percent of total fiscal revenue	In percent of GDP		
Low-income countries						
Lao P.D. R	37.4	9.1	3.7	0.4	501	Copper and gold
Mongolia	61.5	35.8	20.8	8.4	847	Copper and gold
Papua New Guinea	75.3	66.2	31.3	8.8	666	Oil, gas, copper and gold
Timor-Leste	-	109.2	79.8	72.4	353	Oil and gas
Vietnam	22.5	14.5	33.3	9	639	Oil and gas
High-and middle-income countries						
Australia	46.2	9	-	-	34381	-
Brunei	85.3	62	91.6	45.2	25976	-
Indonesia	23.1	6.8	28	5.2	1353	-
Malaysia	8.1	8.8	29.7	6.5	5126	-
Total regional average	18.5	7.3	29.4	6.3	2054	-
Low-income country average	22.9	14.7	32	9	608	-

Source: IMF (2007).

Appendix 2 Macroeconomic indicators

Macroeconomic indicators	2001-2006	1996-2000	1990-1995
Population (million. person)*	5.46	4.86	4.40
Population growth (%)	2.12	2.06	2.52
GDP (current million US\$) **	2,416	1,618	1,276
GDP growth (%)	6.53	6.18	6.46
GDP per capita (constant 2000 US\$) **	379	307	248
GDP per capita growth (%)	4.04	3.68	3.80
Reserve Money (M2) (million US\$)*	450,981	270,728	148,280
Money supply (M2) (%)*	21.14	65.99	30.92
Inflation -CPI (%)	9.73	57.00	15.27
Trade Deficit (million. US\$)***	-219.91	-263.21	-174.92
Trade Deficit /GDP (%)	-9.24	-16.06	-13.14
Foreign reserve (million. US\$)***	220	127	48
External debt (million US\$) *	2,640	2,410	1,965
External debt /GDP (%)	115	152	161
Budget Deficit (including grants)(million US\$)	-104	-58	-100
Budget Deficit /GDP (%)	-4.42	-3.60	-7.61
Budget Deficit (exclude grants)(million US\$)	-149	-121	-145
Budget Deficit /GDP (%)	-6.29	-7.58	-11.21
Exchange Rate (kip/US\$) Official Rate***	10,163	4,094	727
Change of Exchange Rate (%)	4,515764863	68	6

Sources:

* Asian Development Bank (ADB), *Key Indicators for Asia and the Pacific 2008* www.adb.org/statistics

** World Bank, *World Development Indicators CD-ROM (2005)* and

*** International Monetary Fund, *International Financial Statistics CD-ROM August 2008*

Appendix 3: Equations in Lao macroeconomic model

(1) Total investment

$$I = \text{FDI} + \text{DI} + \text{IG}$$

I: total investment, FDI: foreign direct investment, DI: domestic investment, IG: government investment.

(2) Capital stock

$$K(-1) = K + I$$

K(-1): capital stock (lag one year), K: capital stock, I: total investment

(3) Potential non-agriculture product

$$\ln(\text{GDPNS}/\text{LN}) = f((+) \ln(K(-1)/\text{LN}))$$

GDPNS: potential non-agriculture product, LN: non-agriculture population, K(-1): capital stock (lag one year).

(4) Total potential product

$$\text{GDPS} = \text{GDPAS} + \text{GDPNS}$$

GDPS: total potential product, GDPAS: potential agriculture product, GDPNS: potential non-agriculture product.

(5) Demand pressure

$$\text{DS} = (\text{GDP}/\text{GDPS}) * 100$$

DS: demand pressure, GDP: demand side of gross domestic product, GDPS: potential production (supply side).

(6) General price

$$\text{PL} = f((+) \text{DS}, (+) \text{MONP}/\text{GDP}, (+) \text{IP})$$

PL: general price, DS: demand pressure, MONP: money supply (nominal), GDP: demand side of gross domestic product.

(7) Nominal exchange rate

$$\text{RATEU} = f((-) (\text{FDI} + \text{FAID}), \text{PL})$$

RATEU: nominal exchange rate, FDI: foreign direct investment flow (nominal), FAID: Official Development Assistance, ODA (nominal), PL: general price

(8) Real exchange rate

$$\text{RRATEU} = \text{RATEU} * \text{PW}/\text{PL}$$

RRATEU: real exchange rate, RATEU: nominal exchange rate, PW: foreign price, PL: domestic price.

(9) Export

$$\text{EX} = f((+) \text{RRATEU}, (+) \text{GDP})$$

EX: export, RRATEU: real exchange rate, GDP: gross domestic product

(10) Import

$$IM = f ((-) RRATEU, (+) TV)$$

IM: import, RRATEU: real exchange rate, TV: gross domestic product of Thailand and Vietnam.

(11) Gross domestic product

$$GDP = CP + I + G + EX - IM$$

GDP: gross domestic product, I: total investment, G: government expenditure, EX: export, IM: import

(12) Private consumption

$$CP = f ((+) GDP, (+) CP(-1))$$

CP: private consumption, GDP: gross domestic product, CP(-1): private consumption (lag one year).

(13) Domestic investment

$$DI = f ((+) (GDP + GDP(-1)), (-) RISHIP)$$

DI: domestic investment, GDP: gross domestic product, GDP(-1): gross domestic product (lag one year), RISHIP: nominal interest rate (nominal).

(14) Total tax

$$TAX = f ((+) GDP, (+) TAX (-1))$$

TAX: total tax, GDP: gross domestic product, TAX(-1): total tax (lag one year)

(15) Government revenues

$$REV = TAX + NOTAX$$

REV: government revenues, TAX: total tax, NOTAX: non-tax revenue

(16) Government expenditure

$$G = IG + CG$$

G: government revenue, IG: government investment, CG: government consumption

(17) Agricultural population

$$LA = NP - LN$$

LA: agricultural population, NP: total population, LN: non-agricultural population

(18) Non-agricultural population

$$LN = f ((+) WAGE, (+) LN(-1))$$

LN: non-agricultural population, WAGE: wage, LN(-1): non-agricultural population (lag one year)

(19) Wage

$$WAGE = f ((+) GDP, (+) PL, (+) WAGE(-1))$$

WAGE: wage, GDP: gross domestic product, PL: general price, WAGE(-1): wage (lag one year)

(20) Potential agricultural product

$$\text{Ln (GDPAS/LA)} = f ((+) \text{Ln(HPA/LA)})$$

GDPAS: potential agriculture product, HPA: agriculture land area, LA: agriculture population

We have 20 equations in model, which divide into 9 behavioral equations (6, 7, 10, 12, 12-14, 18, 19), 9 identities (1, 2, 4, 5, 8, 11, 15-17), and 2 statistical equations (3, 20). We have exogenous variables such as MONP, IP, FDI, FAID, PW, TV, NOTAX, HPA.

Appendix 4 Estimated function in model

Potential agriculture product function

$$\text{Ln (GDPAS/LA)} = -0.44 + 0.92 * \text{Ln (HPA/LA)}$$

Potential non-agriculture product function

$$\text{Ln(GDPNS/LN)} = -1.22 + 0.63 * \text{Ln(K(-1)/LN)}$$

Consumption function

$$\text{CP} = -180.57 + 0.57 * \text{GDP} + 0.45 * \text{CP}(-1)$$

(-2.48) (3.15) (2.36)

R-SQ: 0.98 F: 623.87

Domestic investment function

$$\text{DI} = 519.32 + 0.45 * (\text{GDP} - \text{GDP}(-1)) - 12.23 * \text{RISHIP}$$

(3.24) (1.30) (-2.09)

R-SQ: 0.20 F: 2.70

Wage function

$$\text{WAGE} = 131.65 + 0.85 * \text{GDP} - 0.033 * \text{PL} - 0.06 * \text{WAGE}(-1)$$

(2.42) (7.79) (0.85) (-0.50)

R-SQ: 0.99 F: 1326.99

Tax function

$$\text{TAX} = -16.17 + 0.069 \cdot \text{GDP} + 0.41 \cdot \text{TAX}(-1) - 26.50 \cdot \text{DD1}$$

$$(-0.96) \quad (2.94) \quad (1.95) \quad (-2.66)$$

R-SQ: 0.91 F: 59.45

Export function

$$\text{EX} = -69.87 + 1.83 \cdot \text{TV} + 0.004 \cdot \text{RRATEU}$$

$$(-0.98) \quad (3.97) \quad (2.56)$$

R-SQ: 0.72 F: 21.28

Import function

$$\text{IM} = -191.36 + 0.49 \cdot \text{GDP} - 0.00071 \cdot \text{RRATEU}$$

$$(-1.19) \quad (3.72) \quad (-1.60)$$

R-SQ: 0.62 F: 14.52

Non-agriculture population function

$$\text{LN} = -33.49 - 0.08 \cdot \text{WAGE} + 1.22 \cdot \text{LN}(-1)$$

$$(-1. \quad (-1.57) \quad (11.44)$$

R-SQ: 0.99 F: 5075.50

General price function

$$\text{PL} = -61.99 + 0.22 \cdot \text{DS} + 188.94 \cdot (\text{MONP}/\text{GDP}) + 0.02 \cdot \text{IP}$$

$$(-1.17) \quad (1.15) \quad (4.47) \quad (7.40)$$

R-SQ: 0.99 F: 1531.77

Nominal exchange rate function

$$\text{RATEU} = 134.35 - 1.20 \cdot (\text{FDI} + \text{FAID}) - 9.97 \cdot \text{PL} - 843.47 \cdot \text{DD1}$$

$$(0.43) \quad (-2.77) \quad (17.32) \quad (1.66)$$

R-SQ: 0.97 F: 173.93

Appendix 5 Results of Final Test

Variables		(%)
		RMSPE
CP	Private consumption	18.04
DI	Domestic investment	25.00
EX	Export	12.75
GDP	Gross domestic product	17.72
I	Investment	30.56
IM	Import	20.18
K	Capital stock	5.66
LN	Non-agriculture population	4.68
PL	General price	9.59
RATEU	Nominal exchange rate	10.00
RRATEU	Real exchange rate	16.57
TAX	Tax	11.70
WAGE	Wage	15.89

Source: authors estimation from model.

Note: RMSPE: Root-Mean-Squared Percent Error (%).

Figure 1 Model flowchart

