# The local FX market and its relation to the real economy

Tarron Khemraj
New College of Florida
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**Abstract**

The paper explores the interconnection between the tradable finite stock of foreign exchange (FTS) in the local FX market and economic growth. A change in market expectation relative to an exchange rate anchor results in shifting the FTS. The model assumes technology growth, growth of physical capital and labour force are dependent on the FTS. It allows for analysing the growth trajectory of remittance and non-remittance receiving economies. The stylized facts indicate a shock to FTS is growth promoting.

**Key Words**: exchange rate anchor, economic growth, remittances, compensation, open economies

## 1. Introduction

It is well known that small open economies and even relatively larger open economies cannot issue their own currencies or sovereign Treasury bills to pay for imports critical to manufacturing and technological accumulation. For example, Jamaica or Guyana cannot pay for a Boeing 737 aircraft, John Deere tractors or Toyota Corollas with their own currencies or Treasury bills. They must first earn foreign exchange by exporting the things they produce or obtain foreign currencies from remittances or capital inflows like foreign direct investments. The Prebisch-Singer hypothesis notes that the terms of trade of primary commodity producers – many of which are small open developing economies – will tend to deteriorate in the very long-term (Harvey et al. 2010; Erten and Ocampo 2013). A. P. Thirlwall has long emphasized that economic growth of small open economies is constrained by the current account of the balance of payments (Thirlwall 2013). This literature, therefore, underscores that in the long run the small open developing economy would need foreign currencies to sustain economic growth. This paper examines how the tradable finite stock of foreign exchange (FTS) constrains long-term economic growth. By situating the analysis in the context of a tradable stock, it places the domestic foreign exchange (FX) at the centre of the analysis.

Other papers examine how foreign exchange availability in the local FX market influences asset holdings of commercial banks, including the expansion of bank loans (Khemraj

2009, Khemraj and Langrin 2011). Given the finite quantity of hard currencies, prudent fiscal policy is also essential for maintaining equilibrium in the domestic FX market (Worrell et al. 2012). An underlying point implicit in the aforementioned papers is the idea that foreign exchange is a scarce resource for small open economies. They are not in abundance even if there is some temporary period of a surfeit, such as a period of commodity price boom. In the long-term commodity prices tend to trend downward (or have zero long-term slope) as recent comprehensive tests of the Prebisch-Singer thesis confirm. In good or bad times, therefore, the small economy needs foreign currencies to import goods and services it cannot produce at home. Therefore, the stock of foreign exchange the country earns is crucial for the process of economic growth. The finite stock is traded in a local market for flexible, fixed and managed float economies.

The contribution of the paper is threefold. First, it explores the mechanism of the local FX market that is subject to demand and supply shocks, often triggered by a change in market expectation. These shocks will either increase or decrease the FTS, thereby influencing economic growth. Second, the paper explores how the FTS is likely to influence economic growth. Third, the effect of central bank target foreign exchange is analysed within the context of the growth model. A recent empirical paper underscores that central banks in small open economies would need to hoard even larger quantities of foreign reserves to stave off exogenous shocks (Moore and Glean 2015).

The paper is organized as follows. Section 2 explains the nature of the local FX market relative to the global one. Section 3 presents a theoretical expectation of the local FX market in which expectation causes the FTS to shift. Section 4 presents a growth model featuring the finite tradable stock. Section 5 provides stylized facts consistent with the model. Section 6 concludes.

## 2. The Domestic FX Market

In each domestic foreign exchange market the US dollar, Euro, Canadian dollar or another global reserve or vehicle currency is traded against the national currency[1]. The markets are localized because there are little or no interconnections across small open economies in terms of money flows. For example, the currency of Guyana is not traded directly against the Jamaican dollar or Ugandan Shilling. This is unlike the interconnectedness of the global FX market where foreign

[1] The main vehicle currency traded in 2013 is the United States dollar, which accounted for 87 percent of all one side trades (BIS 2013).

exchange trades are concentrated in a few financial global centres. As at April 2013, the sales desk in the United Kingdom, United States, Singapore and Japan intermediated 71 percent of foreign currency trades (BIS 2013). The result is a great deal of movement of money among the global centres, thereby creating a global market for the dollar or yen. Triangular arbitrate is much more likely to exist in the global markets. Bi-ask spreads would also be driven to close to zero in the international markets.

In the domestic FX market there is a finite quantity of the specific foreign currency at any moment in time. This finite quantity is traded by commercial banks, cambios and other participants, and a proportion is held by the central bank as official international reserves. A shortage of hard currencies would fuel expectation of a devaluation or depreciation. On the other hand, a surplus could tend to ease sentiments of a depreciation or devaluation in the domestic market. Within any localized foreign exchange market two to four of the global currencies might be traded. There will be a buying and a selling rate for each currency just as in the international centres. However, market makers – in many instances commercial banks – would not always have the quantities of foreign currencies available to make a trade such as taking advantage of cross-rate differentials. Commercial banks are not only obligated to make triangular arbitrage in the home market, but also fulfil the demand requests for foreign exchange from long established customers who need to import goods and services. In many instances, these customers would have borrowed loans in local currency units from the bank. The foreign currency is essential for the business success and loan repayment. In addition, the finite stock of hard currencies in the domestic market will act as a friction preserving the wide bid-ask spread.

Just like in the international market, expectation is crucial in determining shifts in demand and supply. Changes in expectation in the global markets would see a movement of hot monies from one financial centre to another. In the local market expectation would be associated with outflows and inflows of foreign currencies. The inflows depend on export earnings, capital inflows and remittances. The outflows are for importing goods and services, and sending capital overseas. Moreover, we can expect expectation to adjust quicker in the FX market compared with goods markets as noted by Dornbusch (1976). This is because traders – like the commercial banks – are more likely to be attuned to the latest economic events compared with the villager or the factory worker. In other words, the foreign exchange trader would have more information and as a result would more likely act quickly once sufficient quantities of foreign currencies are available to make a trade. In addition, the institutional FX trader would have greater access to foreign currencies if there is need for large trades following major news.

One may ask why the informed institutional traders do not always borrow hard currencies domestically or internationally to take advantage of local cross-rate differentials? First, other domestic banks would face the same constraint having to balance demand request from customers who also have loans in local currency from the said bank. Imperilling the loan portfolio is likely to result in more losses compared with the gains from buying and selling hard currencies. Second, the bank traders would be aware of the inflation pass-through in the case of severe depreciation or devaluation. Inflation would cause the banks – which mainly lend in local currency units – to lose money[2]. Third, such borrowing would increase the volatility in the localized FX market; therefore, making the banks less willing to pursue these trades that can disrupt the business planning of their customers. Therefore, we cannot view the foreign exchange constraint through the lens of the typical borrowing constraint since the availability of foreign currencies in local market is itself a friction.

The changes in expectation would result in a deviation of the perceived exchange rate from the official target rate. In the case of a completely flexible exchange rate system, the rate would adjust seamlessly and the central bank would not care much about it. This is not the case, however, in many instances. As the IMF noted there are 44 economies with a conventional peg, 21 with stabilized arrangement, 2 crawling pegs and 15 countries with crawl-like pegs (IMF 2014). This calls for further understanding of the mechanics of the FX market under an exchange rate target. Exchange rate targeting necessitates that central banks intervene in the FX market either to buy or sell hard currencies. In periods of commodity price booms, strong tourist arrivals and export success, the central bank is able to accumulate ample international reserves. In these periods there is greater likelihood that the target exchange rate would be maintained. However, in times of falling commodity prices or weak tourist arrivals the central bank would find itself losing foreign currency reserves as it attempts to stabilize the exchange rate target.

The central bank intervenes so as to keep market expectation of the exchange rate in line with the target. Positive supply shocks and negative demand shocks would imply expectation of

[2] Of course, this depends on the extent of dollarization and the prevalence of commercial bank lending in domestic and foreign currencies. However, there are fewer dollarized economies versus managed exchange rate economies (IMF 2014).

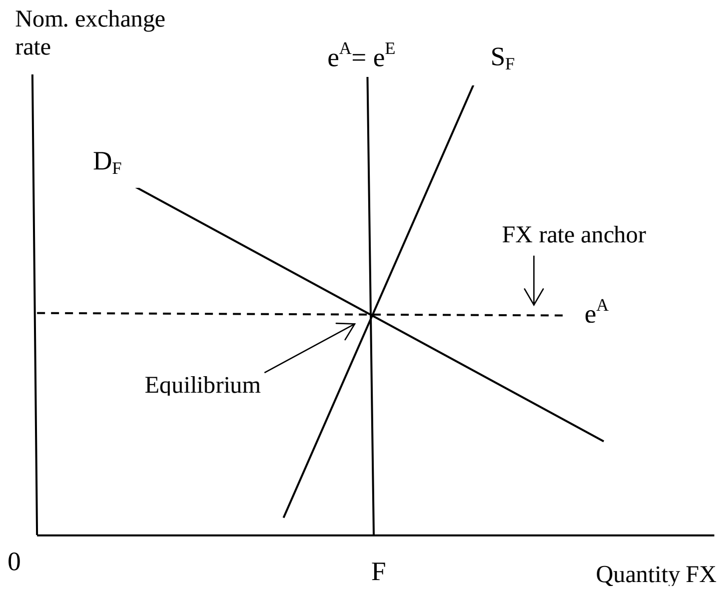
an appreciation of the exchange rate. In these times the monetary authority can accumulate foreign reserves or choose not to. Positive demand shocks and negative supply shocks would imply market expectation of depreciation in the case of a managed float or devaluation for a pegged rate. Here the monetary authority would sell hard currencies into the domestic market to bring expectation back in line with the target. This requires that the monetary authority holds sufficient quantities of hard currencies. The central bank's stock of foreign exchange forms part of the finite quantity available to the small open economy. Therefore, the stock of the finite quantity will change when there is a deviation of market expectation from the target rate in an exchange rate targeting framework. In other words, changes in market expectation will result in a tightening or slackening of the FTS depending on the nature of the shock.

## 3. The Mechanics of the Domestic FX Market

For our purposes, the FTS is defined as a finite stock of foreign currency available to the domestic foreign exchange market at any moment. At this finite quantity the market's expectation of the exchange rate is consistent with the central bank's exchange rate target. We will assume that market expectation is fully adjusted at the finite stock. In other words, at any point on a vertical line the expected exchange rate equals the exchange rate target. In the small open economy the participants in FX market would have access to information that would take some time for the general public to obtain. The quick adjustment of expectation in the FX market implies the central bank has to keep on its toes when defending its exchange rate anchor. In quick time the market will discern a dysfunctional government, excessive monetary growth which finances the fiscal deficit, and dwindling central bank foreign currency reserves. The central bank also needs to hold sufficient reserves so as to inspire confidence that it can defend the fixed exchange rate anchor.

The small open economy produces only a limited number of products and services for exports. It typically does not possess a large manufacturing base with numerous production linkages. The small economy also needs to import capital and intermediate goods for production. Shifts in demand for and supply of foreign exchange will cause expectation to deviate from the target exchange rate. Perhaps these shifts will have symmetric effects on expectation. There is however some evidence that suggest the supply of foreign exchange would be relatively inelastic given that the export supply function is inelastic for small open economies (see Tomarick 2010). This implies that shifts in the foreign exchange demand curve will result in larger deviations of expectation from equilibrium. In other words, there is likely to be asymmetric expectation deviations whereby a shift in the demand curve elicits a larger change in expectation relative to a similar shift in the supply curve. It also implies that devaluation would lead to more demand for foreign exchange than supply, thereby widening the deficit of hard currencies in the local market.

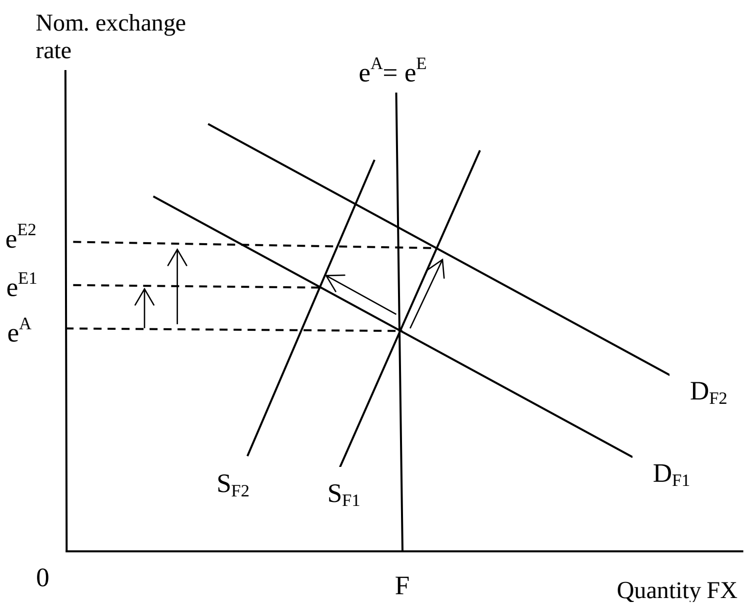
Figure 1 The FX market in equilibrium




The basic idea of the market in equilibrium is illustrated by Figure 1. For the rest of the paper, the nominal exchange rate is quoted as number of units of country *i*'s currency one U.S. dollar buys. So, for example, if $e^A = 3$ it implies a peg of 3 units of local currency per one U.S. dollar. Of course, countries do not only peg against the United States dollar, but we use the said reference currency for the purpose of illustration. On the vertical line expectations are fully adjusted whereby $e^A = e^E$. Here $e^A$= the fixed nominal exchange rate anchor or a crawling target and $e^E$= the market's expected nominal exchange rate. The equilibrium occurs at the intersection of the vertical *F*, the inelastic supply curve and the elastic demand curve. The symbol *F* represents the traded finite stock of foreign exchange. Deviation of $e^E$ from $e^A$ will result from shifts in the supply or demand curves. Such deviations will require the monetary authority to intervene to maintain the target. However, when the central bank intervenes, it is either reducing the FTS (here the central bank is selling FX, thus the country loses foreign currency) or increasing the level of FTS.

Given the inelastic supply response and elastic demand, FX supply shocks have a smaller impact on market expectation versus the same size demand shock. This is demonstrated by Figure 2. An outward shift of the supply curve from $SF_1$ to $SF_2$ causes expectation to deviate from the fixed exchange rate target ($e^{E1} > e^{A}$). However, an exact sized outward shift in demand from $DF_1$ to $DF_2$ results in a larger deviation of market expectation from the anchor such that: $e^{E2} > e^{E1} > e^{A}$. We assume the central bank would respond to these deviations by performing the required foreign exchange market intervention. When the anchor faces a perception threat, $e^{E} > e^{A}$, we expect the monetary authority to sell foreign currencies into the local market. When market perceptions are favourable, $e^{E} < e^{A}$, we expect the central bank can accumulate foreign reserves to meet its required level of import cover.

Figure 2 Asymmetric expectation responses to supply and demand shocks



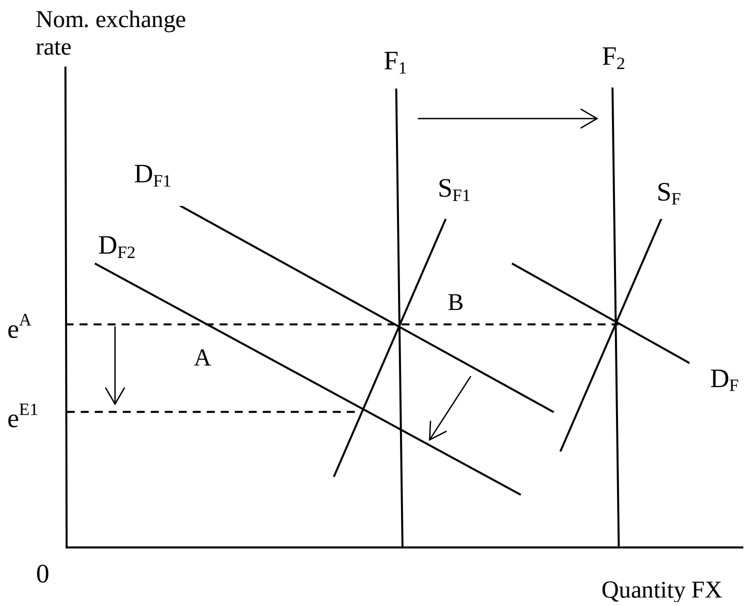

In addition, deviations of market expectation from the exchange rate anchor will result in an adjustment of the stock of finite foreign currency. If $e^{E} > e^{A}$ it signals either a negative supply shock or a positive demand shock. Here the FX market is under pressure and there is rising likelihood the target can come under strain or become less credible. On the other hand, when $e^{E} < e^{A}$ it indicates there is either a positive supply shock or a negative demand shock. Here the FX market pressure is eased as market participants are more likely to have confidence in the fixed target. In general, deviations of expected exchange rate from target will cause the FTS to change position by shifting inward or outward. An inward shift indicates the constraint is more binding or it tightens; while an outward shift indicates a loosening of the constraint. However, the constraint is always there as the market adjusts its expectations given level of foreign currencies in the system.

A more precise definition of the FTS would further illustrate the idea of a shift in the constraint. The FTS is defined as

$$F = FXR - ND \qquad (1)$$

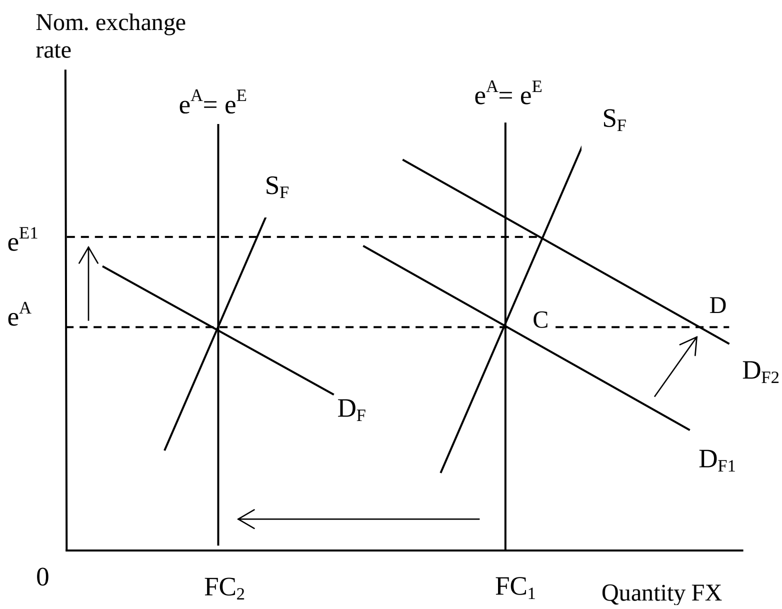
Here *FXR* means the level of central bank foreign exchange reserves and *ND* means the net demand in the market occurring at the exchange rate target. If there is a positive net demand (implying $e^E > e^A$), the constraint declines and shifts inward. This implies a more severe and binding constraint. On the other hand, if there is a negative net demand in the market (implying $e^E < e^A$), the finite stock of hard currencies shifts outward, indicating the constraint is less binding as there is a surplus at the fixed exchange rate anchor.

Figure 3 Negative demand shock and outward shift of finite stock of FX




First, let us examine the case of a negative demand shock as illustrated by Figure 3. Here the demand curve shifts inward from $D_{F1}$ to $D_{F2}$, resulting in a negative net demand (a foreign exchange surplus) of the distance AB along the line representing the exchange rate anchor. Given that $e^{E1} < e^A$ it implies there is less pressure in the FX market. This allows the central bank to accumulate foreign exchange reserves allowing for the target exchange rate to be more credible. Therefore, the constraint will shift outward to $F_2$, and thereby anchoring the short-term supply and demand curves on a higher frontier. Inflation expectations are also fully adjusted along any point on the vertical line $F_2$, as would be the case on $F_1$. The demand curve may shift inward owing to a fall in the price of oil (non-oil producing countries) or macroeconomic stability at home that lessens the demand for capital flight.

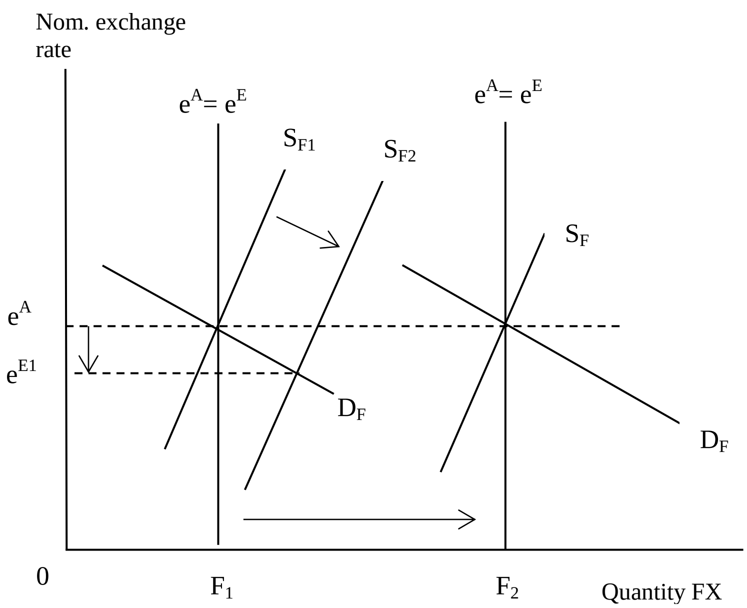
Figure 4 Positive demand shock and inward shift of finite stock of FX




Second, in the case of a positive demand shock, the demand for FX shifts outward from $D_{F1}$ to $D_{F2}$, resulting in a positive net demand (a foreign exchange shortage in the domestic market) equalling the distance CD along the line indicating the target exchange rate. The demand might shift outward owing to an increase in the price of oil (non-oil producers) or uncertainty at home that result in capital flight. This scenario is represented by Figure 4. The shortage of foreign exchange implies market expectation of devaluation is rife; this is indicated by $e^{E1} > e^{A}$. Given the definition equation 1 above, the positive net demand implies the finite stock will decline. If the central bank wants to preserve the target $e^{A}$ it would have to inject foreign currency reserves into the market, possibly until the supply curve shifts to point D, further reducing the stock of foreign exchange available to the economy. The FTS declines shifting inward from $F_1$ to $F_2$. The inward shift occurs along the target exchange rate and it would anchor a new set of FX supply and demand and equilibrium expectations (or possibly along the old supply curve).

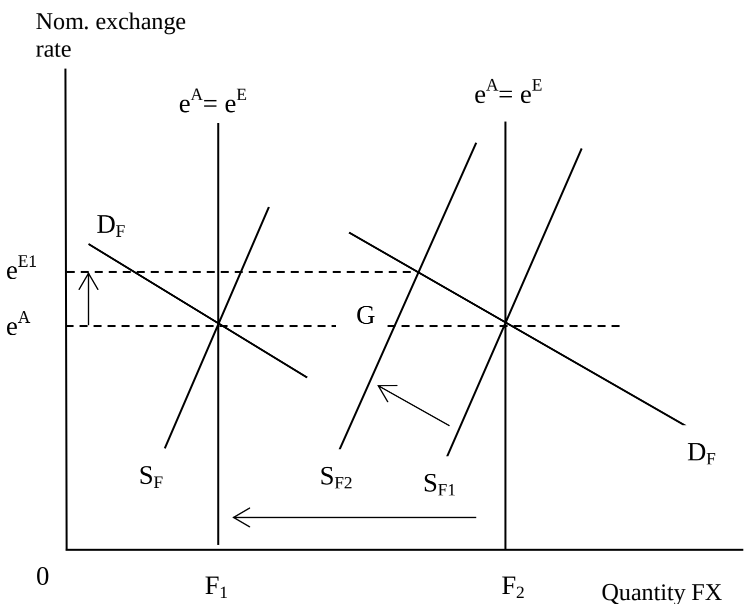
Third, in the case of a positive supply shock, the supply curve shifts outward from $S_{F1}$ to $S_{F2}$, causing a negative net demand (or surplus) at the exchange rate target ($e^A$). The surplus results in an expectation of revaluation instead of devaluation ($e^{E1} < e^A$). The outward shift in supply could result from a commodity price boom or major inflows of foreign capital. The foreign exchange constraint will become less binding and the surplus allows the central bank to accumulate foreign reserves. Both situations – the negative net demand and the central bank's accumulation – take the economy to a higher foreign exchange frontier or a less binding constraint from $F_1$ to $F_2$. The FTS shifts outward, and thereby anchoring a new set of demand and supply curves and expectations (or possibly along the old demand curve). This scenario is summarised in Figure 5.

Figure 5 Positive supply shock and outward shift of FTS




The fourth scenario, shown by Figure 6, is the case of a negative FX supply shock from $S_{F1}$ to $S_{F2}$. The inward shift of foreign exchange could reflect falling export prices or sudden outflow of short-term capital. The negative shock implies there is a positive net demand (a shortage) at the prevailing exchange rate anchor. Therefore, expectation of devaluation will rise causing $e^{E1} > e^A$. The foreign exchange shortage immediately causes the constraint to become more severe. The monetary authority could respond in two ways. First, it can reduce its demand for foreign exchange until the market demand curve shifts inward to point G. Second, it can sell foreign exchange to the market, thereby shifting the supply curve back to $S_{F1}$. In both cases the finite stock has decreased, but less so in the former than latter scenario, as indicated by the inward shift from $F_1$ to $F_2$.

Figure 6 Negative supply shock and inward shift of FTS




**4. The FX Market and Economic Growth**

The debate over whether the financial system leads economic growth or is endogenous to growth of the real sector is an old one in economics (Levine 2005). Prior to the development of endogenous growth theory, the McKinnon and Shaw thesis holds that over regulation associated with financial repression was harmful for economic growth (Fry 1982). Repression implies regulating interest rate below where the market equilibrium would have established, thereby leading to low a rate of savings mobilization, investment and economic growth. It also involves controlling the extension of credit to selected sectors of the economy. Therefore, economic research overwhelmingly supports a market-based system of finance. According to Levine (2005), financial intermediaries and markets can minimize risks associated with moral hazard and adverse selection, pool savings, producing information, and monitor firms and improve corporate governance. However, deregulation associated with financial liberalization could result in (or at least precedes) financial crises and instability that often lead to growth reversals (Kaminsky and Reinhart 1999).

The exchange rate system could adversely impact on long-term economic growth. Schnabl (2008) finds that fixed exchange rate systems for 41 small open economies contributed to faster economic growth. The similar finding was obtained by Vieira et al. (2013) for a larger study of 82 emerging and advanced economies. The results indicate that economic growth is negatively related to exchange rate volatility. The approach of this paper is to examine the impact of the foreign exchange constraint on the growth of aggregate output over time. We have seen in the analysis above that the FTS is related to the exchange rate anchor given expectation in the market.

Let us start the analysis by presenting the canonical Cobb-Douglas aggregate production function for which $\alpha + \beta = 1$.

$$Y = AK^{\alpha}L^{\beta} \tag{2}$$

Taking the log and time derivative allows for expressing the equation in terms of growth rates

$$g_Y = g_A + \alpha g_K + \beta g_L \tag{3}$$

Assume the growth of technology ( $g_A$ ), growth of capital ( $g_K$ ) and growth of labour force ( $g_L$ ) are respectively related to the FTS as follows

$$g_A = g_A^0 + \phi_1(F_t - F^*) \tag{4}$$

$$g_K = g_K^0 + \phi_2(F_t - F^*) \tag{5}$$

$$g_L = g_L^0 - \theta\phi_3 \Delta F_t^2 \tag{6}$$

$F_t$ represents the actual or realized level of the finite stock of foreign exchange in the local market. It represents the sum of the flow of net exports, net capital inflows ( $NI_t$ ), and net capital and remittances ( $CR_t$ ) over time ( $F_t = \sum[(X_t - M_t) + NI_t + CR_t]$ ). The desired or target level of the finite stock is indicated by $F^*$. $F_t$ and $F^*$ are written in upper case letters to underscore that they are levels, while lower case indicate growth rates. The positive parameters $\phi_1$ and $\phi_2$ measure the strength of the effect (the responsiveness) the finite stock – between actual and desired – has on technology and capital growth. In addition, the negative parameter $\phi_3$ also measures the responsiveness of the growth of the labour force given the finite stock of foreign exchange. The parameter $\theta$ indicates the percentage of the finite stock of foreign currencies flowing into the country as remittances in a given year; hence, the labour supply growth is a function of remittances and not the gap (where $0 < \theta < 1$). A parabolic relationship is assumed here to reflect the idea that labour supply growth may eventually decline as the country receives more remittances. This idea is confirmed by several empirical studies (see Kim 2007; Jadottee 2009; Justino and Shemyakina 2012). The symbols $g_A^0$, $g_K^0$ and $g_L^0$ are growth rates of technology, physical capital and the labour force, respectively, not associated with foreign exchange. These are purely driven by domestic conditions – perhaps governance, institutions, geography, labour market conditions, etc. – rather than foreign exchange requirements.

An obvious question is why should capital growth and technology respond to the gap ($F_t - F^*$) while labour responds to the level of remittances? Technology goods and physical capital (machines, power plants, etc.) are largely imports for the small open economy. In this case the gap is important. The targeted finite stock can be seen as the central bank's demand for official international reserves. These quantities are not immediately available to import capital and technology as the central bank obtains them from the locals. Remittances are inflows going directly to labour, who do not receive the gap but a percentage ($\theta$) of the change in the finite stock from one period to the next. The aggregate level of remittance inflow in a single year would equal the summation of individual receipts ($R_j$) of the said year for $N$ persons ($\theta \Delta F_t = \sum_{j=1}^{N} R_j$).

The realized level of the stock of foreign exchange is assumed to follow a random walk with a positive drift. This assumption reflects the fact that central bank foreign exchange reserves for highly open economies typically drift upward over time. Indeed, this behaviour is reflected in the data. The random walk with positive drift and stochastic shock term can be expressed as given by equation 7 (for $|a_2| = 1$). Earlier in the paper we saw that the stock of the finite tradable stock of foreign exchange can shift when there is a change in market expectation. Therefore, we need to include a shock term in the equation of motion for the realized finite stock of foreign exchange.

$$F_t = a_1 + a_2 F_{t-1} + \varepsilon_t \qquad (7)$$

Following Enders (2010) equation 7 has a solution for a given initial value ($F_0$) as

$$F_t = a_1 t + \sum_{i=1}^{t} \varepsilon_{t-i} + F_0 \qquad (8)$$

The parameter $a_1$ measures the constant absolute increase in the finite stock of foreign exchange realized in the local FX market.

The desired or targeted stock of foreign exchange by the central bank is given by the following equation

$$F^* = b_0 + b_1 t - b_2 G^* \qquad (9)$$

Equation 9 could also be interpreted as the monetary authority's reaction function in a managed float or fixed exchange rate economy. A time trend has to be included to indicate that the foreign exchange target will increase over time as GDP and import levels get larger. In other words, the authorities have to maintain a certain amount of import cover. New empirical research indicates that the required level of import cover could be greater than common levels (Moore and Glean 2015). The parameter $b_1$ measures the constant absolute increase of the targeted level of foreign exchange in domestic market. The variable G* indicates the tradeoff on the central bank's balance sheet between desired level of foreign currencies and domestic currency securities such as Treasury bills. The negative coefficient ($-b_2$) is suggestive of monetary sterilization. However, it is much more fundamental than that. When the central bank increases its desired level of foreign exchange over time it takes away from the commercial banks an important profit center since they can buy and sell foreign exchange in the local market and earn profit on the spread. What appears to be sterilization is really the establishment of an alternative opportunity for the commercial banks to make profit in domestic currency instead of foreign exchange securities. This accounts therefore for the tradeoff – as F* increases G* declines on the central bank's balance sheet. Sometimes the tradeoff is seen as an effort by the monetary authority to mop up excess reserves from the banking system. Non-remunerated excess reserves are created when central banks accumulates foreign exchange reserves by paying domestic currency units in the local market. Therefore, a compensating system selling G* is required not only to add a new profit opportunity, but also to mop up zero-interest excess reserves[3].

Substituting equations 4, 5 and 6 into 3 will give

[3] This policy accounts for the buildup of excess liquidity in much of the developing world. Treasury bills are often counted as a liquid asset on the balance sheet of commercial banks. The empirical literature modelling excess liquidity often ignores this possibility.

$$g_Y = (\phi_1 + \alpha\phi_2)(F_t - F^*) - \theta\phi_3 \Delta F_t^2 \quad (10)$$

Further substituting equations 8 and 9 into 10 gives

$$g_Y = (\phi_1 + \alpha\phi_2)(a_1 t + \sum_{i=0}^{t-1} \varepsilon_{t-i} + F_0 - b_0 - b_1 t + b_2 G^*) - \theta\phi_3 (a_1 + \varepsilon_t - \varepsilon_{t-1})^2 \quad (11)$$

Note, from Equation 8 the first difference of the finite tradable stock is

$$\Delta F_t = F_t - F_{t-1} = a_1 t - a_1(t-1) + \varepsilon_t - \varepsilon_{t-1} = a_1 + \varepsilon_t - \varepsilon_{t-1}$$

Equation 11 allows for obtaining the partial effect on growth given a shock to the FTS and central bank compensating effect. Moreover, this is the crucial equation allowing for analysing growth given our focus on the localized FX market. Note that equation 11 was obtained by assuming that $g_A^0 = g_K^0 = g_L^0 = 0$, which allows us to focus only on the relationship between the FX market and economic growth. In addition, we can take the derivative with respect to time to analyse the evolution of aggregate output growth.

A positive shock in the FTS will have the following effect.

$$\partial g_Y / \partial \varepsilon_t = \phi + \alpha\phi_2 - 2\theta\phi_3 (a_1 + \varepsilon_t - \varepsilon_{t-1}) \quad (12)$$

Note, for $\theta = 0$ a positive shock has a positive effect on growth and vice versa: $\partial g_Y / \partial \varepsilon_t = \phi + \alpha\phi_2 > 0$. This implies the foreign currency shock has a permanent positive non-decaying effect on aggregate output growth for non-remittance receiving economies. The overall effect dependents on the size of the positive parameters $\phi_1$ and $\phi_2$ and the capital share $\alpha$. However, when $0 < \theta < 1$ the effect of a positive shock is a function of the fixed parameters and the moving average term ($\varepsilon_t - \varepsilon_{t-1}$). In other words, a shock to FTS has a response in economic growth that follows an MA (1) process for a remittance receiving economy.

Central bank monetary compensation is expected to have a positive non-decaying effect on growth of aggregate output, according to the model.

$$\partial g_Y / \partial G^* = (\phi_1 + \alpha\phi_2) b_2 > 0 \quad (13)$$

In this instance the effect depends on the composite of the parameters $\phi_1$ and $\phi_2$, the capital share $\alpha$ and the size of the parameter $b_2$. As noted above, $b_2$ is often interpreted as the sterilization coefficient with values between 0 to -1. However, if compensation is required for maintaining a stable FX market we could see $b_2$ exceeding -1. The model is predicting that compensation has a long-term positive non-decaying effect on economic growth.

This model has a novel feature in that it allows for deriving an explicit, yet intuitive, expression for the change in aggregate output growth over time. The partial derivative is expressed as

$$\partial g_Y / \partial t = (\phi_1 + \alpha\phi_2)(a_1 - b_1) \tag{14}$$

Equation 14 suggests over time the growth rate is a function of the parameters $\phi_1$ and $\phi_2$, the capital share $\alpha$ and the difference $a_1 - b_1$. The crucial point emanating from equation 14 is the idea that the monetary authority has to make sure its long-term target absolute increase of foreign exchange has to be greater than the actual absolute increase of the stock of foreign exchange in the economy ($a_1 > b_1$). This is the only way to maintain positive long-term growth from foreign exchange requirements over time. If $a_1 = b_1$ the FTS does not determine economic growth. If $a_1 < b_1$ then the long-term growth is negative. This equation indicates that over time economic growth is constrained by the FTS.

**5. Stylized Facts**

An important feature of the model is the idea that a positive shock to the finite stock is associated with a positive effect on economic growth. This hypothesis can be tested using conventional econometric tools. This requires estimating the shocks to FTS. Ideally we should measure the stock of foreign exchange using the total volume purchased in the domestic market. This data set is not available for a large number of countries for a long enough period to estimate an effect on GDP growth. Therefore, the level of international reserves (in US dollars + gold) is used as a proxy for the stock of foreign exchange. This series goes back to the 1960s, thereby providing a long enough time for testing the hypothesis. The following empirical model is estimated

$$\log F_t = \alpha_0 + \alpha_1 \log F_{t-1} + \alpha_3 t + \eta_t \tag{15}$$

The shock term is $\eta_t$ and it is expected to be a stationary time series. Moreover, it is randomly distributed. Equation 15 can be seen as the empirical version of equation 7, which we have noted has a time trend in its solution. Estimating equation 15 allows for extracting the foreign exchange shock.

Table 1 Estimates of equation 15

| Dependent variable: logF(t) | | | | | |
|---|---|---|---|---|---|
| | logF (t - 1) | Trend | GDP growth Unit Root H0: No unit root | Int. Reserves Unit Root H0: No unit root | Time Period |
| Antigua and Barbuda | 0.56, t-stat = 4.49* | 0.39, t-stat = 3.34* | t-stat= −3.31* | t-stat = −6.05* | 1979-2013 |
| The Bahamas | 0.63, t-stat = 5.29* | 0.029, t-stat = 2.69** | t-stat= −3.31* | t-stat = −6.05* | 1965-2013 |
| Bangladesh | 0.59, t-stat = 4.35* | 0.047, t-stat = 3.09* | t-stat= −1.75 | t-stat = −5.28* | 1972-2013 |
| Barbados | 0.79, t-stat = 9.58* | 0.017, t-stat = 2.7** | t-stat= −3.67* | t-stat = −7.99* | 1965-2013 |
| Belize | 0.69, t-stat = 6.5* | 0.029, t-stat = 2.79** | t-stat= −4.2* | t-stat = −4.56* | 1977-2013 |
| Botswana | 0.80, t-stat = 9.6* | 0.056, t-stat = 1.52 | t-stat= −3.18* | t-stat = −4.03* | 1977-2013 |
| Chile | 0.87, t-stat = 13.59* | 0.013, t-stat = 1.74*** | t-stat= −4.25* | t-stat = −5.79* | 1965-2013 |
| Colombia | 0.89, t-stat = 10.6* | 0.08, t-stat = 1.7 | t-stat= −4.65* | t-stat = −3.21** | 1965-2013 |
| Costa Rica | 0.77, t-stat = 11.6* | 0.026, t-stat = 3.2* | t-stat= −4.61* | t-stat = −7.45* | 1965-2013 |
| Dominican Republic | 0.58, t-stat = 4.64* | 0.039, t-stat = 3.22* | t-stat= −8.49* | t-stat = −7.67* | 1965-2013 |
| Fiji | 0.79, t-stat = 8.84* | 0.012, t-stat = 2.17** | t-stat= −8.49* | t-stat = −7.67* | 1965-2013 |
| Grenada | o.51, t-stat = 3.15* | 0.041, t-stat = 3.22* | t-stat= −5.35* | t-stat = −2.78* | 1978-2013 |
| Guyana | 0.85, t-stat = 9.93* | 0.017, t-stat = 2.1** | t-stat= −4.22* | t-stat = −6.6* | 1965-2013 |
| Indonesia | 0.79, t-stat = 7.2* | 0.03, t-stat = 1.68*** | t-stat= −5.0* | t-stat = −9.1* | 1965-2013 |
| Jamaica | 0.77, t-stat = 11.1* | 0.019, t-stat = 2.35** | t-stat= −5.27* | t-stat = −7.37* | 1965-2013 |
| Kenya | 0.72, t-stat = 5.7* | 0.02, t-stat = 2.02** | t-stat= −6.26* | t-stat = −5.9* | 1965-2013 |
| Malawi | 0.42, t-stat = 4.79* | 0.03, t-stat = 6.02* | t-stat= −7.67* | t-stat = −6.39* | 1965-2013 |
| Mauritius | 0.80, t-stat = 8.44* | 0.021, t-stat = 1.98*** | t-stat= −5.49* | t-stat = −5.38* | 1977-2013 |
| Nigeria | 0.79, t-stat = 15.4* | 0.02, t-stat = 2.45** | t-stat= −4.96* | t-stat = −5.6* | 1965-2013 |
| Philippines | 0.81, t-stat = 10.7* | 0.022, t-stat = 2.22** | t-stat= −3.87* | t-stat = −5.12* | 1965-2013 |
| South Africa | 0.81, t-stat = 11.9* | 0.014, t-stat = 2.43** | t-stat= −5.03* | t-stat = −6.6* | 1965-2013 |
| Sri Lanka | 0.72, t-stat = 10.5* | 0.032, t-stat = 3.95* | t-stat= −5.45* | t-stat = −5.36* | 1965-2013 |
| St Kitts and Nevis | 0.69, t-stat = 5.14* | 0.039, t-stat = 2.25** | t-stat= −7.05* | t-stat = −5.68* | 1981-2013 |
| St Lucia | 0.83, t-stat = 7.68* | 0.011, t-stat = 1.26 | t-stat= −3.46* | t-stat= −5.76* | 1981-2013 |
| Suriname | 0.91, t-stat = 13.5* | 0.056, t-stat = 1.07 | t-stat= −4.67* | t-stat = −5.36* | 1976-2013 |
| Thailand | 0.87, t-stat = 10.70* | 0.016, t-stat = 1.75*** | t-stat= −4.29* | t-stat = −3.80* | 1966-2013 |
| Trinidad and Tobago | 0.92, t-stat = 17.0* | 0.064, t-stat = 3.46* | t-stat= −3.43* | t-stat = −4.86* | 1965-2013 |
| Uganda | 0.64, t-stat = 3.61* | 0.07, t-stat = 2.83* | t-stat= −3.05* | t-stat = −4.6* | 1965-2013 |
| * significance at 1%, ** significance at 5%, *** significance at 10% | | | | | |

Table 1 also reports the unit test for GDP growth and the shock. We want both series to be stationary since they enter an ARDL model in the second stage of estimation. The Augmented Dickey-Fuller (ADF) test results suggest both series for the economies are stationary. The lag structure of the ADF equation was selected using the AIC. The model was estimated for only a constant as we do not expect GDP growth or FTS shock to exhibit a permanent upward or downward trend (unlike the level of GDP and level of FX reserves). The table also indicates the coefficient (and accompanying robust t-statistics) for the lagged dependent variable ($F_{t-1}$) and linear trend. The lagged dependent variable is overwhelmingly significant while the trend term is mainly statistically significant with a few exceptions. A chart of the level of foreign exchange reveals (not reported in this paper) a persistent long-term upward trend over the period of analysis. This tendency is consistent with the idea that central banks must maintain an adequate level of foreign currency reserves over time.

Table 2 estimates a bivariate ARDL model in which GDP growth is the dependent variable and foreign exchange shock is the independent variable. We are interested in the long run coefficient estimate of the effect of shock on growth. As noted earlier, we expect a positive long run coefficient between these two variables. The variables are stationary as indicated in Table 1; therefore, there is no need to test for co-integration using the bounds testing method. However, the lagged dependent variable inherent in the ARDL model could result in inconsistent long run coefficient estimates in the presence of residual serial correlation. Table 2, therefore, reports the Lagrange multiplier test for serial correlation for up to 4 years lag. Only for the case of Suriname was the F-statistic large enough to exceed the 10 percent level of significance. Overall, the test for serial correlation could not reject the null hypothesis of serial correlations. Moreover, the overall absence of serial correlation suggests the bivariate ARDL model is not susceptible to omitted variable bias.

The first point to observe about the long run coefficient is they are generally economically significant, except for Barbados and Bangladesh (negative long run coefficient). Economic significance is indicated by a positive long run coefficient, thus being consistent with the theoretical framework presented in the previous section. The coefficient for most of the countries (20 cases out of 28) is statistically significant for at least at the 10% level of significance. Six coefficients are economically significant but statically insignificant, while two economies possessing both economically and statistically insignificant coefficient.

Table 2 Foreign exchange shock and economic growth – ARDL estimates

| | Long Run Coefficient | LM Serial Correlation Test - 4 lags H0: No Serial Corr. | Model | Time Period |
|---|---|---|---|---|
| Antigua and Barbuda | 6.15, t-stat = 0.91 | F-stat = 0.53 | ARDL (1, 0) | 1979-2013 |
| The Bahamas | 6.15, t-stat = 2.7** | F-stat = 0.80 | ARDL (1, 0) | 1965-2013 |
| Bangladesh | −0.09, t-stat = −0.25 | F-stat = 10.8 | ARDL (2, 0) | 1972-2013 |
| Barbados | −1.73, t-stat = −0.24 | F-stat = 1.06 | ARDL (1, 0) | 1965-2013 |
| Belize | 9.91, t-stat = 2.81* | F-stat = 0.4 | ARDL (1, 0) | 1977-2013 |
| Botswana | 7.16, t. stat = 1.78*** | F-stat = 0.51 | ARDL (1, 0) | 1977-2013 |
| Chile | 13.95, t-stat = 2.81* | F-stat = 0.72 | ARDL (1, 1) | 1965-2013 |
| Colombia | 2.68, t-stat = 2.24** | F-stat = 0.52 | ARDL (1, 0) | 1965-2013 |
| Costa Rica | 10.16, t-stat = 1.81*** | F-stat = 1.07 | ARDL (1, 1) | 1965-2013 |
| Dominican Republic | 2.97, t-stat = 1.1 | F-stat = 0.81 | ARDL (1, 2) | 1965-2013 |
| Fiji | 1.15, t-stat = 0.78 | F-stat = 1.24 | ARDL (1, 0) | 1965-2013 |
| Grenada | 7.56, t-stat = 1.89*** | F-stat = 0.51 | ARDL (1, 1) | 1978-2013 |
| Guyana | 12.68, t-stat = 4.88* | F-stat = 1.68 | ARDL (1, 3) | 1965-2013 |
| Indonesia | 3.39, t-stat = 5.14* | F-stat = 0.13 | ARDL (1, 0) | 1965-2013 |
| Jamaica | 4.99, t-stat = 1.38 | F-stat = 0.49 | ARDL (2, 1) | 1965-2013 |
| Kenya | 8.03, t-stat = 4.09* | F-stat = 0.68 | ARDL (1, 0) | 1965-2013 |
| Malawi | 3.65, t-stat = 2.69* | F-stat = 0.68 | ARDL (1, 0) | 1965-2013 |
| Mauritius | 2.4, t-stat = 1.44 | F-stat = 0.17 | ARDL (1, 1) | 1977-2013 |
| Nigeria | 7.65, t-stat = 3.42* | F-stat = 1.16 | ARDL (1, 0) | 1965-2013 |
| Philippines | 12.76, t-stat = 2.68* | F-stat = 0.65 | ARDL (1, 3) | 1965-2013 |
| South Africa | 4.62, t-stat = 3.02* | F-stat = 3.02 | ARDL (1, 1) | 1965-2013 |
| Sri Lanka | 3.0, t-stat = 2.22** | F-stat = 0.42 | ARDL (1, 1) | 1965-2013 |
| St Kitts and Nevis | 13.9, t-stat = 2.25** | F-stat = 0.43 | ARDL (1, 0) | 1981-2013 |
| St Lucia | 19.73, t = 3.06* | F-stat = 1.14 | ARDL (2, 0) | 1981-2013 |
| Suriname | 6.15, t = 1.3 | F-stat = 2.48*** | ARDL (1, 0) | 1976-2013 |
| Thailand | 10.92, t-stat = 1.71*** | F-stat = 0.21 | ARDL (1, 2) | 1966-2013 |
| Trinidad and Tobago | 6.17, t-stat = 2.53** | F-stat = 1.32 | ARDL (1, 0) | 1965-2013 |
| Uganda | 3.25, t = 2.79* | F-stat = 0.32 | ARDL (1, 0) | 1965-2013 |

* significance at 1%, ** significance at 5%, *** significance at 10%

## 6. Conclusion

The paper presents a growth model in which long-term positive economic growth depends on whether the monetary authorities can maintain a targeted absolute increase of the finite stock of foreign exchange (the long-term constraint) that is greater than the realized absolute increase of foreign exchange stock in the local market. Shocks to the FTS result from changing expectations in the domestic FX market. The expectations are pinned down by the exchange rate anchor which varies from a fixed exchange rate to a managed float. The model further suggests that favourable shocks, resulting in an increase in the finite traded stock of foreign currency, have a permanent positive effect on economic growth. A negative shock will exert the opposite permanent negative effect on economic growth, according to the model. This result is consistent with the stylized facts presented. It was noted that conventional sterilization may actually be a situation whereby the central bank maintains a compensating system supplying domestic currency liquid assets to commercial banks given the foreign exchange constraint. In this case the central bank has a compensating reaction function. The theoretical derivation indicates that the compensating sales of liquid assets result in a positive effect on long-term economic growth in an FX constrained small open economy.

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