The dollarization paradox in Cambodia: Network externalities matter

Kheng, Veasna and Pan, Lei and McKinley, Justin

Department of Economics, Monash University, School of Accounting, Economics and Finance, Curtin University, Nossal Institute for Global Health, University of Melbourne

September 2021

The Dollarization Paradox in Cambodia: Network Externalities Matter

Veasna Kheng[*] Lei Pan[†] Justin McKinley[‡§]

Abstract

The increased use of foreign currency as legal tender in Cambodia has been contrary to the general belief that macroeconomic and political stability help reduce dollarization. We provide so far the first explanation for this counterfactual phenomenon. In doing so, this paper develops a theoretical model based on the framework of Uribe (1997) 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 its transaction cost, thus increasing its usage in the economy. This increased use of the dollar further improves the experience of using it, resulting in higher usage of the dollar in the price quotation. The positive interaction of using the dollar as a unit of account and a means of payment causes dollarization to continue to rise, even though the economy has achieved low inflation and political stability.

Keywords: Dollarization; Dollar pricing index; Network externalities

JEL Classification: E41; F41

[*]Department of Economics, Monash University. Email: veasna.kheng@monash.edu

[†]Corresponding author. Contact: School of Accounting, Economics and Finance, Curtin University, Kent St, Perth, WA 6102, Australia. Email: lei.pan@curtin.edu.au

[‡]Nossal Institute for Global Health, University of Melbourne. Email: justin.mckinley@unimelb.edu.au

[§]Veasna Kheng is especially indebted to Horag Choi for his guidance. Veasna would also like to thank Ayushi Bajaj for her discussion and time finding sources for his interest in currency substitution. We appreciate Martin Uribe for his valuable feedback and suggestions. We also gratefully acknowledge comments from Alexandre Dmitriev, and Timothy Kam who served as a discussant of this paper at the 33rd Australian PhD Conference in Economics and Business. We are also grateful to seminar participants at Monash University. The usual disclaimer applies.

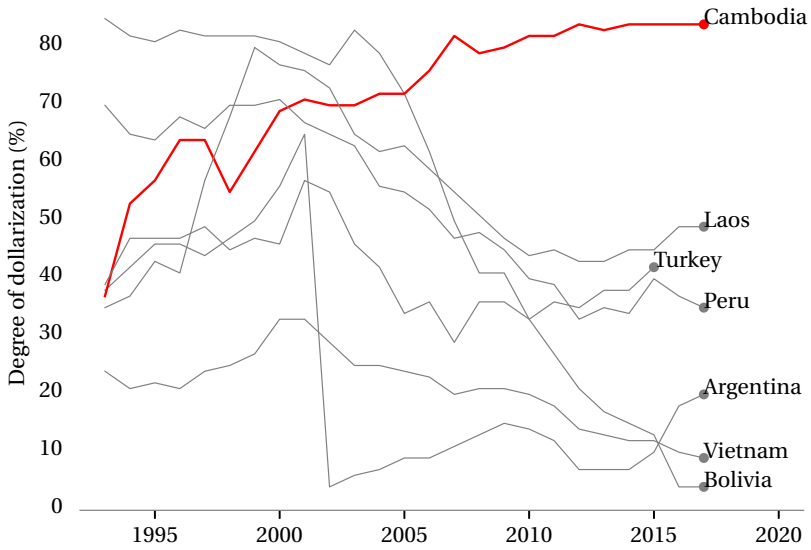
"*In Cambodia, the Ghosts Prefer Dollars.*"

— *The New York Times (2016)*

1 Introduction

The headline in the New York Times (2016) emphasizes the wide use of the US dollar in Cambodia rather than their domestic currency, the riel. *Dollarization* is a financial adaptation (usually in response to high inflation) countries use, wherein they adopt a foreign currency as legal tender. The general observation about the dynamics of dollarization is that as countries stabilize their macroeconomic and political conditions, their degrees of dollarization—the extent of using a foreign currency—gradually declines over time. Uribe (1997) provides a framework that captures this evolution of dollarization well. However, Cambodia appears to be the odd one out among low-income countries that have used a foreign currency. Against the backdrop of its macroeconomic and political stability, Cambodia increased use of a foreign currency, whereas its neighbors (Vietnam and Lao PDR) and others have experienced opposite trends (see Figure 1).

Figure 1: Trends of dollarization in selected highly dollarized economies.



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

Our work provides both a theoretical framework and some empirical evidence to explain this counterfactual phenomenon in Cambodia. We develop a theoretical model based on Uribe's (1997) cash-in-advance framework. Differing from Uribe (1997), we include a new variable which we call *dollar pricing index*,[1] defined as a proportion of an economy that quotes the dollar as a unit of account. This index captures government policies dealing with dollarization and amplifies the network effects of using the dollar in an economy.

Network effects are the central feature in Uribe's (1997) model to explain dollarization dynamics in low-income countries.[2] In his model, Uribe (1997) assumes that an economy's accumulated experience in using the dollar as a medium of exchange acts as 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 dollar usage. Therefore, the inclusion of the dollar pricing index further reduces the transaction cost of buying goods with the dollar, increasing its usage in an economy. The higher usage of the dollar improves the economy's 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 dollarization, even though the economy has achieved social, political, and economic stability.

Two surveys[4] in Cambodia along with qualitative data from Lao PDR, Vietnam, and Peru, support this augmented model's prediction. With the increasing use of foreign currencies as a unit of account in Cambodia, using foreign currencies as a medium of exchange also grows. Over the period 2010-2014, the dollar pricing index and the degree of dollarization have increased from 28% to 43% and 81% to 83%, respectively. This positive relationship was also observed in Cambodian regions. Figure 2 shows that the higher the dollar pricing

[1] To the best of our knowledge, this index, generated from survey data, is only available for the Cambodian economy.

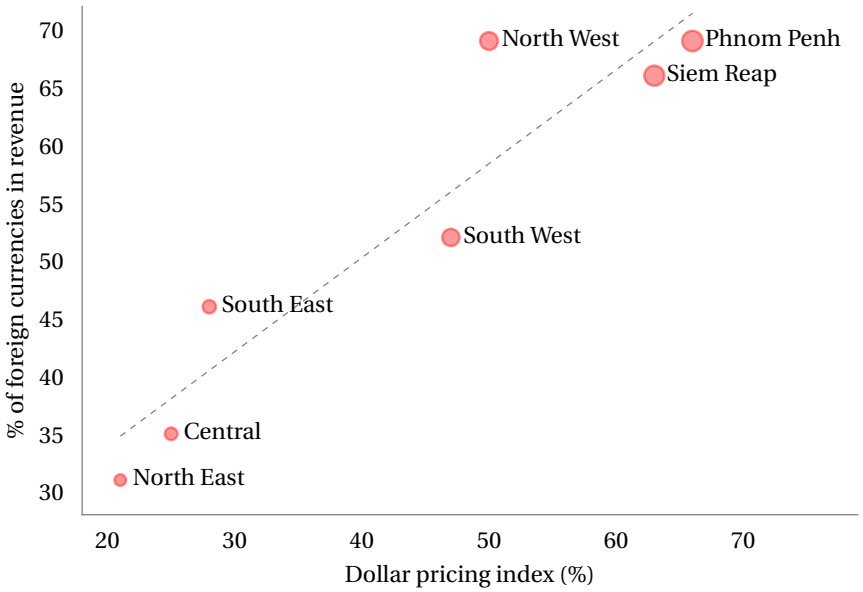
[2] Uribe's (1997) model shows that temporary high inflation triggers an economy to adopt the dollar. Because of the network effects, the degree of dollarization gradually declines when inflation stabilizes in the economy. This model explains the dynamics of dollarization in most low-income countries but fails to explain the increased dollarization in Cambodia, even though inflation has stabilized.

[3] Some dollarized economies, such as Lao PDR Vietnam, and Peru, officially ban the use of a foreign currency as a unit of account, while other like Cambodia do not.

[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.

index observed in a region, the larger the proportion of revenue in foreign currencies the region receives[5].

Figure 2: Dollar pricing index and % of foreign currencies in revenue in Cambodia's regional areas.



Note: 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).

While Cambodia has no restrictions on which currency is used to quote prices, Lao PDR, Vietnam, and Peru have all banned foreign currencies from being used as a unit of account. The ban has decreased the dollar pricing index, thus raising the cost of using the dollar in transactions, further reducing the use of dollars in transactions. Consequently, the degree of dollarization in these countries has gradually declined, as predicted by the Uribe (1997) model.

The rest of the paper proceeds as follows. Section 2 reviews the relevant literature concerning currency risk and network externalities as the roots of dollarization. Section 3 briefly discusses dollarization in Cambodia. Section 4 develops a model of currency substitution. Section 5 discusses the effects of government policies, 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

[5]The survey conducted by Khou (2012) has data for the dollar pricing index, but not for the percentage of foreign currencies in revenue. The data presented in Figure 2 were, therefore, a snapshot in 2016.

the paper with policy implications and model limitations.

2 Currency Risk and Network Externalities

Our study contributes to two main strands of literature. The first is concerned with how currency risk triggers the use of a foreign currency. The second focuses on the network externalities that result from using a foreign currency to help explain the evolution of dollarization in low-income countries.

Craig and Waller (2004) and Camera et al. (2004) developed 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,[6] the domestic currency remains a medium of exchange. This coexistence of both currencies neither supports nor contradicts Gresham's Law that risky money drives safe money out of the economy (Rolnick and Weber, 1986).

Although the currency risk and transaction cost have opposing effects on the extent of currency substitution, their impact magnitudes differ. 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 previously experienced exchange rate instability, implying that de-dollarization 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) develops a simple cash-in-advance model, which our study is most similar. In Uribe's (1997) 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 medium of exchange. In other words, the more experience an economy has with using the foreign currency as a medium of exchange, the lower its transaction cost becomes. These network

[6] The inclusion of the transaction cost in the model is motivated by the fact that in low-income countries, households might need to verify the authenticity of an unfamiliar currency (Engineer, 2000; Tandon, 2003), and spend time switching between currencies (Guidotti, 1992).

effects are also present in the search-theoretical models of money (see e.g., Matsuyama et al., 1993; 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.

Numerous studies provide empirical evidence of the network effects on hysteresis. For instance, Valev (2010) uses survey data to examine 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).

3 The Dollarization in Cambodia

The currency risk and network externalities are the roots of rising dollarization in Cambodia. Cambodians had already lost trust in the domestic currency, the riel, and economic institutions (e.g., banks) were abolished during the Khmer Rouge regime.[7] The riel was reintroduced back into the economy in March 1980, after the fall of the Khmer Rouge. Yet, people preferred barter and gold for most domestic transactions (De Zamaroczy and Sa, 2002). This loss of confidence was exacerbated by a significant depreciation of the riel during the period between 1988-1991.

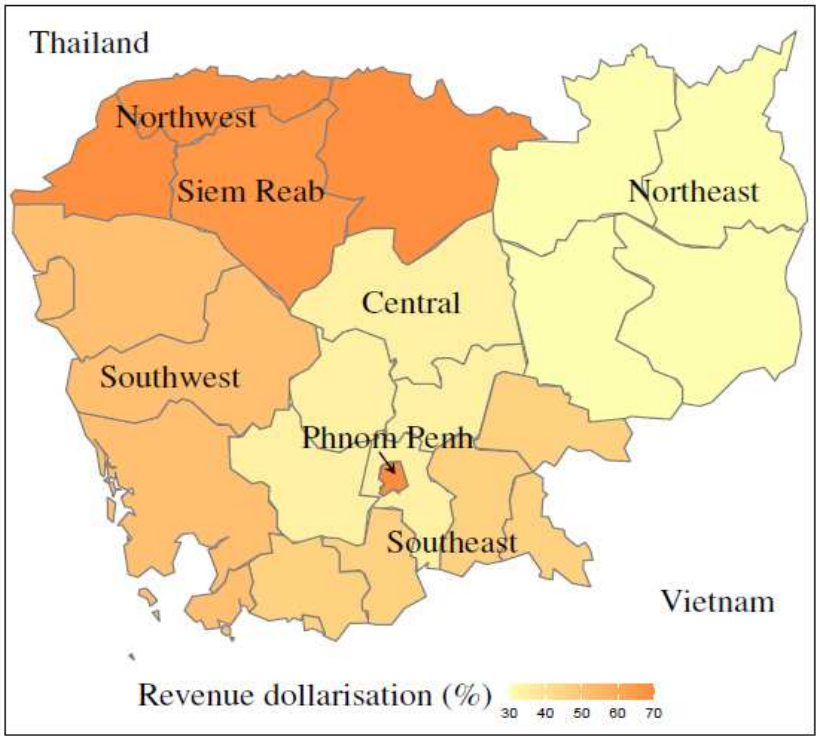
In the early 1990s, the usage of the US dollar rapidly grew as Cambodia opened up to foreign investments and aid. The United Nations Transitional Authority spent around USD 1.7 billion – around 75% of Cambodia's GDP at the time – on rents and local services for its peacekeeping operations, including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

To promote price stability and economic growth, Cambodia hasn't placed restrictions on using foreign currencies, thus leading to the use of multiple currencies in the country. The type of currency used as a means of payment is positively associated with the type of cur-

[7] The Khmer Rouge was responsible for the Cambodian Genocide from 1975 to 1979.

rency used as a unit of account. For instance, as merchants in Phnom Penh City use the US dollar to display prices for approx 65% of their total products, they also receive around 69% of their revenues in the US dollars (Figure 2). Moreover, the type of currency used in price quotation depends mainly on types of goods and services[8], and whom Cambodians do business with. As a result, the degree of dollarization differs across regions and concentrates in urban areas, tourism sites, and near trade borders (Figure 3).

Figure 3: The use of foreign currencies across regions in Cambodia



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

Since increasingly integrating into the world in the early 1990s, Cambodia's economy has performed spectacularly (e.g., its average annual GDP growth is around 7%) while also allowing foreign currencies as a unit of account during this time (e.g., quoting products in foreign currencies). Hence, the degree of dollarization has increased from 35% in 1993 to 84% in 2017. This upward trend of dollarization in Cambodia appears to make it the odd

[8] e.g., The US dollar is predominantly used to quote salaries and pay employees in the private sector as well as international organizations, and for big-ticket items, such as houses and vehicles.

one out among other dollarized economies. To the best of our knowledge, the theoretical model we develop in the next section is the first effort to formally explain this counterfactual phenomenon.

4 Model

The theoretical framework used in this study is a cash-in-advance model, as presented in Uribe (1997). Differing from Uribe (1997), we introduce the role of a foreign currency as a unit of account to amplify the network effects of using a foreign currency. In addition, we incorporate the degree of government regulations on the use of foreign currencies in price quotations. These inclusions are motivated by observations of dollarized economies. Some dollarized economies, such as Lao PDR, 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.[9]

The economy is a small open dual-currency system in which a foreign currency, henceforth denoted as dollar, is used along with the domestic currency, the 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:

$$\int_0^{\infty} e^{-\rho t} U(C_t) dt, \tag{1}$$

where ρ 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 $\theta \in [0,1]$,

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

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 θ is always positive: $c(\theta) > 0$.

[9] We could only find data concerning the use of foreign currency as a unit of account for these four countries.

Households can use either riels or dollars to pay for goods. However, using dollars incurs a transaction cost that differs across goods θ. That is, the unit transaction cost of buying good θ 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 medium of exchange, and it is referred to as *dollarization 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:[10] $q = 0$ 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 as a unit of account (The variable q is the main feature that this paper contributes relative to Uribe's (1997) work.[11]). While the 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 assumptions:

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

Assumption 1 states that the transaction cost is strictly increasing in θ, and becomes infinitely large as θ approaches 1. This prohibitive cost ensures that there always exists a positive demand for the domestic currency, as observed in dollarized economies. But the transaction cost is strictly decreasing in both k_t and q_t. This decreased cost captures the network externalities resulting from adopting the dollar as an alternative legal tender. In addition, the condition $\lim_{k\to\infty} \phi_k = 0$ and $\lim_{q\to 1} \phi_q = 0$ is for technical 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, 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), expressed as units of riels per unit of dollars. In addition, they can buy or sell an internationally traded, dollars-

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

[11] 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 dollarization phenomenon in Cambodia because there is no reinforcing mechanism to amplify the network effects of using a foreign currency.

denominated bonds, 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. We assume strict purchasing power parity and perfect capital mobility to ensure that this is the real interest rate in both the domestic economy and the world. 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:

$$w_t = b_t + m_t + d_t. \tag{2}$$

As the goods market opens, one household member goes to purchase the desired amount of each good θ, while another member receives an endowment of y_t units of each good θ. All goods θ are traded internationally at the common price of one dollar or E 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. Denote Θ_t^d and Θ_t^m as 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:

$$\frac{m_t}{1+\pi_t} \geq \int_{\Theta_t^m} c_t(\theta)\, d\theta, \tag{3}$$

$$d_t \geq \int_{\Theta_t^d} \left[1 + \phi(\theta, k_t, q_t)\right] c_t(\theta)\, d\theta, \tag{4}$$

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 $i > 0$). Moreover, 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:

$$\dot{w}_t = r\, b_t + \frac{m_t}{1+\pi_t} - m_t - \int_{\Theta_t^d} \left[1 + \phi(\theta, k_t, q_t)\right] c_t(\theta)\, d\theta - \int_{\Theta_t^m} c_t(\theta)\, d\theta + y_t + \tau_t. \tag{5}$$

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 maximize its lifetime utility Equation (1) subject to the constraints Equations (2)-(5) by taking as given the initial wealth (w_o) and paths $\left[\pi_t, q_t, k_t, y_t\right]_{t=0}^{\infty}$ and satisfying the No-Ponzi condition. The first-order conditions associated with the household's optimisation problem are Equations

(3)-(5) binding and (hereafter, we drop time subscripts when no risk of confusion arises)

$$\Theta^d = [0, \bar{\theta}(k,q,\pi)), \tag{6}$$

$$\Theta^m = [\bar{\theta}(k,q,\pi), 1], \tag{7}$$

$$\bar{\theta}(k,q,\pi) = \begin{cases} 0 & \text{if } \phi(0,k,q) \geq \pi \\ \theta \text{ such that } \phi(\theta,k,q) = \pi & \text{otherwise} \end{cases} \tag{8}$$

$$c(\theta) = c(\bar{\theta}(k,q,\pi)) \quad \text{for } \theta \in \Theta^m, \tag{9}$$

$$\frac{u_c(c(\theta(k,q,\pi)))}{1+\phi(\theta,k,q)} = \frac{u_c(c(\bar{\theta}(k,q,\pi)))}{1+\pi} \quad \text{for } \theta \in \Theta^d, \tag{10}$$

$$\dot{\lambda} = \lambda[\rho - r], \tag{11}$$

$$U_C(C)\, u_c(c(\theta(k,q,\pi))) = \lambda[1+\phi(\theta,k,q)][1+r] \quad \text{for } \theta \in \Theta^d. \tag{12}$$

Equations (6) and (7) show 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 4). This cut-off good is referred to as the degree of dollarization at time t. Equation (8) shows that when the degree of dollarization 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,π) 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 5). Equations (9) and (10) state that $c(\theta)$ is continuous and strictly decreasing in θ for $\theta \in \Theta^d$, and constant for $\theta \in \Theta^m$. Equation (11) implies that λ – the shadow price of wealth related to flow constraint Equation (5) – is constant over time because the interest rate equals the discount rate at the steady state. Equation (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 is equal to 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 4: Degree of dollarization

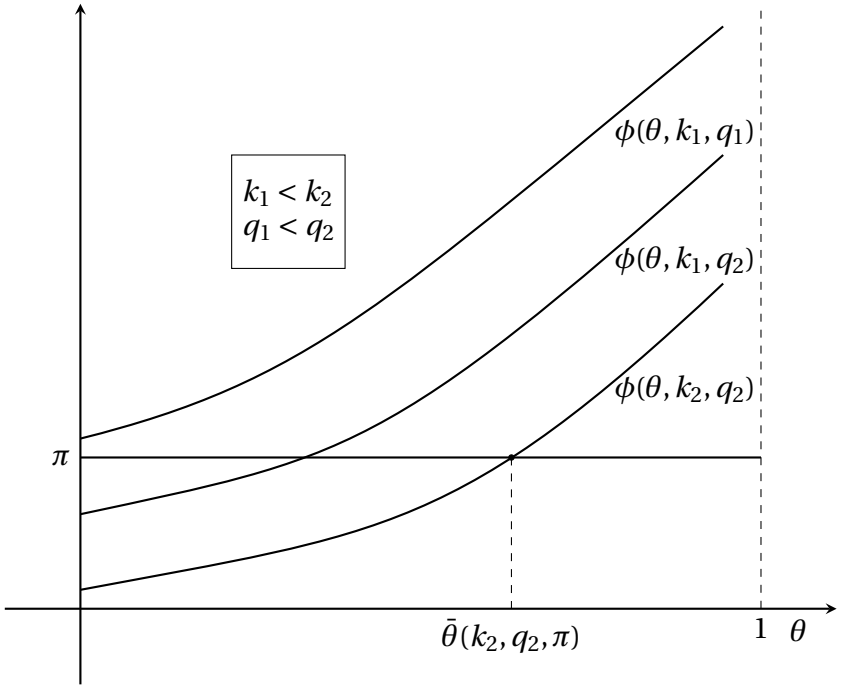
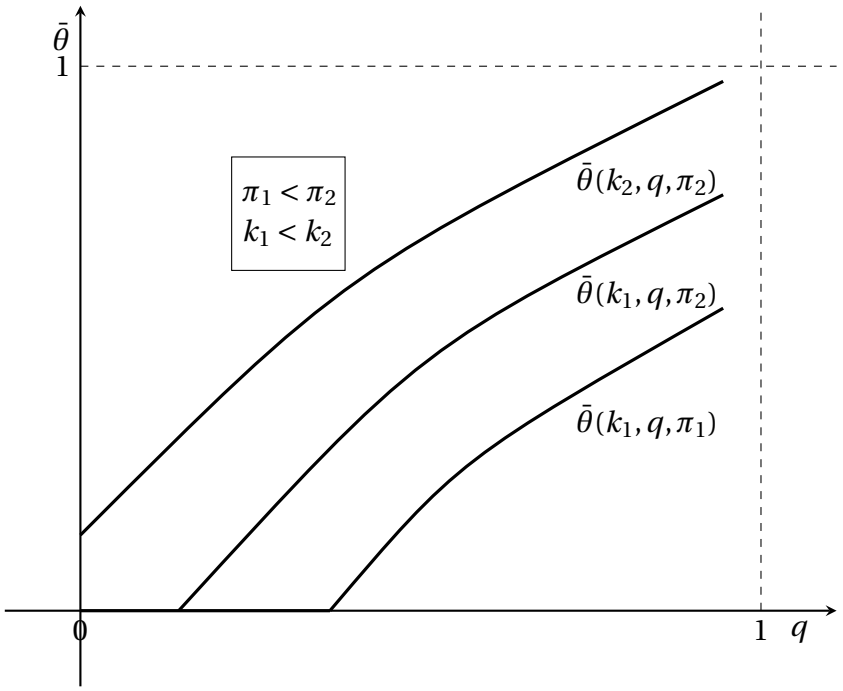


Figure 5: The function of $\bar{\theta}(k, q, \pi)$



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

$$\dot{k} = f(\bar{\theta}(k,q,\pi)) - \delta_k k, \tag{13}$$

$$\dot{q} = h(\bar{\theta}(k,q,\pi)) - (\delta_q + \eta) q, \tag{14}$$

where $\dot{x}$ is the time derivative of x, δ_x refers the depreciation rate of x; η refers to the degree of government regulations on using the dollar as a unit of account, 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 states that as more people use dollars for purchasing 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 dollarization 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 η captures the effects of government intervention in using the dollar in price quotations. The more stringent the regulations, the faster the fall of the dollar pricing index. For analytical convenience, η is assumed to be between 0 and 1 and satisfy $\eta + \delta_q \in (0,1]$.

The Steady-State Equilibrium

To simplify and characterize the steady state, Equations (13) and (14) can be rewritten as

$$\dot{k} = F(k,q,\pi) - \delta_k k, \tag{15}$$

$$\dot{q} = H(k,q,\pi) - (\delta_q + \eta) q, \tag{16}$$

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

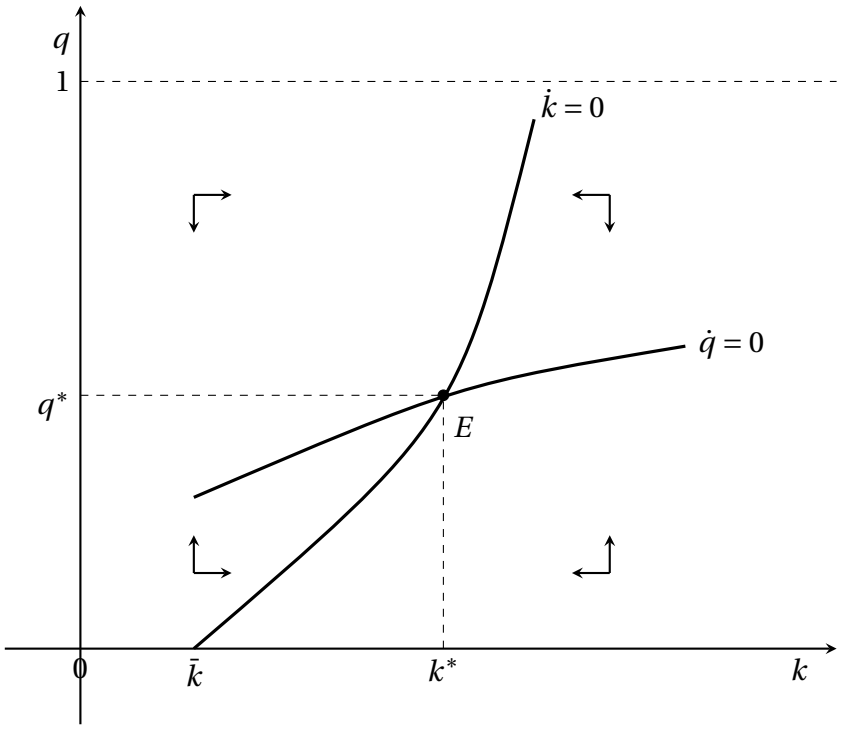
A steady-state equilibrium is defined by the stock of dollarization and that of the dollar pricing index (k^*, q^*), which satisfy the following two equations:

$$F(k^*, q^*, \pi) - \delta_k k^* = 0, \tag{17}$$

$$H(k^*, q^*, \pi) - (\delta_q + p) q^* = 0. \tag{18}$$

This steady-state equilibrium (k^*, q^*) is globally and uniquely stable. Consider Figure 6, drawn in the (k, q) space to see this heuristically. The curves $\dot{k} = 0$ and $\dot{q} = 0$, corresponding respectively to Equations (17) and (18), have a positive slope so that a higher dollar price index is associated with a higher dollarization capital in equilibrium. Moreover, the slope of $\dot{k} = 0$ curve is steeper than that of $\dot{q} = 0$ curve at the equilibrium.

Figure 6: The dynamics of q and k



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:

$$\frac{dq}{dk}\Big|_{\dot{k}=0} = \frac{\delta_k - F_k(k, q, \pi)}{F_q(k, q, \pi)}, \tag{19}$$

where $F_k \equiv \partial F/\partial k$ and $F_q \equiv \partial F/\partial q$. Equation (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 (19) is strictly positive. Similarly, when the same method and argument are applied to Equation (16), the slope of $\dot{q} = 0$ curve, given below, is also strictly positive:

$$\left.\frac{dq}{dk}\right|_{\dot{q}=0} = \frac{H_k(k,q,\pi)}{\delta_q + \eta - H_k(k,q,\pi)}. \tag{20}$$

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:

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

The second line is a result of substituting $F(k^*,q^*,\pi)/k^*$ for δ_k in Equation (19) and $H(k^*,q^*,\pi)/q^*$ for $\delta_q + \eta$ in Equation (20). The third and last line results from simplifying and rearranging the terms in the second line (note that all functions are evaluated at the equilibrium point). Assumptions 1 and 2 together with Equation (8) show that this inequality is satisfied (see proof in Appendix B).

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 characterized 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 characterized 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 6.

Finally, since this paper focuses on developing economies that have already experienced high inflation, the steady-state stock of dollarization 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 6. 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 zero ($\theta(k_0, 0, \pi) > 0$). Assumption 1 implies that as q approaches one, the slope of the $\dot{k} = 0$ curve approaches infinity. Likewise, k approaches infinity, the slope of $\dot{q} = 0$ approaches zero.

Therefore, the two demarcation curves ($\dot{k} = 0$ and $\dot{q} = 0$) intersect only once at the point $E(k^*, q^*)$. This point is the globally stable equilibrium because regardless of where a point (k, q) starts, it tends to move toward point E as indicated by the directional arrows (see Figure 6).

5 The Effects of Government Policies

This section illustrates how changes in government policies affect the steady-state equilibrium and presents three relevant cases to explain the rise and fall of the degree of dollarization in low-income countries.

5.1 The Effects of Changes in Inflation

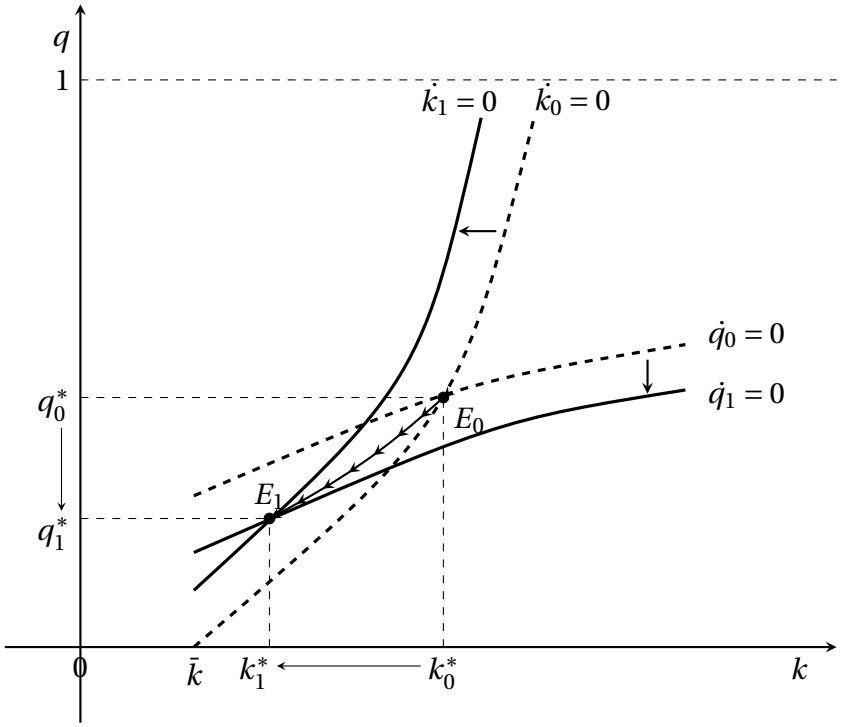
First, consider what happens to the equilibrium when a government reduces inflation. Empirically, when high-inflation countries have decreased the inflation rate to a lower level for some time, their dollarization has gradually declined (see e.g., Figure 10 and Figure A.2). Figure 7 explains how this mechanism works.

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

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

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 high levels that they cannot generate enough social learning by adopting the foreign currency to compensate for their depreciation. Hence, 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 7: The effects of falling inflation



5.2 The Effects of Changes in Dollar Quotation

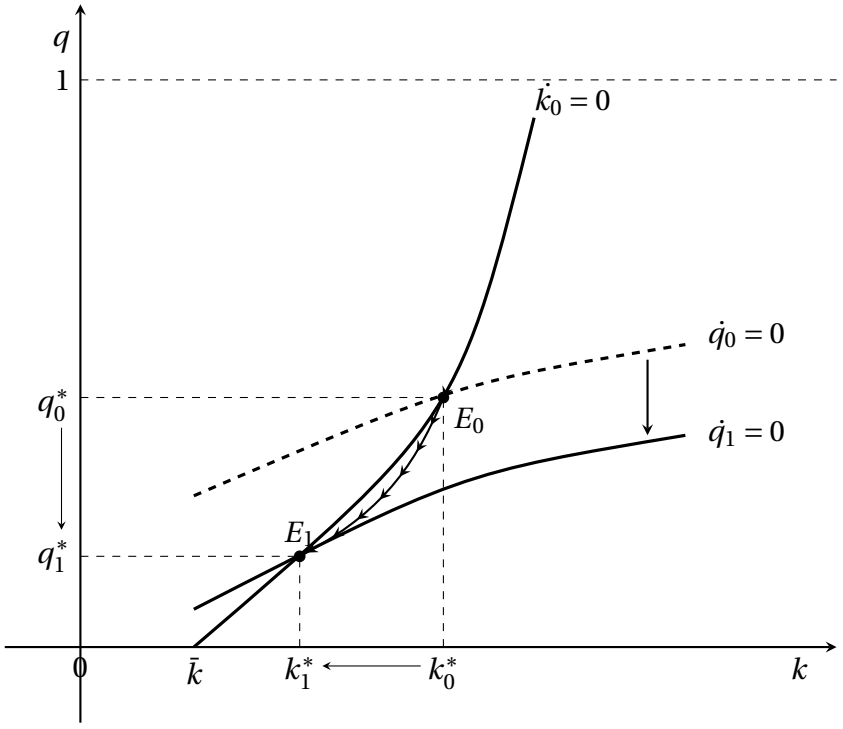
Next, consider how the equilibrium changes when a government imposes restrictions on dollar quotations. Restricting the use of the dollar as a unit of account affects only the $\dot{q} = 0$

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 η – the degree of regulations on the use of the foreign currency as price quotation – leads to a decrease in q. That is,

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

As the curve $\dot{q} = 0$ shifts downward, from the $\dot{q}_0 = 0$ curve to the $\dot{q}_1 = 0$ curve (Figure 8), 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 dollarization and dollar pricing index capitals are lower than before.

Figure 8: The effects of increasing regulation on dollar quotation

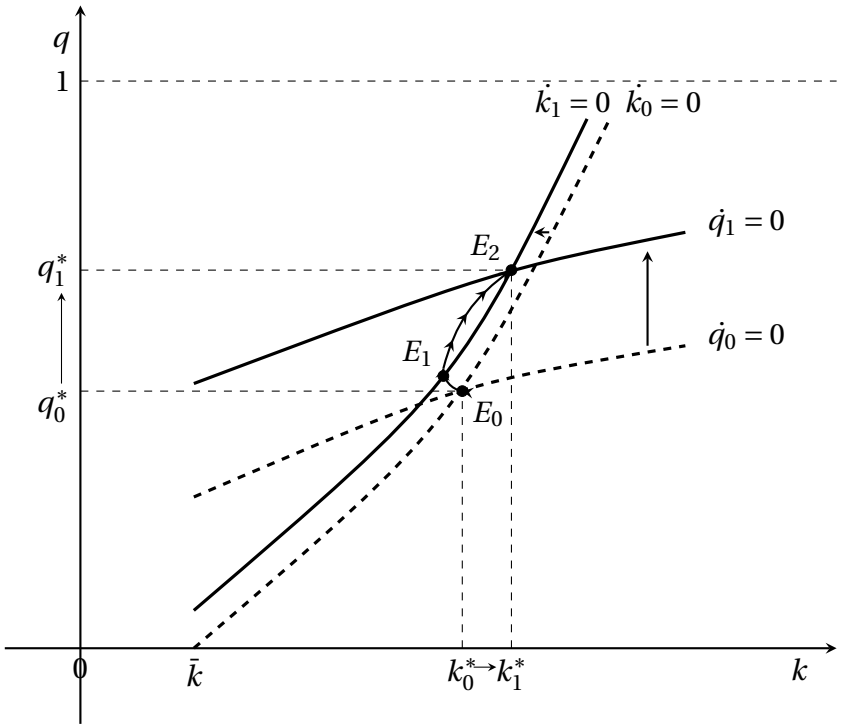


5.3 The Effects of Changes in Inflation and Dollar Quotation

Finally, consider a case where 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 9, 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 dollarization 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 9: The effects of a decrease in inflation and an increase in dollar quotation



6 The Model Predictions and Evidence

The illustrations shown in Figures 7 to 9 explain the upward trend of dollarization in Cambodia and the downward trends in Lao PDR, Vietnam, and Peru. Since its first national election in 1993, the Cambodian riel has maintained an average depreciation rate of around 2%. However, the Cambodian government has acquiesced to using the dollar and hasn't had any restrictions on how foreign currencies are used. In particular, the government has not imposed any regulation on which currency is used to quote products' prices (Kubo, 2017). This implies that η – the degree of regulations on using the dollar for price quotation – approaches zero. Because the network externalities of using the dollar are stronger than the

currency risk, the dollarization degree has increased (Table 1 and Figure 10).

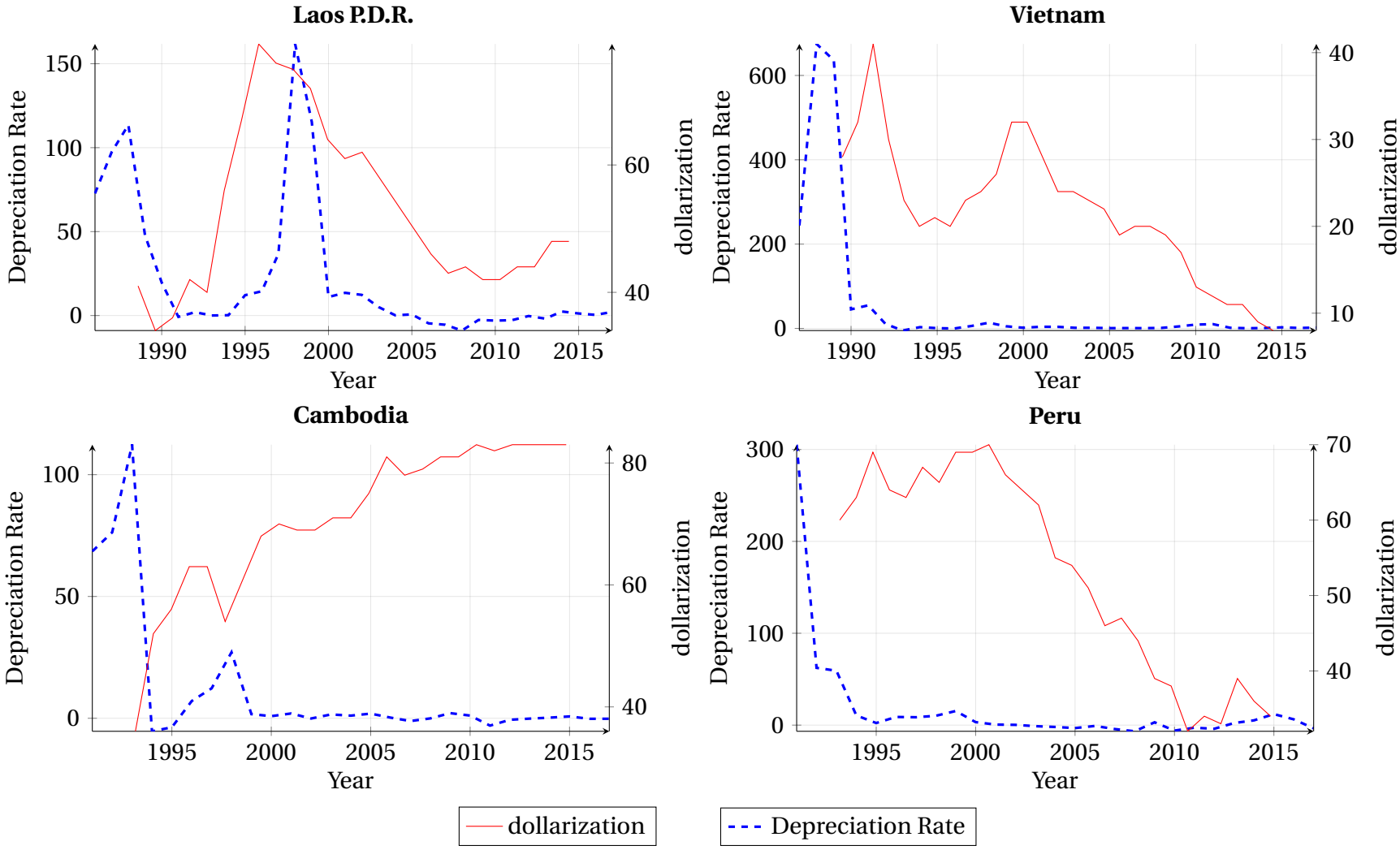
In contrast, Lao PDR, Vietnam, and Peru have repeatedly restricted their economies by forbidding price quotations in foreign currencies. For instance, as in Cambodia, it has been common in Lao PDR for firms and households to use foreign currencies as a means of exchange and unit of account instead of its local currency, the kip. The use of the Thai baht and the US dollar was common throughout Lao PDR, particularly in urban areas, tourism sites, and the Thai 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 Lao PDR even established 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 foreign currencies. The increased cost and low depreciation rates in Lao PDR, Vietnam, and Peru, have reduced the degree of dollarization in these economies (Table 1 and Figure 10).

Table 1: Regulations on dollarization in four selected countries

	Quotation of Prices in Foreign Currency
Cambodia	No control
Lao PDR	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 500 million Vietnamese dong.
Peru	In 2004, Peru enacted a law stipulating that all prices be denominated in soles, the local currency.

Note: Data for Cambodia, Vietnam, and Lao PDR are sourced from Kubo (2017), and data for Peru are obtained from Castellares et al. (2019).

Figure 10: Depreciation rate and dollarization in four selected countries



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

7 Concluding Remarks

In this paper, we provide, so far, the first explanation for the puzzle of increasing dollarization in Cambodia. To this end, we develop a theoretical model based on the framework of Uribe (1997) by introducing a new stock variable, *dollar pricing index*, and the degree of government regulations on the stock variables. This index, defined as a proportion of an economy that uses a foreign currency (denoted dollar) as a unit of account, amplifies the network effects of the dollar usage. Because the impacts of the network externalities have proven to be more substantial than those of currency risk, the positive interaction between the use of the dollar as a unit of account and a medium of exchange raises dollar usage, even though Cambodia has achieved economic and political stability.

Our model has important implications for dollarized economies. Suppose a dollarized economy wishes to reduce the widespread use of foreign currencies in their countries. In that case, they need to stabilize not only their macroeconomic conditions (e.g., reduce inflation) but also increase the transaction cost of using 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).

Despite our model's usefulness, it does have one notable limitation. The model only produces one stable steady state. Hence, it cannot capture the hysteresis of dollarization like the Uribe (1997) model, which provides two stable, steady states and one unstable steady state. However, since our work focuses on the low-income countries that have previously experienced high inflation and thus a certain degree of dollarization, we find this limitation acceptable. Our model sufficiently deals with our objective to explain whether a particular degree of dollarization continues to rise or fall due to government regulations on the use of a foreign currency as a unit of account.

Declaration of conflict of interest: The authors have no conflict of interest to declare.

References

Camera, G., Craig, B., and Waller, C.J. (2004). Currency competition in a fundamental model of money. *Journal of International Economics*, 64(2), 521–544.

Castellares, R. and Toma, H. (2019). Effects of a mandatory local currency pricing law on the exchange rate pass-through. BIS Working Paper No. 785. Available online at: https://www.bis.org/publ/work785.pdf

Clements, B. and Schwartz, G. (1993). Currency substitution: The recent experience of Bolivia. *World Development*, 21(11), 1883–1893.

Craig, B. and Waller, C.J. (2004). Dollarization and currency exchange. *Journal of Monetary Economics*, 51(4), 671–689.

De Zamaroczy, M. and Sa, S. (2002). Macroeconomic adjustment in a highly dollarized economy: The case of Cambodia. IMF Working Paper, WP/02/92.

Duffy, J. and Ochs, J. (2002). Intrinsically worthless objects as media of exchange: Experimental evidence. *International Economic Review*, 43(3), 637–673.

Engineer, M. (2000). Currency transactions costs and competing fiat currencies. *Journal of International Economics*, 52(1), 113–136.

Guidotti, P. E. and Rodriguez, C. A. (1992). Dollarization in Latin America: Gresham's law in reverse? *IMF Staff Papers*, 39(3), 518–544.

Khou, V. (2012). Functionality of the monetary plurality in Cambodia. Unpublished PhD dissertation. Lyon: Université Lumière Lyon.

Kiyotaki, N. and Wright, R. (1989). On money as a medium of exchange. *Journal of Political Economy*, 97(4), 927–954.

Kubo, K. (2017). *Dollarization and De-dollarization in Transitional Economies of Southeast Asia*. Springer.

Lucas, R.E. (1982). Interest rates and currency prices in a two-country world. *Journal of Monetary Economics*, 10(3), 335–359.

Matsuyama, K., Kiyotaki, N. and Matsui, A. (1993). Toward a theory of international currency. *Review of Economic Studies*, 60(2), 283–307.

Melvin, M. and Fenske, K. (1992). Dolarization and monetary reform: Evidence from the Cochabamba region of Bolivia. *Revista de Análisis Económico–Economic Analysis Review*, 7(1), 125–138.

National Bank of Cambodia (2016). Dollarization in Cambodia: Evi-

dence from a survey conducted in 2014-2015. Available online at: https://www.nbc.org.kh/download_files/research_papers/english/9445Dollarization inCambodiaasofOctober20.pdf

Rolnick, A.J. and Weber, W.E. (1986). Gresham's law or Gresham's fallacy? *Journal of Political Economy*, 94(1), 185–199.

Tandon, A. and Wang, Y. (2003). Confidence in domestic money and currency substitution. *Economic Inquiry*, 41(3), 407–419.

The New York Times. (2016). In Cambodia, the Ghosts Prefer Dollars. Available online at: https://www.nytimes.com/2016/04/09/world/asia/cambodia-qingming-festival-ghosts-prefer-dollars.html

Trejos, A. and Wright, R. (1995). Search, bargaining, money, and prices. *Journal of Political Economy*, 103(1), 118–141.

Uribe, M. (1997). Hysteresis in a simple model of currency substitution. *Journal of Monetary Economics*, 40(1), 185–202.

Valev, N. T. (2010). The hysteresis of currency substitution: Currency risk vs. network externalities. *Journal of International Money and Finance*, 29(2), 224–235.

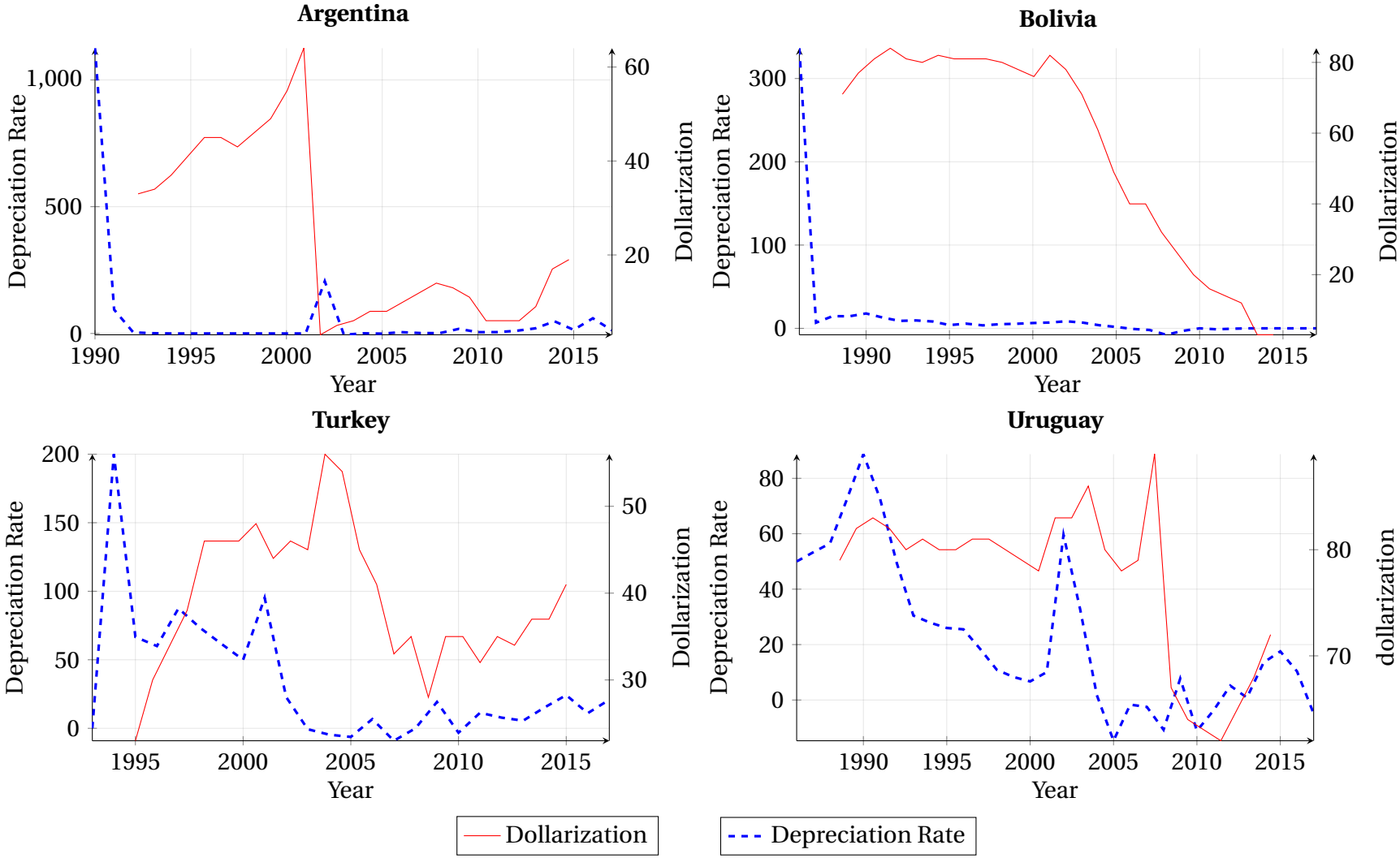
Appendix A

Table A1: Data sources used to construct dollarization in eight selected countries

	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.
Uruguay	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.

Note: dollarization is a ratio of foreign currency deposits to broad money (M2). Data for Cambodia are supplemented by the data from the Ministry of Economy and Finance, Cambodia, where the author Veasna Kheng worked as an economist in 2015.

Figure A2: Depreciation rate and dollarization in Argentina, Bolivia, Turkey and Uruguay



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

Appendix B

The following proof responds to inequality (21). First, rewrite the expression $(F - F_k k)(H - H_q q) - F_q H_k q k$ 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

$$\phi_\theta[\theta_2 - \theta_1] + \phi_k[k_2 - k_1] + \phi_q[q_2 - q_1] > \phi(\theta_2, k_2, q_2) - \phi(\theta_1, k_1, q_1);\ \forall \pi, \tag{B.1}$$

where $k_2 > k_1$ and $q_2 > q_1$ and thus $\theta_2 > \theta_1$ (θ strictly increases in k and q). Adding and subtracting π from the right hand side of inequality (B.1) and applying Equation (8), we obtain:

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

Thus, the inequality (B.1) becomes

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

where $\theta_k = -\phi_k/\phi_\theta$ and $\theta_q = -\phi_q/\phi_\theta$ by applying the implicit theorem on Equation (8). The assumption 2 together with (B.2) yields

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

By setting $k_1 = 0$ and $q_1 = 0$, the inequality (B.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, $H - H_k k^* - H_q q^*$ ■.