# Essays on Open Economy

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# Abstract

This dissertation consists of three chapters. The first one examines the causes of falling labour share in OECD and non-OECD countries since the 1980s. It finds that while both groups of countries experience a more-than-one of elasticity substitution between capital and labour, the factors driving down labour share in both groups differ. In the former, export and volatility are key drivers, but in the latter, major forces are financial openness and relative price of investment. The second chapter develops a model of currency substitution to explain the upward trend of dollarisation in Cambodia. This model shows that the interaction between the role of a foreign currency as a means of payment and a unit of account increases the degree of dollarisation, even after Cambodia has stabilised its inflation. The last chapter develops and estimates a small open economy real-business cycle (SOE-RBC) model to study the dynamics of Cambodian current account. Differing from existing studies, the paper includes net unilateral transfers and net foreign direct investment (FDI) as additional sources of macroeconomic fluctuations. This SOE-RBC model shows that these two sources play more important roles in explaining current-account variation than existing ones—productivity and interest rate. The model generates Cambodian saving-and-investment behaviour that matches well the evolution of its current account: The measurement error is just about 4% and the correlation between data and model is around 0.93. This well-fitted model is then used to predict the future trend of the current account, as the negative shocks of productivity, remittance and FDI hit the economy with COVID-19 pandemic in 2020.

# Declaration

This thesis is an original work of my research and contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

Signature:

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Date: 07 February 2021

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This thesis is dedicated to my late father.

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# CHAPTER 1

# THE DECLINE OF LABOUR SHARE IN OECD AND NON-OECD SINCE THE 1980S

Abstract

This paper examines the causes of falling labour share in OECD and non-OECD countries since the 1980s by using Karabarbounis and Neiman (2014)'s labour share model. While both groups of countries experience a more-than-one of elasticity substitution between capital and labour, the factors driving down labour share in both groups differ. In the former, export and volatility are key drivers, but in the latter, major forces are financial openness and relative price of investment. Overall, technological advancement—as reflected by declining relative price of investment—coupled with globalisation and low economic risk is a key factor in explaining a long-term decline of labour share worldwide.

JEL Classification Numbers: E25; F66; O33

Key words: Labour share; Trade; Volatility; Financial openness; Elasticity of substitution

## 1.1 Introduction

Since the work of Kaldor (1957), the evolution of the labour's income share has been believed to be constant. This constancy of factor share is known as one of Kaldor (1957)'s stylised facts in macroeconomic models, particularly growth model (Elsby et al., 2013; Karabarbounis and Neiman, 2014). However, this stylised fact has recently been questioned or even rejected because over the last three decades, the trends of the share of GDP going to labour has been downward in many countries. Figure 1.1, for example, shows the declining labour share of the four largest economies, whose combined GDP accounts for almost half of the world GDP. These downward trends have occurred not just in these four economies, but also they have been seen in most part of the world, as documented comprehensively by Karabarbounis and Neiman (2014).

This worldwide phenomenon has led to a large body of research that investigate what factors have attributed to this secular decline. Two recent works have drawn worldwide attention. Piketty (2014) offers the fundamental laws of capitalism that help explain the evolution of capital share in the long run. His first law simply shows that the share of GDP going to capitalists increases as capital accumulates. However, this conclusion holds only if the elasticity of substitution between labour and capital exceeds unity. Based on this logic, Karabarbounis and Neiman (2014) provide evidence that labour and capital have been highly substitutable since the 1980. This high elasticity (around 1.28) enables them to draw the conclusion that the falling relative price of investment goods induces firms to replace labour by capital to such large extent that the income share of labour falls.

To contribute to existing literature on the causes of falling labour share, this paper uses Karabarbounis and Neiman (2014)'s labour share model as a prototype, from which the econometric models are specified to test the determinants of the labour share.

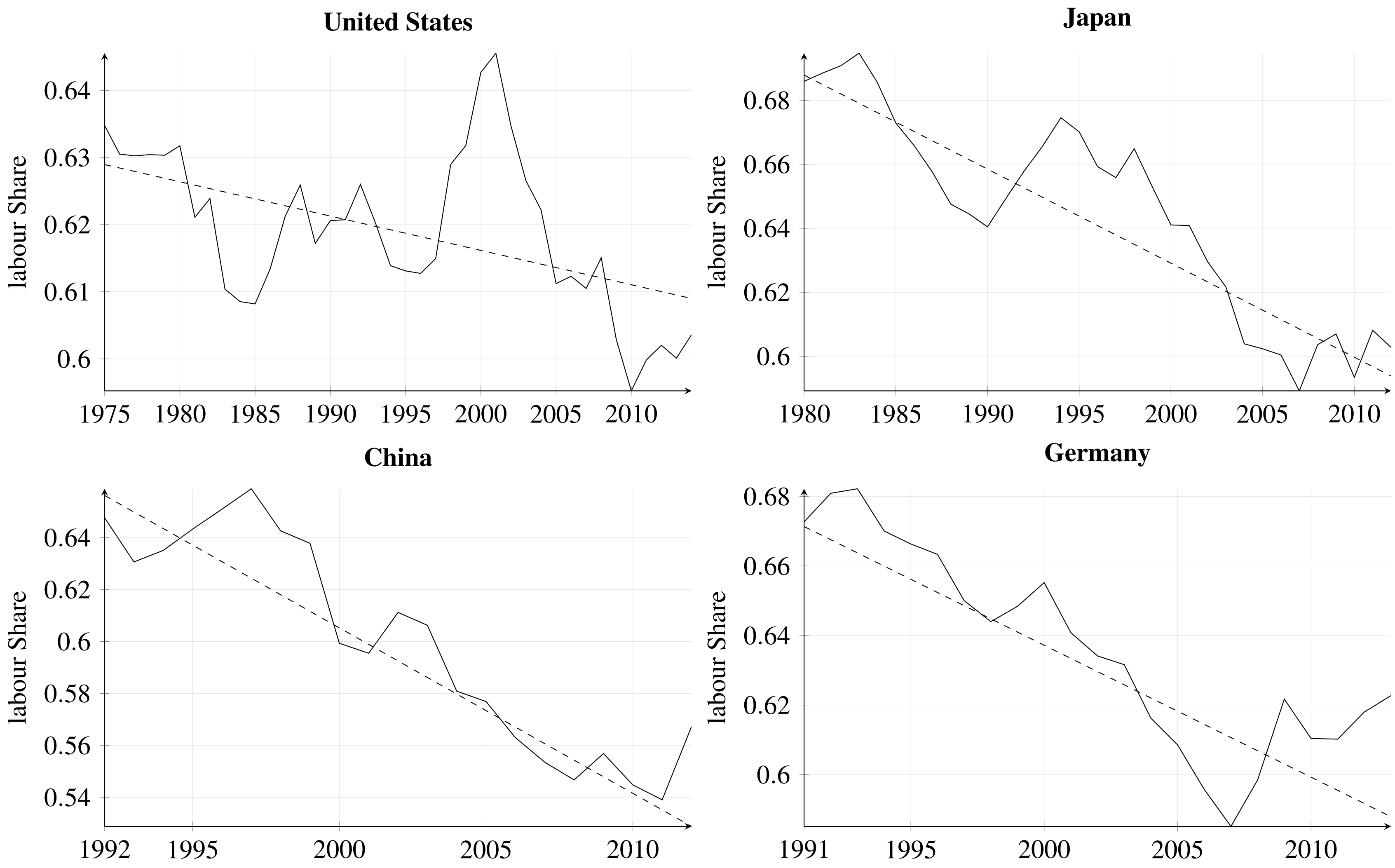



Figure 1.1: Declining labour share in four largest economies.

The figure shows the labour share and its linear trend for the world's four largest economics from 1975.

This paper is a synthesis between the works by Elsby et al. (2013) and Karabarbounis and Neiman (2014). Improving upon them by dealing with endogeneity bias, the paper includes a new explanatory variable: *risk* measured by the real GDP volatility, which affects both labour share and return rate of investment. Low risk tends to encourage firms to invest and hire more, but high risk as in the 2007-09 recession (Figure 1.2, for example) leads firms to dis-invest and lay off (Kang et al., 2016). Because of high substitution between capital and labour, firms utilise capital more proportionally than labour at the time of low risk, thus leading to the decline of labour share. On the top of these, the paper also compares the studies of falling labour share between Organisation for Economic Co-operation and Development (OECD) and non-OECD countries because these two groups of countries have different characteristics such as economic performances and risk.

To quantitatively determine the causes of the labour share, the paper analyses the data set covering from 1975 to 2014 for 30 OECD countries and 23 non-OECD countries by using two estimation methods. The first one is a robust regression estimation[1] to deal with the long-run growth rates (at least 15 years) of variables, and the second one is a fixed effect estimation to deal with the short-run growth rates (5 years) of variables. The results show that while both groups of countries experience a more-than-one elasticity of substitution between capital and labour, the forces of declining labour share are different. Export and volatility seem to be the drivers in the advanced nations. A 10 percent increase in export growth leads to a 1 percent decrease in the growth of labour share, and a 10 percent decrease in volatility causes a 2.5 percent decline in labour share growth. But in the developing nations, relative price of investment goods and financial openness appear to be the factors. As the growth of relative price of investment goods declines 10 percent, the labour share growth also declines about 2 percent and a 10 percent growth of financial openness leads to just a 0.4 per cent decline in the labour share growth.

[1] Appendix 1.D explains what a robust regression is.

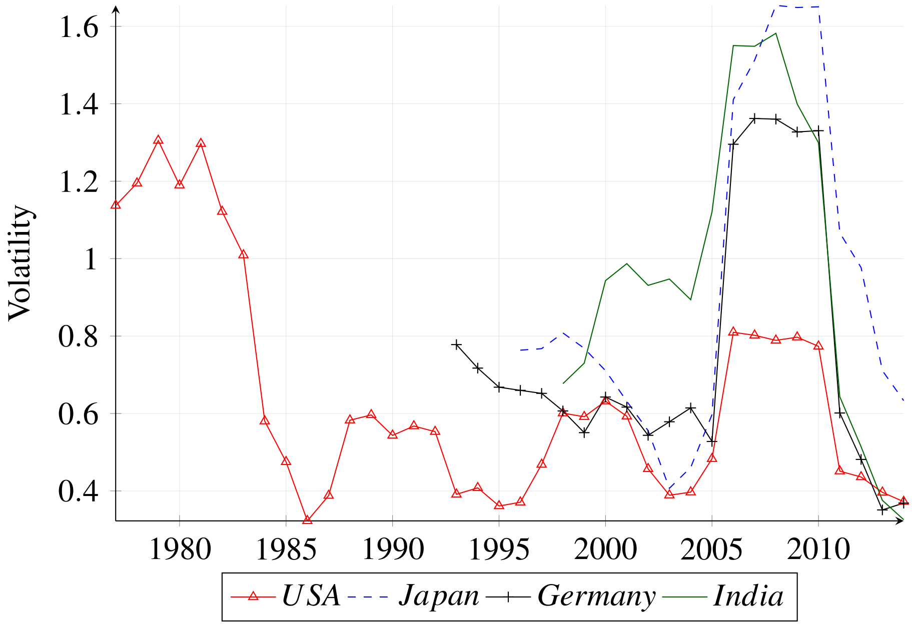



Figure 1.2: Volatility trend of four large economies.

The figure shows the volatility trend of the four large economies in the world since the 1980s. The volatility is measured by the standard deviation of quarterly 5-year moving average of GDP's growth. Since China's quarterly GDP is not available, India's data is used instead.

Taking the results together, the paper finds that as labour and capital become more highly substitutable, the declining relative price of investment goods—because of technological improvement in the production of investment goods—coupled with the availability of funds, low risk and increasingly global competition induces firms to become more capital intensive. And in order for them to stay globally competitive, they must have suppressed production costs, particularly wages, leading to falling labour share in both developed and developing nations. This co-occurrence repudiates the prediction by conventional theories of trade based on international differences in factor endowment that labour share should fall in a capital abundant country but rise in a labour abundant country.

The remainder of this work proceeds as follows. Section 2 reviews relevant works. Section 3 introduces the model of the labour share, followed by the estimation of elasticity of substitution between capital and labour in section 4. Section 5 extends the model of the labour share by including other identified factors of labour share. Section 6 deals with estimation methods, data, and results. Section 7 concludes.

## 1.2 Related Literature

This paper relates to two other strands of literature. One estimates the elasticity of substitution between capital and labour, denoted $\sigma$, whose value plays a crucial role in pointing the direction of relationship between a factor's relative price and its income share. The results are inconclusive because the estimates of $\sigma$ appear to systematically depend on the choice of functional form of econometric models and are extremely sensitive to variations in measurement and data construction (Berndt, 1976). While some researchers such as Berndt (1976)—a highly cited author on this topic—supports the unit elasticity, Klump et al. (2008) among others reject it. Chirinko (2008) surveys a large portion of literature on this estimate and concludes that the value of $\sigma$ is in the range of 0.40-0.60. Recently Karabarbounis and Neiman (2014) and Koh et al. (2020) find this elasticity to be significantly greater than 1.

The second body of literature looks at possible explanations behind the downward trends of labour share. Blanchard et al. (1997) attributes the upward trends of capital shares in most Europe countries to changes in labour market institutions such as more generous treatment of unemployment, increases in employment protection, minimum wage legislation. These labour market conditions have over time induced firms to moving away from labour, increasing an unemployment and capital accumulation, and thus leading to lower income share to labour.

However, one of the changes in market condition, namely de-unionisation , is not empirically supported by Elsby et al. (2013) who elaborate on the decline of the U.S labour share at the country and industry levels. Instead, they offer evidence that features the global integration—the offshoring of the labour intensive component of the U.S supply chain—as a leading potential factor of the decline in the U.S labour share over the last three decades. They argue that by offshoring the more labour-intensive part of U.S production, the rest of production in the U.S economy is more likely to become capital intensive. As capital is more than unit-elastic with respect to labour as shown by Karabarbounis and Neiman (2014) and Koh et al. (2020), the U.S labour share will fall when the relative price of investment goods declines.

Elsby et al. (2013)'s conclusion on the role of global integration in declining labour share is reinforced by the findings by Dao (2017). The latter group show theoretically and empirically that technological advancement—in addition to global integration—also plays dominant roles in explaining the decline of labour share in advanced countries as well as in emerging and developing countries. Technological progress, embodied in faster productivity growth in the investment goods sector relative to the remaining sectors, pushes the price of investment goods down and therefore propels firms to substitute capital for labour. Because of highly substitutable between labour and capital, the labour share of income falls.

## 1.3 A Model of the labour Share

The model of the labour share mainly relates the income shares of factors to their relevant prices, and markups but the direction of their relationships depends on the value of the elasticity of substitution. In this model, economy consists of two sectors. In the first sector, final consumption and investment goods are produced by assembling intermediate inputs using a constant elastic of substitution (CES) production technology; and in the second one, those intermediate inputs are, in turn, produced by combination of physical capital and labour with the same CES technology and Hicks-neutral technological progress.

Time is a discrete, infinite horizon, $t = 0, 1, 2, \ldots$. All payments in this economy are made in terms of the final consumption goods's price–denoted $p_t^c$–which is the numeraire.

### 1.3.1 Final Consumption Good

Competitive producers use a CES aggregate of a continuum of intermediate inputs $i \in [0, 1]$ to produce the final consumption good $C_t$ as follows:

$$C_t = \left( \int_0^1 c_t(i)^{\frac{\varepsilon-1}{\varepsilon}} di \right)^{\frac{\varepsilon}{\varepsilon-1}}, \tag{1.1}$$

where $\varepsilon$ is an elasticity of substitution between input varieties and exceeds 1 (because intermediate inputs are numerous, thus easily substitutable) and assumed to be constant over time, and $c_t(i)$ is the input i's quantity. These producers purchase these inputs from monopolistically competitive firms that charge prices $p_t(i)$ equal to the markups $\mu$ over marginal cost. The markups—depending on the parameter $\varepsilon$—are also constant over time.

The profit maximisation implies that the demand for input variety i for use in producing the final consumption good is $c_t(i) = \left( \frac{p_t(i)}{p_t^c} \right)^{-\varepsilon} C_t$. This consumption good is assumed to be the numeraire and has the price of 1. Because the final goods market is competitive, this good has the price equal to the marginal cost of production. That is,

$$P_t^c = \left( \int_o^1 p_t(i)^{1-\varepsilon} di \right)^{\frac{1}{1-\varepsilon}} = 1.$$

### 1.3.2 Final Investment Good

In the similar fashion as in modelling the final consumption goods, competitive producers of the final investment good $X_t$ employ the same production technology and continuum of inputs i to produce $X_t$ as follows:

$$X_t = \left(\frac{1}{\xi_t}\right)\left(\int_0^1 x_t(i)^{\frac{\varepsilon-1}{\varepsilon}} di\right)^{\frac{\varepsilon}{\varepsilon-1}}, \tag{1.2}$$

where the exogenous variable $\xi_t$ is the relative level of technology in the final consumption good production to that in the final investment good production at time $t$. As the technology of producing the investment good advances more than that of producing the consumption good, the relative level of technology $\xi_t$ falls.

To maximise their profits, the final investment good producers choose the level of the demand for input variety $x_t(i) = \xi_t^{1-\varepsilon}\left(\frac{p_t(i)}{P_t^X}\right)^{-\varepsilon} X_t$ for use in the production of the final investment good $X_t$ whose price equals the marginal cost of production:

$$P_t^X = \xi_t \left(\int_0^1 p_t(i)^{1-\varepsilon} di\right)^{\frac{1}{1-\varepsilon}} = \xi_t. \tag{1.3}$$

Equation (1.3) implies that the relative price of the investment goods—denoted $\frac{P_t^X}{P_t^c}$—is equal to the relative level of technology $\xi_t$. This equality shows that the relative price of the investment goods declines when the technology in the investment good production improves relatively to that in the consumption good production and vice versa.

### 1.3.3 Producers of Intermediate Inputs

To supply outputs—denoted $y_t(i) = c_t(i) + x_t(i)$—to above two kinds of final producers, a producer of the immediate input variety i rents capital $(k)$ and labour $(l)$ from households at a given rate $R_t$ and a given wage $W_t$ respectively and assembles them using a constant return to scale technology: $y_t(i) = F(k_t(i), l_t(i))$. This producer of intermediate inputs takes input prices and the aggregate demand, $Y_t = C_t + \xi_t X_t$, as given and faces the following profit-maximisation problem:

$$\max_{p_t(i),y_t(i),k_t(i),l_t(i)} \Pi(i) = p_t(i)y_t(i) - R_t k_t(i) - W_t l_t(i), \tag{1.4}$$

subject to the constrained output: $y_t(i) = c_t(i) + x_t(i) = p_t(i)^{-\varepsilon} Y_t$. The first-order conditions with respect to capital and labour are given respectively by

$$p_t(i)F_{k,t}(i) = \mu R_t,$$
$$p_t(i)F_{l,t}(i) = \mu W_t.$$

Unlike the competitive producers of final goods, this monopolistically competitive producer has a certain degree of market power to set the marginal revenue product of factors as a markup $\mu = \frac{\varepsilon}{\varepsilon-1}$ over factor prices.

### 1.3.4 Household

The household derives its utility from consuming goods $C_t$ and its dis-utility by supplying labour $l_t$. It buys final goods ($C_t$ and $X_t$) from final good producers. It uses the investment goods to build up the existing capital stock, and supplies it and labour to the intermediate input producers at the rate $R_t$ and the wage $W_t$, respectively. It also owns all firms in the economy and receives their profits as dividends in every period. Besides, it holds some assets $B_t$ that yields a real interest rate $r_t$ and it is in zero net supply. At some period $t_0$, the household solves

$$\max_{\{C_t,l_t(i),X_t,K_{t+1},B_{t+1}\}_{t=t_o}^{\infty}} E_{t_o}\left(\sum_{t=t_0}^{\infty} \beta^{(t-t_o)} U(C_t, L_t; \chi_t)\right), \tag{1.5}$$

subject to initial capital $K_0$ and assets $B_0$, the law of motion for the capital stock, $K_{t+1} = (1-\delta)K_t + X_t$, and its budget constraint as follows:

$$C_t + \xi_t X_t + B_{t+1} = \int_0^1 [W_t l_t(i) + R_t k_t(i) + \Pi_t(i)]\, di + (1 + r_t) B_t,$$

where $\beta$ is a discount factor; $\chi_t$ is a household preference shifter; $\delta$ is a depreciation rate, and the aggregate capital stock and labour supplied by the household are respectively

$$K_t = \int_0^1 k_t(i) di,$$
$$L_t = \int_0^1 l_t(i) di.$$

The condition leading to the household optimisation is when the household invests in physical capital up to the point where the marginal benefit of investing in capital (rental rate) equals the marginal cost of investing in capital (rental cost): $R_{t+1} = \xi_t(1 + r_{t+1}) - \xi_{t+1}(1 - \delta)$, where $1 + r_{t+1} = \frac{U_C(C_t, L_t)}{\beta E_t(U_C(C_{t+1}, L_{t+1}))}$ is the gross real interest rate. Denoting a variable with asterisk as the variable in the steady state, we obtain

$$R^* = \xi^*(\frac{1}{\beta} + \delta - 1) = \xi^*(r^* + \delta). \tag{1.6}$$

### 1.3.5 Equilibrium

The general equilibrium in this hypothetical economy occurs when, given a path of exogenous variables, (a) all markets for labour, capital, assets, final goods and intermediate inputs are clear at every date; (b) final good producers and intermediate input producers maximise their profits, and (c) the household maximises its expected utility. This equilibrium is symmetric. That is, $p_t(i) = P_t^c = 1$, $k_t(i) = K_t$, $l_t(i) = L_t$, $c_t(i) = C_t$, $x_t(i) = \xi_t X_t$, and $y_t(i) = Y_t = F(K_t, L_t)$.

### 1.3.6 The Production Function

The intermediate input producers use the CES production technology—introduced by Arrow et al. (1961)—to produce the inputs by nesting capital and labour with Hicks-neutral technological progress as follows:

$$Y_t = F(K_t, L_t) = A_t \left[ \alpha (K_t)^{\frac{\sigma-1}{\sigma}} + (1-\alpha)(L_t)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}. \tag{1.7}$$

In this specification, the parameter $\alpha$ governs the income share of capital; $A_t$ refers to Hicks-neutral technology, and $\sigma$ is the elasticity of substitution between capital and labour[2]. From Equation (1.7), the marginal products of capital and labour are given respectively by

$$F_{K,t} = \alpha (A_t)^{\frac{\sigma-1}{\sigma}} \left( \frac{Y_t}{K_t} \right)^{\frac{1}{\sigma}} = \mu R_t,$$
$$F_{L,t} = (1-\alpha)(A_t)^{\frac{\sigma-1}{\sigma}} \left( \frac{Y_t}{L_t} \right)^{\frac{1}{\sigma}} = \mu W_t,$$

### 1.3.7 The labour Share

The total income is composed of three parts: (1) wages for labour services, (2) rentals for capital services, and (3) profits as dividends. Thus, income share of labour, capital, and profit are respectively given by:

$$S_{L,t} = \frac{W_t L_t}{Y_t} = \left( \frac{1}{\mu} \right) \left( \frac{W_t L_t}{W_t L_t + R_t K_t} \right),$$
$$S_{K,t} = \frac{R_t K_t}{Y_t} = \left( \frac{1}{\mu} \right) \left( \frac{R_t K_t}{W_t L_t + R_t K_t} \right),$$
$$S_{\Pi} = \frac{\Pi_t}{Y_t} = \frac{\mu - 1}{\mu},$$

[2]As $\sigma$ approaches 1, equation (1.7) becomes the Cobb-Douglash producton function: $F(K_t, L_t) = A_t K_t^{\alpha} L_t^{1-\alpha}$.

where $S_{L,t} + S_{K,t} + S_{\Pi} = 1$. Given these income shares along with the marginal product of capital, we can derive the labour share as a function of the markups, capital's rental price for some value of the distribution parameter and the elasticity of substitution as[3]:

$$1 - S_{L,t}\mu = \alpha^{\sigma} \left(\mu R_t\right)^{1-\sigma}. \tag{1.8}$$

Equation (1.8) says that if $\sigma = 1$, the labour share becomes $S_{L,t} = (1-\alpha)/\mu$ , which is constant. If $\sigma > 1$, the labour share is positively related to the capital's rental price but this relationship become negative if $\sigma < 1$. This indicates that some value of $\sigma$ plays a very important role in pointing the direction of relationship between labour share and capital's rental price[4]. However, this parsimonious model, like others, has a drawback by excluding some other determinants of the labour share.

Next section deals with the estimation of the parameter of $\sigma$, followed by discussion on some other factors that are identified as leading candidates behind the falling labour share.

## 1.4 The Estimation of Elasticity of Substitution

Following Karabarbounis and Neiman (2014)'s strategy to control for cross-country heterogeneity in both economic parameters and measurement practices, we rewrite Equation (1.8) in proportionate changes between two arbitrary periods $t_2 > t_1$ as:

$$\left(\frac{1}{1-S_L\mu}\right)\left[1 - S_L\left(1+\hat{S_L}\right)\mu\right] = \left(1+\hat{R}\right)^{1-\sigma}, \tag{1.9}$$

[3]We can also derive the labour share through the marginal product of labour: $S_{L,t} = (\frac{1-\alpha}{\mu})^{\sigma} w^{1-\sigma}$. equation (1.6) shows that in the steady state, the growth rate of $R$ equals that of $\xi$ given that constant discount factor $\beta$ and constant depreciation rate $\delta$ over time but not necessarily across countries. Since internationally comparable data on growth in $\xi$ are more readily available than wage growth, the labour share in equation (1.8) is preferred when it is used to estimate the value of $\sigma$.

[4]Appendix 1.B provides a general form of neoclassical production function.

where $\hat{V} = \frac{\Delta V}{V} \approx \Delta lnV$ denotes the proportional change of some variable $V$ from $t_1$ to $t_2$ and we drop subscripts of variables corresponding to the initial period $t_1$ for notational convenience. Taking a linear approximation of equation (1.9) around $\hat{R} = 0$, setting[5] $\mu = 1$ and adding a constant $(\gamma)$ and an idiosyncratic error term $(e)$ yields the following basic econometric model:

$$\left(\frac{S_{L,j}}{1-S_{L,j}}\right)\hat{S_{L,j}} = \gamma + (\sigma - 1)\hat{R}_j + e_j, \tag{1.10}$$

where $j$ denotes observations. We measure the proportionate change of all variables ( denoted by "hat" variables) as the linear trend in the log of the variable and substitute variables' average values for their levels. From Equation (1.6), the growth rate of capital's rental price $(\hat{R})$ is equivalent to that of the relative price of investment goods $(\hat{\xi})$ when discount factor $(\beta)$ and depreciation rate $(\delta)$ are assumed to be fixed over time, but allowed to vary across countries.

Initially, to see whether we can replicate Karabarbounis and Neiman (2014)'s results and to ensure that the sources of data are reliable, we follow their steps in selecting the sample by using their dataset. We select 53 countries based on the availability of data from 1975 to 2014 in the new version PWT9.0 as shown in the table 3 in the appendix A. This selection is in the range of their samples: from 47 countries to 58 countries.

The variable $S_L$ is measured as the share of labour compensation in GDP at current national prices. The relative price of investment $(\xi)$ is a ratio of investment deflator to consumer price index, which are obtained by dividing normal and real values of investment and household consumption respectively.

Figure 1.3 presents the scatter plots between the long-run linear trends of the relative price

[5]For the rest of this work, the mark-ups are assumed to be unity for two main reasons. First, data of mark-ups are not observable, particularly at macro levels. Second, when Karabarbounis and Neiman (2014) use the imputed data of mark-ups, they still find the magnitude of coefficient of the regressor in Equation (1.10) does not differ much:
- The average of coefficients of the regressor is 1.28 when the mark-ups are unity.
- The average is 1.26 when the mark-ups are not unity and not constant.

of investment goods and those of the labour share. The fitted line of their relationships is upward, implying that the elasticity of substitution $\sigma$ is greater than 1. Using the same method “robust regression” as in Karabarbounis and Neiman (2014), we obtain the estimate of $\sigma$ of 1.18, statistically significant at 10% level. This estimate[6] is not statistically different from the point estimate of 1.25 by Karabarbounis and Neiman (2014). This implies that the data we use at national levels provides similar results that are estimated by Karabarbounis and Neiman (2014) using data at corporate levels.

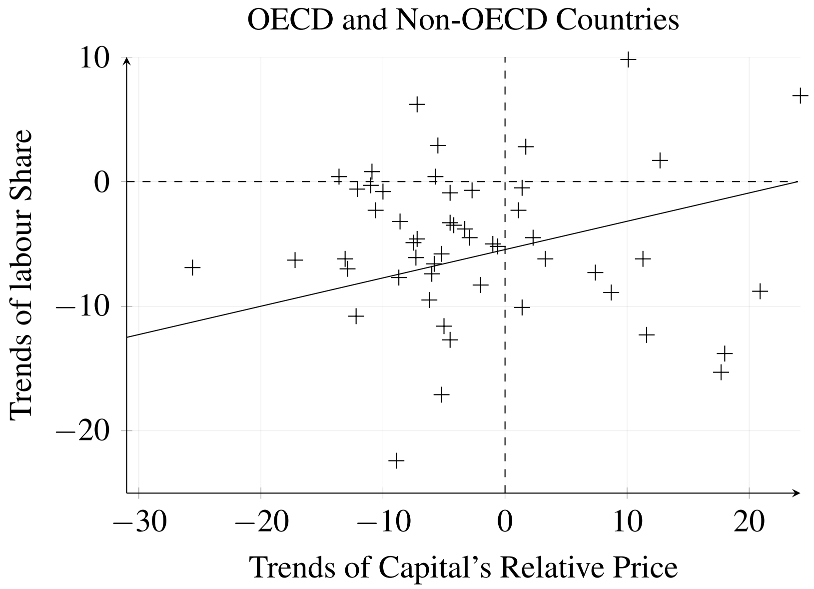



Figure 1.3: Trends of labour Share and Capital’s Relative Price for 53 Countries

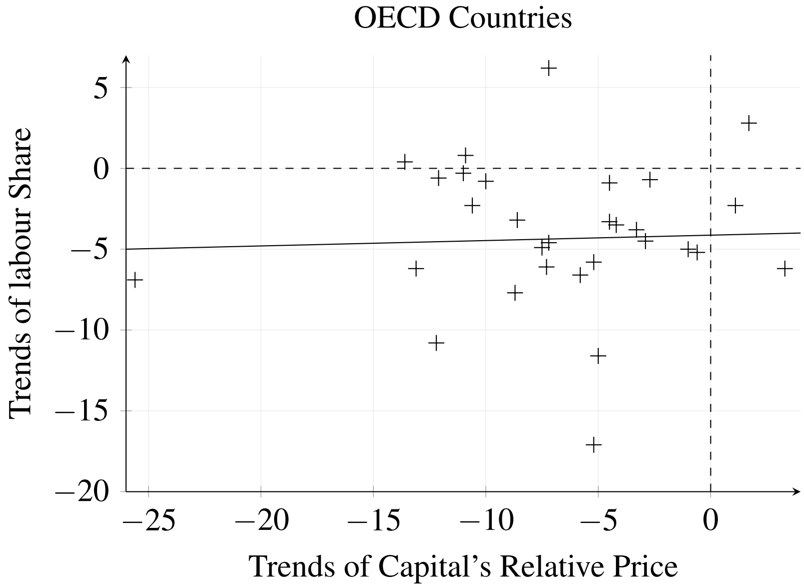
The figure plots the trend in the log labour share against the trend in the log relative price of capital. All values are scaled to represent percent changes per 10 years. For example, a value of 10 for the trend in the log relative price of capital means a 10 percent increase in capital’s relative price every 10 years. We drop one observation (Azerbaijan) because of its extremely low value. The solid line is the fitted line between these two trends with the R-squared of 7.5%

Interestingly, when we separate[7] the sample into two groups—30 OECD countries and 23 non-OECD countries—we observe that our estimate appears to be driven more statistically by non-OECD countries as seen in the scatter plots in the figure 1.4. This leads us

[6]The 95% confidence interval is between 0.98 and 1.39.

[7]This classification was at the time I selected the data at the beginning of 2018 according to the list of OECD countries.

to investigate if the result from OECD nations differs from that from non-OECD nations.



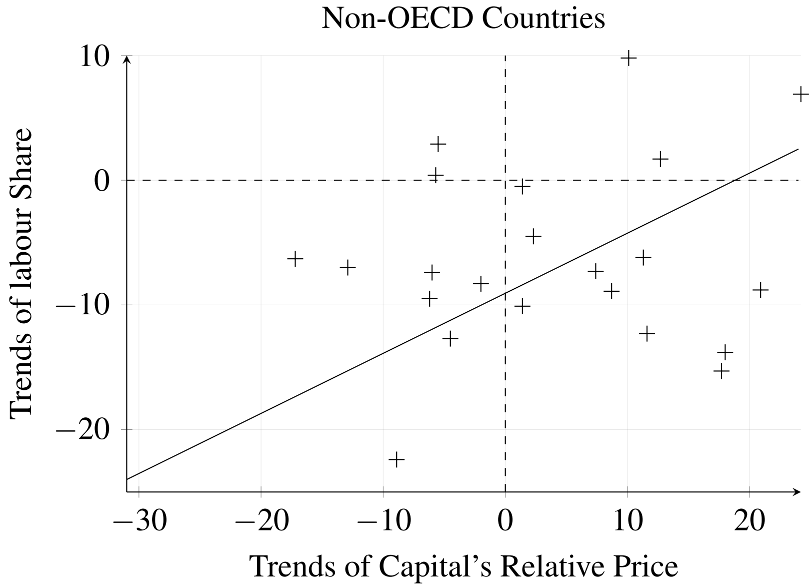




Figure 1.4: Trends of labour Share and Capital's Relative Price for OECD and Non-OECD Countries.

The figure plots the trend in the log labour share against the trend in the log relative price of capital for two groups of countries. All values are scaled to represent percent changes per 10 years. For example, a value of 10 for the trend in the log relative price of capital means a 10 percent increase in capital's relative price every 10 years. One observation (Azerbaijan) in non-OECD countries is dropped because of its extremely low value. The solid line is the fitted line between these two trends. The fitted line for OECD countries has the R-squared of 0.1% and that for non-OECD countries has the R-squared of 26%.

## 1.5 Econometric Model Specifications

To empirically investigate other factors identified in existing literature, we modify the baseline model of labour share in equation (1.10) by including other omitted factors, which are buried in the error term $e_j$. Dao (2017) categorise labour share's determinants into three groups: technology, trade/globalisation and labour market institutions. Additionally, we introduce the role of volatility (risk) in dragging the labour share down as well, but we put labour market conditions (namely bargaining power as measured by unionisation), as pointed out first by Blanchard et al. (1997), into the error term for two reasons. First is the data availability, and second is the effect of unionisation on labour share is statistically insignificant (Elsby et al., 2013). Since we don't know a true functional form about relationships between those factors and labour share, we assume that they relate to labour share in the same way as the rental price of capital does.

Like Karabarbounis and Neiman (2014), we fundamentally treat the relative price of investment goods as a given variable[8] and obtain the following econometric model:

$$\hat{S_{L,j}} = \gamma_0 + \gamma_1 \hat{\xi}_j + \gamma_2 \hat{Z}_j + \gamma_3 v_j + \varepsilon_j, \tag{1.11}$$

where $\gamma_o$ is a constant; $\varepsilon$ is an error term; v is a volatility of real GDP, and $Z$ is a vector of other explanatory variables: export, import, and financial openness. In this equation (1.11), we cannot estimate the value of $\sigma$ as in the equation (1.10), but we can point out whether it is greater than or equal to unity based on the sign and significance of coefficient of the relative price of investment goods.

Volatility is an indicator used to capture risk which affects firms' investment and hiring behaviour and reflects the return rate of investment. Kang et al. (2016) point that high volatility makes firms temporarily reduce employment and investment. For example, the

[8] We also consider the possibility that this relative price may be influenced by the other factors. See the appendix B for details.

2007-09 recession in most parts of the world was greatly contributed by heightened economic volatility (Ozturk and Sheng, 2018). In the time of low volatility, firms tend to invest and hire more, but it also reflects the low return rate of investment, implying that capital's rental price is low. Since labour and capital are highly substitutable as shown by Karabarbounis and Neiman (2014), firms use capital more proportionally than labour. As a result, the labour share of income falls. We measure this volatility by the standard deviation of growth rate of real GDP .

Current research, using firm-level data, shows that export firms are more likely to be more productive, larger and have a higher capital labour ratio than purely local companies (Forslid and Okubo, 2016). More exports imply that more income share goes to capital. In contrast, more imports lead to shrinking outputs, reflecting increasing labour share. We measure the variables—export and import—as ratios of nominal export and import to nominal GDP respectively.

Financial openness measures a country's degree of a capital account openness (Chinn and Ito, 2006). Theory proposes that capital account liberalisation can enhance the development of financial system through three channels. First, financial openness helps reduce financial control in protected financial markets, thus driving an interest rate to its competitive market equilibrium (Shaw, 1973). Second, it allows foreign and domestic investors to pursue more portfolio diversification. Third, liberalisation process improves the efficiency level of the financial system by removing inefficient financial institutions and building up more pressure for a reform of the financial infrastructure. This improvement helps alleviate information asymmetry, therefore reducing moral hazard and adverse selection. All of these points indicates that financial openness raises the availability of funds and reduces the cost of capital for investors. Consequently, the labour share declines as firms use more capital because of its lower cost. We measure financial openness by Chinn-Ito Index constructed by Chinn and Ito (2006)

Dao (2017) emphasise that technological advancement, particularly the rapid advance of information and communication, accelerates the automation of routine task. Thus, labour exposed more to such tasks tends to be replaced by capital, leading to lower income share to labour. Autor et al. (2020) shows that technological progress leads to the rise of superstar firms that tend to reap disproportionate rewards (high profit levels), implying declining labour share. This technological advancement is reflected by the relative price of investment goods.

## 1.6 Estimation Methods, Data and Results

### 1.6.1 Estimation Method and Data

For robustness, we use two estimation methods to operationalise the equation (1.10) and (1.11). First, following Karabarbounis and Neiman (2014), we employ the robust regression to deal with long-run growth rates (at least 15 years) of variables $(\hat{V})$, which result in the cross-country data set. Because our cross-section data sizes are small that estimated results can be sensitive to one or a few outlier observations, the robust regression can help mitigate this sensitivity by giving less weight to those observations that lie further from the regression line. The method starts by dropping observations with Cook's distance greater than 1. Then an iterative process calculates weights based on absolute residuals. The process stops when the maximum change between the weights from one iteration to the next is below some tolerant level (Karabarbounis and Neiman, 2014).

Second, we apply the fixed effect estimation to deal with the short-run growth rates of variables $(\hat{V})$, as we slice a whole period into non-overlapping consecutive five-year periods. For example, for the whole period 1995-2014, we obtain 4 subdivided periods: 1995-1999; 2000-2004; 2005-2009; and 2010-2014. This method allows us to increase the number of observations of the samples and helps capture time-invariant heterogeneity in each country and controls for any shocks that are common to all countries in a given year.

To operationalise these econometric models, we select the data sets of 30 OECD countries and 23 non-OECD countries covering from 1975 to 2014. We obtain financial openness index from Chinn & Ito's data set, and the remaining variables from the Penn World Table version 9.0. For each country, we choose only those with at least 15 years of data (Table 1.A in Appendix 1.A for details). Table 1 presents descriptive statistics of all variables used in this empirical analysis.

| Variable | Obs | Mean | Std.Dev. | Min | Max |
|---|---|---|---|---|---|
| labour Share | 1370 | 0.57 | 0.09 | 0.21 | 0.80 |
| Investment Deflator | 1370 | 0.71 | 0.29 | 0.00 | 1.78 |
| Consumer Price Index | 1370 | 0.68 | 0.28 | 0.00 | 1.58 |
| Export ( % of GDP) | 1370 | 0.45 | 0.36 | 0.07 | 2.30 |
| Import ( % of GDP) | 1370 | 0.45 | 0.33 | 0.07 | 2.24 |
| Growth rate of GDP | 1317 | 3.33 | 4.38 | -54.05 | 29.61 |
| Chinn-Ito index | 1329 | 0.71 | 0.34 | 0.00 | 1.00 |

Table 1.1: Descriptive statistics.

Table 1 reports key statistics of variables used in the empirical analysis. Investment deflator is a ratio of nominal investment to real investment. Chinn-Ito index is normalized between zero and one. Zero indicates a country with the least financial openness. One is the most financial openness. Since most countries in non-OECD countries do not have quarterly data on GDP, we use annual data to estimate volatility.

### 1.6.2 Results

Table 1.2 shows the results[9] based on Equation (1.10) and (1.11). Using the robust regression, we find the elasticity of substitution between capital and labour are significantly

[9]This paper—like other studies that use macroeconomic data—is susceptible to measurement issues (and omitted variables) of variables such as labour share as mentioned in Autor et al. (2020).

greater than 1: $\sigma = 1.36$ for non-OECD countries and $\sigma = 1.18$ for pooled countries (these are close to what Karabarbounis and Neiman (2014) find). This high elasticity indicates that the labour share and capital's relative price are positively associated. However, the capital's relative price appears not to have any significant association on labour share when other determinants are included in a model. This finding lends support to the aggregate analysis by Elsby et al. (2013) that firms' shift to be capital-intensive to exploit declining prices of equipment has not been a key factor behind the evolution of the payroll share over the past 25 years in the U.S.

Export and import have correct signs in most of model specifications for all three samples: OECD, Non-OECD and pooled data. Export and Import appear to be positively related to labour share throughout all samples and models. As an average, their magnitudes of coefficients are twice as much for OECD countries as for non-OECD countries. This implies that workers in advanced countries, particularly those employed by labour-intensive firms, have borne the brunt of the declining labour share more than their counterparts in developing countries because of global integration.

The coefficients of the other two variables—volatility and financial openness—are contrary to what we have expected but statistically insignificant for most cases. These counter-intuitive results are probably a result of small samples' sizes (only 23 for Non-OECD study and 30 for OECD study) or because of the estimation method: the robust regression cannot capture other unobserved effects such as time and country fixed effects.

To deal with these possible issues, we use the fixed effect estimation method. As shown in Table 1.3, all regressors but imports have expected signs. While the capital's relative price still has no significant relationship with labour share in OECD study, its association become statistically significant for more than half of model specification in non-OECD study and pooled study.

| **OECD Countries** | | | | |
|---|---|---|---|---|
| Regressors | (1) | (2) | (3) | (4) |
| Relative Price of Investment Goods | 0.06 | 0.02 | 0.16 | 0.16 |
| | (-0.19) | (-0.12) | (-0.14) | (-0.14) |
| Export | | -0.31** | -0.41*** | -0.46*** |
| | | (-0.14) | (-0.14) | (-0.16) |
| Import | | 0.35** | 0.43*** | 0.45** |
| | | (-0.15) | (-0.15) | (-0.17) |
| Volatility | | | 0.1 | 0.1 |
| | | | (-0.07) | (-0.07) |
| Financial Openness | | | | 0.03 |
| | | | | (-0.02) |
| Observations | 30 | 30 | 30 | 29 |
| R-squared | 0 | 0.18 | 0.28 | 0.31 |
| **Non-OECD Countries** | | | | |
| Regressors | (5) | (6) | (7) | (8) |
| Relative Price of Investment Goods | 0.36** | 0.11 | 0.15 | 0.21 |
| | (-0.16) | (-0.17) | (-0.18) | (-0.19) |
| Export | | -0.04 | -0.08 | -0.26* |
| | | (-0.15) | (-0.16) | (-0.13) |
| Import | | 0.18 | 0.19 | 0.41*** |
| | | (-0.16) | (-0.17) | (-0.12) |
| Volatility | | | -0.04 | -0.07 |
| | | | (-0.07) | (-0.07) |
| Financial Openness | | | | 0.04 |
| | | | | (-0.05) |
| Observations | 23 | 22 | 22 | 21 |
| R-squared | 0.2 | 0.1 | 0.12 | 0.69 |
| **Pooled Data** | | | | |
| Regressors | (9) | (10) | (11) | (12) |
| Relative Price of Investment Goods | 0.18* | 0.04 | -0.03 | -0.06 |
| | (-0.1) | (-0.08) | (-0.09) | (-0.08) |
| Export | | -0.26*** | -0.14 | -0.26*** |
| | | (-0.08) | (-0.09) | (-0.09) |
| Import | | 0.28*** | 0.16 | 0.29*** |
| | | (-0.09) | (-0.1) | (-0.09) |
| Volatility | | | -0.05 | -0.06* |
| | | | (-0.04) | (-0.03) |
| Financial Openness | | | | 0.05** |
| | | | | (-0.02) |
| Observations | 53 | 52 | 52 | 49 |
| R-squared | 0.06 | 0.19 | 0.09 | 0.26 |

Table 1.2: Results for long-run growth rates using robust regression method.

Notes: *,**,*** denote significance at the 10, 5, and 1 per cent level, respectively and figures in parentheses are standard errors. Robust regression is used to give less weight to outlier observations, which can significantly affect regression results when a sample is relatively small. And the long-run refers to at least 15 years.

| OECD Countries | | | | |
|---|---|---|---|---|
| Regressors | (13) | (14) | (15) | (16) |
| Relative Price of Investment Goods | 0.34** | 0.1 | 0 | 0 |
| | (-0.14) | (-0.08) | (-0.09) | (-0.09) |
| Export | | -0.10** | -0.10** | -0.11** |
| | | (-0.05) | (-0.05) | (-0.05) |
| Import | | -0.08 | -0.09 | -0.08 |
| | | (-0.05) | (-0.06) | (-0.06) |
| Volatility | | | 0.25** | 0.23* |
| | | | (-0.12) | (-0.13) |
| Financial Openness | | | | 0.01 |
| | | | | (-0.02) |
| Observations | 138 | 138 | 113 | 110 |
| R-squared | 0.24 | 0.34 | 0.44 | 0.45 |
| Numberof Countries | 30 | 30 | 30 | 29 |
| **Non-OECD Countries** | | | | |
| Regressors | (17) | (18) | (19) | (20) |
| Relative Price of Investment Goods | 0.06 | 0.14* | 0.20* | 0.18 |
| | (-0.09) | (-0.08) | (-0.11) | (-0.11) |
| Export | | -0.01 | 0 | -0.03 |
| | | (-0.05) | (-0.05) | (-0.05) |
| Import | | -0.01 | -0.04 | 0 |
| | | (-0.05) | (-0.06) | (-0.06) |
| Volatility | | | 0.05 | 0.02 |
| | | | (-0.08) | (-0.08) |
| Financial Openness | | | | -0.04** |
| | | | | (-0.02) |
| Observations | 94 | 94 | 78 | 72 |
| R-squared | 0.1 | 0.16 | 0.17 | 0.29 |
| Number of Countries | 23 | 23 | 23 | 21 |
| **Pooled Data** | | | | |
| Regressors | (21) | (22) | (23) | (24) |
| Relative Price of Investment Goods | 0.14* | 0.18*** | 0.21*** | 0.18*** |
| | (-0.07) | (-0.05) | (-0.07) | (-0.07) |
| Export | | -0.02 | -0.01 | -0.02 |
| | | (-0.03) | (-0.03) | (-0.03) |
| Import | | -0.06 | -0.08** | -0.06 |
| | | (-0.04) | (-0.04) | (-0.04) |
| Volatility | | | 0.07 | 0.07 |
| | | | (-0.06) | (-0.06) |
| Financial Openness | | | | -0.03** |
| | | | | (-0.01) |
| Observations | 232 | 232 | 191 | 182 |
| R-squared | 0.06 | 0.11 | 0.16 | 0.19 |
| Number of Countries | 53 | 53 | 53 | 50 |

Table 1.3: Results for short-run growth rates using fixed effect method.

Notes: *,**,*** denote significance at the 10, 5, and 1 per cent level, respectively and figures in parentheses are standard errors. Fixed effect estimation includes both time and country fixed effects. And the short-run is a 5-year span.

Although export's relationship with the labour share is still significant and strong in OECD countries, it is not in non-OECD countries and in all countries combined. For most cases, import's effects on labour share are statistically insignificant. Risk appears to have a significant association with the labour share in OECD countries, but not in non-OECD and pooled countries. On the other hand, financial liberalisation is significantly related to the labour share in non-OECD and pooled countries, but not in OECD countries. For the elasticity of substitution between capital and labour, while the pooled samples still produces a similar and significant estimate of 1.14, non-OECD sample does not but OECD data gives a significant estimate of 1.34 instead.

Although these two methods produce somewhat different results, when we look at the effects of capital's relative price, export, volatility and financial openness altogether, we can possibly conclude that drivers behind the evolution of the labour share are not the same in OECD countries as in non-OECD countries.

For OECD countries, export and risk appear to be major factors strongly associated with the labour share since the 1980s. This implies that large, export-orienting firms along with their decisions to invest in the globally competitive world play a significant role in determining the income share going to workers. These large firms tend to have more bargaining power to drive wages and benefits down by offshoring some of their labour intensive components or relocating their productions to labour abundant countries.

On the other hand, for non-OECD countries, the key drivers of the labour share appear to be financial openness and capital's relative price. The more liberalised a country's financial system, the more firms are able to access lower costs of funds and the more likely they are to become more capital intensive by exploiting the falling prices of investment goods and new technologies that these investment goods provide. Given high elasticity of substitution between capital and labour, the labour share of income falls.

For the results as a whole, we can see why the income share going to labour has declined for the last three decades in both developed and developing countries. As labour and capital become more highly substitutable, the falling price of investment goods—because of technological improvement in the intermediate sector—coupled with the availability of funds, low risk and increasingly global competition, induces firms to become more capital intensive. And in order for them to stay globally competitive, they need to suppress production costs, particularly wages.

## 1.7 Conclusion

In this paper we use Karabarbounis and Neiman (2014)'s model of labour share as the prototypical model to empirically investigate the factors behind declining labour share in both OECD and non-OECD countries since the 1980s. We find that while production factors (capital and labour) are highly substitutable in both groups of countries, the drivers of falling labour share differ in each group. In the advanced countries, export and economic risk—measured by volatility of real GDP—are the key factors, but in the developing ones the major factors are financial liberalisation and relative price of investment goods. As a whole, we conclude that advanced technology—reflected by declining relative price of investment goods—combined with globalisation and low economic risk is a key factor in understanding a secular decline of labour share worldwide. This is because large firms tend to be more capital intensive by exploiting low costs of funds and low price of investment goods. And also they tend to have more bargaining power over labour by offshoring some of their labour intensive products or moving their productions oversea, mainly to labour abundant countries.

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# Appendix 1.A

| **30 OECD Countries** | | | **23 Non-OECD Countries** | | |
|---|---|---|---|---|---|
| Country | Begin | End | Country | Begin | End |
| Australia | 1975 | 2012 | Armenia | 1991 | 2011 |
| Australia | 1995 | 2013 | Azerbaijan | 1994 | 2012 |
| Belgium | 1985 | 2013 | Bahrain | 1995 | 2013 |
| Canada | 1975 | 2013 | Belarus | 1990 | 2012 |
| Czech Republic | 1992 | 2014 | Bolivia | 1975 | 2013 |
| Denmark | 1995 | 2014 | Brazil | 1992 | 2009 |
| Estonia | 1994 | 2013 | China | 1992 | 2012 |
| Finland | 1975 | 2014 | Hong Kong | 1980 | 2012 |
| France | 1975 | 2013 | Macao | 1996 | 2012 |
| Germany | 1991 | 2013 | Colombia | 1992 | 2012 |
| Hungry | 1995 | 2013 | Costa Rica | 1975 | 2012 |
| Iceland | 1975 | 2005 | Kyrgyzstan | 1990 | 2012 |
| Italy | 1980 | 2014 | Lithuania | 1995 | 2013 |
| Japan | 1980 | 2012 | Namibia | 1995 | 2013 |
| Latvia | 1994 | 2013 | Niger | 1995 | 2013 |
| Luxembourg | 1995 | 2012 | Peru | 1978 | 2010 |
| Mexico | 1993 | 2012 | Philippines | 1992 | 2012 |
| Netherlands | 1980 | 2014 | Moldova | 1995 | 2012 |
| New Zealand | 1982 | 2013 | Singapore | 1980 | 2010 |
| Norway | 1978 | 2013 | South Africa | 1985 | 2013 |
| Poland | 1995 | 2013 | Taiwan | 1995 | 2009 |
| Portugal | 1995 | 2014 | Thailand | 1975 | 2010 |
| Republic of Korea | 1975 | 2013 | Tunisia | 1992 | 2011 |
| Slovakia | 1993 | 2013 | | | |
| Slovenia | 1995 | 2013 | | | |
| Spain | 1995 | 2013 | | | |
| Sweden | 1994 | 2014 | | | |
| Switzerland | 1995 | 2012 | | | |
| United Kingdom | 1987 | 2013 | | | |
| United States | 1975 | 2014 | | | |

Table 1.A: A list of countries with at least 15 year data for labour share.

# Appendix 1.B

Given the neoclassical production function : $Y = F(K,L)$ where $K$ is capital and $L$ is labour, we can derive the capital's income share–denoted $S_K$–as

$$S_K = \frac{KF_K}{F},$$

where the subscript of the function denotes as the derivative. Differentiating this equation with respect to capital yields

$$\frac{\partial S_K}{\partial K} = \frac{KF_{KK}}{F} + \frac{F_K\left(F - KF_K\right)}{F^2}. \tag{1.B.1}$$

Because production function $F$ is homogenous of degree 1 in $(K,L)$, we get $LF_L = F - KF_K$. Substituting this into equation (1.B.1) and using the definition of elasticity of substitution by Hicks (1932)—$\sigma = (F_K F_L)/(F F_K L)$—we obtain:

$$\frac{\partial S_K}{\partial K} = \frac{KF_{KK}}{F} + \frac{\sigma LF_{KL}}{F}. \tag{1.B.2}$$

Taking the partial derivative of the expression $LF_L = F - KF_K$ with respect to capital and using Young's theorem $(F_K L = F_L K)$ yields $LF_{KL} = -KF_{KK}$. Replacing this equality in equation(1.B.2) yields:

$$\frac{\partial S_K}{\partial K} = (1-\sigma)\frac{KF_{KK}}{F}. \tag{1.B.3}$$

Because of the diminishing return of capital, $F_{KK} \leq 0$, the sign of equation (1.B.3) depends on whether $\sigma$ is greater than 1. This implies that all other things remain the same, when $\sigma > 1$, the capital's income share rises as capital increases more proportionally than $R$ declines. However, if $\sigma = 1$, the factor shares are constant ■.

# Appendix 1.C

We consider the possibilities that the price of investment goods appears to be influenced by the other factors in the model as well. That is,

$$\hat{\xi}_j = \lambda_o + \lambda_1 \hat{Z}_j + \lambda_2 v_j + u_j. \qquad (1.C.1)$$

Substituting equation (1.C.1) into equation (1.11) $(\hat{S_{L,j}} = \gamma_0 + \gamma_1 \hat{\xi}_j + \gamma_2 \hat{Z}_j + \gamma_3 v_j + \varepsilon_j)$, we obtain the following reduced form equation as follow:

$$\hat{S_{L,j}} = \pi_0 + \pi_1 u_j + \pi_2 \hat{Z}_j + \pi_3 v_j + \omega_j. \qquad (1.C.2)$$

equation (1.C.2) shows total effects of the other explanatory variables $(Z\&v)$ on the labour share and the impact of other omitted variables $(u_j)$ influencing capital's relative price on the labour share.

When we estimate the system of two equation (1.C.1) and (1.C.2), we perform two-stage residual inclusion estimation (2SRI). First, we regress equation (1.C.1) to obtain the estimated residual $(\hat{u_j})$. Second, we replace the error term $u_j$ by its estimated value in equation (1.C.2) and then apply 5000-replication bootstrap.

Table 1.C.1 presents the results based on the system of these two equations. Under the robust regression for the long run growth rates, capital's relative price is not significantly influenced by the other factors in all model specifications for the OECD country study, but it becomes significantly impacted by export and import only in the model specification (1.C.1.8) and (1.C.1.12) for the non-OECD study and pooled country study respectively.

While export is a significant driver of labour share in all model specifications for the OECD sample, it is not for the other two samples. Import significantly impacts labour share only in one model specification (1.C.2.4) for the OECD sample, but for the non-

OECD and pooled samples it does not. The residual—the other factors affecting the capital's relative price—and volatility do not have significant impacts on labour share in all model specifications for all three samples. Financial openness has significant effects on labour share for just the pooled sample, but its effects are counter-intuitive.

Table 1.C.2 reports the results of the system based on the fixed effect estimation. Only export has significant impacts on both capital' relative price and labour share for the OECD sample. For the non-OECD sample, while only import and volatility significantly impact capital's relative price, no factors have significant impacts on labour share. For the pooled sample, while all factors—export, import, volatility, and financial openness—significantly affect capital's relative price, only residual has significant impacts on labour share in models (1.C.2.22) and (1.C.2.23) but not in (1.C.2.24). Overall, the results show that while some of the factors—export, import, volatility and financial openness—appear to have significant impacts on capital's relative price in some model specification for all three samples, their overall effects on labour share are insignificant in most model specifications. Therefore, we conclude our findings based on the results from the economic model specification (1.10).

**OECD Countries**

| Regressors | (1.C.1.2) | (1.C.2.2) | (1.C.1.3) | (1.C.2.3) | (1.C.1.4) | (1.C.2.4) |
|---|---|---|---|---|---|---|
| Residual (uhat) | | 0.02 | | 0.16 | | 0.16 |
| | | (-0.12) | | (-0.14) | | (-0.14) |
| Export | 0.1 | -0.31** | 0.13 | -0.39** | 0.22 | -0.43** |
| | (-0.21) | (-0.14) | (-0.21) | (-0.14) | (-0.22) | (-0.16) |
| Import | -0.17 | 0.35** | -0.19 | 0.40** | -0.29 | 0.41** |
| | (-0.22) | (-0.15) | (-0.23) | (-0.15) | (-0.24) | (-0.17) |
| Volatility | | | -0.12 | 0.08 | -0.13 | 0.08 |
| | | | (-0.1) | (-0.06) | (-0.1) | (-0.06) |
| Financial Openness | | | | | -0.03 | 0.03 |
| | | | | | (-0.03) | (-0.02) |
| Observations | 30 | 30 | 29 | 30 | 28 | 29 |
| R-squared | 0.03 | 0.18 | 0.1 | 0.28 | 0.16 | 0.31 |

**Non-OECD Countries**

| Regressors | (1.C.1.6) | (1.C.2.6) | (1.C.1.7) | (1.C.2.7) | (1.C.1.8) | (1.C.2.8) |
|---|---|---|---|---|---|---|
| Residual (uhat) | | 0.11 | | 0.15 | | 0.21 |
| | | (-0.17) | | (-0.18) | | (-0.19) |
| Export | -0.14 | -0.06 | -0.05 | -0.08 | -0.39** | -0.34*** |
| | (-0.22) | (-0.14) | (-0.23) | (-0.16) | (-0.17) | (-0.11) |
| Import | 0 | 0.18 | 0.01 | 0.19 | 0.35** | 0.49*** |
| | (-0.24) | (-0.16) | (-0.24) | (-0.17) | (-0.16) | (-0.1) |
| Volatility | | | 0.11 | -0.02 | 0.04 | -0.06 |
| | | | (-0.1) | (-0.07) | (-0.1) | (-0.07) |
| Financial Openness | | | | | 0.06 | 0.05 |
| | | | | | (-0.08) | (-0.05) |
| Observations | 22 | 22 | 22 | 22 | 21 | 21 |
| R-squared | 0.04 | 0.1 | 0.1 | 0.12 | 0.33 | 0.69 |

**Pooled Data**

| Regressors | (1.C.1.10) | (1.C.2.10) | (1.C.1.11) | (1.C.2.11) | (1.C.1.12) | (1.C.2.12) |
|---|---|---|---|---|---|---|
| Residual (uhat) | | 0.04 | | -0.03 | | -0.06 |
| | | (-0.08) | | (-0.09) | | (-0.08) |
| Export | -0.16 | -0.27*** | 0 | -0.14 | -0.31*** | -0.24*** |
| | (-0.15) | (-0.08) | (-0.15) | (-0.09) | (-0.1) | (-0.09) |
| Import | 0.05 | 0.28*** | -0.1 | 0.16 | 0.26*** | 0.27*** |
| | (-0.16) | (-0.09) | (-0.16) | (-0.1) | (-0.1) | (-0.09) |
| Volatility | | | 0.13** | -0.05 | 0.05 | -0.06* |
| | | | (-0.06) | (-0.04) | (-0.06) | (-0.03) |
| Financial Openness | | | | | -0.02 | 0.05** |
| | | | | | (-0.04) | (-0.02) |
| Observations | 52 | 52 | 52 | 52 | 50 | 49 |
| R-squared | 0.04 | 0.19 | 0.14 | 0.09 | 0.25 | 0.26 |

Table 1.C.1: Results for long-run growth rates using robust regression method.

Notes: *,**,*** denote significance at the 10, 5, and 1 per cent level, respectively and figures in parentheses are standard errors and the standard errors in the model specifications (16.) are obtained by 5000-replication bootstrap. Robust regression is used to give less weight to outlier observations, which can significantly affect regression results when a sample is relatively small . And the long-run refers to at least 15 years.

| OECD Countries | | | | | | |
|---|---|---|---|---|---|---|
| Regressors | (1.C.1.14) | (1.C.2.14) | (1.C.1.15) | (1.C.2.15) | (1.C.1.16) | (1.C.2.16) |
| Residual (uhat) | | 0.1 | | 0 | | 0 |
| | | (-0.08) | | (-0.09) | | (-0.09) |
| Export | -0.16** | -0.11** | -0.13** | -0.10** | -0.12** | -0.11** |
| | (-0.06) | (-0.05) | (-0.06) | (-0.04) | (-0.06) | (-0.05) |
| Import | 0.04 | -0.07 | 0.06 | -0.09 | 0.06 | -0.08 |
| | (-0.07) | (-0.05) | (-0.07) | (-0.05) | (-0.07) | (-0.06) |
| Volatility | | | 0.12 | 0.25** | 0.16 | 0.23* |
| | | | (-0.16) | (-0.12) | (-0.16) | (-0.13) |
| Financial Openness | | | | | -0.02 | 0.01 |
| | | | | | (-0.02) | (-0.02) |
| Observations | 138 | 138 | 113 | 113 | 110 | 110 |
| R-squared | 0.16 | 0.34 | 0.21 | 0.44 | 0.22 | 0.45 |
| Number of Countries | 30 | 30 | 30 | 30 | 29 | 29 |
| **Non-OECD Countries** | | | | | | |
| Regressors | (1.C.1.18) | (1.C.2.18) | (1.C.1.19) | (1.C.2.19) | (1.C.1.20) | (1.C.2.20) |
| Residual (uhat) | | 0.14* | | 0.20* | | 0.18 |
| | | (-0.08) | | (-0.11) | | (-0.11) |
| Export | -0.02 | -0.01 | -0.03 | -0.01 | -0.03 | -0.04 |
| | (-0.08) | (-0.05) | (-0.07) | (-0.05) | (-0.07) | (-0.05) |
| Import | 0.28*** | 0.03 | 0.33*** | 0.03 | 0.32*** | 0.06 |
| | (-0.08) | (-0.05) | (-0.07) | (-0.05) | (-0.07) | (-0.05) |
| Volatility | | | 0.15 | 0.08 | 0.21* | 0.06 |
| | | | (-0.1) | (-0.08) | (-0.1) | (-0.08) |
| Financial Openness | | | | | -0.04 | -0.05** |
| | | | | | (-0.03) | (-0.02) |
| Observations | 94 | 94 | 78 | 78 | 72 | 72 |
| R-squared | 0.26 | 0.16 | 0.43 | 0.17 | 0.48 | 0.29 |
| Number of Countries | 23 | 23 | 23 | 23 | 21 | 21 |
| **Pooled Data** | | | | | | |
| Regressors | (1.C.1.22) | (1.C.2.22) | (1.C.1.23) | (1.C.2.23) | (1.C.1.24) | (1.C.2.24) |
| Residual (uhat) | | 0.18*** | | 0.21*** | | 0.18*** |
| | | (-0.05) | | (-0.07) | | (-0.07) |
| Export | -0.07 | -0.04 | -0.07 | -0.02 | -0.07* | -0.03 |
| | (-0.05) | (-0.03) | (-0.04) | (-0.03) | (-0.04) | (-0.03) |
| Import | 0.23*** | -0.02 | 0.27*** | -0.02 | 0.28*** | -0.01 |
| | (-0.05) | (-0.03) | (-0.05) | (-0.03) | (-0.04) | (-0.03) |
| Volatility | | | 0.14* | 0.10* | 0.20*** | 0.11* |
| | | | (-0.07) | (-0.05) | (-0.07) | (-0.06) |
| Financial Openness | | | | | -0.04** | -0.04*** |
| | | | | | (-0.02) | (-0.01) |
| Observations | 232 | 232 | 191 | 191 | 182 | 182 |
| R-squared | 0.16 | 0.11 | 0.29 | 0.16 | 0.34 | 0.19 |
| Number of Countries | 53 | 53 | 53 | 53 | 50 | 50 |

Table 1.C.2: Results for short-run growth rates using fixed effect method.

Notes: *,**,*** denote significance at the 10, 5, and 1 per cent level, respectively and figures in parentheses are standard errors and the standard errors in the model specifications (16.) are obtained by 5000-replication bootstrap. Fixed effect estimation includes both time and country fixed effects. And the short-run is a 5-year span.

# Appendix 1.D

Here is a brief introduction[10] to robust regression methods. For linear regression, the ordinary least squares (OLS) estimates are not optional when some of the regression assumptions are invalid. Robust regression approaches[11] give an alternative to OLS by having less restrictive assumptions. These approaches seek to identify outliers and minimise their influence on the coefficient estimates.

Outliers tend to pull the fitted line too far in their direction by getting more weight. We would normally expect that each observation's weight would be $1/n$ in a data set of size $n$. However, outliers may get so much more weight that they distort the coefficient estimates.

For the first approach, suppose that we have a data set with $n$ observations such that

$$y_i = \beta x_i + \varepsilon_i$$
$$\Rightarrow \varepsilon_i(\beta) = y_i - \beta x_i,$$

where $i = 1, \ldots, n$ and the error term $\varepsilon_i(\beta)$ depends on the regression coefficient. OLS is known as $L_2$**-norm regression** because it minimizes the $L_2$-norm of the residuals. $L_1$**-norm regression (known as least absolute deviation)**—an alternative to OLS—minimises the $L_1$-norm of the residuals. That is, the least absolute deviation estimator is

$$\hat{\beta}_{LAD} = arg\ min_{\beta} \sum_{i=1}^{n} |\varepsilon_i(\beta)|.$$

Another frequently used robust regression approach is a class of estimators known as **M-estimators**, which attempt to minimise the sum of a selected function $\rho\left(\varepsilon_i(\beta)\right)$. That is,

[10] For further details, see Andersen (2007).
[11] For a robust regression used in STATA, see Verardi and Croux (2009).

M-estimators are given by

$$\hat{\beta}_M = arg\ min_\beta \sum_{i=1}^{n} p\left(\varepsilon_i(\beta)\right).$$

The subscript M stands for “maximum likelihood” because $\rho\left(\varepsilon_i(\beta)\right)$ is related to the likelihood function for a suitable assumed residual distribution. If assuming normality, $\rho(x) = x^2/2$ leads to the ordinary least squares estimate.

# CHAPTER 2

# A MODEL OF CURRENCY SUBSTITUTION: EXPLAINING THE DOLLARISATION PHENOMENON IN CAMBODIA

Abstract

Dollarisation—the use of a foreign currency as legal tender—in Cambodia does not fit the general trend that as macroeconomic and political conditions stabilise in dollarized economies, their degree of dollarization decreases. To explain this phenomenon, this paper extends Uribe (1997) model by including a dollar pricing index to amplify the network effects of using a foreign currency, denoted dollar. The dollar pricing index, a proportion of an economy denominated by the dollar, reduces the dollar's transaction cost, thus increasing its usage in the economy. This increased use of the dollar then improves the experience of using it, which increases the use of the dollar in the price quotation. This positive interaction of using the dollar as a unit of account and a means of payment raises the degree of dollarisation, even though the economy has achieved low inflation and political stability.

*Keywords*: Dollarisation; Dollar pricing index; Network externalities

*JEL classification*: E41; F41

## 2.1 Introduction

High inflation has caused many developing countries, such as Cambodia, Laos, Peru, and Bolivia, to use a foreign currency (dollar) in parallel to or instead of their national currency[1]. This sort of financial adaptation is known as *dollarisation* or *currency substitution*. The general belief about the evolution of dollarisation is that as dollarised economies experience macroeconomic and political stability for extended periods of time, their level of dollarisation gradually declines (Menon, 2008). For instance, as both the Laos and Vietnam have achieved an average annual economic growth of about 7% and inflation of about 6% along with political stability in the last two decades, their degrees of dollarisation have respectively declined from 32% and 75% in 2001 to 8% and 48% in 2017. However, although Cambodia has had similar experiences throughout the same period, its dollarisation trend has continued to grow from 35% in 1993 to 84% in 2017 (Figure 2.1).

To help explain this upward trend of dollarisation in Cambodia, Menon (2008) offers three possible factors: exports, inflows of foreign direct investments (FDI), and aid. Yet, the data (Figure 2.2) do not actually support this conjecture. In Vietnam, the total averages of these three factors from 2000 to 2017 accounted for about 83% of the country's gross domestic product (GDP), which was higher than in Cambodia. However, whereas Vietnam's dollarisation has expectantly shown a downward trend, Cambodia's has increased.

For the sake of understanding the causes behind this phenomenon, this paper extends Uribe (1997) cash-in-advance model by including a *dollar pricing index*, defined as a proportion of an economy that quotes the dollar as a unit of account. The inclusion of this variable amplifies the network effects of using the dollar in an economy.

[1]Recently, Venezuela has been reported to increasingly use U.S. dollars since experiencing more than three-digit inflation in 2015 (International Monetary Fund, 2019).

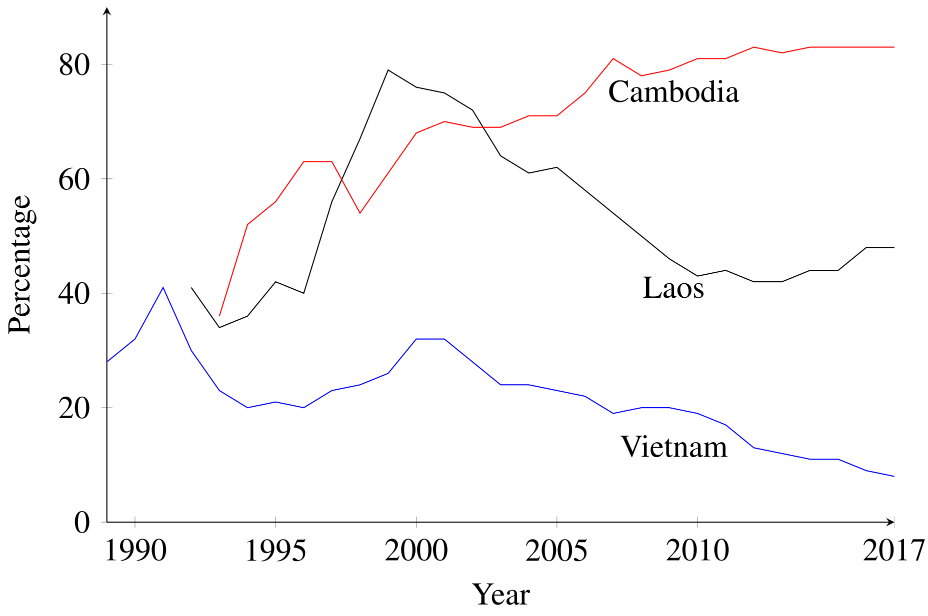


Figure 2.1: Trends of dollarisation in Cambodia, Laos, and Vietnam.

Notes: Degree of dollarisation is a ratio of dollar-denominated deposits to broad money (M2). Data were sourced from International Monetary Fund Country Reports (Appendix A).

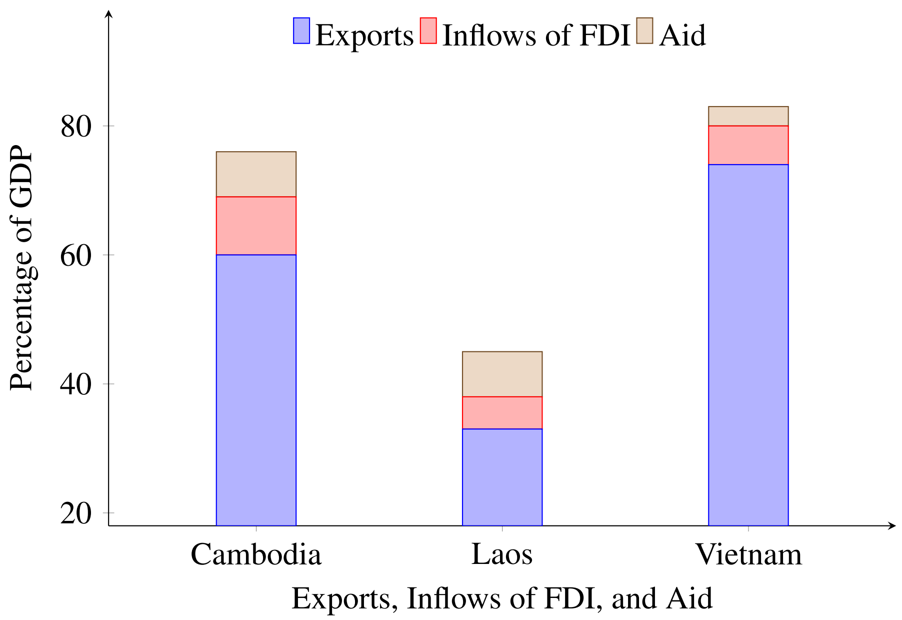


Figure 2.2: An average of exports, net inflows of FDI, and aid as percentage of GDP from 2000 to 2017.

Notes: The period of data selection is based on data availability. Aid is "Net official development assistance and official aid received." The data came from World Development Indicators (2019).

The network effects are the central feature in Uribe (1997) model to explain dollarisation dynamics in developing countries[2]. In the model, he assumes that an economy's accumulated experience in using the dollar as a medium of exchange acts an externality that lowers the transaction cost of buying goods with dollars. However, the network effects would be far more significant if dollar quotations were included[3] because dollar-denominated goods promote and ease its usage. Thus, the inclusion of the dollar pricing index further reduced the transaction cost of buying goods with the dollar, increasing its use in an economy. This increased use of the dollar then improves the knowledge of using it, encouraging the economy to quote the prices in dollars. The interaction between the use of the dollar in the price quotation and the accumulated experience of using it increases the degree of dollarisation, even though the economy has achieved social, political, and economic stability.

Two waves of survey data[4] in Cambodia along with qualitative data from Laos, Vietnam, and Peru, support this augmented model's prediction. As Cambodia's economy has increasingly used foreign currencies as a unit of account, the use of foreign currencies as a means of exchange has also grown. The dollar pricing index and the degree of dollarisation have increased from 28% to 43% and 81% to 83%, respectively, during 2010–2014. This positive relationship was also observed in Cambodia's cross-regional areas. Figure 2.3 shows that the higher the dollar pricing index a region has, the higher proportion of revenue in foreign currencies the region receives.

While Cambodia has no restrictions on which currency is used to quote prices, Laos,

[2]Uribe (1997) model shows that a temporary high inflation triggers an economy to adopt the dollar. Because of the network effects, the degree of dollarisation declines gradually when the inflation stabilises in the economy. This model explains well the dynamics of dollarisation in most developing countries; however, it does not explain the evolution of dollarisation in Cambodia—Dollarisation trend continues to increase, even though Cambodia's inflation has stabilised.

[3]Some dollarised economies, such as Laos, Vietnam, and Peru, officially ban a foreign currency from being used as a unit of account, while another like Cambodia does not forbid such a role of foreign currency in its economy.

[4]The first survey was conducted by Khou (2012) in 2010 with a sample of 1106 local merchants, and the second one was conducted by the National Bank of Cambodia (NBC) and JICA research institute in 2014–2015 with a sample of 856 enterprises.

Vietnam, and Peru have banned foreign currencies from being used as a unit of account. This ban has decreased the dollar pricing index, thus raising the cost of using the dollar in transactions. This increased cost has reduced the use of dollars in transaction. As a result, the degree of dollarisation in these countries has gradually declined, as predicted by Uribe (1997) model.

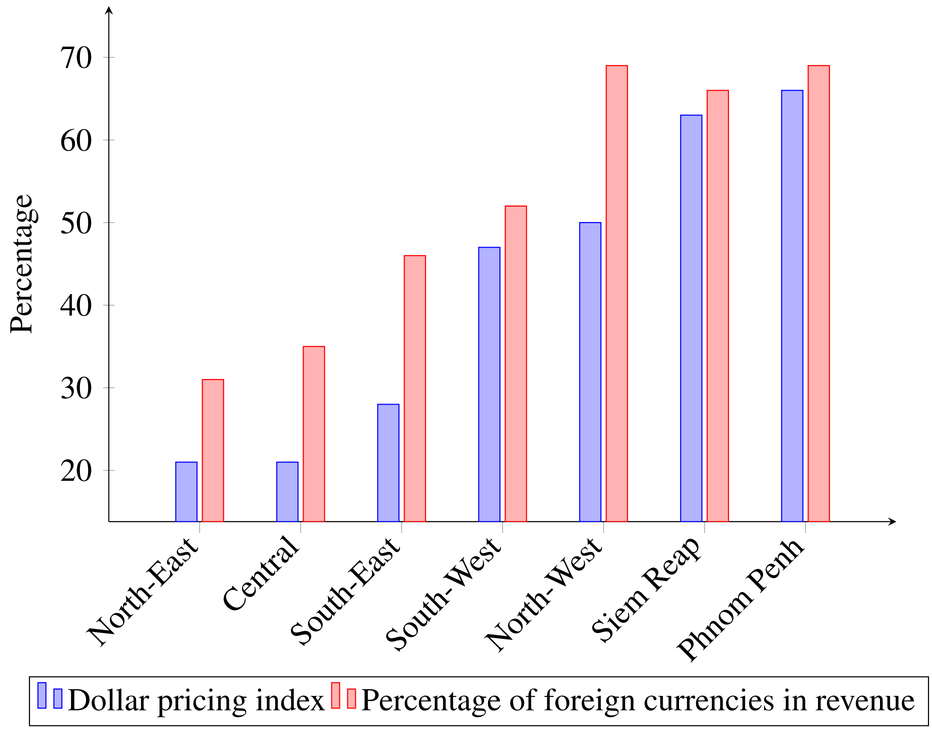


Figure 2.3: Dollar pricing index and percentage of foreign currencies in revenue in Cambodia's cross-regional areas.

Notes: The dollar pricing index is measured by a proportion of products that merchants quote their prices in foreign currencies. The data were retrieved from National Bank of Cambodia (2016, p. 53–58).

The rest of the paper proceeds as follows. Section 2 reviews the relevant literature concerning with currency risk and network externalities as the roots of dollarisation. Section 3 briefly discusses the dollarisation in Cambodia. Section 4 presents a model of currency substitution. Section 5 discusses government policies' effects including how changes in depreciation rate (or inflation), dollar pricing index, or both affect the equilibrium. Section 6 provides some qualitative evidence to support the model's predictions, and Section

7 concludes the paper with a policy implication and its limitation.

## 2.2 Currency Risk and Network Externalities

This paper is related to two main strands of literature. One is concerned with how currency risk triggers the use of a foreign currency. The other focuses on the network externalities of using a foreign currency to help explain the evolution of dollarisation in developing countries.

Craig and Waller (2004) and Camera et al. (2004) develop a model in which households use both domestic and foreign currencies in their transactions. Because the domestic currency is perceived to have a relatively high probability of losing its value before its use in a transaction, households tend to use and accept the foreign one instead. However, because using the foreign currency incurs a transaction cost, the domestic one still remains a means of exchange. The inclusion of the transaction cost in the model is motivated by the fact that in developing countries, the households might need to verify the authenticity of an unfamiliar currency (Engineer, 2000; Tandon and Wang, 2003), and spend time switching between currencies (Guidotti and Rodriguez, 1992).

These two factors—currency risk and transaction cost—lead to the coexistence of both currencies in the economy, which neither supports nor contradicts Gresham's Law that risky money drives safe money out of the economy (Rolnick and Weber, 1986). Yet, although they are offsetting factors in explaining the extent of currency substitution, the studies by Melvin and Fenske (1992) and Clements and Schwartz (1993) show that the effects of a decrease in currency risk are weaker in an economy that has already experienced a history of exchange rate instability, implying that de-dollarisation might not occur or may be slow in such economies.

Based on the idea that using a foreign currency incurs a transaction cost, Uribe (1997) presents a simple cash-in-advance model, to which this paper is the closest. In his model, the network externalities play a central role in explaining the continued existence of the foreign currency in an economy once it has already been widely used as a means of exchange. In other words, the more experience an economy has with using the foreign currency as a means of exchange, the lower its transaction cost becomes. These network effects are also present in the search theoretical models of money (see Matsuyama et al. (1993) and Trejos and Wright (1995)). Kiyotaki and Wright (1989) show that even an item without any intrinsic value can become a means of payment if widely accepted as such. Then, the use of such a thing fundamentally becomes the norm. This indicates that if a foreign currency is broadly used during a period of high inflation, its use will continue after inflation returns to a lower level.

Empirically, the network effects on hysteresis have been supported in several studies. For example, Valev (2010) uses survey data to test the impacts of currency risk and network externalities as causes of hysteresis of currency substitution in Bulgaria. He finds the network externalities to be a major factor of hysteresis (see also Duffy and Ochs[2002] and Samreth[2011]).

## 2.3 The Dollarisation in Cambodia

The currency risk and network externalities are the roots of rising dollarisation in Cambodia. Cambodians had already lost trust in the domestic currency (riel) when the riel and economic institutions (e.g., banks) among others were abolished during the Khmer Rouge regime, known as the Cambodia Genocide, from 1975 to 1979. In March 1980, the riel was introduced back into the economy. Yet, people preferred barter and gold for most domestic transactions (De Zamaroczy and Sa, 2002). This loss of confidence in the riel was further eroded by the fact that the riel became highly depreciated against the dollar during the period 1988–1991.

In the early 1990s, the U.S. dollar's use grew rapidly as Cambodia was open to foreign investments and aid. The United Nations Transitional Authority spent around USD 1.7 billion—about 75% of Cambodia's GDP at that time—on rents and local services for its peacekeeping operations including assisting Cambodia with its first national election in 1993 (National Bank of Cambodia, 2016, p. 8).

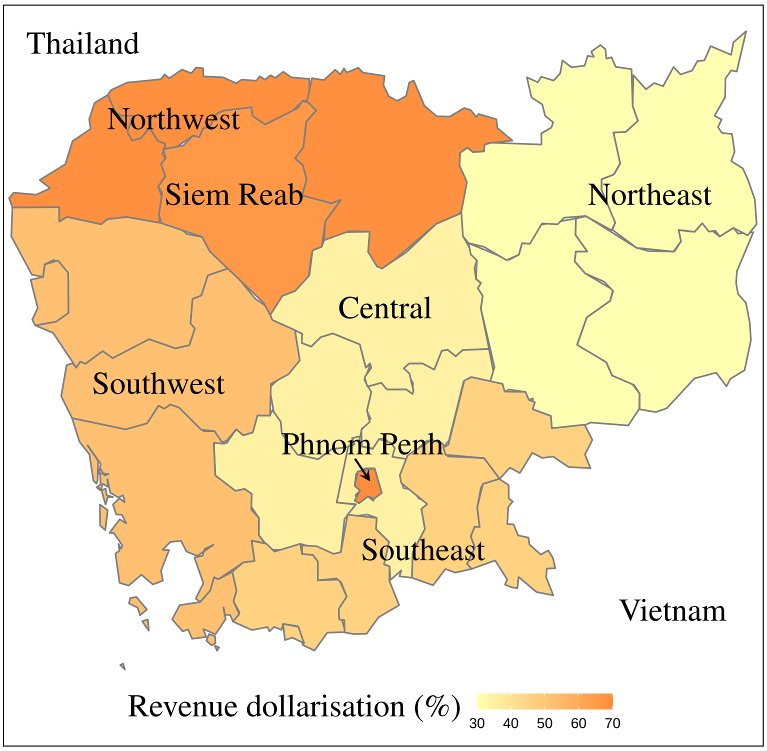


Figure 2.4: The use of foreign currencies across regions in Cambodia.

Notes: Revenue dollarisation is a fraction of foreign currencies in revenues. The U.S. dollar is used predominantly in two cities—Phnom Penh and Siem Reap. The U.S. dollar and Thai currency (baht) are widely used along the northeast and southwest border with Thailand. The U.S. dollar and the Vietnamese dong are frequently seen along the southeast border with Vietnam. In the other regions, which are mainly rural, the domestic currency (riel) is predominant. Source: National Bank of Cambodia (2016, p. 53–58).

For the sake of price stability and economic growth, Cambodia has placed no restrictions on the use of foreign currencies, thus leading multiple currencies to be in use. The type of currency used as a means of payment is positively associated with the type of currency used as a unit of account. For instance, as merchants in Phnom Penh City use the U.S. dollar to display prices for approx 65% of their total products, they also receives around 69% of their revenues in the U.S. dollars (Figure 2.3). And the type of currency used in price quotation depends mainly on types of goods and services[5], and whom Cambodians do business with. As a result, the degree of dollarisation differs across regions, and concentrates in urbane areas, tourism sites and near trade borders (Figure 2.4).

Since Cambodia was increasingly integrated into the world in the early 1990s, it has performed spectacularly (e.g, its an average annual GDP growth is around 7%), but it has made it easy for foreign currencies to be used because products have been quoted in a foreign currency. Consequently, the degree of dollarisation has increased from 35% in 1993 to 84% in 2017. To the best of my knowledge, this upward trend of dollarisation in Cambodia appears to be the odd one out among other dollarised economies. The model developed in the next section helps explain this odd.

## 2.4 A Model of Currency Substitution

The theoretical framework is a cash-in-advance model, as presented in Uribe (1997). Differing from Uribe (1997), I include the role of a foreign currency as a unit of account to amplify the network effects of using the foreign currency. In addition, I incorporate a government's degree of regulations on the use of the foreign currency in price quotation. These inclusions are motivated by observations in dollarised economies: Some dollarised economies, such as Laos, Vietnam, and Peru, officially ban a foreign currency from being used as a unit of account, while Cambodia allows such a role of foreign currency in its economy[6].

[5]e.g., the U.S. dollar is predominantly used to quote salaries and pay employees in the private sector as well as international organisations, and for big-ticket items, such as houses and vehicles

[6]I have data of only these four countries about using a foreign currency as a unit of account. For other dollarised economies, I could not find any document that shows whether they have allowed a foreign currency to be used in the price quotation.

The economy is a small open dual-currency system, in which a foreign currency, denoted dollar, is used along with a domestic currency, riel. This economy is endowed and populated by a large number of infinitely lived, identical households whose preferences are defined over paths of consumption, $\{C_t\}_{t=0}^{\infty}$, and represented by the following lifetime utility function:

$$\int_0^{\infty} e^{-\rho t} U(C_t)\,\mathrm{d}t, \tag{2.1}$$

where $\rho$ is a discount rate and $U(\cdot)$ is an instantaneous utility function which is assumed to be continuously differentiable, strictly increasing, and strictly concave. Consumption is a composite of a continuum of goods, $c_t(\theta)$, indexed by $\theta \in [0,1]$,

$$C_t = \int_0^1 u(c_t(\theta))\,\mathrm{d}\theta,$$

where $u(\cdot)$ is assumed to be continuously differentiable, strictly increasing, and strictly concave, and to satisfy $\lim_{c\to 0} u_c(0) = \infty$. The condition $u_c(0) = \infty$ implies that a consumption of every type of good $\theta$ is always positive: $c(\theta) > 0$.

Households can use riels or dollars to pay for goods. However, using dollars incurs a transaction cost that differs across goods $\theta$. That is, the unit transaction cost of buying good $\theta$ with dollars is $\phi(\theta, k_t, q_t)$. The variable $k_t$ represents the economy's accumulated experience at time $t$ with using dollars as a means of exchange , and it is referred to as *dollarisation capital*. The variable $q_t \in [0,1]$—referred to as *dollar pricing index*—is a proportion of products that merchants quote their prices in dollars[7]: $q = 0$ means that all products' prices are displayed in the local currency, riel; $q = 1$ indicates all prices are quoted in the foreign currency, dollar. This dollar pricing index indicates the economy's accumulated experience at time $t$ with using dollars in dollar quotation (This variable $q$ is the main feature that this paper contributes relative to Uribe (1997) work[8].) While the

[7]Cambodia's survey data show that $q$ was 28% in 2010 and 43% in 2014 for the economy as a whole.

[8]If we relabel $q$ and $k$ as one variable to capture an economy's accumulated experience in using a foreign currency, the model is unable to explain the dollarisation phenomenon in Cambodia because there is no reinforcing mechanism to amplify the network effects of using a foreign currency.

paths of $k_t$ and $q_t$ are taken as given, both variables are endogenously determined and positively reinforcing each other at the aggregate level. The function $\phi(\theta, k_t, q_t)$ satisfies the following assumption:

**Assumption 1.** $\phi : [0,1] \times \Re^+ \times [0,1] \rightarrow \Re^+$ *is non-negative, twice continuously differentiable, and strictly convex in three arguments and satisfies* $\phi_\theta > 0$, $\phi_k < 0$, $\phi_q < 0$, $\lim_{k\rightarrow\infty} \phi_k = 0$, $\lim_{q\rightarrow 1} \phi_q = 0$, *and* $\lim_{\theta\rightarrow 1} \phi(\theta, k, q) = \infty$.

Assumption 1 states that the transaction cost is strictly increasing in $\theta$, and becomes infinitely large as $\theta$ approaches 1. This prohibitive cost ensures that there always exists a positive demand for the domestic currency. But this transaction cost is strictly decreasing in both $k_t$ and $q_t$. This decreased cost is used to capture the network externalities resulting from adopting the dollar as an alternative legal tender. Additionally, the condition $\lim_{k\rightarrow\infty} \phi_k = 0$ and $\lim_{q\rightarrow 1} \phi_q = 0$ is made for analytical convenience when characterising a steady state.

There exist only two types of markets in this endowed economy: financial market and goods market. As in Lucas (1982), the financial market opens first, and the goods market opens only after the former closes. At time $t$, the households hold a stock of riel-denominated wealth $W_t$. With this amount of money, they go to the financial market to obtain their desired balance of dollars ($d_t$) and riels ($M_t$) with a nominal exchange rate ($E_t$). This exchange rate—expressed as units of riels per unit of dollars—is set by the government. In addition, they can buy or sell an internationally traded, dollars-denominated bond, $b_t$, at the price of one dollar per unit. This bond bears the constant real interest rate $r > 0$ in dollars at time $t$ (strict purchasing power parity and perfect capital mobility are assumed to ensure that this rate is both the domestic and international one). Denoting $w_t \equiv W_t/E_t$ and $m_t \equiv M_t/E_t$, the household's budget constraint in dollars is given by

$$w_t = b_t + m_t + d_t. \tag{2.2}$$

As the goods market opens, one member of the household goes to purchase the desired amount of each good $\theta$, while another member receives an endowment of $y_t$ units of each good $\theta \in [0,1]$ and sells it in the good market. All goods $\theta$ are traded internationally at the common price of one dollar or $E$ ($E$ is a nominal exchange rate : amount of riels per 1 dollar)per unit. When selling their goods, producers can accept either riels or dollars. If they take riels, they have to wait until the financial market opens to convert riels into dollars. Letting $\Theta_t^d$ and $\Theta_t^m$ be the set of goods the household purchases with dollars and riels at time $t$, respectively, the household faces the cash-in-advance constraints to purchase goods with riels and dollars as follows:

$$\frac{m_t}{1+\pi_t} \geq \int_{\Theta_t^m} c_t(\theta)\,\mathrm{d}\theta, \tag{2.3}$$

$$d_t \geq \int_{\Theta_t^d} [1+\phi(\theta,k_t,q_t)]\, c_t(\theta)\,\mathrm{d}\theta, \tag{2.4}$$

where $\pi_t \equiv \dot{E}_t/E_t$ is the depreciation rate (or inflation rate) at time $t$ that needs to satisfy $(1+r)(1+\pi_t) > 1$ so that there is always a cost of liquidity of services provided by currency holdings (a nominal interest rate $i > 0$). In addition, the household does not have any debt after exiting the economy: $\lim_{t\to\infty} e^{-tr} w_t \geq 0$. Denoting $\tau_t \equiv T_t/E_t$ to be the government's transfers to households in terms of dollars, the household's evolution of real wealth is given by

$$\dot{w}_t = rb_t + \frac{m_t}{1+\pi_t} - m_t - \int_{\Theta_t^d} [1+\phi(\theta,k_t,q_t)]\, c_t(\theta)\,\mathrm{d}\theta - \int_{\Theta_t^m} c_t(\theta)\,\mathrm{d}\theta + y_t + \tau_t. \tag{2.5}$$

The representative household chooses paths $\left[c_t(\theta)_{\theta\in(0,1)}, \Theta_t^m, \Theta_t^d, m_t, d_t\right]_{t=0}^{\infty}$ to maximise its lifetime utility (2.1) subject to the constraints (2.2)–(2.5) by taking as given the initial wealth $(w_o)$ and paths $[\pi_t, q_t, k_t, y_t]_{t=0}^{\infty}$ and satisfying the No-Ponzi condition. The first-order conditions associated with this household's optimisation problem are (2.3)–(2.5) binding and (hereafter, I drop time subscripts when no risk of confusion arises.)

$$\Theta^d = [0, \bar{\theta}(k,q,\pi)), \tag{2.6}$$

$$\Theta^m = [\bar{\theta}(k,q,\pi), 1], \tag{2.7}$$

$$\bar{\theta}(k,q,\pi) = \begin{cases} 0 & \text{if } \phi(0,k,q) \geq \pi \\ \theta \text{ such that } \phi(\theta,k,q) = \pi & \text{otherwise} \end{cases} \tag{2.8}$$

$$c(\theta) = c(\bar{\theta}(k,q,\pi)) \quad \text{for } \theta \in \Theta^m, \tag{2.9}$$

$$\frac{u_c(c(\theta(k,q,\pi)))}{1+\phi(\theta,k,q)} = \frac{u_c(c(\bar{\theta}(k,q,\pi)))}{1+\pi} \quad \text{for } \theta \in \Theta^d, \tag{2.10}$$

$$\dot{\lambda} = \lambda[\rho - r], \tag{2.11}$$

$$U_C(C)u_c(c(\theta(k,q,\pi))) = \lambda[1+\phi(\theta,k,q)][1+r] \quad \text{for } \theta \in \Theta^d. \tag{2.12}$$

Equations (2.6) and (2.7) shows that there exists a cut-off good $\bar{\theta}(k,q,\pi) \in [0,1]$ at time $t$, such that goods with index $\theta \geq \bar{\theta}(k,q,\pi)$ are bought with riels and the rest with dollars (Figure 2.5). This cut-off good is referred to as the degree of dollarisation at time $t$. Equation (2.8) shows that when the degree of dollarisation is positive, it is given by the good whose cost is the same whether it is purchased with dollars or with riels. Assumption 1 implies that $\bar{\theta}(k,q,\pi)$ is continuous and any triple $(k,q,\pi)$ such that $\bar{\theta}(k,q,\pi) > 0$, $\bar{\theta}(k,q,\pi)$ is strictly increasing in all three arguments, continuously differentiable, and strictly concave in $k$ and $q$ (Figure 2.6; Appendix C). Equations (2.9) and (2.10) state that $c(\theta)$ is continuous and strictly decreasing in $\theta$ for $\theta \in \Theta^d$, and constant for $\theta \in \Theta^m$. Equation (2.11) implies that $\lambda$—the shadow price of wealth related to flow constraint (2.5)—is constant over time because the interest rate equals the discount rate at the steady state. Equation (2.12) shows that the marginal utility of consumption of the goods bought with dollars is equal to the product of the shadow price of wealth and the effective price of the goods. This effective price equals its direct cost $(1+\phi)$ plus the opportunity cost of holding $(1+\phi)$ units of dollars required by the dollar cash-in-advance constraint to buy one unit of goods.

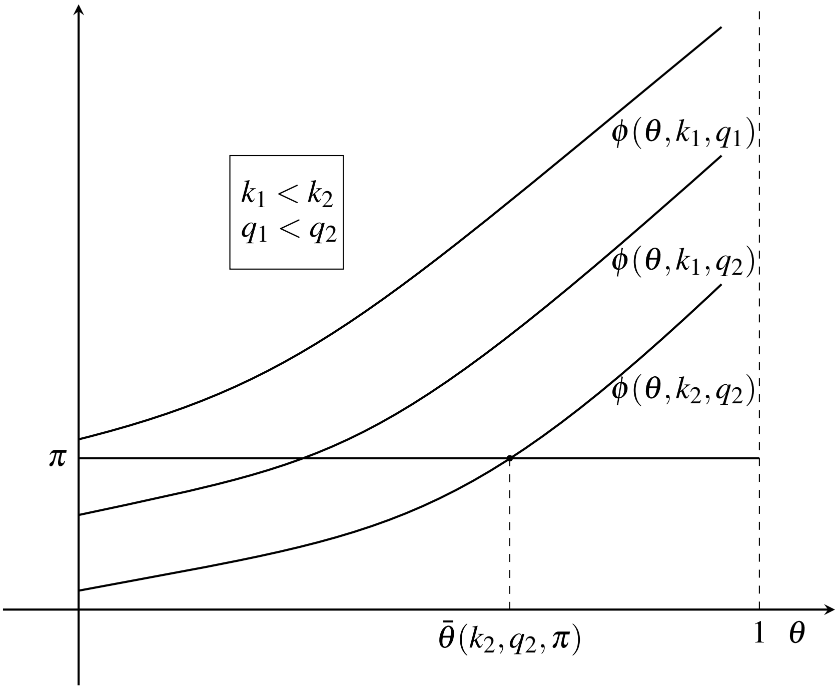


Figure 2.5: Degree of dollarisation.

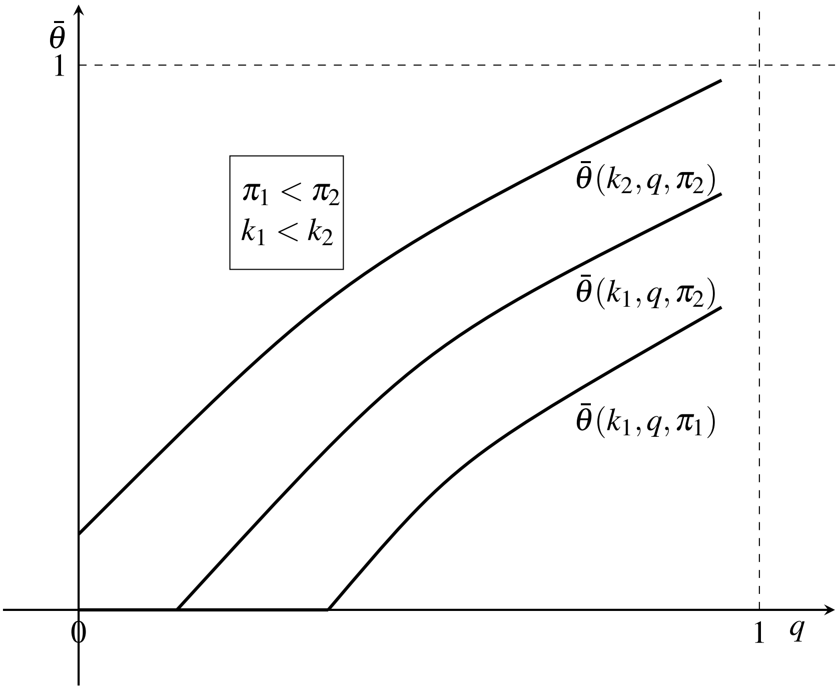


Figure 2.6: The function of $\bar{\theta}(k, q, \pi)$.

Following Uribe (1997), I postulate the dollarisation capital $k$ and the dollar pricing index $q$ to evolve respectively as follows:

$$\dot{k} = f(\bar{\theta}(k,q,\pi)) - \delta_k k, \tag{2.13}$$

$$\dot{q} = h(\bar{\theta}(k,q,\pi)) - (\delta_q + \eta)q, \tag{2.14}$$

where $\dot{x}$ is the time derivative of $x$, $\delta_x$ refers the depreciation rate of $x$; $\eta$ refers to the degree of government regulations on using the dollar as a unit of account—This variable $\eta$ is one of the main features that differentiate this work from Uribe (1997). And $f(\cdot)$ and $h(\cdot)$ satisfy the following assumption.

**Assumption 2.** *$f$ and $h : [0,1] \to \Re^+$ are continuously differentiable, strictly increasing, and strictly concave, with $f(0) = 0$ and $h(0) = 0$.*

Assumption 2 says that as more people use dollars for buying goods, the amount of dollars circulating the economy and the proportion of the economy that quotes prices in dollars increases. That is, there is social learning by doing in the process of adopting dollars as a legal tender. The depreciation rates $\delta_k \in (0,1]$ and $\delta_q \in (0,1]$ together with $f(0) = 0$ and $h(0)$ mean that the stock of dollarisation and that of the dollar pricing index gradually decrease as the dollar is no longer used in the economy—the economy as a whole forgets how to use the dollar. The degree of regulations $\eta$ captures the effects of government intervention in the use of the dollar in price quotation. The more stringent the regulations, the faster the fall of the dollar pricing index. For analytical convenience, $\eta$ is assumed to be between 0 and 1 and satisfy $\eta + \delta_q \in (0,1]$.

**The Steady-State Equilibrium**

To simplify and characterise the steady state, Equation (2.13) and (2.14) can be rewritten as

$$\dot{k} = F(k, q, \pi) - \delta_k k, \tag{2.15}$$

$$\dot{q} = H(k, q, \pi) - (\delta_q + \eta) q, \tag{2.16}$$

where $F$ and $H$ are the composites of functions $f$ and $\theta$ and $h$ and $\theta$, respectively. Assumption 2 together with the fact that $\theta$ is strictly increasing and concave in $k$ and $q$ implies that $F$ and $H$ are also strictly increasing and concave in $k$ and $q$.

A steady-state equilibrium is defined by the stock of dollarisation and that of the dollar pricing index $(k^*, q^*)$, which satisfy the following two equations:

$$F(k^*, q^*, \pi) - \delta_k k^* = 0, \tag{2.17}$$

$$H(k^*, q^*, \pi) - (\delta_q + p) q^* = 0. \tag{2.18}$$

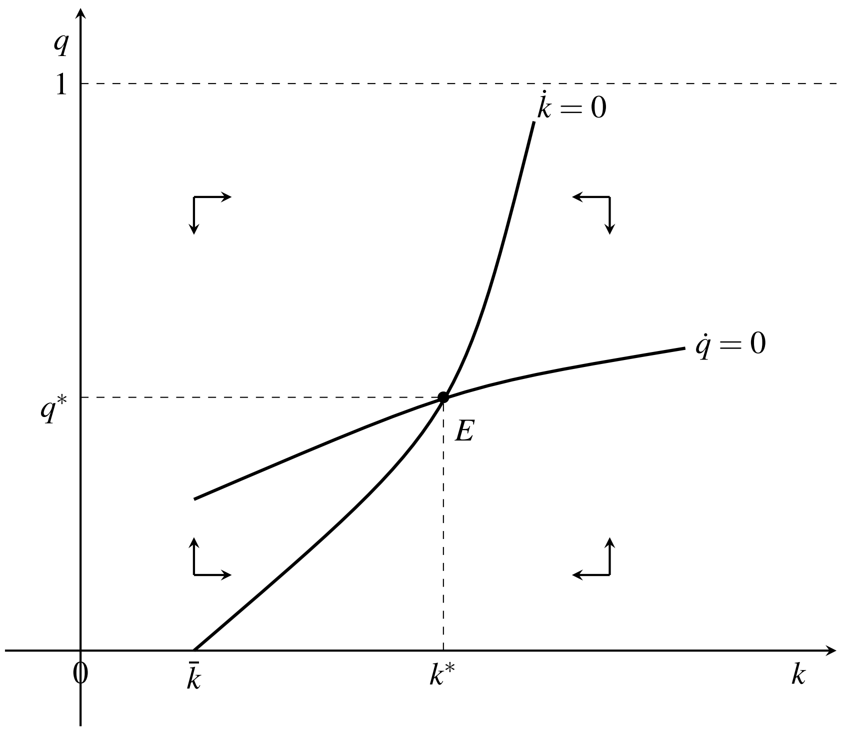


Figure 2.7: The dynamics of $q$ and $k$.

This steady-state equilibrium $(k^*, q^*)$ is globally and uniquely stable. To see this heuristically, consider Figure 2.7, drawn in the $(k,q)$ space. The curves $\dot{k} = 0$ and $\dot{q} = 0$, corresponding respectively to Equations (2.17) and (2.18), have a positive slope so that a higher dollar price index is associated with a higher dollarisation capital in equilibrium. Moreover, the slope of $\dot{k} = 0$ curve is steeper than that of $\dot{q} = 0$ curve at the equilibrium.

To show that these statements are true, first consider the slope of $\dot{k} = 0$ curve in the $(k,q)$ space. Based on the implicit function theorem, this slope is given by

$$\left.\frac{\mathrm{d}q}{\mathrm{d}k}\right|_{\dot{k}=0} = \frac{\delta_k - F_k(k,q,\pi)}{F_q(k,q,\pi)}, \tag{2.19}$$

where $F_k \equiv \partial F/\partial k$ and $F_q \equiv \partial F/\partial q$. Equation (2.15) implies that $\delta_k = F(q,k,\pi)/k$ as $\dot{k} = 0$. The fact that $F$ is strictly concave in $k$ and $F(0,q,\pi) \geq 0$ yields the following inequality:

$$\begin{aligned} F(k,q,\pi) &> F_k(k,q,\pi)k + F(0,q,\pi) \\ &> F_k(k,q,\pi)k. \end{aligned}$$

This inequality leads to $\delta_k - F_k(k,q,\pi) > 0$, thus proving that Equation (2.19) is strictly positive. Similarly, when the same method and argument are applied to the equation (2.16), the slope of $\dot{q} = 0$ curve, given below, is also strictly positive:

$$\left.\frac{\mathrm{d}q}{\mathrm{d}k}\right|_{\dot{q}=0} = \frac{H_k(k,q,\pi)}{\delta_q + \eta - H_k(k,q,\pi)}. \tag{2.20}$$

Second, to show that the slope of $\dot{k} = 0$ curve is steeper than that of $\dot{q} = 0$ curve at the equilibrium, we need to prove that the following inequality is true:

$$
\begin{array}{rcl}
\left.\frac{\mathrm{d}q}{\mathrm{d}k}\right|_{\dot{k}=0} & > & \left.\frac{\mathrm{d}q}{\mathrm{d}k}\right|_{\dot{q}=0} \\
& \Updownarrow & \\
\frac{F/k-F_k}{F_q} & > & \frac{H_k}{H/q-H_q} \\
& \Updownarrow & \\
(F-kF_k)(H-qH_q) & - & qkF_qH_k > 0 \\
& \Updownarrow & \\
kH_k(F-kF_k-qF_q)+qF_q(H-kH_k-qH_q) & + & (F-kF_k-qF_q)(H-kH_k-qH_q) > 0.
\end{array}
$$

The second line is a result of substituting $F(k^*,q^*,\pi)/k^*$ for $\delta_k$ in (2.19) and $H(k^*,q^*,\pi)/q^*$ for $\delta_q+\eta$ in (2.20). The third and last lines result from simplifying and rearranging the terms in the second line (note that all functions are evaluated at the equilibrium point). Assumption 1 and 2 together with Equation (2.8) show that this inequality is satisfied (Appendix C).

Third, the dynamic movements of $k$ and $q$ are dictated by the signs of the time derivatives of $k$ and $q$, respectively. Since $\partial\dot{k}/\partial q = F_q > 0$, all the points below the $\dot{k}=0$ curve are characterised by $\dot{k}<0$ and all the points above the curve by $\dot{k}>0$. Similarly, because $\partial\dot{q}/\partial k = H_k > 0$, all the points to the left of the $\dot{q}=0$ curve are characterised by $\dot{q}<0$ and all the points to the right of the curve by $\dot{q}>0$. Therefore, the $\dot{k}=0$ curve and $\dot{q}=0$ curve divide the phase space into four regions, each with its own distinct pairing of signs of $\dot{k}$ and $\dot{q}$, as indicated by the right-angled directional arrows in Figure 2.7.

Finally, since this paper focuses on developing economies that have already experienced high inflation, the steady-state stock of dollarisation as shown by Uribe (1997) is positive while the dollar pricing index is 0 ($q=0$). This steady-state stock is denoted by $\bar{k}$ in Figure 2.7. At the point $(\bar{k},0,\pi)$, the $\dot{q}=0$ curve lies above the $\dot{k}=0$ curve because $\dot{q}=F(\bar{k},0,\pi)$ is greater than 0 ($\theta(k_0,0,\pi)>0$). Assumption 1 implies that as $q$ approaches to 1, the slope of the $\dot{k} = 0$ curve approaches infinity. Likewise, $k$ approaches infinity, the slope of $\dot{q} = 0$ approaches 0.

Therefore, the two demarcation curves ($\dot{k} = 0$ and $\dot{q} = 0$) intersect only once at point $E(k^*, q^*)$. This point is the globally stable equilibrium because no matter where a point $(k, q)$ starts, it tends to move toward point $E$ as indicated by the directional arrows.

## 2.5 The Effects of Government Policies

In this section, I illustrate how changes in government policies affect the steady-state equilibrium and present three relevant cases to explain the rise and fall of the degree of dollarisation in developing countries.

### 2.5.1 The Effects of Changes in Inflation

First, consider what happens to the equilibrium when a government reduces inflation. Empirically, when high-inflation countries decreased the inflation rate to a low level for a certain period of time, their dollarisation has gradually declined (e.g., see Figure 2.11; Figure 2.A). To see how this mechanism works, look at what happens to the model presented in Figure 2.8.

A decrease in inflation causes the $\dot{k} = 0$ curve to shift to the left, from the $\dot{k_0} = 0$ curve to the $\dot{k_1} = 0$ curve, but the $\dot{q} = 0$ curve moves downward, from the $\dot{q_0} = 0$ curve to the $\dot{q_1} = 0$ curve. These directional movements are derived from the fact that

$$\left.\frac{\mathrm{d}q}{\mathrm{d}\pi}\right|_{\dot{k}=0} = -\frac{F_\pi(k,q,\pi)}{F_q(k,q,\pi)} < 0, \text{ and } \left.\frac{\mathrm{d}q}{\mathrm{d}\pi}\right|_{\dot{q}=0} = \frac{H_\pi(k,q,\pi)}{\delta_q + \eta - H_q(k,q,\pi)} > 0.$$

Now the economy is governed by the new curves $\dot{k_1} = 0$ and $\dot{q_1} = 0$. At the point $E_0$, both $q_0^*$ and $k_0^*$ are at such a high level that they cannot generate enough social learning by adopting the foreign currency to compensate for their depreciation. Consequently, both stocks gradually decline through a stable saddle path $E_0E_1$ until they reach a new steady state at point $E_1$, where the new level of both stocks are lower than before.

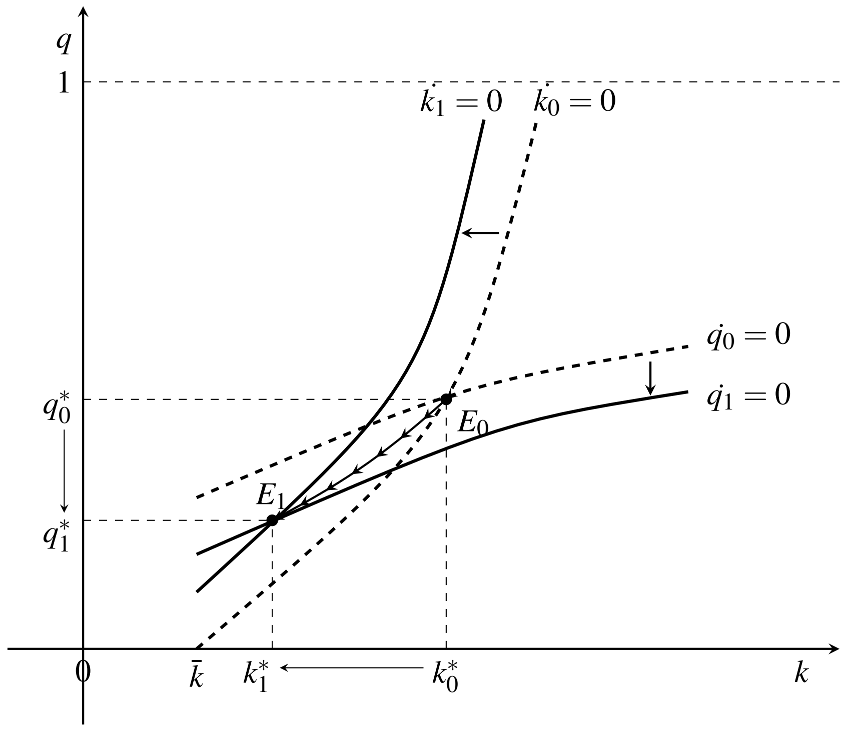


Figure 2.8: The effects of falling inflation.

### 2.5.2 The Effects of Changes in Dollar Quotation

Next, consider how the equilibrium changes when a government imposes restrictions on dollar quotation. Restricting the use of the dollar as a unit of account affects only the $\dot{q} = 0$ curve, making the stock of the dollar pricing index depreciate more quickly. In other words, if the other variables remain the same, an increase in $\eta$—the degree of regulations on the use of the foreign currency as price quotation—leads to a decrease in $q$. That is,

$$\left.\frac{\mathrm{d}q}{\mathrm{d}\eta}\right|_{\dot{q}=0} = -\frac{q}{\delta_q + \eta - H_q(k,q,\pi)} < 0.$$

As the curve $\dot{q} = 0$ shifts downward, from the $\dot{q_0} = 0$ curve to the $\dot{q_1} = 0$ curve (Figure 2.9), the equilibrium moves along a stable saddle path $E_0E_1$ from the point $E_0$ to the point $E_1$, where the stock of dollarisation and dollar pricing index capitals are lower than before.

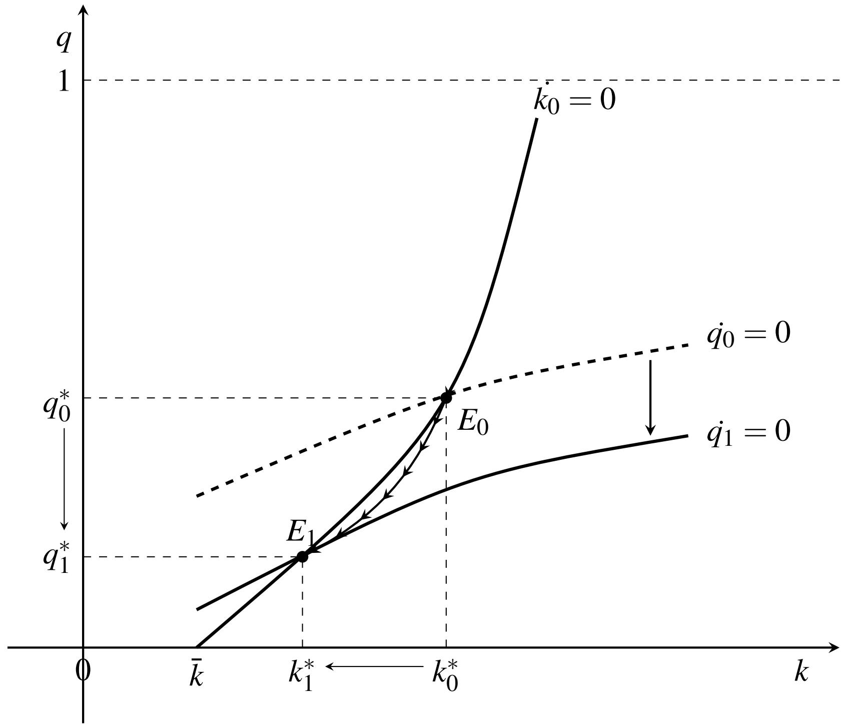


Figure 2.9: The effects of increasing regulation on dollar quotation.

### 2.5.3 The Effects of Changes in Inflation and Dollar Quotation

Finally, consider a case in which a government has lowered inflation but has relaxed restrictions on using the dollar as a unit of account. Melvin and Fenske (1992), Clements and Schwartz (1993), and Valev (2010) provide evidence that the effects of network externalities are stronger than those of currency risk. This evidence implies that the shift of the $\dot{q} = 0$ curve (from the $\dot{q_0} = 0$ to the $\dot{q_1} = 0$), as shown in Figure 2.10, is larger than that of the $\dot{k} = 0$ curve (from the $\dot{k_0} = 0$ to $\dot{k_1} = 0$). Since the point $E_0$ is below both new curves, the stock of dollarisation initially declines, but that of dollar pricing index increases along the stable saddle path $E_0E_1E_2$ from $E_0$ to $E_1$. From $E_1$ onward, both stocks gradually rise to reach the new equilibrium at the point $E_2$, where the level of both stocks are higher than before.

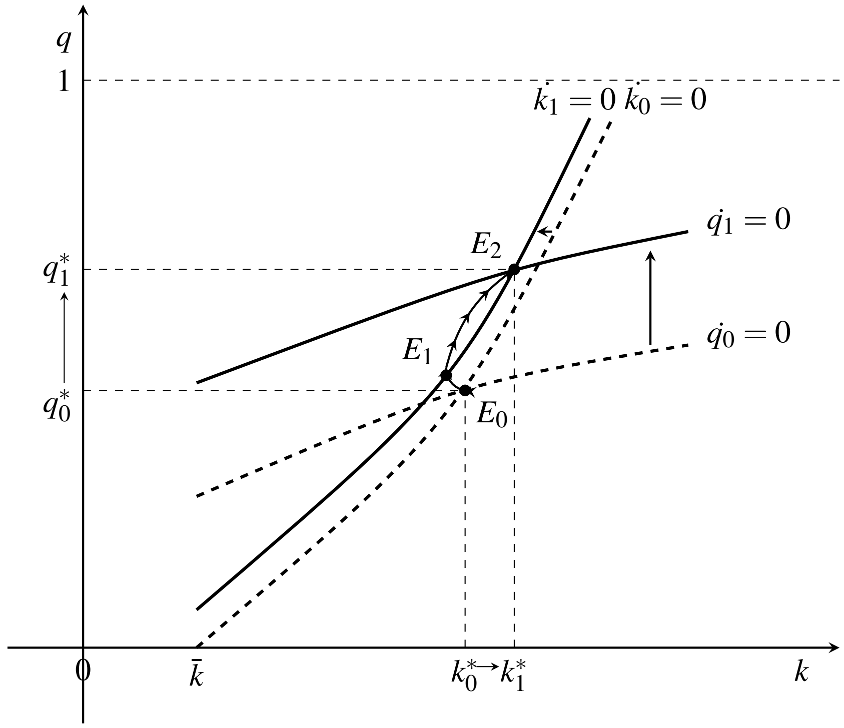


Figure 2.10: The effects of a decrease in inflation and an increase in dollar quotation.

## 2.6 The Model's Predictions and Some Evidence

The illustrations Figure 2.8–2.10 suggest the explanations behind the upward trend of dollarisation in Cambodia and the downward trends in Laos, Vietnam, and Peru. Since Cambodia increasingly adopted the use of the dollar in the early 1990s, it has maintained its average depreciation rate of about 2%. However, the Cambodian government has acquiesced to the dollar's use, and has had no restrictions on how foreign currencies are used. In particular, it has not imposed any regulation on which currency is used to quote products' prices (Kubo, 2017). This implies that $\eta$–the degree of regulations on using the dollar for price quotation—approaches 0. Because the network externalities of using the dollar are proved stronger than the currency risk, the dollarisation degree has increased. In contrast, Laos, Vietnam, and Peru have repeatedly restricted their economies by forbidding price quotations in foreign currency. For instance, as in Cambodia, it has been a common practice in Laos for firms and households to use foreign currencies as a means of exchange and unit of account instead of its local currency, the kip. The use of the Thai baht and the U.S. dollar is common throughout the country, particularly in urban areas, tourism sites, and Thailand's border. However, in the 2000s, the Laotian government imposed regulations on dollar-denominated bank lending and prohibited pricing in dollars. To enforce the regulations, the Bank of the Laos even set up a committee to conduct regular inspections to monitor the price quotation of products in markets, shops, companies, and trade fairs or exhibitions (Kubo, 2017). This regulation has increased the cost of using the foreign currency. This increased cost and low depreciation rates in Laos, Vietnam, and Peru, have reduced the degree of dollarisation in these economies (Table 2.1; Figure 2.11).

| | Quotation of Prices in Foreign Currency |
|---|---|
| Cambodia | No control |
| Laos | In 1990, Laos issued Decree No53/CM to prohibit the use of foreign currency for domestic transactions, but it was not strictly enforced. In March 2008, the decree was upgraded for stringent enforcement with penalties. |
| Vietnam | Vietnam banned (but did not strictly enforce) foreign currency for quoting prices in the 1990s. In 2011, the restriction was upgraded to raise the penalties to a maximum of VND 500 million. |
| Peru | In 2004, Peru enacted a law stipulating that all prices be denominated in soles, the local currency. |

Table 2.1: Regulations on dollarisation in four selected countries countries.

Source: Data for Cambodia, Vietnam, and Laos were taken from Kubo (2017), and data for Peru came from Castellares and Toma (2020).

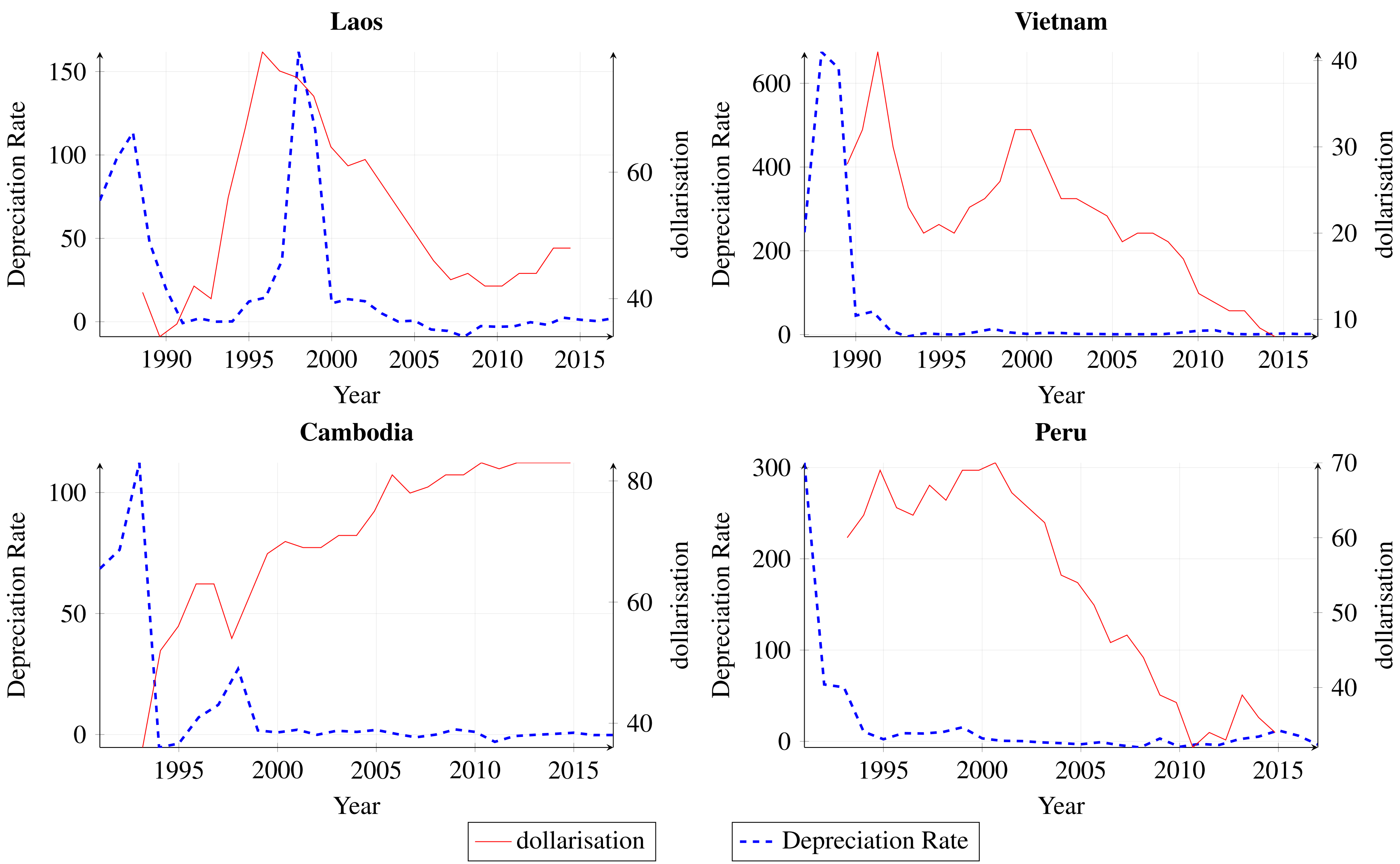


Figure 2.11: Depreciation rate and dollarisation in four selected countries.

Notes: The degree of dollarisation is a ratio of foreign currency deposits to broad money (M2). The data to construct dollarisation were sourced from various IMF Country Reports (Appendix A) and the exchange rate came from International Financial Statistics (2019).

## 2.7 Conclusion

Cambodia has experienced different dynamic dollarisation among dollarised economies, whose trend continues to rise against the backdrop of the country's macroeconomic and political stability. To explain this phenomenon, this paper extends Uribe (1997) model by incorporating the dollar pricing index, which is the proportion of an economy that uses a foreign currency, denoted dollar, as a unit of account. This variable amplifies the network effects of the use of the dollar. Because the impact of the network externalities has proved more substantial than those of currency risk, the positive interaction between the use of the dollar as a unit of account and a means of exchange raises dollar usage, even if Cambodia has achieved economic and political stability.

This extended model has clear implications for dollarised economies. To reduce the widespread use of a foreign currency, dollarised economies need to stabilise not only their macroeconomic conditions (e.g., by decreasing inflation) but also increase the transaction cost of the use of the foreign currency (significantly restricting the foreign currency from being used as a unit of account because foreign currency-denominated goods explicitly promote the use of the foreign currency.)

This model has its limitation, though: it produces only one stable steady state; therefore, it cannot capture the hysteresis of dollarisation like Uribe (1997) model that provides two stable steady states and one unstable steady state. However, since this work focuses on the developing countries that had already experienced high inflation and thus a certain degree of dollarization, this model suffices to deal with the present objective: Explain whether this particular degree of dollarisation continues to rise or fall as a result of governments regulations on the use of a foreign currency as a unit of account.

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# Appendix 2.A

| | Sources |
|---|---|
| Cambodia | IMF Staff Country Reports: No. 95/108, No. 99/33, No. 00/134, No. 06/265, No. 09/325, No. 11/45, No. 14/33, and No. 18/369. |
| Laos | IMF Staff Country Reports: No. 96/54, No. 98/77, No. 3, No. 02/62, No. 04/394, No. 06/398, No. 08/340, No. 11/44, No. 13/369, No. 15/45, and No. 17/53. |
| Vietnam | IMF Staff Country Reports: No. 95/93, No. 99/56, No. 03/382, No. 07/386, No. 12/165, No. 16/240, and No. 18/215. |
| Peru | IMF Staff Country Reports: No. 95/108 , No. 99/33 , No. 00/160, No. 06/265 , No. 09/325 , No. 11/45 , No. 14/33 , and No. 18/369. |
| Argentina | IMF Staff Country Reports: No. 95/110, No. 98/38, No. 00/134 , No. 03/226, No. 05/236, No. 17/409. |
| Bolivia | IMF Staff Country Reports: No. 95/24, No. 97/99, No. 00/38, No. 03/258, No. 05/393, No. 07/248, No. 10/27, No. 12/149, No. 15/334, and No. 18/379. |
| Turkey | IMF Staff Country Reports: No. 96/112, No. 00/14, No. 02/138, No. 05/163, No. 07/362, No. 10/278, No. 13/363, No. 16/104, and No. 18/110. |
| Uruguy | IMF Staff Country Reports: No. 95/75, No. 99/102, No. 01/183, No. 04/327, No. 06/425, No. 08/45 , No. 10/43, No. 14/6, 15/81, and No. 18/23. |

Table 2.A: Data sources used to construct dollarisation in eight selected countries.

Notes: dollarisation is a ratio of foreign currency deposits to broad money (M2). Data for Cambodia were supplemented by the data from the Ministry of Economy and Finance, Cambodia, where I worked as an economist in 2015.

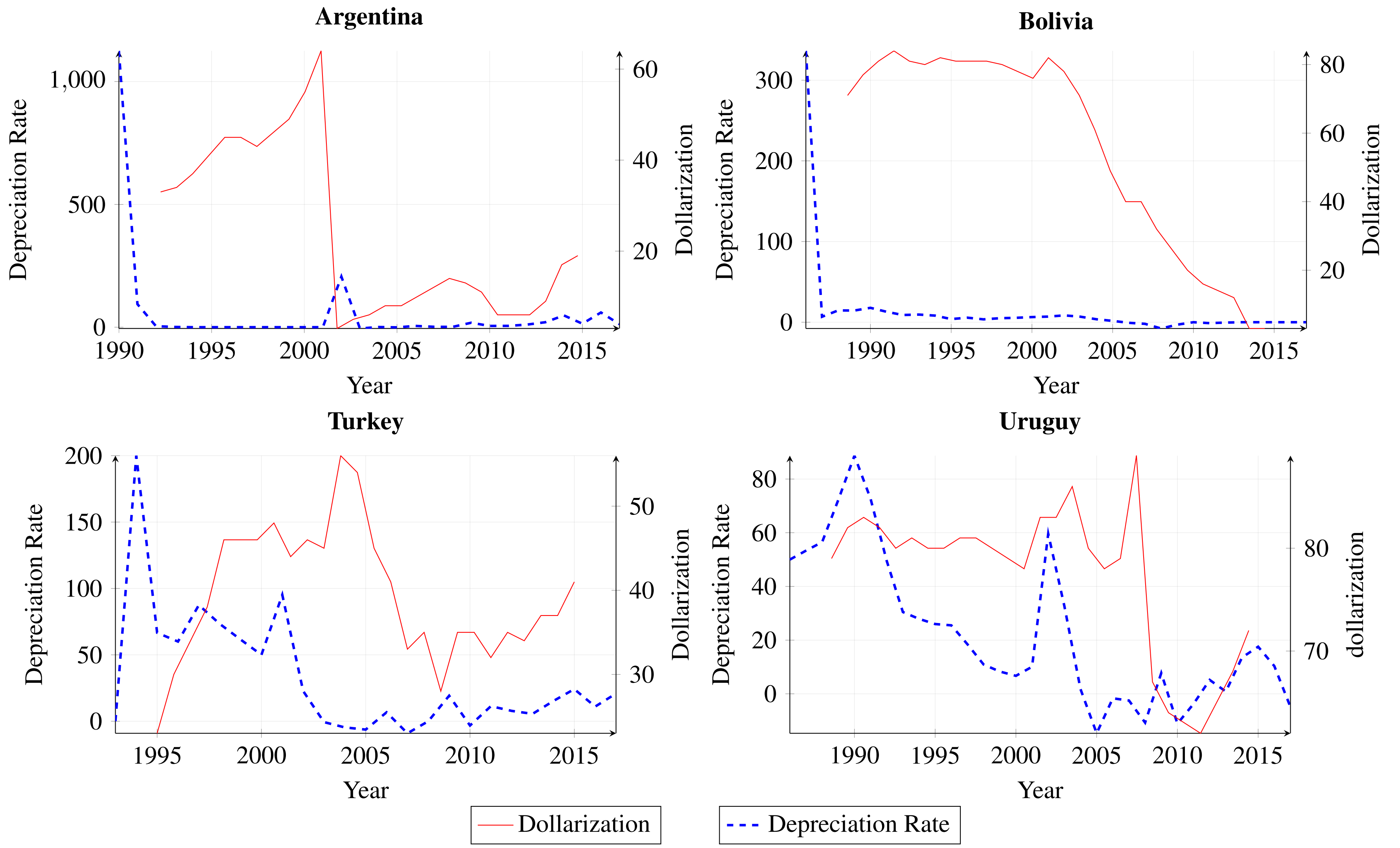


Figure 2.A: Depreciation rate and dollarization in four selected countries.

Notes: The degree of dollarization is a ratio of foreign currency deposits to broad money (M2). The data to construct dollarization were sourced from various IMF Country Reports and the exchange rate came from International Financial Statistics (2019).

# Appendix 2.B

This is to show that $\bar{\theta}$ is strictly increasing in three arguments $(k,q,\pi)$ and strictly concave in $k$ and $q$. The equation (2.8) shows that the value of $\bar{\theta}$ is given by $\phi(\bar{\theta},k,q)=\pi$. Let $G(\bar{\theta},k,q,\pi)=\phi(\bar{\theta},k,q)-\pi$. The implicit function theorem implies that the derivative of $\bar{\theta}$ with respect to $k$ is given by

$$\frac{\mathrm{d}\bar{\theta}}{\mathrm{d}k} = -\frac{G_k}{G_\theta} = -\frac{\phi_k}{\phi_\theta} > 0, \quad \text{(by assumption 1)}$$

where a subscript of a function denotes as a partial derivative (e.g $G_k = \partial G/\partial k$). Denoting $H(k,\bar{\theta}) = d\bar{\theta}/dk$ and then taking total differentials of this expression with respect to $k$ yields

$$\begin{aligned}
\frac{\mathrm{d}^2\bar{\theta}}{\mathrm{d}k^2} &= H_k + H_\theta \frac{\mathrm{d}\bar{\theta}}{\mathrm{d}k} \\
&= -\frac{(\phi_{kk}\phi_\theta - \phi_{\theta k}\phi_k)}{\phi_\theta^2} - \frac{(\phi_{k\theta}\phi_\theta - \phi_{\theta\theta}\phi_k)}{\phi_\theta^2}\frac{\mathrm{d}\bar{\theta}}{\mathrm{d}k} \\
&= -\frac{[\phi_{kk}\phi_\theta^2 + \phi_{\theta\theta}\phi_k^2]}{\phi_\theta^3} < 0.
\end{aligned}$$

The last line is a result of substituting $-\phi_k/\phi_\theta$ for $\mathrm{d}\bar{\theta}/\mathrm{d}k$ and employing the theorem of additively separable function[9]. Note that the denominator of the last line expression is positive, so are two terms of the numerator.

For $q$ and $\pi$, use the same procedure to obtain the results ■.

[9]For example, a function of two variables $F(x,y)$ will be called additively separable if it can be written as $f(x)+f(y)$ for some single-variable functions $f(x)$ and $f(y)$.

# Appendix 2.C

The following proof responds to inequality (2.21). First, rewrite the expression $(F - F_k k)(H - H_q q) - F_q H_k qk$ as

$$(F - F_k k - F_q q)(H - H_k k - H_q q) + H_k k(F - F_k k - F_q q) + F_q q(H - H_k k - H_q q)$$

Next, show that the terms in parentheses are positive. The assumption 1 implies that

$$\phi_\theta[\theta_2 - \theta_1] + \phi_k[k_2 - k_1] + \phi_q[q_2 - q_1] > \phi(\theta_2, k_2, q_2) - \phi(\theta_1, k_1, q_1);\ \forall \pi, \qquad (2.C.1)$$

where $k_2 > k_1$ and $q_2 > q_1$ and thus $\theta_2 > \theta_1$ ($\theta$ strictly increases in $k$ and $q$). Adding and subtracting $\pi$ from the right side of inequality (2.C.1) and applying equation (2.8), we obtain

$$[\phi(\theta_2, k_2, q_2) - \pi] - [\phi(\theta_1, k_1, q_1) - \pi] = 0.$$

Thus, the inequality (2.C.1) becomes

$$\theta_2 - \theta_1 > -\frac{\phi_k}{\phi_\theta}[k_2 - k_1] - \frac{\phi_q}{\phi_\theta}[q_2 - q_1] = \theta_k[k_2 - k_1] + \theta_q[q_2 - q_1], \qquad (2.C.2)$$

where $\theta_k = -\phi_k/\phi_\theta$ and $\theta_q = -\phi_q/\phi_\theta$ by applying the implicit theorem on the equation (2.8). The assumption 2 together with (2.C.2) yields

$$\begin{aligned} f(\theta(k_2, q_2, \pi)) - f(\theta(k_1, q_1, \pi)) &> f_\theta[\theta_2 - \theta_1] \\ &> f_\theta \theta_k[k_2 - k_1] + f_\theta \theta_q[q_2 - q_1]. \end{aligned} \qquad (2.C.3)$$

By setting $k_1 = 0$ and $q_1 = 0$, the inequality (2.C.3) becomes

$$
\begin{aligned}
F(k_2, q_2, \pi) &> F_k k_2 + F_q q_2 + F(0, 0, \pi) \\
&> F_k k_2 + F_q q_2.
\end{aligned}
$$

Thus, $F - F_k k^* - F_q q^* > 0$. Analogously, $H - H_k k^* - H_q q^*$ ■.

# CHAPTER 3

# THE EVOLUTION OF CAMBODIAN CURRENT ACCOUNT: A GENERAL DYNAMIC EQUILIBRIUM ANALYSIS

Abstract

This paper develops and estimates a small open economy real-business cycle (SOE-RBC) model to study the dynamics of Cambodian current account. Differing from existing studies, the paper includes net unilateral transfers and net foreign direct investment (FDI) as additional sources of macroeconomic fluctuations. The model shows that these two sources play more important roles in explaining current-account variation than existing ones—productivity and interest rate. The model generates Cambodian saving-and-investment behaviour that matches well the evolution of its current account: The measurement error is just about 4% and the correlation between data and model is around 0.93. This well-fitted model is then used to predict the future trend of the current account, as the negative shocks of productivity, remittance and FDI hit the economy with COVID-19 pandemic in 2020.

*Keywords*: Real business cycle; Dynamics of current account balance

*JEL classification*: F3; F41

## 3.1 Introduction

Cambodia has performed particularly well in recent decades. The average annual output growth is about 7%, making it one of the fastest growing economies in the world; the inflation rate has been stable, around 3%, and the poverty rate has dropped significantly from 47.8% in 2007 to 13.5% in 2014. However, one aspect of Cambodian economic performance appears to evoke concerns among policymakers: the country's external balances, shown in Figure 3.1, have been the worst among its top trading partners[1]. Cambodian trade and current account balance-to-GDP ratios are around -6% and -11% on average for a period 1993–2018, respectively.

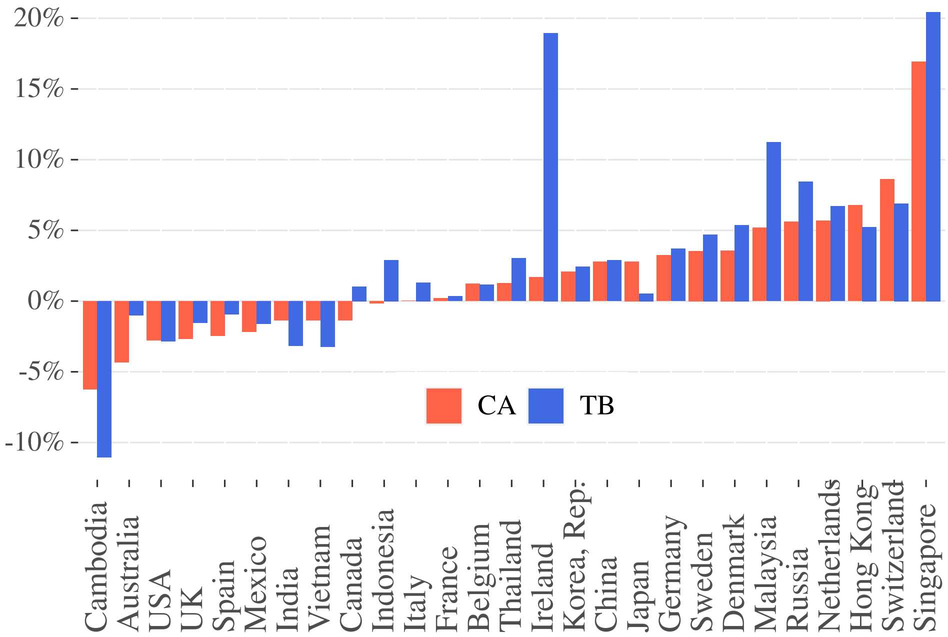


Figure 3.1: Average of trade balance and current account balance of Cambodia and its top trading partners for a period 1993–2018.

Notes: CA and TB refers to current account and trade balance-to-GDP ratios, respectively. The source of data is the World Development Indicator.

[1] Whose combined trade (imports + exports) is more than 95% of Cambodia's total trades with the rest of the world.

To examine the dynamics of Cambodian current account, this paper develops and estimates a small open economy real-business cycle (SOE-RBC) model. Existing RBC literature, such as Arezki et al. (2017), Chang and Fernández (2013), Choi and Mark (2009) among others, identify a shock of productivity, interest rate or both as a key source of macroeconomic fluctuation. In addition to these two shocks, this paper includes net foreign direct investment (FDI) and net unilateral transfer as additional factors in explaining the fluctuation of Cambodian current account.

Four observations motivate the inclusion of these two additional shocks: (1) For developing countries, FDI plays an important role in economic growth and development because FDI not only provides host countries with physical capital and new technology but also improves their human capital through on-the-job training, acquisition and diffusion of technical, managerial and organisational skills (Agbola, 2013; Kheng et al., 2017); (2) Foreign aid and remittance have a positive effect on growth because they help reduce poverty, smooth consumption and ease the capital constraints of the poor (Nwaogu and Ryan, 2015; Catrinescu et al., 2009); (3) The lower middle-income countries have increasingly received the inflows of FDI and secondary incomes (or unilateral transfers) for the last two decades (Figure 3.2); and (4) Cambodia in this group of countries has received net unilateral transfers about 8% of GDP per year, which is about twice as large as its own government expenditure, and net FDI around 12% of GDP in the last decade.

The model demonstrates that the shocks of transitory productivity and interest rate are still primary sources of macroeconomic fluctuation, as previously shown by Chang and Fernández (2013). But, for the current account-to-output ratio, FDI and unilateral transfer play more important roles in explaining its variation. Together, these two sources account around 50% for variation of Cambodian current account. This magnitude might justify the fact that Cambodia's economy and external imbalance have been supported by external sources since Cambodia had been devastated by domestic and regional wars in the 1970s.

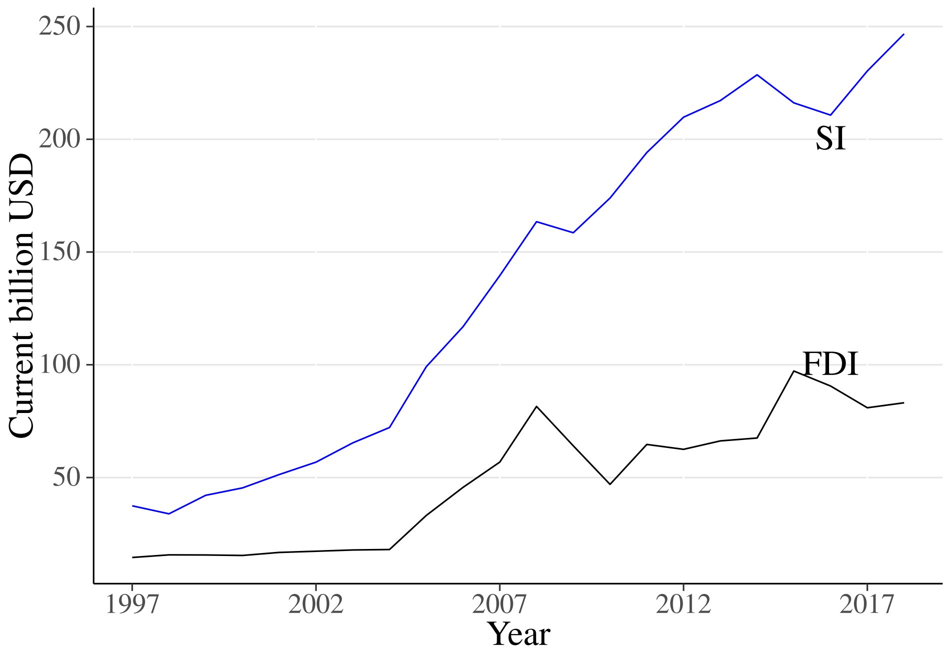


Figure 3.2: The trends of net foreign direct investment (FDI) and net secondary incomes (SI) in Low-and Middle-income Countries for a period 1997–2018.

Notes: The World Bank classifies lower middle-income economies as those with a gross national income (GNI) per capita between 1036 USD and 4045 USD. Cambodia is in this group. The source of data is the World Development Indicator.

In the quantitative analysis of the model, I feed the historical data on both key exogenous and endogenous variables[2] into the calibrated model, run the model, and observe the extent to which current account choices made by agents in the model mimic the actual time paths of the data. The model generates national saving behaviour that matches well the evolution of Cambodian current account: the measurement error is just about 4% and the correlation between data and model is around 0.93. This result is much improved from the model estimated without the inclusion of FDI and unilateral transfers—the correlation between current account data and the later model is about 0.80 and the measurement error is about 58%.

This well-fitted model is then used to predict the future trend of the current account, as

[2]Output, consumption, investment, trade balance, current account balance, net unilateral transfers, and net foreign direct investment.

negative shocks of productivity, remittance and FDI hit the economy with COVID-19 pandemic in 2020. The model predicts that if no shock happens in 2020, current account-to-output ratio will increase by 1-percentage point from -12% in 2019 to about -11% in 2020. However, because of COVID-19 pandemic, World Bank (2020) expects Cambodia's economy to contract around 1% in 2020. This implies that transitory productivity drops around 1% too by holding other things the same (Equation 3.1). With this drop, the model expects current account-to-output ratio to improve about 3-percentage points, jumping to -8% in 2020. In addition, the World Bank forecasts that net FDI-to-output ratio declines about 2-percentage points. This fall causes the current account-to-output ratio to improve about 2.5-percentage points in 2020, as predicted by the model.

Sayeh and Chami (2020) estimate that the remittance flows to poor and developing countries are expected to drop 20% or more from their 2019 level. For Cambodia, the World Bank (2020) expects households to face significant income losses, as about 80,000 migrant workers have returned home, and it estimates the government's revenue and grants (% of GDP) to drop by 8-percentage points. With the assumption that net unilateral transfer-to-output falls about 8-percentage points, the model predicts that the current current-to-output ratio will drop about 8-percentage points. Putting these three shocks together, the current account-to-output ratio will be around -14% in 2020, which is close to the prediction of -14.1% by the World Bank (2020), but a bit far from the forecast of -22.2% by the International Monetary Fund (2020).

The remainder of the paper is organised as follows. The next section discusses the evolution of Cambodian current account balance and its components. Section 3 presents relevant literature which discusses two perspectives of current account balance. Section 4 reports the main assessment of the model in which I examine current account outcomes implied by consumer choices when they are presented with historical data. Section 5 predict the trend of current account-to-output ratio, as negative shocks of productivity, remittance and FDI hit the economy in 2020. Section 6 concludes.

## 3.2 Cambodian Current Account

Figure 3.3 presents the trends of Cambodian current account balance (CA) and its components: trade balance (TB), primary income balance (PI), and secondary income balance (SI). The current account balance has fluctuated around -5% of GDP from 1993 to 2007; afterwards, it has been declining considerably, reaching around -12% of GDP in 2018. This current account balance would be much worse without positive inflows of net secondary income, which is around 8% of GDP per year.

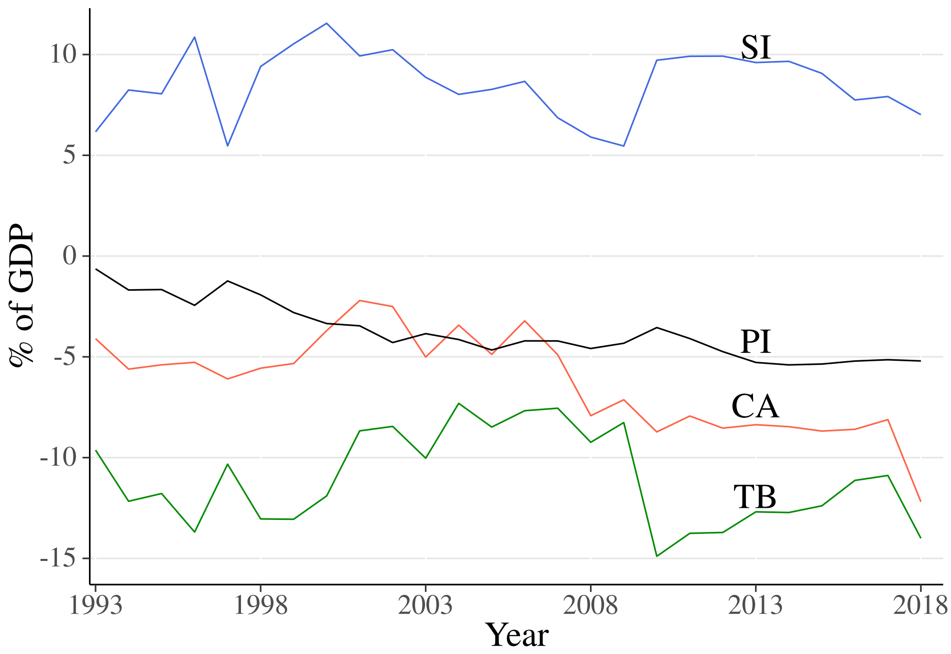


Figure 3.3: Trends of Cambodian current account balance and its components for a period 1993–2018.

Notes: Primary income balance (PI) is the income that Cambodian residents earn from, less that they pay to, the rest of the world from working (e.g. wages) and from financial investments (e.g. dividends). Secondary incomes balance (SI) refers to transactions between Cambodian residents and the rest of the world where one party provides something to be consumed by another party without receiving anything in return (e.g. emergency food aid). The source of data is the World Development Indicator.

Corresponding to this growing deficits, Cambodia has increasingly received capital inflows, as foreigners buy Cambodian assets, directly invest in the country, and also make loans in exchange for Cambodian purchases of imported goods and services. As shown in Figure 3.4, the trend of net FDI as percentage of GDP has been increasing considerably from just 2% in 1993 to about 14% in 2018.

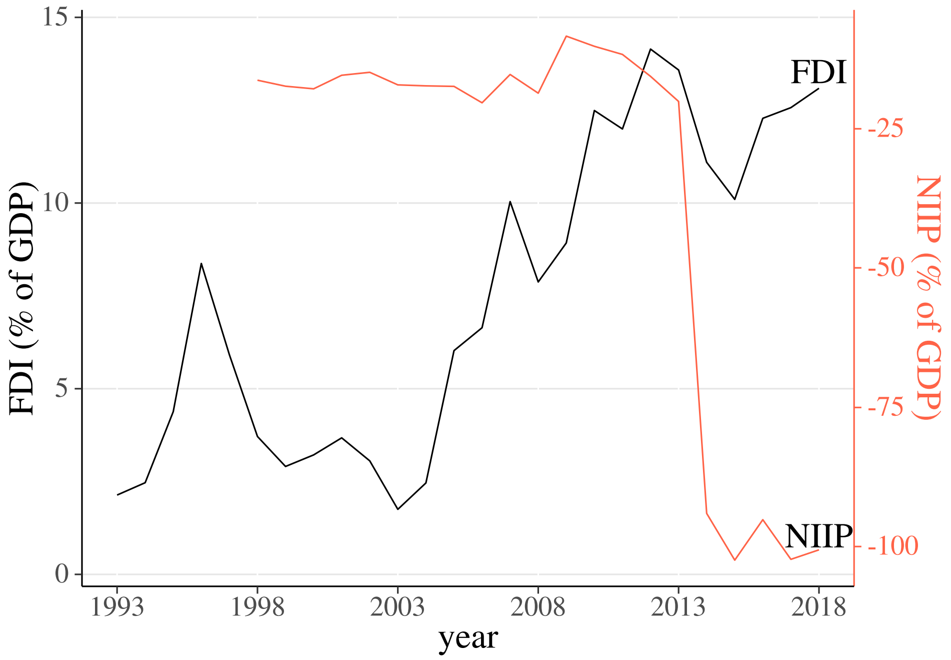


Figure 3.4: Trends of Cambodia net foreign direct investment (FDI) and net international investment position (NIIP) for a period 1993–2018.

Notes: Net international investment position (NIIP) is the difference value between external assets and external liabilities. The external assets are the foreign assets owned by Cambodia's government, companies, and citizens. The external liabilities are the foreigners-owned domestic assets. The change in NIIP is the current account balance. The source of data is the World Development Indicator.

The accumulation of current account deficits and capital inflows implies that Cambodia's net international investment position (NIIP) has been worsening, particularly in the last decade (Figure 3.4). As of 2018, Cambodia's NIIP is around -100% of GDP. This large stock of financial obligations implies that the flow of primary income—income payments and receipts such as interests and dividends—that must be paid out of the country's current productions is getting worse, as shown in Figure 3.3. The Cambodian current account is weakly counter cyclical. Its correlation with HP filtered GDP is -0.09 (the smoothing parameter value is 100 because all data are annual.)

## 3.3 Literature Review: Two Views on Current Account

Accounting identities provide two ways to look at a current account balance: one in terms of trade flows and related payments, and the other in terms of saving, investment, and international financial flows. Although they are two sides of the same coin, each gives a useful, different insight into a current account issue (Bernanke, 2005).

The elasticity approach[3] views the current account balance as the net trade of a country. Thus, relative prices of traded goods along with their determinants play a key role in explaining the current account's evolution. This approach is helpful in assessing the short-run implications of exchange rates on the current account. However, its ability to explain long-run current account balance is limited (Yang, 2011). This limitation might have been one of reasons researchers have turned to the intertemporal approach.

From the intertemporal perspective, people's saving and investment decisions are forces behind the current account's evolution—people will borrow and lend to smooth consumption over time when facing their uneven income streams (Schmitt-Grohé et al., 2008). A number of papers, such as Schmidt-Hebbel et al. (1992), Edwards (1995), and Masson et al. (1998), have explored the determinants of saving for both developing and industrial nations. Many of these papers contribute people's saving to real interest rate, the terms of trade, economic growth, economic development, and demographics (dependent ratio). But, much smaller number of studies have investigated the determinants of investment in developing countries. For example, Servén (1998) empirically investigate the link be-

[3]This approach was developed by Charles Bickerdike, Joan Robinson, and Lloyd Metzler, thus commonly known as Bickerdike-Robinson-Metzler Condition (Dornbusch, 1975). This condition is satisfied when a country's currency depreciation helps improve its trade balance (Bleaney and Tian, 2014).

tween private investment and macroeconomic uncertainty. Using 5 key macroeconomic variables—inflation, growth, the terms of trade, the real exchange rate, and the price of capital goods—to measure volatility, he finds that there is a significantly negative association between private investment and uncertainty.

In addition to these indirect studies of the current account, a large number of researches have directly examined the current account balance. For example, Abbasoğlu et al. (2019) uses the model developed by Engel and Rogers (2006) to study the trend of Turkish current account. They argue that as households expect their incomes to grow relatively faster to the rest of the world, households tend to borrow more to finance their current consumption. As a result, their current account balance gets worse.

This intertemporal approach has also been used in the real business cycle (RBC) model to assess the effects of shocks in productivity or demand on the current account balance (Calderon et al., 2002). Exploiting the information in net exports and consumption to identify the persistence of productivity, Aguiar and Gopinath (2007) find that shocks to trend growth—rather than temporary shocks around a stable trend —are the key factors of the fluctuations of macroeconomic variables (income, consumption, investment and trade balance) in emerging economies. However, this hypothesis—the cycle is the trend—gets a little support from the work of Garcia-Cicco et al. (2010). Using the data over the period 1990–2005 to estimate the parameters of a small open economy RBC model for Argentina and Mexico, Garcia-Cicco et al. (2010) conclude that both temporary and permanent productivity shocks do not explain well the fluctuations of trade balance (among other variables) in these two countries. But, when Garcia-Cicco et al. (2010) augment Aguiar and Gopinath (2007) model by including preference shocks, country-premium shocks, and a debt elasticity of the country premium, their augmented model does a good job at explaining the observed business cycles in Argentina and Mexico.

To compare the relative merits of the works between Aguiar and Gopinath (2007) and Garcia-Cicco et al. (2010), Chang and Fernández (2013) set up and estimate a RBC model that uses stochastic trends with financial frictions and interest rate shocks by employing the same Mexico data as in Aguiar and Gopinath (2007). Their emcommpassing model assigns a major role to financial frictions, but a minor role to trend shocks in amplifying traditional (transitory) productivity shocks to aggregate fluctuations.

Within this standard framework, the current account balance behaves as a buffer against the transitory shocks in productivity or demand, thus acting as smoothing instrument. Therefore, the current account is predicted to fluctuate around its fixed mean in the long run. However, data in both some developed countries and developing ones do not actually support this prediction. To help explain this puzzle, Choi et al. (2008) and Choi and Mark (2009) include an endogenous discount factor in the model to explain the trends of the current account in Japan, UK and US. For instance, by letting societal consumption to affect the subjective discount factor, Choi et al. (2008) are able to account for the evolution of the U.S current account from 1975 to 2005.

The RBC model developed in the next section, however, still uses an exogenous discount factor and is able to mimic the actual paths of the current account. This indicates that whether the discount factor is endogenous or exogenous is not really a key factor to explain macroeconomic fluctuation. It demonstrates that when a model is appropriately specified, calibrated, and estimated, it can mimic actual data well.

## 3.4 The Small Open Economy Real-Business-Cycle Model

This section presents a theoretical framework used to study the evolution of Cambodian current balance. It is a standard, single-good, single-asset small open economy presented in Chang and Fernández (2013), which incorporates both permanent productivity shocks as in Aguiar and Gopinath (2007) and financial friction shocks as in Garcia-Cicco et al. (2010). Two key features that differentiate this paper from Chang and Fernández (2013) are the inclusion of net unilateral transfers and impact of FDI on technological growth. For comparison, I also present the results of the standard model in Appendix 3.B.

### 3.4.1 Economy

Time is discrete and indexed by $t = 0, 1, 2, ...$ For each period, the single-final good is produced with the Cobb-Douglas technology as follows.

$$Y_t = a_t K_t^{1-\alpha} (\Gamma_t h_t)^{\alpha}, \tag{3.1}$$

where $\alpha \in (0, 1)$ governs labour share of output, $Y_t$ denotes output in period $t$, $K_t$ denotes capital in period $t$, $h_t$ denotes labour input in period $t$, and $a_t$ and $\Gamma_t$ represent a transitory productivity shock and a permanent productivity shock, respectively. The sources of these shocks are not limited to exogenous changes in technology but other disturbances as well, such as variation in terms-of-trade.

Note that lower case letters denote variables that do not contain a trend in equilibrium, but upper case letters represents variables with a trend in equilibrium. Specifically, a detrended variable $x_t = \frac{X_t}{\Gamma_{t-1}}$. In addition, $\rho_x \in (-1, 1)$ and $\mu_x$ denote a persistence and long-run mean of variable $x$, respectively. These two notations are used in following reduced form stochastic equations.[4]

The transitory productivity shock $a_t$ is assumed to follow a first-order autoregressive process (AR(1)) in a log form:

$$log(a_t) = \rho_a log(a_{t-1}) + \varepsilon_t^a,$$

where $\varepsilon_t^a$ represents independently and identically distributed draws from a normal distri-

[4]Refers to equations in which a macroeconomic motivation is limited compared to structural equations, in which there is an underlying economic explanation.

bution with zero mean and standard deviation $\sigma_a$ ($\varepsilon_t^a \overset{i.i.d}{\sim} N(0,\ \sigma_a^2)$).

The variable $\Gamma_t$ denotes the cumulative product of productivity growth shock, $g_t$. That is, $\Gamma_t = g_t\Gamma_{t-1} = \prod_{s=0}^{t} g_s$. This productivity growth is assumed to follow an autoregressive distributed one lag (ADL(1,1)) as follows:

$$log(g_t/\mu_g) = \rho_g log(g_{t-1}/\mu_g) + \gamma(fdi_{t-1} - \mu_{fdi}) + \varepsilon_t^g, \qquad \varepsilon_t^g \overset{i.i.d}{\sim} N(0,\ \sigma_g^2),$$

where $fdi_t$ denotes net foreign direct investment-output ratio at time $t$, the parameter $\gamma$ is an effect of the difference of $fdi_t$ from its mean ($\mu_{fdi}$) on the productivity growth, and $fdi_t$ itself is assumed to follow the AR(1) process:

$$fdi_t = (1-\rho_{fdi})\mu_{fdi} + \rho_{fdi} fdi_{t-1} + \varepsilon_t^{fdi}, \qquad \varepsilon_t^{fdi}, \overset{i.i.d}{\sim} N(0,\ \sigma_{fdi}^2).$$

The capital stock accumulates according to the following law of motion:

$$K_{t+1} = (1-\delta)K_t + I_t - \Phi(K_{t+1}, K_t), \tag{3.2}$$

where $\delta \in [0,1]$ is the constant rate of depreciation, $I_t$ denotes gross investment in period $t$, and $\Phi$ is the adjustment cost of installing capital and has the quadratic form,

$$\Phi(K_{t+1}, K_t) = \frac{\phi}{2}\left(\frac{K_{t+1}}{K_t} - \mu_g\right)^2 K_t,$$

where $\phi$ is the capital adjustment cost parameter and non-negative.

The economy is populated by a large number of infinitely lived, identical households who face the period-by-period budget constraint,

$$W_t h_t + u_t K_t + NT_t + q_t D_{t+1} = C_t + I_t + D_t, \tag{3.3}$$

where $W_t$ is the wage rate, $u_t$ is the rental rate of capital, $NT_t$ denotes the net unilateral transfers with the rest of the world, $D_t$ denotes the level of debt due in period $t$, $q_t$ is the time $t$ price of debt due in period $t+1$, $C_t$ is consumption.

The ratio of net unilateral transfer to output, denoted $nt_t$, is assumed to follow the AR(1) process:

$$nt_t = (1-\rho_{nt})\mu_{nt} + \rho_{nt} nt_{t-1} + \varepsilon_t^{nt}, \qquad \varepsilon_t^{nt} \overset{i.i.d}{\sim} N(0, \sigma_{nt}^2).$$

The price of debt $(q_t)$ is sensitive to the level of outstanding debt and takes the form:

$$\frac{1}{q_t} = R_t + \psi \left[ \exp\left( \frac{D_{t+1}}{\Gamma_t} - \bar{d} \right) - 1 \right], \tag{3.4}$$

where $\psi$ is the elasticity of the interest rate to variations in indebtedness, $\bar{d}$ denotes the steady-state level of normalized debt, and $R_t$, a country specific gross interest rate, is assumed to equal the product of the world gross interest rate ($R_t^*$) and a country specific spread ($S_t$):

$$R_t = S_t R_t^*. \tag{3.5}$$

The world interest rate is random and fluctuates around its long-run mean $\bar{R}^*$ according to

$$log(R_t^*/\bar{R}^*) = \rho_R log(R_{t-1}^*/\bar{R}^*) + \varepsilon_t^R.$$

The deviations of the country spread from its long-run level, $S$, depend on expected future productivity as follows:

$$log(S_t/S) = -\eta E_t log(a_{t+1} g_{t+1}^{\alpha}/\mu_g^{\alpha}),$$

where $\eta$ is the elasticity of the spread to the future productivity, and $E_t$ is the expectation operator.

In addition, competitive firms are assumed to finance a portion of their wage bill in advance. In particular,

$$W_t\,(1+\theta(R_{t-1}-1)) = \frac{\alpha}{h_t}Y_t. \tag{3.6}$$

This says that the firms hire labour up to the point where the marginal product of labour is equal to the wage rate including financial costs. The firms borrow from households and pay a fraction $\theta$ of the wage bill in advance.

**Equilibrium**

Being subject to (3.1)–(3.3) and the no-Ponzi game constraint ($lim_{j\to\infty}E_t(D_{t+j}\prod_{s=0}^{j}q_s) \leq 0$), and taking as given the process $a_t, \Gamma_t$, $R_t$, and the initial condition $K_0$ and $D_{-1}$, the household seeks to maximise the following lifetime utility function

$$E_0\sum_{t=0}^{\infty}\beta^t u(C_t, h_t, \Gamma_{t-1}),$$
$$u(C_t, h_t, \Gamma_{t-1}) = \frac{(C_t - \tau\Gamma_{t-1}h_t^{\omega})^{1-\sigma}}{1-\sigma},$$

where $\sigma$ governs an intertemporal elasticity of substitution, $\omega$ governs the Frisch elasticity, and $\tau$ is a labour parameter. The Euler's equations in the stationary form are given by

$$u_c(c_t, h_t) = \lambda_t,$$
$$u_h(c_t, h_t) = -\lambda_t w_t,$$
$$\lambda_t g_t\left[1+\phi\left(\frac{g_t k_{t+1}}{k_t}-\mu_g\right)\right] = \beta E_t\lambda_{t+1}\left[u_{t+1}+1-\delta+\frac{\phi}{2}\left(\left(\frac{g_{t+1}k_{t+2}}{k_{t+1}}\right)^2-\mu_g^2\right)\right],$$
$$q_t g_t \lambda_t = \beta E_t \lambda_{t+1},$$

where $\lambda_t$ is a shadow price related to the budget constraint (3.3) in period $t$. By eliminating $\lambda_t$, and replacing the values of the marginal utility of consumption and labour, these optimal conditions can be rewritten as

$$w_t = \tau\omega h_t^{\omega-1}, \tag{3.7}$$

$$\left[1+\phi\left(\frac{g_t k_{t+1}}{k_t}-\mu_g\right)\right] = q_t\left[u_{t+1}+1-\delta+\frac{\phi}{2}\left(\left(\frac{g_{t+1}k_{t+2}}{k_{t+1}}\right)^2-\mu_g^2\right)\right], \tag{3.8}$$

$$q_t\left[c_t-\tau h_t^{\omega}\right]^{-\sigma} = \beta g_t^{-\sigma}E_t\left[c_{t+1}-\tau h_{t+1}^{\omega}\right]^{-\sigma}. \tag{3.9}$$

Given the equilibrium processes of consumption, capital, hours, and debt, output is obtained from (3.1), investment from (3.2), price of debt from (3.4), and interest rate from (3.5). Then, the equilibrium process of the trade balance is obtained from the definition and (3.3)

$$\begin{aligned} tb_t &= y_t - c_t - i_t \\ &= d_t - q_t g_t d_{t+1} - nt_t, \end{aligned}$$

where $tb_t$ denotes the trade balance in period $t$. Finally, the equilibrium process of the current account, denoted $ca$, is given by the sum of the trade balance, net investment income, and net unilateral transfer or it is equal to the net foreign assets. That is,

$$\begin{aligned} ca_t &= tb_t - (1-q_{t-1})d_t + nt_t \\ &= -q_t g_t d_{t+1} + q_{t-1}d_t. \end{aligned}$$

### 3.4.2 Solution, Calibration, and Estimation

Because this system of nonlinear stochastic difference equations does not normally have closed form solutions, this work, like other RBC literature, uses log-linearization to approximate the equilibrium conditions around the stationary steady state.

| Parameter | Description | Value |
|---|---|---|
| $\sigma$ | Intertemporal elasticity of substitution $(1/\sigma)$ | 2 |
| $\beta$ | Subjetive discount factor | 0.96 |
| $\omega$ | Labor supply elasticity $(1/(\omega-1)$ | 1.6 |
| $\tau$ | Labor parameter so that labour input at steady state is 1/3 | 1.72 |
| $\delta$ | Depreciate rate of capital | 0.10 |
| $\psi$ | Debt elastic interest rate parameter | 0.001 |
| $\bar{R}^{*}$ | Gross world interest rate | 1.01 |
| $S$ | Long-run gross country interest rate premium | 1.0543 |
| $\bar{d}$ | Debt-to-GDP ratio | 0.16 |
| $\alpha$ | Parameter governing income labour share | 0.4018 |

Table 3.1: Calibrated parameters.

Notes: One period in the model is 1 year.

The main parameter values are presented in Table 3.1. The first six parameters are standard in the literature: The coefficient of relative risk aversion, $\sigma$, is 2; the subjective discount factor, $\beta$, is 0.96; the parameter, $\omega$, is set at 1.6 so that the labour supply elasticity is 1.67; $\tau$ is 1.72 to make working time one third in the long run; the depreciation rate, $\delta$, is 0.10 per year; the debt elastic interest rate, $\psi$, is 0.001; and the gross world interest rate, $\bar{R}^{*}$, is 1.01 per year in the long run. The three remaining parameter values are based on Cambodian data. The long-run gross country interest rate premium is 1.0543 according to Damodaran (2015). The long-run debt-to-GDP, $\bar{d}$ is 0.16 based on the initial value of data availability of net international investment position as percentage of GDP from 1998 to 2018. Finally, the parameter $\alpha$ is 0.4018, based on Cambodian labour share data from 2004 to 2017. This number is not exactly equal to labour share. As Equation (3.6) shows, it is calibrated as the labour share[5] times $[1+\theta(R-1)]$. This implies that $\alpha$ has a distribution determined by the posterior distribution of $\theta$.

The remaining parameters are estimated with the random walk MetropolisHastings algo-

[5]As an average of 38.9% from 2004 to 2017 estimated by the Internatioal Labour Organization (2019)

rithm using Dynare. These estimated parameters include the parameters of the exogenous shocks and three other parameters: the capital adjustment cost, $\phi$, the elasticity of the spread with respect to the expected productivity, $\eta$, and the working capital requirement, $\theta$. I estimate the model using log differences of $Y$ (output), $C$ (consumption) and $I$ (investment); and levels of $TB/Y$ (ratio of trade balance to output), $CA/Y$ (ratio of current account balance to output), $NT/Y$ (ratio of net unilateral transfers to output) and $FDI/Y$ (net foreign direct investment to output) for a period 1993–2018. The data[6], expressed in real local currency per capita, are retrieved from the World Bank Development Indicator. Hence, these observable variables are defined as in the World Bank.

Table 3.2 presents prior and posterior distributions of the estimated parameters. For three parameters—$\rho_{nt}$, $\rho_{fdi}$ and $\gamma$—I use Cambodian data to obtain their prior distributions. For the rest of estimated parameters, their prior values are the same as those in Chang and Fernández (2013). The bold parameters are the parameters whose posterior means are significantly different from their prior values at 10% level.

[6] Appendix 3.C presents the variables's business cycle moments and graphs.

| | | Prior distribution | | | Posterior distribution | | |
|---|---|---|---|---|---|---|---|
| Parameter | Description | Density | Mean | STD | Mode | Mean | 90% Conf. Interval |
| $\rho_a$ | AR(1) coef. transitory productivity process | Beta | 0.95 | 0.02 | 0.94 | 0.91 | [0.87, 0.95] |
| $\rho_g$ | AR(1) coef. permanent productivity process | Beta | 0.72 | 0.02 | 0.73 | 0.72 | [0.69, 0.76] |
| $\rho_R$ | AR(1) coef. world interest rate process | Beta | 0.83 | 0.05 | 0.80 | 0.87 | [0.78, 0.93] |
| $\rho_{nt}$ | **AR(1) coef. transfer-output ratio process** | Beta | 0.31 | 0.19 | 0.00 | 0.15 | [0.01, 0.26] |
| $\rho_{fdi}$ | coef. FDI-output ratio process | Beta | 0.89 | 0.09 | 0.93 | 0.92 | [0.86, 0.98] |
| $\phi$ | **Capital adjustment cost parameter** | Gamma | 6.00 | 3.46 | 7.40 | 15.76 | [8.17, 23.31] |
| $\eta$ | Spread elasticity | Gamma | 1.00 | 0.10 | 0.92 | 0.93 | [0.77, 1.08] |
| $\theta$ | Working capital parameter | Beta | 0.50 | 0.22 | 0.50 | 0.50 | [0.14, 0.88] |
| $\gamma$ | Effect of FDI-output ratio on productivity growth | Normal | 0.10 | 0.07 | 0.05 | 0.08 | [0.02, 0.14] |
| $\sigma_a$ | STD(%) of coef. transitory productivity shock | Gamma | 0.74 | 0.56 | 0.25 | 0.45 | [0.08, 0.76] |
| $\sigma_g$ | STD(%) of coef. permanent productivity shock | Gamma | 0.74 | 0.56 | 0.33 | 0.65 | [0.03, 1.24] |
| $\sigma_R$ | **STD(%) of coef. world interest rate shock** | Gamma | 0.72 | 0.31 | 0.31 | 0.37 | [0.15, 0.59] |
| $\sigma_{nt}$ | STD(%) of transfer-output ratio shock | Gamma | 0.72 | 0.31 | 1.38 | 1.35 | [1.01, 1.68] |
| $\sigma_{fdi}$ | **STD(%) of FDI-Y output shock** | Gamma | 0.72 | 0.31 | 1.14 | 1.17 | [0.78, 1.56] |
| $\sigma_{CA}$ | STD(%) of measurement error in CA-Y ratio | Gamma | 2.00 | 1.00 | 2.82 | 2.30 | [1.59, 2.94] |
| $\sigma_{TB}$ | STD(%) of measurement error in TB-Y ratio | Gamma | 2.00 | 1.00 | 3.85 | 3.28 | [1.95, 4.56] |
| $\sigma_Y$ | **STD(%) of measurement error in Y** | Gamma | 2.00 | 1.00 | 10.61 | 11.09 | [9.28, 12.84] |
| $\sigma_C$ | **STD(%) of measurement error in C** | Gamma | 2.00 | 1.00 | 0.60 | 0.66 | [0.31, 1.04] |
| $\sigma_I$ | **STD(%) of measurement error in I** | Gamma | 2.00 | 1.00 | 0.39 | 0.52 | [0.18, 0.86] |
| $\sigma_{NT}$ | **STD(%) of measurement error in NT-Y ratio** | Gamma | 2.00 | 1.00 | 0.48 | 0.63 | [0.27, 0.98] |
| $\sigma_{FDI}$ | STD(%) of measurement error in FDI-Y ratio | Gamma | 2.00 | 1.00 | 1.32 | 1.51 | [0.94, 2.04] |

Table 3.2: Distributions of estimated parameters.

**Variance and Shock Decomposition**

Table 3.3 presents the variance decomposition–how much exogenous shocks contribute to variations in macroeconomic variables. Overall, the shocks of world interest rate and transitory productivity play more important roles than the shock of permanent productivity growth in explaining macroeconomic fluctuations. This finding lends support to the study by Chang and Fernández (2013). This result is still robust when the model is estimated without FDI and unilateral transfers (Table 3.B). In addition, the shock of FDI appears to have the same role as the interest rate shock in explaining the observed business cycle in Cambodia. This highlights the important role of FDI in developing economies. But, for the ratio of current account to output, FDI and unilateral transfers play more important roles in explaining its variation. Together, they account for about 50 percent of variation of Cambodian current account-to-output ratio.

Figure 3.5 shows the shock decomposition of current account-to-output ratio for a period 1994–2018. The black line depicts the deviations of the current account-to-output ratio from its steady state. The coloured bars refer to the contribution of the shocks to those deviations. For more than first half of the period, FDI and unilateral transfers have contributed more to current account-to-output ratio, but in the later period, productivity contributed more to the ratio of current account balance to output. This might explain the fact that for developing countries, capital initially plays an important role in economic growth and development, but as economies become more developed, productivity becomes a more important factor. However, throughout the period, a large part of the deviations of current account-to-output ratio is not explained by the smoothed shocks, but rather by the unknown initial value of the state variables.

| Variable | $\sigma_a$ | $\sigma_g$ | $\sigma_R$ | $\sigma_{nt}$ | $\sigma_{fdi}$ | $\sigma_{CA}$ | $\sigma_{TB}$ |
|---|---|---|---|---|---|---|---|
| y: output | 50.93 | 13.04 | 28.16 | 0.00 | 4.71 | 0.00 | 0.00 |
| c: consumption | 38.70 | 11.38 | 23.76 | 0.01 | 17.42 | 0.00 | 0.00 |
| i: investment | 40.59 | 14.95 | 16.61 | 0.01 | 19.75 | 0.00 | 0.00 |
| tb/y: trade balance-output ratio | 28.69 | 6.60 | 25.34 | 0.02 | 30.74 | 0.00 | 7.98 |
| ca/y: current account balance-output ratio | 23.04 | 5.19 | 20.66 | 26.58 | 23.43 | 4.12 | 0.00 |

Table 3.3: Variance decomposition.

Notes: $\sigma_{CA}$ and $\sigma_{TB}$ are the measurement errors in current account-to-output ratio and trade balance-to-output ratio, respectively.

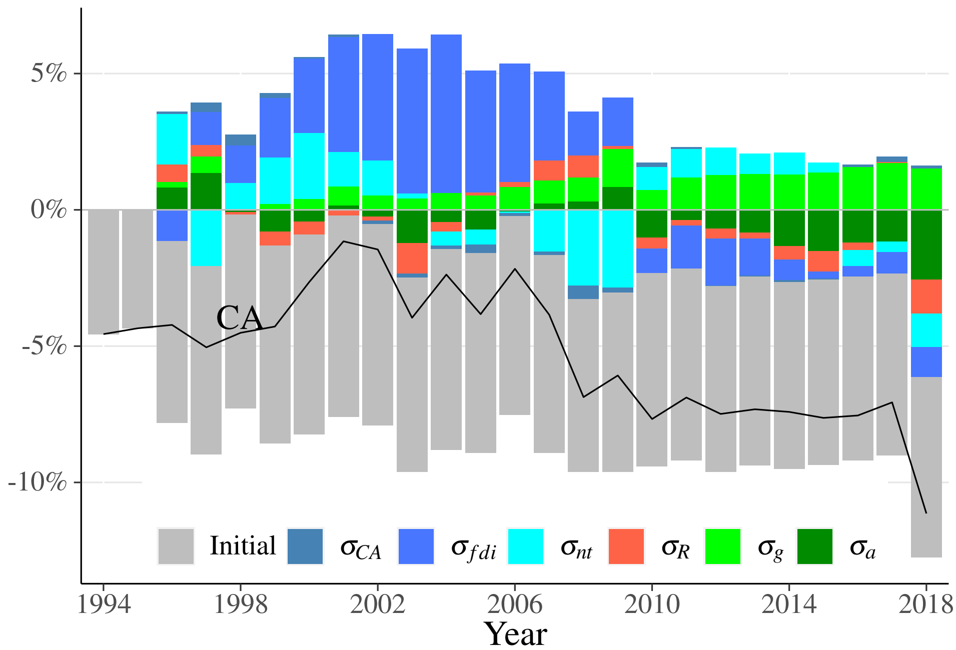


Figure 3.5: Shock decomposition.

Notes: The black line depicts the deviations of the current account-to-output ratio from its steady state. The coloured bars correspond to the contribution of the respective shocks to those deviations. ”Initial value” refers to the part of those deviations not explained by the shocks.

### 3.4.3 Impulse Responses

This section discusses how output, consumption, investment, labour, trade balance and current account-to-output ratio respond to a 1-percent positive shock of each of five exogenous variables: transitory productivity, permanent productivity, world interest rate, unilateral transfers, and FDI.

The impulse responses of output, consumption, labour, and investment are expressed in percentage deviations from the deterministic steady state. The impulse response of trade balance and current account-to-output ratio are expressed in percentage-point deviation from the steady state. Data are non-stationary. To recover a non-stationary variable($\hat{Z}$), we need to add one-lagged cumulative sum of log of productivity growth back to the stationary variable($\hat{z}$). That is,

$$\hat{Z}_t = \hat{z}_t + \hat{\Gamma}_{t-1} = \hat{z}_t + \sum_{s=1}^{t-1} log(g_s),$$

where $\hat{Z}_t = log(Z_t/Z)$ denotes percentage deviations of $Z_t$ from its steady state $Z$.

**Responses to a positive transitory technology shock**

Figure 3.6 presents the impulse response functions of six variables of interest to a transitory technological shock of 1 percent in period 0. In response to this innovation, the model predicts an expansion in output, consumption and investment, but a deterioration in trade balance and current account-to-output ratio. The initial improvement in the technology raises capital productivity which leads to increased investment. Also, this technological improvement raises the real wage which leads to increased labour supply. Through the consumption-leisure choice, consumption increases. Because the technological shock is more persistent ($\rho_a = 0.91$), households expect their income to increase for several periods. As a consequence, consumption-smoothing households have less incentive to save their increased income, but they have more incentive to borrow against future income to finance their current consumption. This means that the initial increase in domestic absorption $(C_0 + I_0)$ is larger than the initial increase in output.

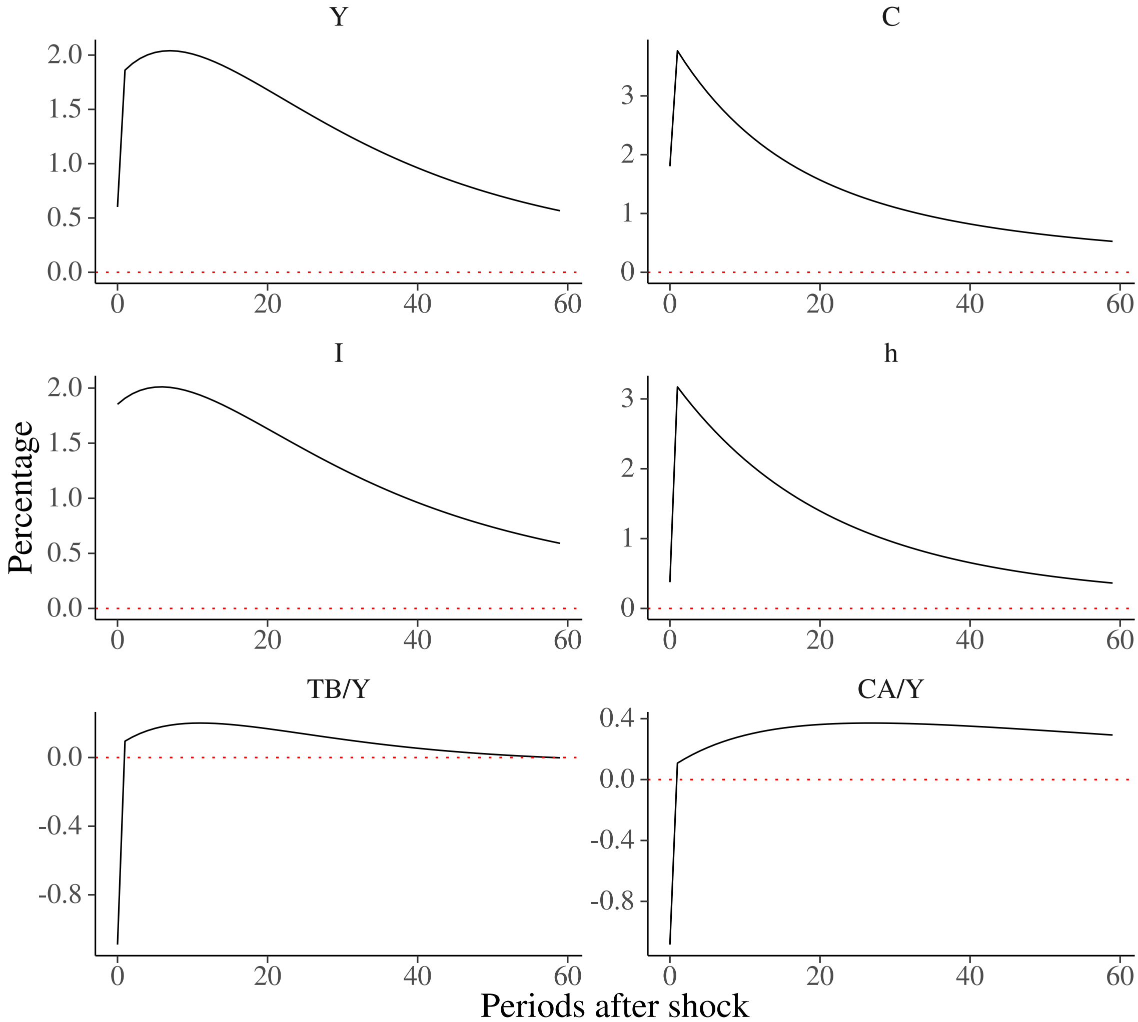


Figure 3.6: Responses to a 1-percent transitory productivity shock.

Notes: The impulse responses of $Y$, $C$, $I$, and $h$ are expressed in percentage deviations from the steady state. The impulse responses of $TB/Y$ and $CA/Y$ are percentage-point deviation from the steady state.

In period 1, as the increase in investment in period 0 comes into production, output suddenly increases about 1.3-percent points, consumption increases about 2-percent points, but investment just slightly increases about 0.1-percent points. Since trade balance and current account-to-output ratios raises from -1.08% to 0.1%, it implies that an increase in output is greater than that of domestic absorption. This indicates that agents start saving more of their increased income because of transient shock of productivity.

**Responses to a positive permanent technology shock**

As displayed in Figure 3.7, the impulse response functions of the interested variables to a permanent technological shock of 1 percent in period 0 are similar to those in Figure 3.6.

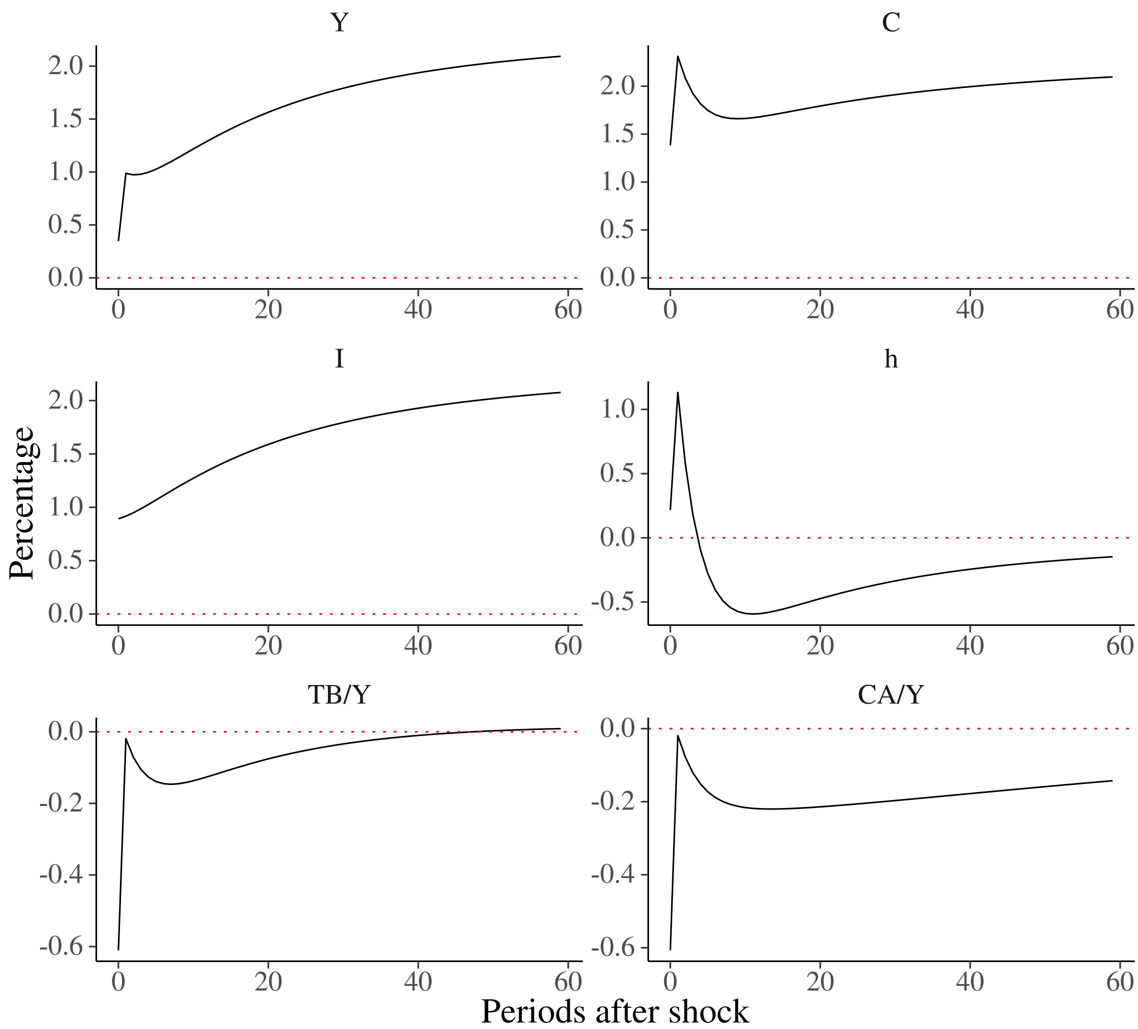


Figure 3.7: Responses to a 1-percent permanent productivity shock.

Notes: The impulse responses of $Y$, $C$, $I$, and $h$ are expressed in percentage deviations from the steady state. The impulse responses of $TB/Y$ and $CA/Y$ are percentage-point deviation from the steady state.

The improved technology raises capital productivity, thus increasing investment. Also, this improvement raises wage which encourages more labour supply. Because of permanent technological shock, households expect their income to increase over time. Therefore, they have more incentive to borrow to finance their current consumption. This causes the initial expansion in domestic absorption to exceed that in output, thus worsening the trade balance and current account-to-output ratios.

In period 1, while output and consumption increases about 0.7% points, investment remains largely the same. Consequently, trade balance and current account-to-output ratios improve, but still they are still below their steady states. Afterwards, they steadily declines for many periods. This deterioration is driven by rising capital and slowly declining consumption as a result of positive permanent productivity shock.

**Responses to a positive world interest rate shock**

Figure 3.8 presents the impulse response functions of the interested variables to a 1-percent shock of world interest rate in period 0. Initially, consumption and investment decrease about 1-percentage point while output is not effected. Higher interest encourages households to save more but discourages firms to invest because of higher costs. As a result, trade balance and current current-to-output ratios initially improves about 1-percentage point.

In period 1, output declines sharply because of the drop of capital in period 0. This decreased output together with more persistent interest rate ($\rho_R = 0.87$) causes consumption to decline much further (almost 2-percentage point drop). But, investment slightly rises because of gradually declining interest rate. Since trade balance and current account-to-output ratios decrease to about -0.25-percentage point below their steady states, it indicates that output is less than domestic absorption. Afterwards, investment gradually improves, so do output and consumption. While trade balance-to-output ratio gradually improves, current account-to-output ratio remains about 0.25 percentage point below its steady state. This is because the interest increase raises debt payments.

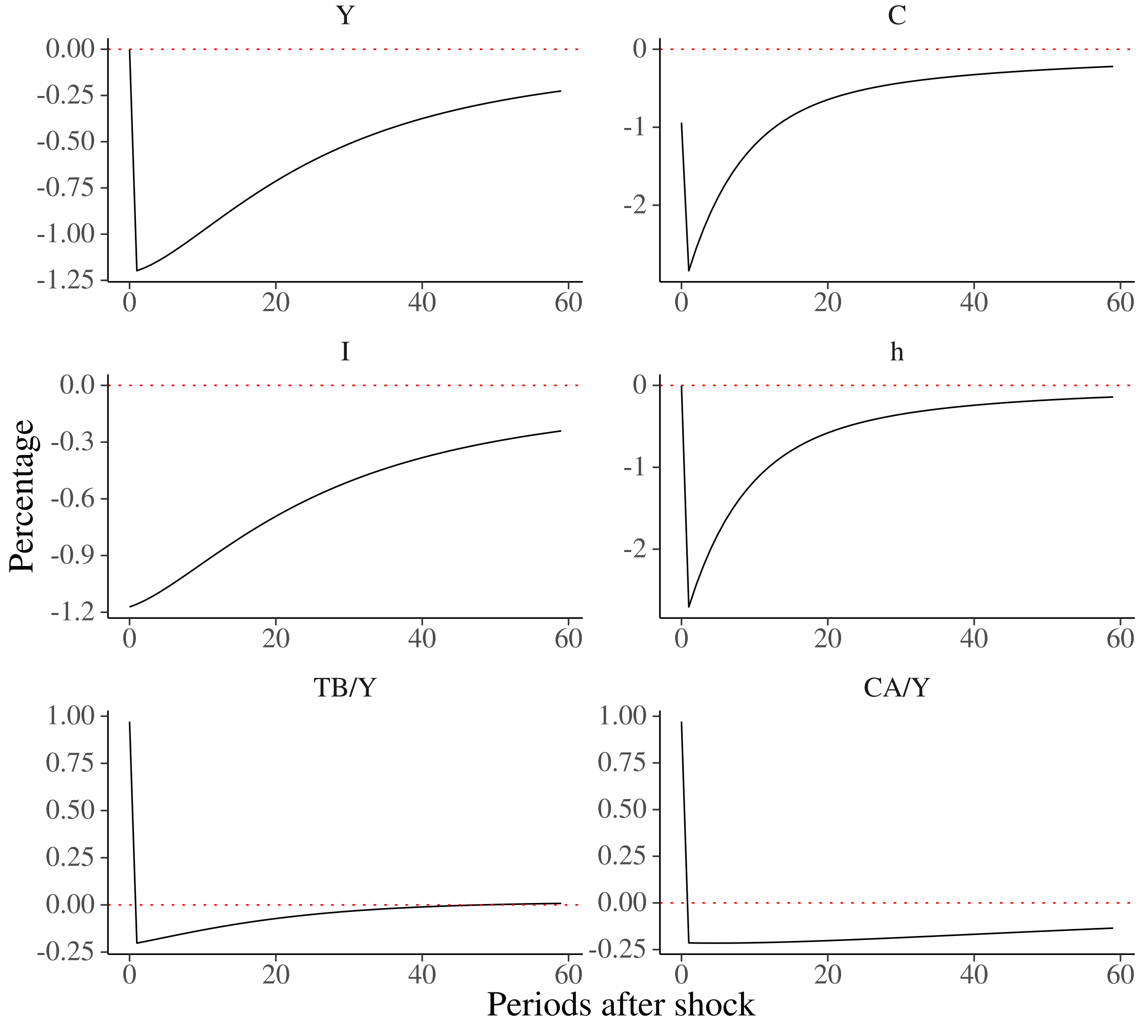


Figure 3.8: Responses to a 1-percent world interest rate shock.

Notes: The impulse responses of $Y$, $C$, $I$, and $h$ are expressed in percentage deviations from the steady state. The impulse responses of $TB/Y$ and $CA/Y$ are percentage-point deviation from the steady state.

**Responses to a positive unilateral transfer shock**

One-percent shock of unilateral transfer on the interested variables is presented in Figure 3.9. Initially, consumption, investment and current account-to-output ratio respond positively, but insignificantly to this innovation while output and trade balance-to-output are not affected. The initial increased source of income causes consumption to rise. However, since this source is just transitory ($\rho_{nt} = 0.15$), consumption-smoothing households save more of this increased income. The increased saving means less debt and lower interest rate, which leads to an increased investment. Less debt, by definition, implies that current account improves.

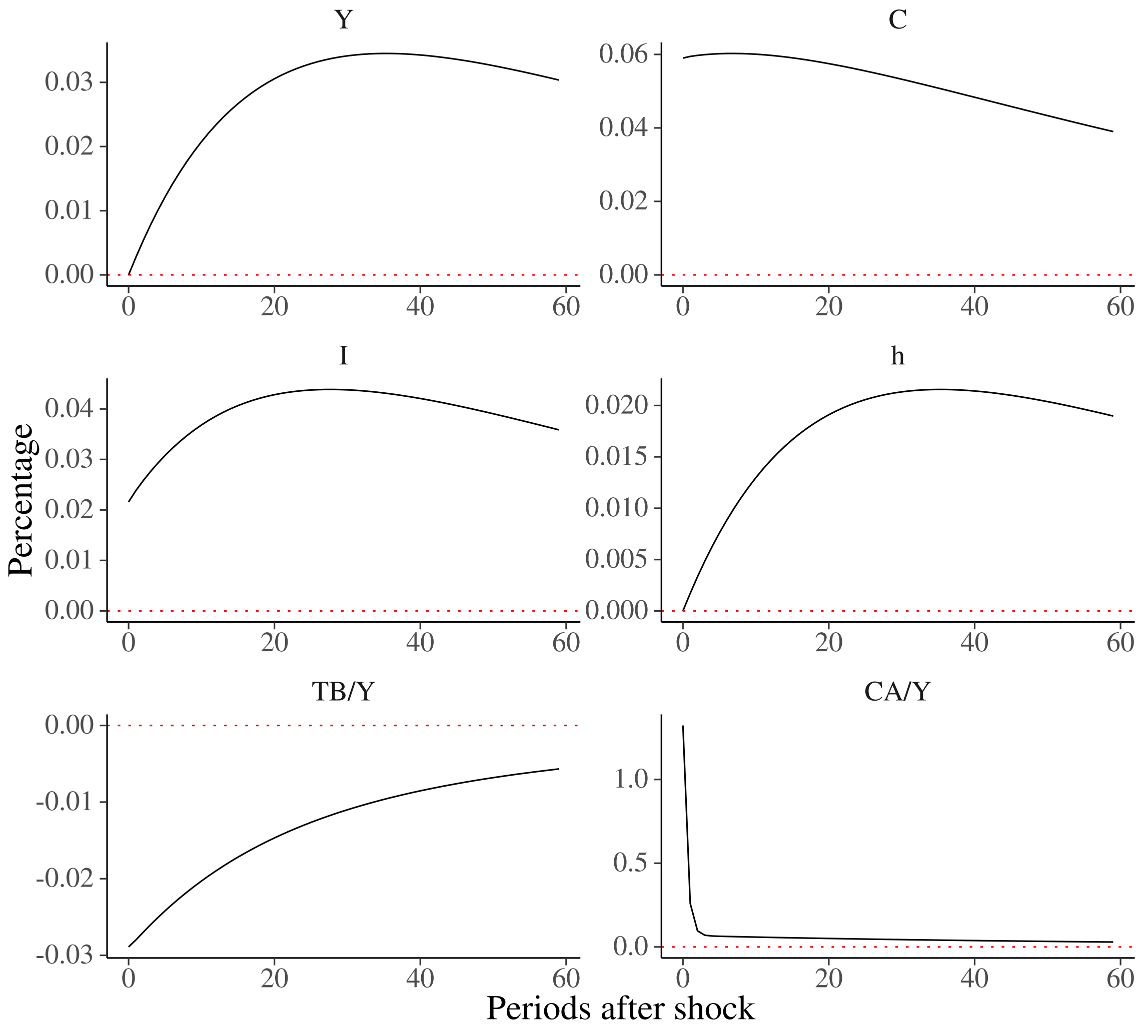


Figure 3.9: Responses to a 1-percent unilateral transfer-to-output shock.

Notes: The impulse responses of $Y$, $C$, $I$, and $h$ are expressed in percentage deviations from the steady state. The impulse responses of $TB/Y$ and $CA/Y$ are percentage-point deviation from the steady state.

In period 1, while output and investment increases slightly, consumption remains about the same as in period 0. Because of low persistent unilateral transfer, current account-to-output ratio declines sharply back to almost its steady level. Afterwards, capital continues to accumulate because of high persistent interest rate ($\rho_R = 0.87$), and so does output. The increased output together with increased saving allows households to maintain a similar level of their consumption over time.

**Responses to a positive net foreign direct investment**

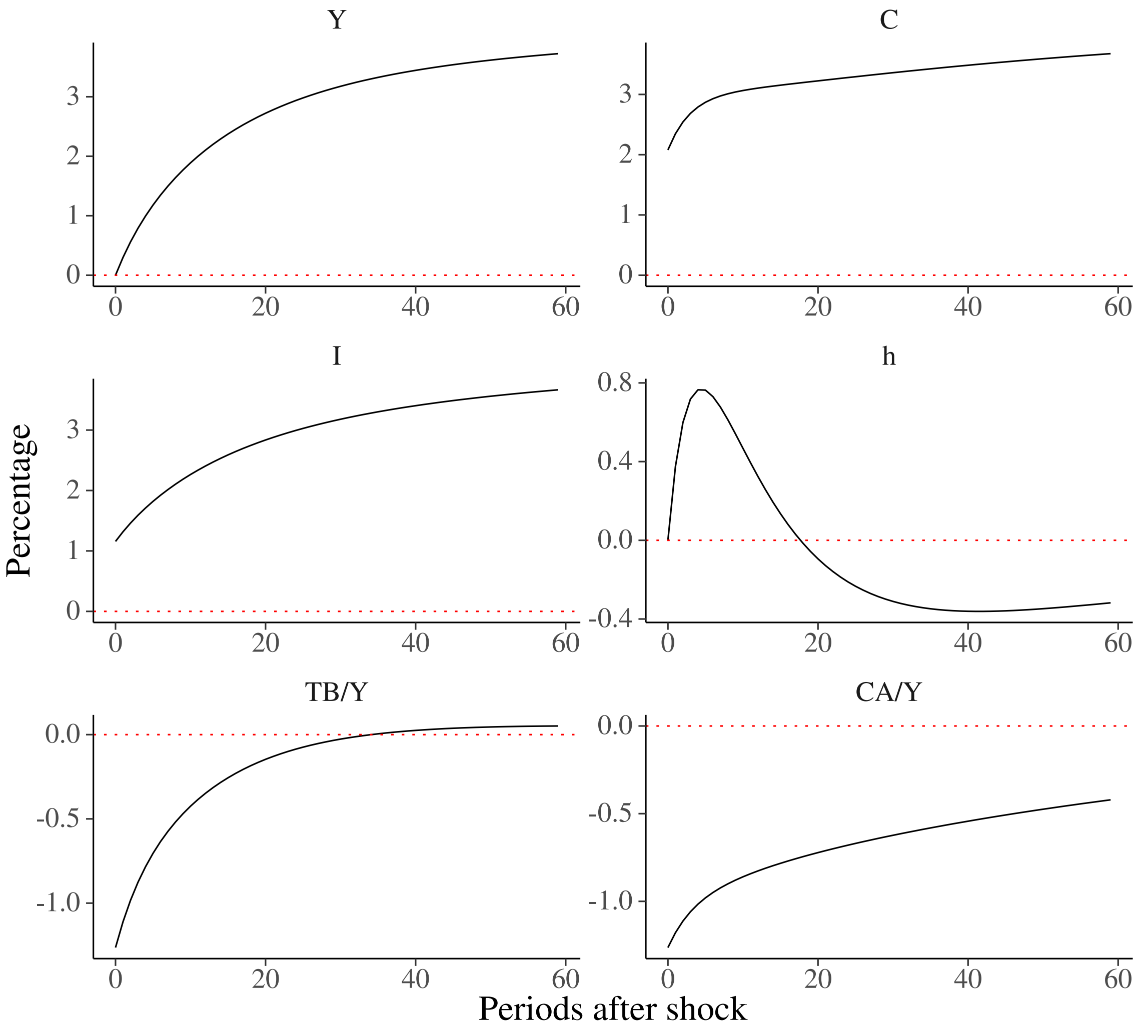


Figure 3.10: Responses to a 1-percent FDI to-output shock.

Notes: The impulse responses of $Y$, $C$, $I$, and $h$ are expressed in percentage deviations from the steady state. The impulse responses of $TB/Y$ and $CA/Y$ are percentage-point deviation from the steady state.

Figure 3.10 displays the impulse response functions of the interested variables to 1-percent shock of FDI in period 0. Initially, consumption and investment increase, but output remains unaffected, thus leading trade balance and current account-to-output ratios to drop. FDI positively affects permanent technological growth. This improved technology raises capital productivity and wage, thus increasing investment and consumption. Afterwards, investment, output and consumption continue to expand. But, trade balance and current account-to-output ratios start improving gradually towards their steady states. This implies that domestic absorption remains larger than output but their difference approaches to zero over time. This is because FDI and productivity trend are quite persistent ($\rho_{fdi} = 0.87$ and $\rho_g = 0.72$): agents increase consumption and investment at slower rates.

## 3.5 An Explanation of Current Account

This section discusses how well the model explains Cambodian current account time series from 1993 to 2018. First, I run the economy by showing agents in the model the historical data of output, consumption, investment, trade balance-to-output ratio, current account balance-to-output ratio, net unilateral transfer-to-output ratio, and net foreign direct investment-to-output ratio. I then compare the trend of current account-to-output ratio produced by the model to that of the observed one.

Figure 3.11 shows the results of this experiment. Because the measurement error in current account-to-output ratio ($\sigma_{CA}$) is just 4.12%, as shown Table 3.3, the model captures the evolution of the current account-to-output ratio well[7]. Initially, the model over-predicts about 5-percentage points. Afterwards, it almost overlaps the observed data throughout the sample period. The correlation of both time series is 0.93. This estimated model is much better than the model estimated without the inclusion of FDI and unilat-

[7]The model also closely mimics the dynamics of trade balance-to-output ratio. The measurement error in trade balance-to-output ratio ($\sigma_{TB}$) is about 8% and the correlation of both time series is 0.92.

eral transfers–the measurement error is about 58% for the latter model and the correlation between current account data and the latter model is about 0.80 (Table 3.B; Figure 3.B.1). This well-fitted model is useful when it is used in the next section to predict the future trend of current account-to-output ratio.

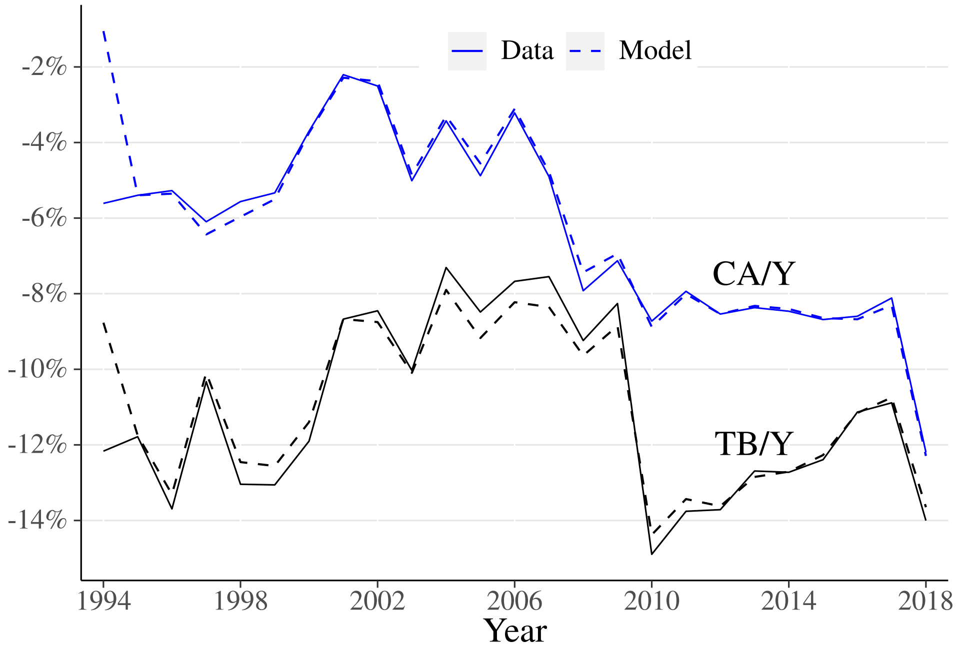


Figure 3.11: Trends of current account and trade balance.

Notes: The solid line represents the empirical ratios of current account balance and trade balance to GDP. The dashed line represents the ratios predicted by the model.

## 3.6 Prediction

This section presents the simulation of negative effects of temporary productivity, unilateral transfers, and foreign direct investment on Cambodian current account starting in 2020.

**No shocks hit the economy**

To set the benchmark, I first present the prediction of a scenario in which no shocks hit Cambodian economy in 2020. As shown in Figure 3.12, trade balance and current account-to-output ratios are expected to improve about 1-percentage point from -14% and -12% in 2019 to -13% and -11% in 2020, respectively.

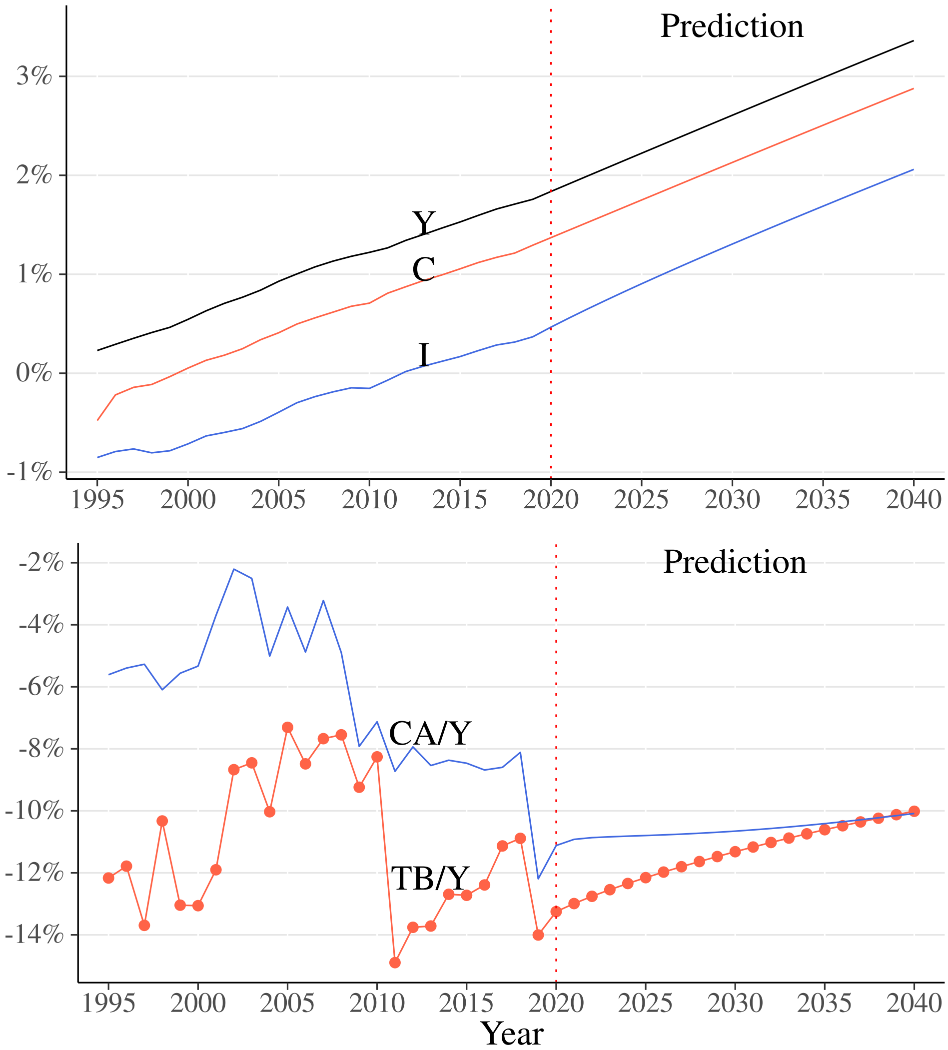


Figure 3.12: No shocks hit the economy in 2020.

### Three negative shocks hit the economy

Three important events adversely impact Cambodia's economy. First, COVID-19 adversely affects FDI, unilateral transfers, and temporary productivity. In particular, COVID-19 temporarily destroys Cambodia's tourism whose receipt is about 20% of GDP in 2018. Second, European Union (EU) has partially suspended Cambodia's trade preferences (Everything But Arms). This gives a temporary shock to Cambodia's key exporting sector–garment industry accounting about 80% of total exports–thus lowering transitory productivity. And third, EU also lists Cambodia among "High-Risk Nations" for money laundering. This negative image along with above events discourages FDI into Cambodia.

World Bank (2020) predicts that Cambodia's economy contracts 1% in 2020. Equation 3.1 implies that transitory productivity falls 1% as well provided that other things remain the same. In addition, the World Bank expects net FDI-to-output ratio to drop about 2-percentage points in 2020. Furthermore, Sayeh and Chami (2020) estimate that the remittance flows to poor and developing countries are expected to decline 20% or more from their 2019 level. For Cambodia, the World Bank (2020) projects that remittance inflows are expected to slow substantially as migrant workers have returned (and those living abroad may have less income because of the global economic slowdown) to Cambodia, and it estimates that the government's revenue and grants (% of GDP) to fall about 8-percentage points. Thus, the following predictions are based on these numbers.

**(a) Transitory productivity drops 1 percentage point**

Figure 3.13 is the effect of a 1-percentage point drop of transitory productivity. The initial decline of productivity lowers capital productivity which leads to lower investment. Also this productivity drop reduces wage which causes labour supply to decline. Through the labour-leisure choice Euler equation, consumption also declines. Because this shock is more persistent, households save more to prepare for future income decline. As a result, the fall of output is smaller than that of domestic absorption, thus leading to improved trade balance and current account-to-output ratios: about 2-percentage points above their levels when no shocks occur in 2020. In 2021, the trade balance and current account sharply decline because output drops, and consumption starts increasing to its previous level because of the nature of temporary shock. Afterwards, while trade balance gradually improves, the current account continue to fall steadily. This worsening current account is due to increasingly accumulated debts over time.

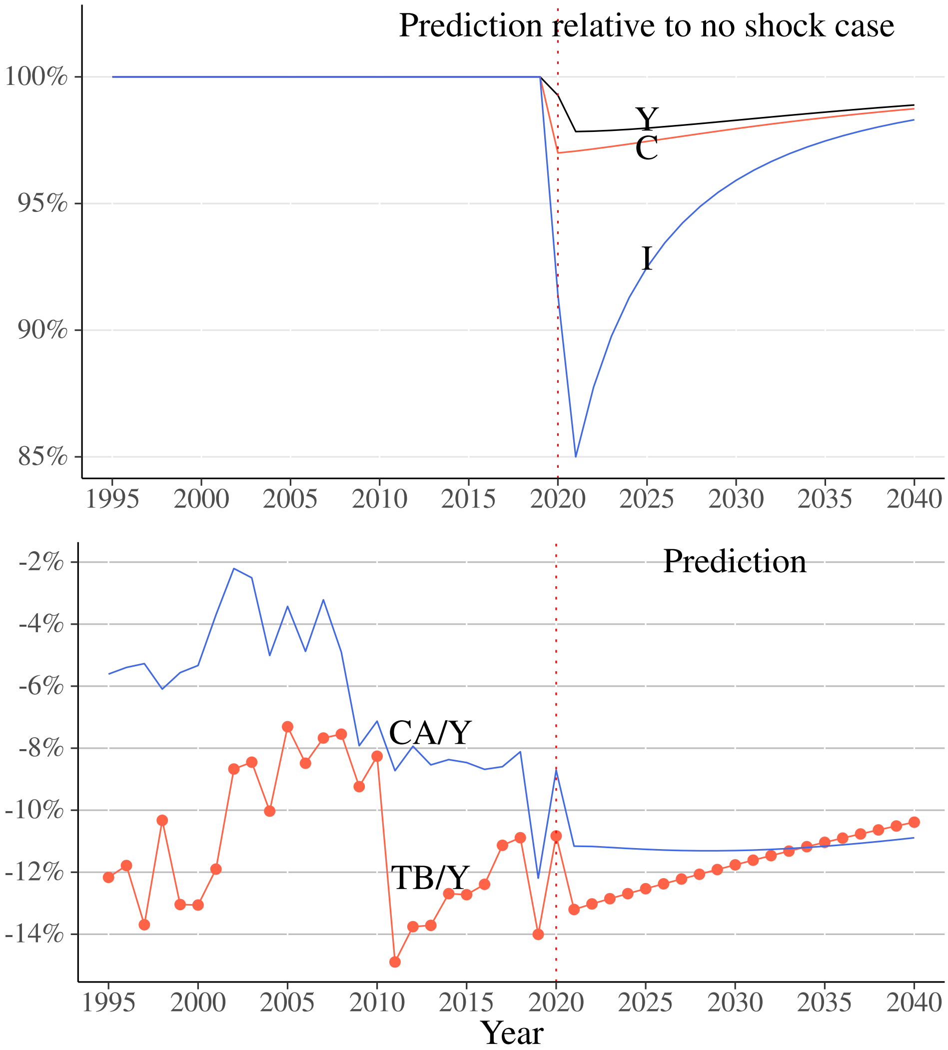


Figure 3.13: 1-percent drop in transitory productivity.

Notes: The top panel shows a relative value of output, consumption, and investment to their value when no shocks hit the economy.

**(b) FDI-to-output ratio drops 2 percentage points**

Figure 3.14 displays the effect of a 2-percentage point drop of FDI. The initial effect is similar to that of the fall of temporary productivity shock. The fall of FDI reduces permanent technology which leads to reduction in capital and labour productivity. Therefore, consumption and investment decline, leading to improvement in trade balance and current current in 2020 about 2-percentage points. Afterwards, the trade balance and current account gradually decrease for several periods. This gradual fall rather than sudden drop as in the previous case in 2021 is a result of households' adjusting their behaviour in respond to permanent shock of productivity trend: The general principle of how consumption-smoothing agents respond to shock is "finance temporary output shocks by running current account deficits or surpluses without much change in spending and adjust to permanent output shocks by changing spending without much change in the current account" (Schmitt-Grohé et al., 2008).

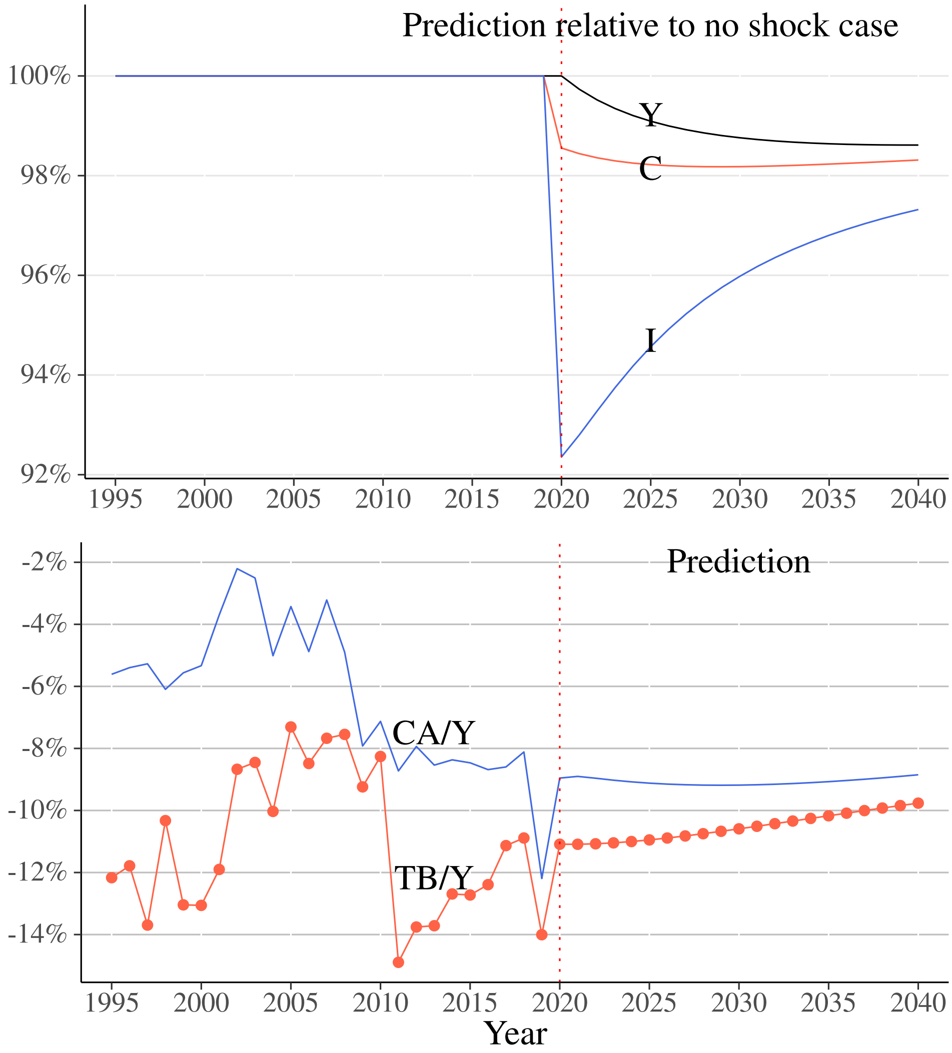


Figure 3.14: 2-percentage point drop in FDI-to-output ratio.

Notes: The top panel shows a relative value of output, consumption, and investment to their value when no shocks hit the economy.

**(c) Net unilateral transfer-to-output ratio drops 8 percentage points**

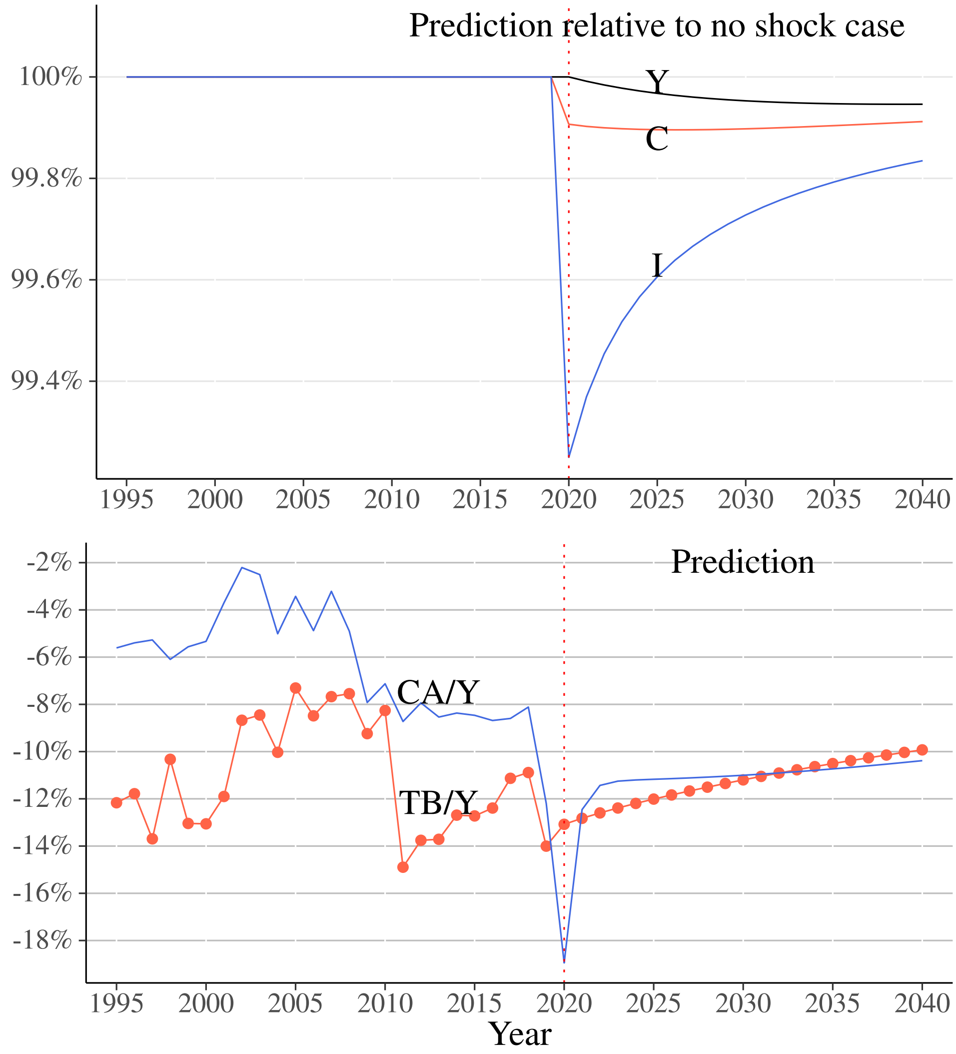


Figure 3.15: 8-percentage point drop in net neutral transfers.

Notes: The top panel shows a relative value of output, consumption, and investment to their value when no shocks hit the economy.

Figure 3.15 is the effect of a 8-percentage point drop of net unilateral transfers. Because this shock is much less persistent, and household's consumption behaviour is driven by permanent income, but not temporary income, the initial drop of this source of income hardly affects consumption, investment, output and trade balance, as shown by variance decomposition in Table 3.3. However, it has, by definition, one-to-one positive relation with current account. Therefore, the 8-percentage point drop of unilateral transfer implies that current current-to-output ratio also declines about 8-percentage points. Afterwards, it quickly improves back to its previous levels because this shock is just short-lived.

Putting all these shocks together, the model predicts that the current account-to-output ratio will be -14% in 2020, which is very close to the prediction of -14.1% by World Bank (2020), but relatively far from the forecast of -22.2% by International Monetary Fund (2020).

## 3.7 Conclusion

To explain the dynamics of Cambodian current account, I develops and estimates a small open economy real-business cycle (SOE-RBC) model. Differing from the standard model, I includes two additional sources of macroeconomic fluctuation: net unilateral transfers and net foreign direct investment (FDI). The model demonstrates that these two sources play more important roles in explaining current-account variation than productivity and interest rate. Together, they account about 50% for the variation of current account-to-output ratio.

In the quantitative analysis of the model, I present consumers in the model with historical observations on the both exogenous and endogenous variables, run the economy, and compare the current account implied by the model with the data. The model generates consumers' saving and investment behaviour that matches well the evolution of Cambodian current account. This well-fitted model is then used to predict the future trend of the current account as negative shocks hit the economy in 2020. With 1-percent drop of transitory productivity, 2-percentage point drop of FDI-to-output ratio, and 8-percentage point drop of unilateral transfer-to-output ratio, the model predicts that the current account-to-output ratio will be -14%, which is pretty much the same as the forecast of -14.1% by World Bank (2020).

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# Appendix 3.A: Linearisation

Here is a brief explanation of how to linearize a function with respect to a mix of bases, the level for some variables and the log for others ( for more details, see Uribe and Schmitt-Grohé (2017, p. 85–88)). Let's consider the expression

$$y_t = y(x_t, z_t).$$

We want to linearize this expression with respect to the logs of $y_t$ and $x_t$, and with respect to the level of $z_t$. Let $\hat{y}_t = log(y_t/y)$ and $\hat{x}_t = log(x_t/x)$ denote the log-deviations of $y_t$ and $x_t$ with respect to their steady-state values ($y$ and $x$), and let $\hat{z}_t = z_t - z$ denote the deviation of $z_t$ from its steady-state value ($z$). Then, the above expression can be rewritten as

$$ye^{\hat{y}_t} = y\left(xe^{\hat{x}_t}, \hat{z}_t + z\right)$$

Differentiating this expression with respect to hatted variables around their steady-state values yields

$$y\hat{y}_t = y_x x\hat{x}_t + y_z z\hat{z}_t,$$

where $y_x$ and $y_z$ are the partial derivatives of $y(\cdot,\cdot)$ with respect to $x_t$ and $z_t$, all evaluated at the steady state. Dividing both sides of the expression by $y$ and letting $\varepsilon_{yx} = y_x x/y$ denote the elasticity of $y$ with respect to $x$ and $\varepsilon_{yx} = y_z z/y$ denote the semi-elasticity of $y$ with respect to $z$ yield

$$\hat{y}_t = \varepsilon_{yx}\hat{x}_t + \varepsilon_{yz}\hat{z}_t.$$

# Appendix 3.B: Results of model without FDI and transfers

| Variable | $\sigma_a$ | $\sigma_g$ | $\sigma_R$ | $\sigma_{CA}$ | $\sigma_{TB}$ |
|---|---|---|---|---|---|
| y: output | 41.09 | 30.49 | 33.35 | 0.00 | 0.00 |
| c: consumption | 40.98 | 23.06 | 43.59 | 0.00 | 0.00 |
| i: investment | 38.25 | 41.45 | 26.74 | 0.00 | 0.00 |
| ca/y: current account balance-output ratio | 15.19 | 6.66 | 18.57 | 58.31 | 0.00 |
| tb/y: trade balance-output ratio | 4.26 | 1.88 | 5.22 | 0.00 | 88.47 |

Table 3.B: Variance decomposition.

Notes: $\sigma_{CA}$ and $\sigma_{TB}$ are the measurement errors in current account-to-output ratio and trade balance-to-output ratio, respectively.

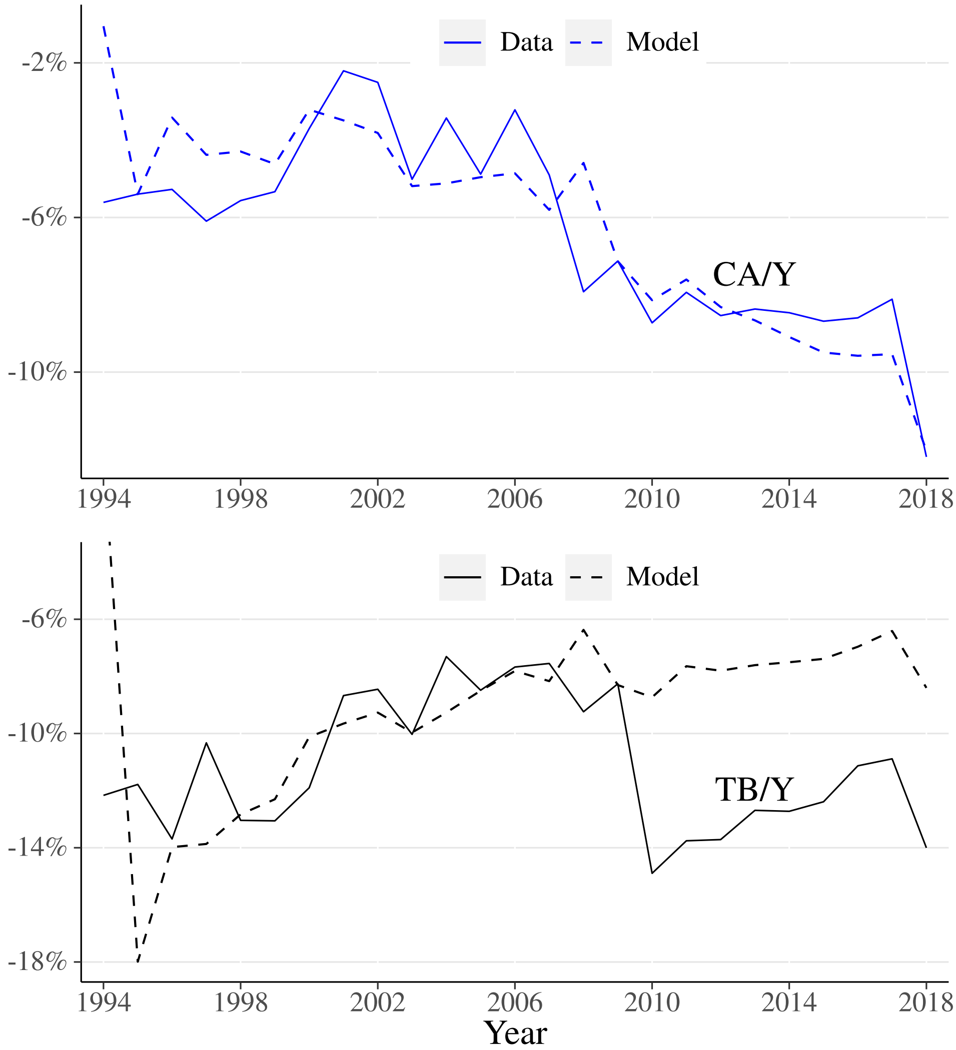


Figure 3.B.1: Trends of current account and trade balance.

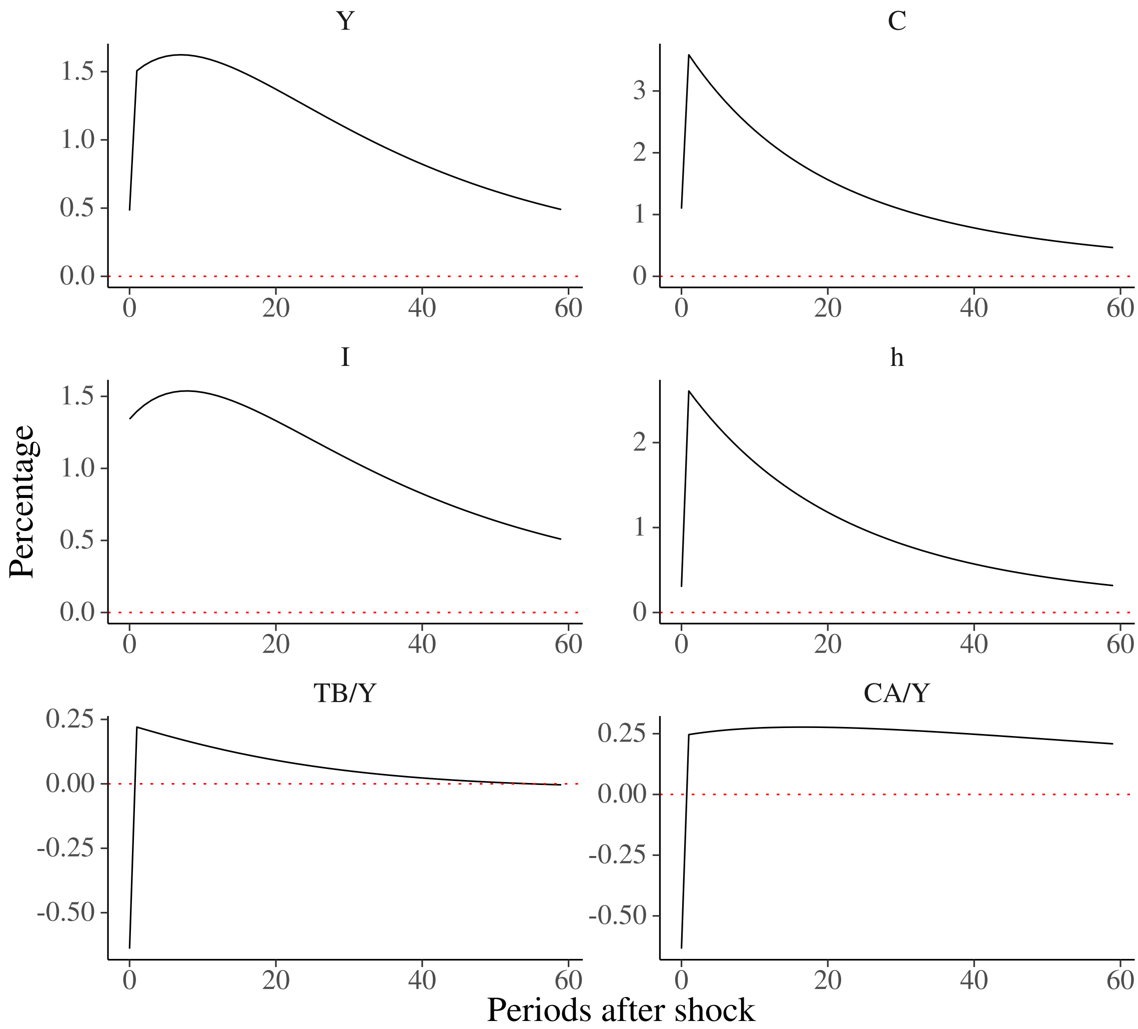


Figure 3.B.2: Responses to a 1-percent transitory productivity shock.

Notes: The impulse responses of $Y$, $C$, $I$, and $h$ are expressed in percentage deviations from the steady state. The impulse responses of $TB/Y$ and $CA/Y$ are percentage-point deviation from the steady state.

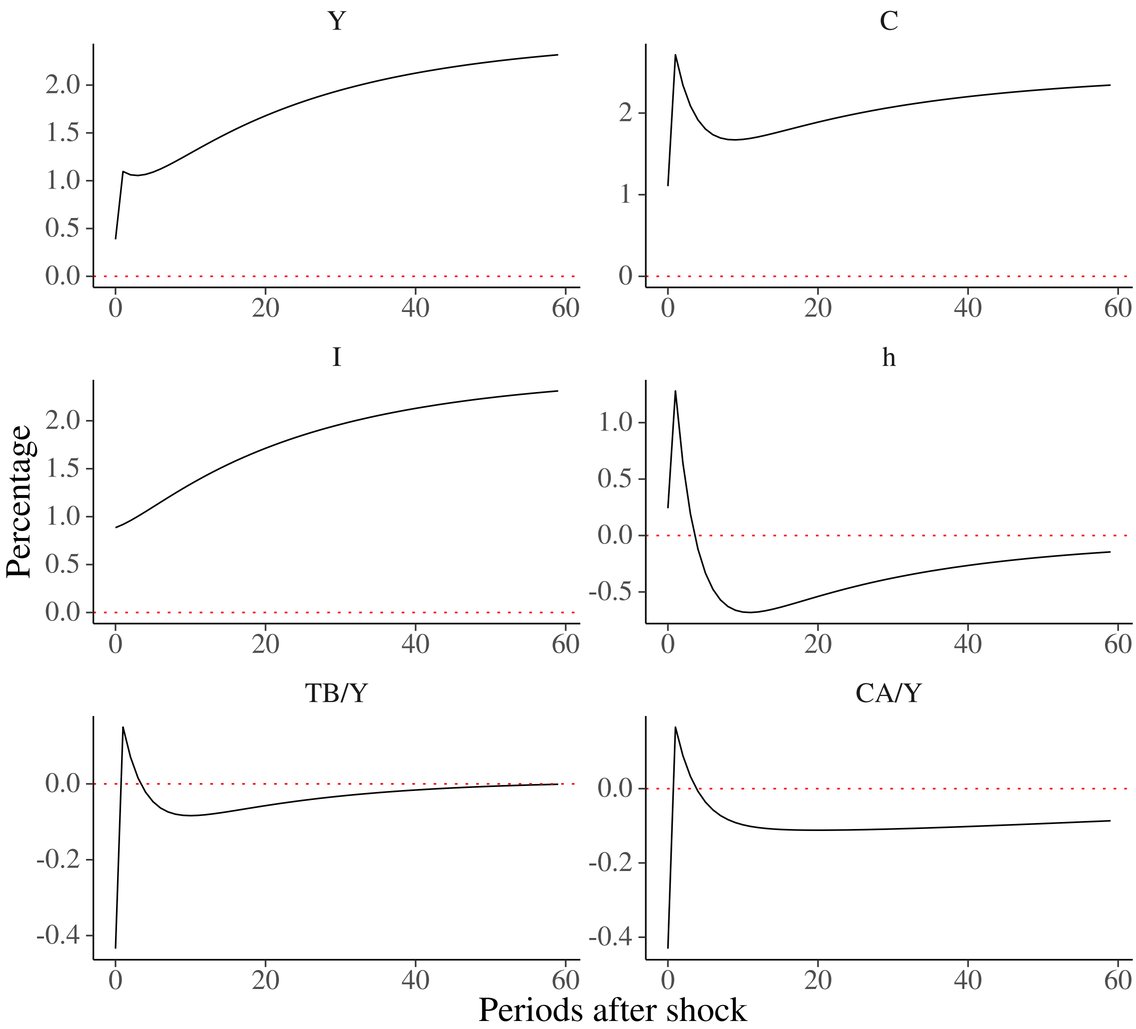


Figure 3.B.3: Responses to a 1-percent permanent productivity shock.

Notes: Notes: The impulse responses of $Y$, $C$, $I$, and $h$ are expressed in percentage deviations from the steady state. The impulse responses of $TB/Y$ and $CA/Y$ are percentage-point deviation from the steady state.

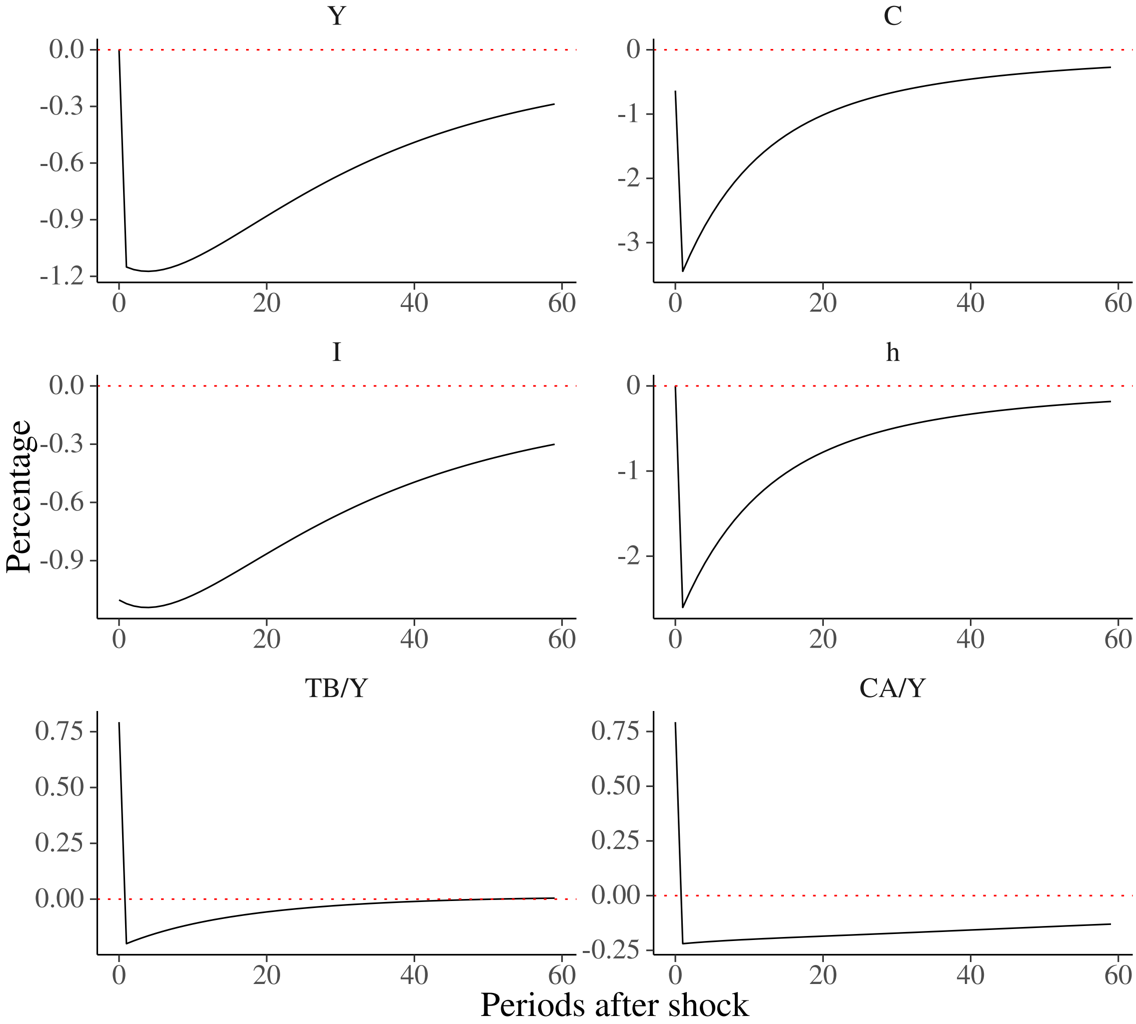


Figure 3.B.4: Responses to a 1-percent world interest rate shock.

Notes: The impulse responses of $Y$, $C$, $I$, and $h$ are expressed in percentage deviations from the steady state. The impulse responses of $TB/Y$ and $CA/Y$ are percentage-point deviation from the steady state.

# Appendix 3.C

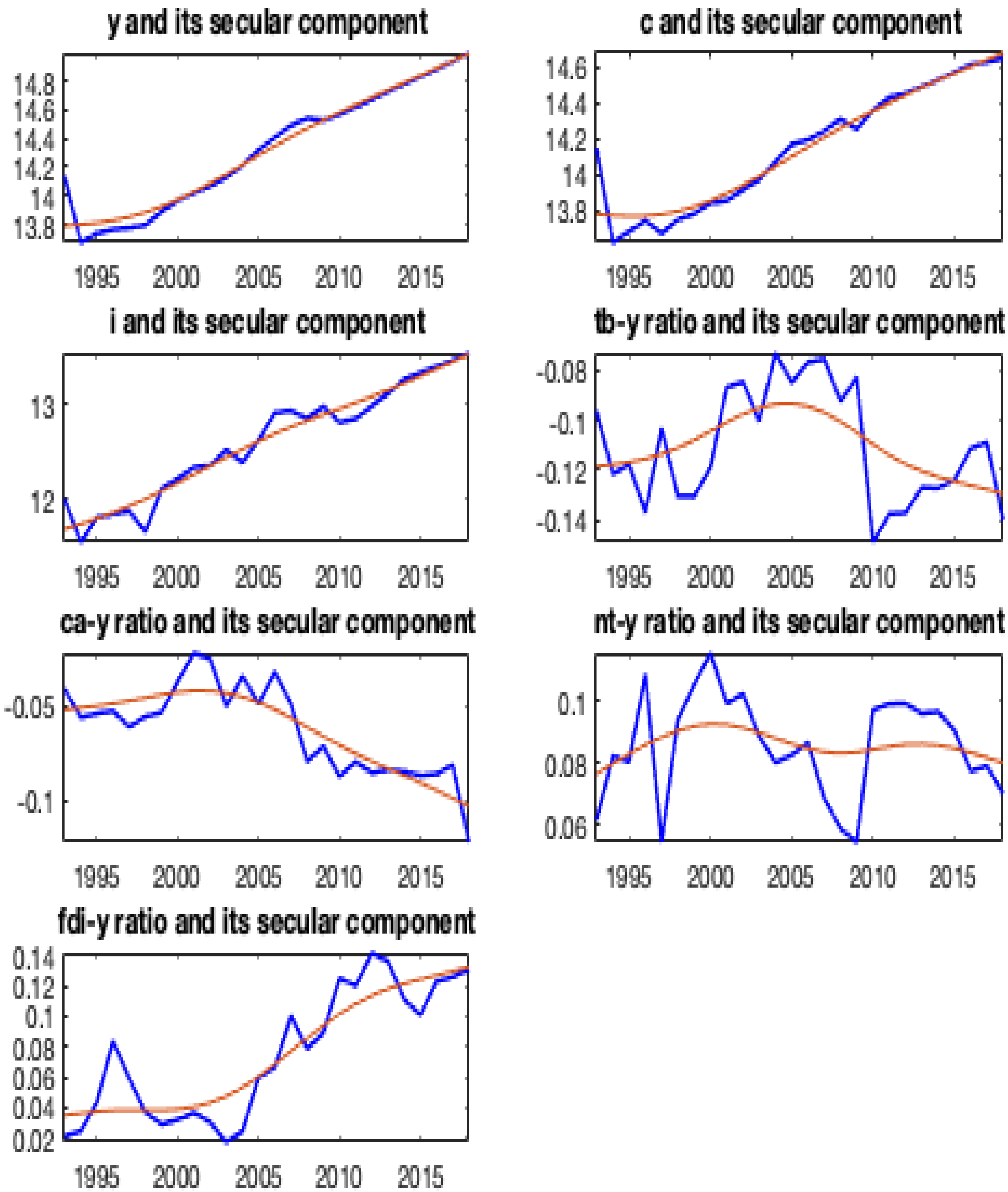


Figure 3.C.1: Cambodian data and their secular component as logarithm values.

Notes. The data are HP filtered with the smoothing parameter value of 100.

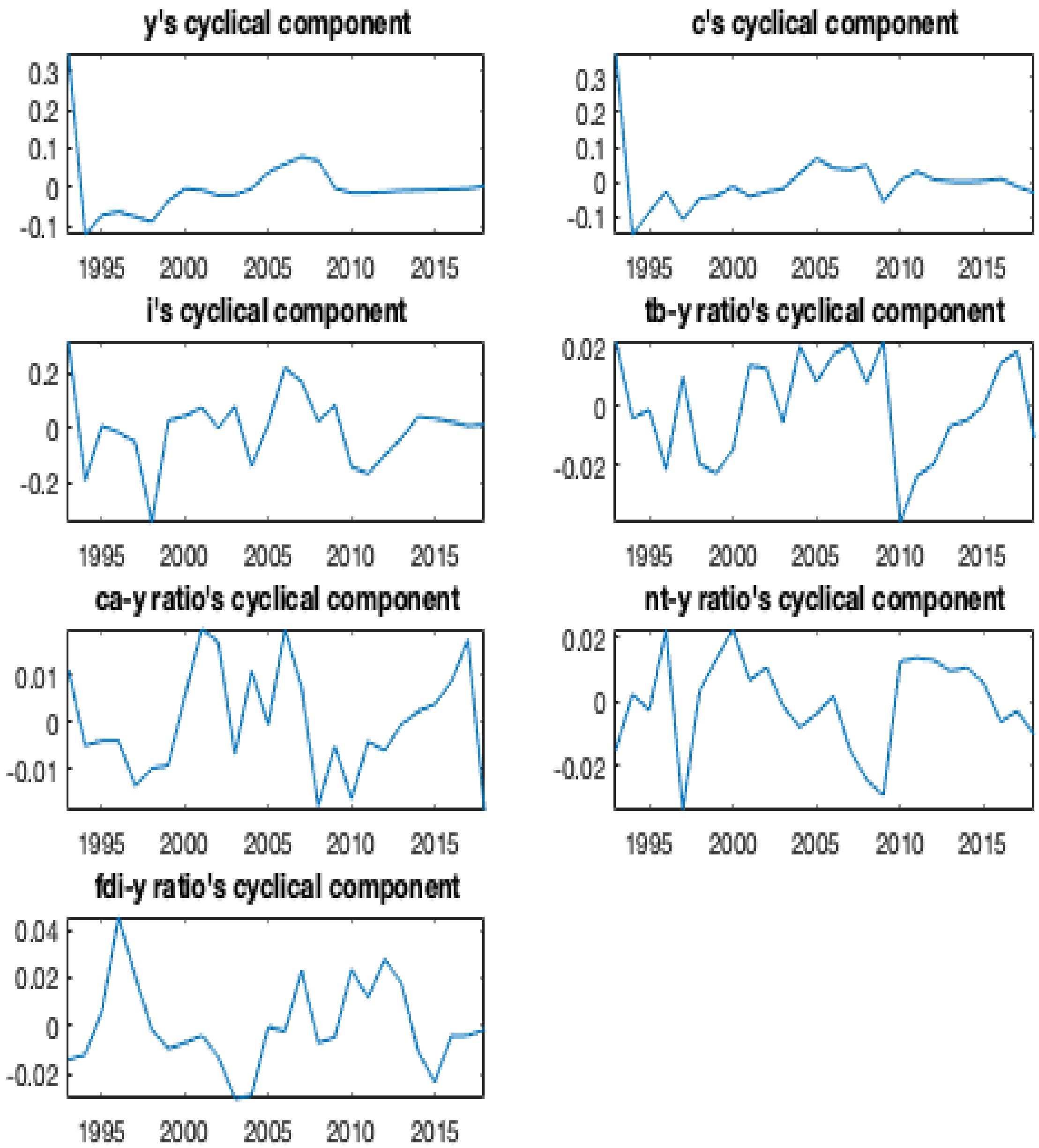


Figure 3.C.2: Cyclical component of Cambodian data as logarithm values.

Notes. The data are HP filtered with the smoothing parameter value of 100.

| Variable | STD | STD relative to y's STD | Correlation with y | Autocorrelation |
|---|---|---|---|---|
| y: output | 0.08 | 1.00 | 1.00 | -0.01 |
| c: consumption | 0.09 | 1.06 | 0.95 | -0.21 |
| i: investment | 0.13 | 1.58 | 0.71 | 0.04 |
| ca/y: current account balance-output ratio | 0.02 | 0.21 | 0.43 | 0.26 |
| tb/y: trade balance-output ratio | 0.01 | 0.14 | 0.31 | 0.20 |
| nt/y: net unilateral transfers-output ratio | 0.01 | 0.17 | -0.28 | 0.18 |
| fdi/y: net FDI-output ratio | 0.02 | 0.21 | -0.17 | 0.47 |

Table 3.C: Business cycle moments of Cambodian data.