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The Real Exchange Rate Policy Trilemma in Developing Economies

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Abstract

This paper discusses some of the inter-temporal issues that arise in the pursuit of real undervaluation to achieve rapid development. Policy makers face a trade-off between achieving a capital stock target in a given amount of time on the one hand and boosting real wages and output in the short run, on the other. This generates a trilemma whereby development-focused policy makers can choose to pursue two out of three desirables: (1) use the real exchange rate as an instrument of development policy, (2) meet the development target within a politically relevant time frame, and (3) maintain political stability. The optimal path under a policy with "unambitious" aims will resemble the typical electoral business cycle trajectory whereby policy makers maintain real overvaluation over much of the cycle. By contrast, achieving relatively ambitious capital stock targets within a relatively short time requires the potentially unpopular strategy of choosing a highly undervalued real exchange rate at the beginning of the planning horizon and gradually *increasing* the degree of undervaluation thereafter as wages rise. Relevant structural differences between countries imply different initial levels of real undervaluation, distinct optimal trajectories over time, and hence, varying degrees of political trade-offs.

Keywords: Real exchange rate, development, political business cycles, optimal policy, capital accumulation.

JEL codes: O11, O25, F43,

1 Introduction

Several recent studies have shown the benefits of real exchange rate undervaluation in developing economies. Periods of sustained output growth and capital accumulation tend, on average, to be associated with real undervaluation. While the jury is still out regarding the relative importance of the underlying mechanisms that lead from undervaluation to growth, the finding raises another highly pertinent question. Insofar as policymakers have some influence over the real exchange rate, what prevents them from pursuing undervaluation in a sustained fashion? In this paper I explore, in a simple manner, interesting labor market issues that arise naturally when intertemporal considerations are incorporated into the execution of real exchange rate policies. My analysis identifies a trilemma whereby development-oriented policy makers are forced to choose two out of three policy goals: (1) successfully pursue an ambitious capital stock/employment target through real exchange rate policy, (2) achieve the target within a given time horizon (possibly dictated by elections), and (3) maintain the real exchange rate within a range that avoids political disruption and conflict. The investigation here contributes to two bodies of literature, one that studies the effect of sustained real exchange rate movements on growth and another that explores the political economy of exchange rate management.

Like most economic policy choices, real exchange rate/monetary policies create winners and losers and potentially generates tensions between short-run versus long-run consequences. Take first the evidence on long-term benefits suggested by recent empirical studies. Based on a panel study involving 188 countries and the time period 1950-2004, Rodrik [2008] finds that real exchange rate undervaluations are positively associated with better growth performance. This effect is particularly significant and robust for developing countries. Razmi et al. [2012], who analyze the relationship between real undervaluation and investment – based on a similarly large panel dataset – find a robust positive association, which again is statistically significant only for developing countries. Unlike the Rodrik model, which hypothesizes the presence of market imperfections to a greater degree in the non-tradable sectors of developing economies, the latter study develops a theoretical model where the presence of underemployment in developing countries plays a key role in explaining the main empirical finding.[1] Other evidence suggests that *sustained* episodes of accelerated investment and growth are often preceded by real undervaluations.[2] To the extent that either less than full employment and/or external economies of scale create room for endogenous growth, a well thought out real exchange rate policy could help accelerate movement towards industrialization.

For real exchange rate policy to serve as a development policy tool, it appears crucial that the relative price signal be stable and reliable. Given its size and topical importance, China presents a pertinent case study here. There has been significant debate in recent years about whether or not China has passed the "Lewis" turning point.[3] What is much less controversial is the presence of a large pool of underemployed labor, especially in the rural and semi-urban areas, on the eve of the economic reforms that took off in earnest in the early 1980s: a pool that is now considerably smaller after years of rapid capital accumulation and industrialization. Figure 1 below displays the time plots of real exchange rate misalignment, $Misalignment1$ and changes in the (log) of the level of capital stock per person, $GROWTH\_KL$ for the period 1973-2014. The former series, sourced from

[1] Other studies that have found a positive effect of real undervaluation on long-run growth include Levy-Yeyati and Sturzenegger [2007], Polterovich and Popov [2002], Berg et al. [2008], and Gala [2008] among others.

[2] See for Hausmann et al. [2005], Libman et al. [2017], and Freund and Pierola [2008] for investigations of growth, investment, and export surges, respectively.

[3] See, for example, Meiyan [2010] and Minami and Ma [2010].

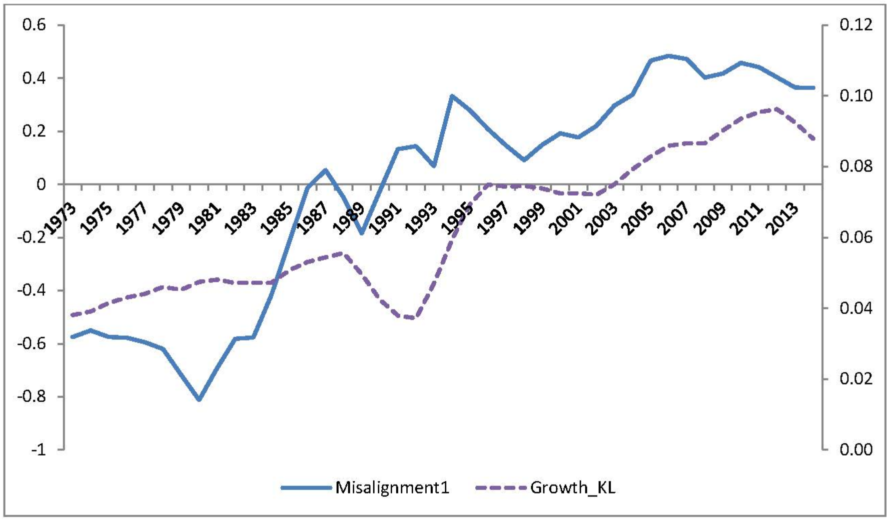

Figure 1: China: Exchange rate misalignment, *Misalignment1* (left scale) and change in capital stock per person, *Growth_KL* (right scale), 1973-2014. Sources: *CEPII EQCHANGE* and *Penn World Table*, 9.0, respectively.

the recently developed CEPII *EQCHANGE* database,[4] shows deviation of the real exchange rate from a level calculated after adjusting for the Balassa-Samuelson effect. The latter is calculated from the capital stock data provided by the *Penn World Table 9.0* database.[5]

Figure 1 illuminates something striking; ignoring the brief dip in the late 1980's, the significant and sustained increase in growth of capital stock per person that began in the late 1970's is closely shadowed by a sustained increase in the misalignment index (from an overvaluation of nearly 8 percent to an undervaluation of nearly 10 percent). While China is an illustrative case, existing literature has highlighted the significance of sustained devaluations in other contexts.

Assuming then that policy makers are aware of the benefits of stable and undervalued exchange rates, and are generally well-intentioned, what inhibits successful implementation of enabling macroeconomic policies? Several factors come to mind including the credibility of policy, fear of inflation, balance sheet effects, limited ability to control the real exchange rate, and a desire for greater monetary policy autonomy, among others. As pointed out by Rapetti [2012] and Dornbusch [1996] in the Latin American context, political economic considerations assume increased salience here. For example, part of the reason why policy makers cannot sustain real undervaluations surely has to do with distributional concerns. In the presence of nominal rigidities, large devaluations are

[4]This series is based on time-varying weights constructed using 186 trading parters and 5 year averages. See Couharde et al. [2017] for details. A second broader series, based in addition to the Balassa-Samuelson effect, on terms of trade and net foreign asset data, yields a very similar picture but is available beginning only in 1981. The figure shows the negative of the values in the database so as to make upward movements correspond to real depreciations rendering them consistent with the way I define the real exchange rate in this paper.

[5]See Feenstra et al. [2015] for a description. Consistent with the real exchange rate variable, the numbers are 5 year (geometric) averages, i.e., individual points represent averages for five-year windows, using the expression, $GROWTH\_KL = (kl_{t+5} - kl_t)^{0.2} - 1$.

likely to reduce the purchasing power of wages in terms of tradables.[6] This, in turn, may limit the options that policy makers can pursue, especially since, as Edwards [1996] observes, the "political ramifications of a major economic disturbance, such as the abandonment of a promised parity, will tend to be more pronounced in countries with a higher degree of structural political instability."[7] Distributional consequences of relative price changes are likely to be a factor limiting the use of real exchange rate policy in the service of capital accumulation.

Weak substitution effects on the supply and demand sides, at least in the short run, create an additional headache for policy makers seeking to employ price signals to confront short-run cyclical issues. The failure to change economic behavior rapidly implies that devaluations could have contractionary effects on output and employment on impact.[8] Indeed, the temptation to appreciate the real exchange rate for short-run gains may be rather strong in these circumstances.

In sum, numerous hurdles complicate the use of the real exchange rate as an instrument of long-run development policy. Most importantly from the perspective of this paper, these complications often involve intertemporal trade-offs in the labor market. As argued below, this often forces policy makers to choose between rapid development/industrialization and political stability.

This paper utilizes a simple optimal control framework to examine some of the political economy challenges posed by the use of the real exchange rate as a development policy tool. The model employs a"dependent economy" framework, enabling me to incorporate trade-offs between capital accumulation and tradable sector employment on the one hand, and real wages and non-tradable employment on the other. Seen from another angle, the model analyzes the intertemporal balancing act between the short- and longer runs that many policy makers face. The analysis suggests that ambitious capital stock targets imply an initial undervaluation followed by continuous and increasing undervaluation as wages rise along the optimal path. The greater the wage sensitivity to falling underemployment, the smaller the set of feasible capital stock targets. The shorter the amount of time available to reach the target, the greater the initial undervaluation required. Changes in policy preferences and structural parameters change the path and nature of exchange rate policy. For example, a stronger positive effect of capital accumulation on economy-wide employment will raise the optimal initial level of the real exchange rate and reduce the further depreciation required along the trajectory to the capital stock target. Large short-run contractionary effects of devaluations, by way of contrast, will lower the optimal initial undervaluation, but increase the pace of further undervaluation required, culminating in a lower real wage at the end of the day.

By now, a substantial body of literature has emerged that explores the political economy of exchange rate policy. However, unlike the present paper, this literature mostly focuses on issues of exchange rate regime choice, international and national coordination, and short-run issues such as those pertaining to business and electoral cycles.[9] I contribute to the literature by zooming

[6] A more subtle effect is detected by Cravino and Levchenko [2015], who find that devaluations in Mexico raise the price of tradables consumed by poorer households more than those consumed by rich households.

[7] See Alesina and Perotti [1996] for evidence regarding the negative impact of inequality-fueled instability on investment.

[8] See, for example, Krugman and Taylor [1978] for a formalized presentation of the contractionary devaluation argument initially made by Diaz-Alejandro [1963]. Lizondo and Montiel [1989] provide an extended overview.

[9] Klein and Marion [1997] investigate the durations of exchange rate pegs when policy makers weigh the political costs of correcting misalignments against the economic benefits of doing so. Dornbusch [1996] considers the political factors that prevent authorities from correcting overvaluations even when the path to currency crises becomes increasingly clear. Leblang [1999] explore the connections between the nature of the political system and the choice of exchange rate regime, while Stein and Streb [2004] consider the timing of devaluations relative to the election cycle. Frieden et al. [2001] is an example of the body of papers that conclude that governments tend to maintain appreciated exchange rates up until after the elections in order to keep purchasing power high. See Frieden and Broz

in narrowly on labor market trade-offs and long-run growth issues in the context of a developing economy with significant un(der) employment.[10] The implied time path of the real exchange rate, as a result, differs sharply from the former body of literature. For sufficiently short planning horizons and relatively unambitious capital stock targets, however, I show that the optimal trajectory emerging from the present set-up resembles that of the electoral cycle literature.

Before I conclude this section, it may be pertinent to make a couple of observations about the nature of real depreciations. As noted by Cooper [1971](p. 3) in his classic study of large exchange rate changes in developing countries, devaluations are "one of the most dramatic – even traumatic – measures of economic policy that a government may undertake."[11] The policy analyzed here, by contrast, is in the nature of a controlled, forethought path of the real exchange rate. It is assumed that the monetary authorities have sufficient reserves to defend any preferred level of the nominal exchange rate. My assumption of continuously balanced trade ensures that capital account problems do not force the authorities' hand. Large devaluations at any given point in time originate from calculated measures rather than from panic in the face of sudden stops, financial contagion, or terms of trade shocks.

On a final note, one would be remiss in not (briefly) addressing the elephant in the room: can authorities typically influence the path of the real exchange rate over time? The textbook answer depends, of course, on various factors such as the degree of capital account openness, the monetary/exchange rate regime, and the secular stance of fiscal policy. Much of the recent microfounded macroeconomic theory has seen the real exchange rate as an endogenous variable, its value being determined in a general equilibrium set-up by 'deeper' parameters such as preferences, factor endowments, and productivity. Empirical literature indicates, however, that the real exchange rate tracks the nominal exchange rate rather closely over time which, in turn, suggests that controlling the latter may effectively influence the former as well. Governments have a variety of policy options including monetary and fiscal policy, capital controls, saving incentives, and foreign exchange reserve management, and the evidence suggests that at least some governments have successfully employed these instruments to influence real exchange rates.[12] Indeed, as the discussion above and the analysis below suggests, the degree to which policy can influence the real exchange rate in a developing economy may itself be a function of the intertemporal dilemmas involved. In any event, my approach here is to explore the path of optimal policy *if* policy makers could implement it when faced with intertemporal labor market trade-offs. This implicitly requires some kind of societal consensus about assignment of policy weights if disruptive social conflict is to be avoided.

The next section develops the basic framework and investigates its properties. Section 3 carries out comparative dynamic thought experiments employing a simplified linear version of the framework. Section 4 concludes.

[2006] for a survey of the literature on the political economy of exchange rate regimes and polices.

[10] One interesting contrast between the present paper and the electoral cycle literature is that the latter often assumes a positive discount rate, that is, future values of the variables of interest get more weight (since they lie closer in time to the next elections). My long-run developmental focus here implies the opposite assumption.

[11] Steinberg and Malhotra [2014] calculate that, between 1973-2006, military dictators lost power during 17 percent of their forty-eight devaluation episodes and democratic leaders did so in 38 percent of their seventy-nine devaluations.

[12] See, for example, the "fear of floating" literature originating with Calvo and Reinhart [2002], who showed that, following the Asian crises, developing countries have systematically intervened in the foreign exchange market to manage the behavior of exchange rates. See also Guzman et al. [2017] for a discussion of the various options available to policy makers to influence the real exchange rate.

2 Formal Setup and Simple Analytics

This section develops the formal framework and highlights some of its implications.

2.1 The setting

The formal set-up here consists of a small open economy that produces a tradable good and a non-tradable one. The two are represented by the subscripts T and N when associated with the relevant variables. The foreign currency price of the tradable good is determined in the world market exogenously to the small economy and we assume it to be fixed at 1. The framework incorporates an independent investment function, non-tradable output that is determined by demand, and contractionary devaluations in the short-run.

Our focus is on political economic considerations in the labor market. Specifically, policy makers have a capital stock target. Worker preferences dictate that some sort of societal consensus be developed on how to achieve the target while balancing labor market considerations. The policy makers, therefore, have an objective function that assigns weights ϕ_1, ϕ_2, and ϕ_3 respectively, to: (1) the real wage in terms of tradables, i.e., the real wage in terms of non-tradables (w) divided by the real exchange rate (q), (2) non-tradable sector employment (L_N), and (3) tradable sector employment (L_T). The real exchange rate here is defined as the price of tradables relative to non-tradables ($q = eP_T/P_N = e/P_N$). Denoting the discount factor by ρ, the policy makers are, therefore, interested in executing a real exchange rate profile that maximizes

$$\max_q \int_0^T \left[\phi_1 \ln\left(\frac{w}{q}\right) + \phi_2 \ln(L_N) + \phi_3 \ln(L_T)\right] e^{-\rho t} dt \tag{1}$$

subject to a constraint that is yet to be defined. Tradable output, Y_T , is limited by the level of the capital stock through a Leontief technology function.

$$Y_T = \min\left(K, \frac{L_T}{a}\right) \tag{2}$$

where K is the level of the capital stock in the tradable sector and a denotes the unit labor coefficient (i.e., the reciprocal of average and marginal labor productivity). Since labor is the only factor of production in the non-tradable sector, and we simplify by ignoring the extraction of rents from a fixed factor of production (i.e., land), therefore, by definition:

$$Y_N = wL_N \tag{3}$$

The wage function is strictly increasing and convex in K. Capital accumulation increases demand for labor, and hence puts upward pressure on wages. The intensity of this pressure increases as the pool of underemployed/unemployed labor shrinks.

$$w = w(K);\ w', w'' > 0 \tag{4}$$

As shown in the Appendix, the convexity of the wage function also helps satisfy the Mangasarian sufficient conditions for a global optimum. Ignoring capital depreciation, the differential equation governing the evolution of the capital stock is specified as:

$$\dot{K} = g(r - \overline{r})K; \; g' > 0, g'' = 0 \tag{5}$$

where $\overline{r}$ is the minimum level of the profit rate below which investment turns negative, $g(0) = 0$, $g' > 0$, and $g'' = 0$, and dots over variables denote time derivatives. The assumed linearity of the investment function with respect to profit rate differentials simplifies the analysis considerably. The capital goods are internationally tradable.

$$r = \frac{eY_T - WaK}{eK} = 1 - \frac{wa}{q} \tag{6}$$

The non-tradable market-clearing condition is simply given by:

$$Y_N = C_N \tag{7}$$

Substituting from equation (3):

$$wL_N = C_N \tag{8}$$

With trade assumed to be continuously balanced, consumption of tradables is simply the difference between tradable output and investment.

$$C_T = Y_T - \dot{K} \tag{9}$$

The assumption of balanced trade is admittedly unrealistic for the short-run, and relaxing it will make a qualitative difference to our analysis. For example, any increase in investment will not then come at the expense of tradable (and, given the specific form of preferences assumed below, non-tradable) consumption. However, trade balance considerations are tangential to the core of the present analysis and the simplification seems worth the cost in terms of generality. Moreover, balanced trade is a reasonable assumption over an extended period of time, especially for a developing economy. From equations (5), (6), and (9),

$$C_T = \left[1 - g\left(1 - \frac{wa}{q} - \overline{r}\right)\right] K \tag{10}$$

Consumer optimization, based on a simple additively separable log linear specification,[13] implies that

$$q = \frac{C_N}{C_T} \tag{11}$$

which, after substitution from eqs. (3), (11) and (8), yields the expression for employment in the non-tradable sector:

$$L_N = \frac{1 - g\left(1 - \frac{wa}{q} - \overline{r}\right)}{w(K)} qK \tag{12}$$

Two crucial derivatives will prove informative in the subsequent analysis:

[13]Specifically, max $U = lnC_T + lnC_N$ s.t. $qC_T + C_N = E$, where E is total national expenditure.

$$\frac{dL_N}{dK} = \frac{q}{w}\left[(1-g)\left(1-\frac{w'K}{w}\right)+\frac{w'g'K}{q}\right] > 0 \tag{13}$$

$$\frac{dL_N}{dq} = \left(1-g-g'\frac{wa}{q}\right)\frac{K}{w} < 0 \tag{14}$$

An increase in the capital stock raises employment in the tradable sector and hence demand for non-tradables, increasing employment. It also, however, raises the real wage, which reduces output for a given level of demand. A sufficient (but not necessary) condition for non-tradable employment to increase – a plausible hypothesis – is that the real wage rise less than proportionately in response to capital stock increases.

A real depreciation (rise in q) has opposing effects on non-tradable employment. On the one hand, L_N rises due to substitution towards non-tradables. On the other hand, real income falls in terms of tradables, causing lower demand for both goods. In line with Krugman and Taylor [1978] and other literature, I assume that the short-run effect of a depreciation is contractionary, i.e., non-tradable employment declines. In formal terms, this requires that, $1-g<g'\,\frac{wa}{q}$. I assume this inequality to be strictly satisfied from here on. In intuitive terms, this stiffens the trade-off faced by policy-makers between the short-run and long-run effects of undervaluation on employment.

Another derivative underlines the demand-side nature of non-tradable output.

$$\frac{dL_N}{dw} = -\left(1-g-g'\frac{wa}{q}\right)\frac{qK}{w^2} = \frac{ag'K-L_N}{w} > 0 \tag{15}$$

where the rightmost expression derives from equation (12). A higher real wage (in terms of non-tradables) increases consumption at the expense of investment. This has a salutary effect on non-tradable employment and output.

Using information from (2), (4), and (12), we can now express the policy maker's problem in a more detailed manner. The initial capital stock (at $t=0$) is K_0 which is strictly less then the target stock, K_T. Formally, policy makers maximize the present value of a weighted measure of the labor market subject to the evolution of the capital stock.

$$\max_q \int_0^T \phi_1 \ln\left(\frac{w}{q}\right)+\phi_2 \ln\left[\frac{1-g\left(1-\frac{wa}{q}-\overline{r}\right)}{w(K)}qK\right]+\phi_3\ln(aK)\}e^{-\rho t}dt \tag{16a}$$

$$\text{s.t.}\quad \dot{K} = g\left(1-\frac{wa}{q}-\overline{r}\right)K \tag{16b}$$

$$K(0)=K_0,\ K(T)=K_T, \lim_{t\to T}K(t)=K_T \tag{16c}$$

Planners face the problem of devising a policy path $\{q^*(t)\}$ that maximizes the labor market functional subject to the constraints captured by equations (16b) and (16c). The presence of two boundary value conditions renders an additional transversality condition moot.

Based on the set-up here, the current value Hamiltonian takes the form:

$$H \equiv \left\{\phi_1\ln\left(\frac{w}{q}\right)+\phi_2\ln\left[\frac{1-g\left(1-\frac{wa}{q}-\overline{r}\right)}{w(K)}qK\right]+\phi_3\ln(aK)\right\}+\lambda g\left(1-\frac{wa}{q}-\overline{r}\right)K \tag{17}$$

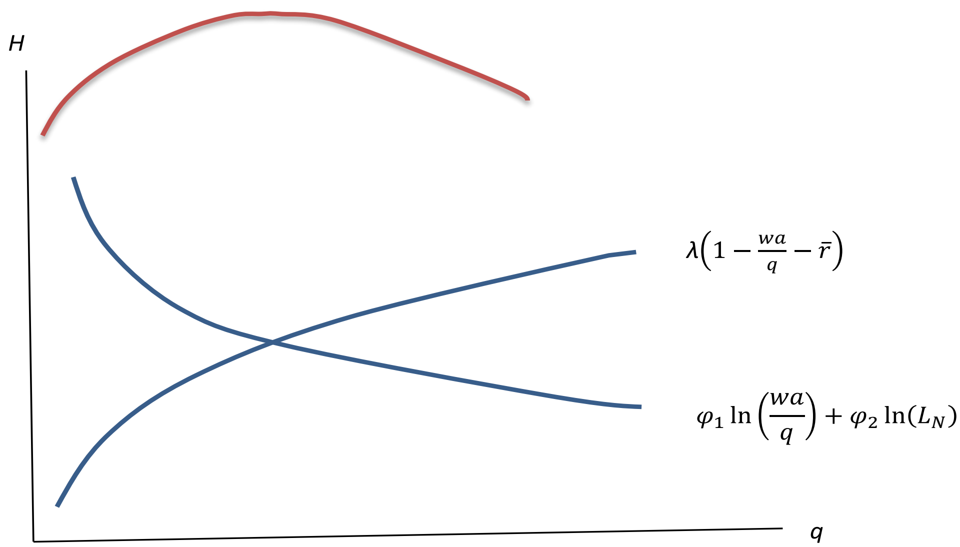

Figure 2: Illustration of policy makers' trade-offs

where λ is the costate variable representing the shadow value of capital.

2.2 Broad implications

As alluded to earlier, changes in the real exchange rate create trade-offs. Perhaps a figure will help illustrate the nature of the problem. Figure 2 is drawn under the assumption that the shadow price of capital is non-negative. As we see below, this shadow value does indeed turn out to be positive. The costs faced by policy makers in the form of lower real wages and nontradable employment are falling in the real exchange rate. The benefits in the form of investment, on the other hand, are increasing in q. Both functions are drawn as concave (see the appendix for an exploration of the sufficiency conditions). The Hamiltonian, H, is drawn at each given instant for the corresponding value of q.

Employing Pontryagin's maximum principle, the solution for the shadow value in terms of the real exchange rate can be derived from the first order condition, which yields:

$$\lambda = \frac{(\phi_1 - \phi_2)\frac{q}{wa} + \phi_2 \frac{g'}{1-g}}{g'K} \tag{18}$$

A sufficient (but not necessary) condition for the shadow value to be positive is that $1-g < g' \frac{wa}{q}$, which is the same condition as that required for real devaluations to be contractionary in the short run.[14]

[14]One can also confirm, by employing equations (17) and (18), that the first order condition defines a maximum, as long as $1-g < g' \frac{wa}{q}$.

It may be useful here to say a few words about the intuition underlying the condition for λ to be positive. As illustrated earlier by Figure 2, the marginal cost of a rise in q (a real devaluation) appears in the form of lower real wages and reduced non-tradable employment. This is countered by the marginal benefit of increased investment. If $\phi_2 = 0$, that is, policy makers assign no weight to non-tradable employment, then a real depreciation creates an immediate trade-off between the other two objectives, i.e., boosting the real wage versus increasing accumulation. The shadow value of capital must be positive to encourage accumulation. If, on the other hand, $\phi_1 = 0$, that is, policy makers assign no importance to the real wage, then the trade off between this variable and accumulation is ameliorated, but, as long as $1 - g < g' \frac{wa}{q}$, another trade-off re-appears – that between non-tradable sector employment and accumulation. A real depreciation reduces the former but raises the latter. Again, the shadow value of capital must be positive. In brief, as long as real depreciation has a non-negative cost, λ must be positive.

The real exchange rate varies positively with the shadow value of capital. Mathematically,

$$\frac{dq}{d\lambda} = \frac{wg'}{\phi_1 + \phi_2 \left[\left(\frac{g'}{1-g} \frac{wa}{q} \right)^2 - 1 \right]} K > 0 \tag{19}$$

The expression on the right hand side is positive since we have already assumed $\frac{g'}{1-g} \frac{wa}{q} > 1$ in line with the contractionary short-run effects of a real devaluation. Put succinctly,

$$q = q(\lambda);\ q' > 0 \tag{20}$$

The marginal cost to benefit ratio of devaluation is increasing in q.[15] This implies that a rise in the real exchange rate should be accompanied by a rise in the shadow value of capital. Keeping this in mind will help guide intuition through the thought experiments in later sections.

Applying standard techniques, we can now derive an expression for the motion of λ.

$$\dot{\lambda} = -(\phi_1 - \phi_2) \frac{w'}{w} - \frac{\phi_2 + \phi_3}{K} - \frac{\phi_2}{1-g} \frac{w'g'}{q} + \lambda \left(\frac{w'g'}{q} K - g + \rho \right) \tag{21}$$

Let's for a moment ignore the second term (i.e., $(\phi_2 + \phi_3)/K$) – which appears due to the non-linearity of the log specification – and the subjective discount rate. Notice then, in the interest of building intuition, that assuming a constant real wage w, will make the right hand side vanish around the steady state. Rising wages in response to capital accumulation and the decline in underemployment thereof play a central role in driving the dynamics of our system.

We have arrived at a system of two differential equations, (5) and (21). The Jacobian determinant of the system is given by:

$$J = \begin{vmatrix} \dot{K}_K & \dot{K}_\lambda \\ \dot{\lambda}_K & \dot{\lambda}_\lambda \end{vmatrix} \tag{22}$$

$$\frac{\partial^2 H}{\partial q^2} = -\frac{\phi_1 + \phi_2 \left[\left(\frac{g'}{1-g} \frac{wa}{q} \right)^2 - 1 \right]}{q^2} < 0$$

[15] The expressions for marginal cost (MC) and marginal benefit (MB) are given respectively by: $MC = \frac{\phi_1}{q} - \frac{\phi_2}{q} [1 - \frac{g'}{(1-g)} \frac{wa}{q}]$ and $MB = \frac{g'w}{q^2} K$.

where, evaluated at the steady state,

$$\dot{K}_K = -\frac{w'}{w} g'(1-\overline{r})K < 0 \tag{23a}$$

$$\dot{K}_\lambda = \frac{q'}{q} g'(1-\overline{r})K > 0 \tag{23b}$$

$$\dot{\lambda}_K = -\frac{\phi_1 - \phi_2}{w}\left[w'' - \frac{(w')^2}{w}\right] + \frac{\phi_2+\phi_3}{K^2} - \frac{wg'}{q}\left[w'' - \frac{(w')^2}{w}\frac{wg'}{q}\right] + \lambda\frac{w'g'}{q}\left(2 + \frac{w''}{w}K\right) \tag{23c}$$

$$\dot{\lambda}_\lambda = \left(\frac{wg'}{q}K + \rho\right)t + \phi_2 w'g'\frac{q'}{q^2}\left(1 - \frac{wg'}{q}\right) - (\phi_1 - \phi_2)\left(1 + \frac{w'}{w}K\right)\frac{q'}{K} \tag{23d}$$

The first two partial differentials (i.e., $\dot{K}_K$ and $\dot{K}_\lambda$) are easily and unambiguously signed. The sign for $\dot{\lambda}_K$ is slightly more involved. The terms in the square brackets are both negative, owing to the convexity of the $w(.)$ function. Thus, a sufficient, but by no means necessary, condition for this partial to be positive is that $\phi_1 \geq \phi_2$. In intuitive terms, the contribution of capital to labor market conditions *weakens* as the economy builds up its capital stock and wages rise steeply. This feature drives, in our later analysis, two important results. First, it places a limit on how ambitious policy makers can be while setting the capital stock target. Second, it helps ensure that the real exchange rate is depreciating as the economy approaches the target.

Finally, $\dot{\lambda}_\lambda$ is ambiguously signed. The term in the first parentheses is positive and that in the second parentheses is ambiguous but very likely positive.[16] The last term too is ambiguously signed, although non-positive if we assume that that $\phi_1 \geq \phi_2$. On the whole the right hand side could be positive or negative, although, as long as $\phi_1 \approx \phi_2$, the former is more likely.

If $\dot{\lambda}_\lambda$ is positive, the path that leads to the steady state is unambiguously unique, i.e., we get a saddle path solution. The stable arm is negatively-sloped (see the Appendix for a derivation of the slope). In the following sub-sections, we will analyze this case. Assuming that $\dot{\lambda}_\lambda$ is negative, on the other hand, yields qualitatively similar results and adds little to the analysis when we analyze the saddle path case. This case is discussed in the Appendix.

Our non-linear system can only be analyzed qualitatively (the Appendix derives explicit time paths for a simplified version of the model here). Figure 3 captures our dynamic set-up with the help of a phase diagram. The $\dot{K} = 0$ is upward-sloping. An increase in the capital stock raises the real wage and reduces profitability. A higher shadow price of capital is required to maintain a given level of investment. The other isocline is downward-sloping since raising the capital stock or the shadow value of capital has the same (positive) effect on the rate of change of λ. The negatively-sloped stable arm in the figure is represented by the curve labeled *SS*. This, of course, corresponds to the unique (saddle) path to the steady state.

Since the link from the real exchange rate to investment is the main focus, it may be useful to make the use of the terms over- and undervaluation more precise. For any given level of capital stock, I will treat the corresponding level of λ on the stable arm, i.e., on the unique solution path, as the benchmark. Assuming that the initial capita stock is below its steady state level, I will refer to the real exchange rate as:

[16] It is positive as long as the elasticity of investment with respect to the real wage is less than one, i.e., as long as investment responds less than proportionally to a change in the profit rate.

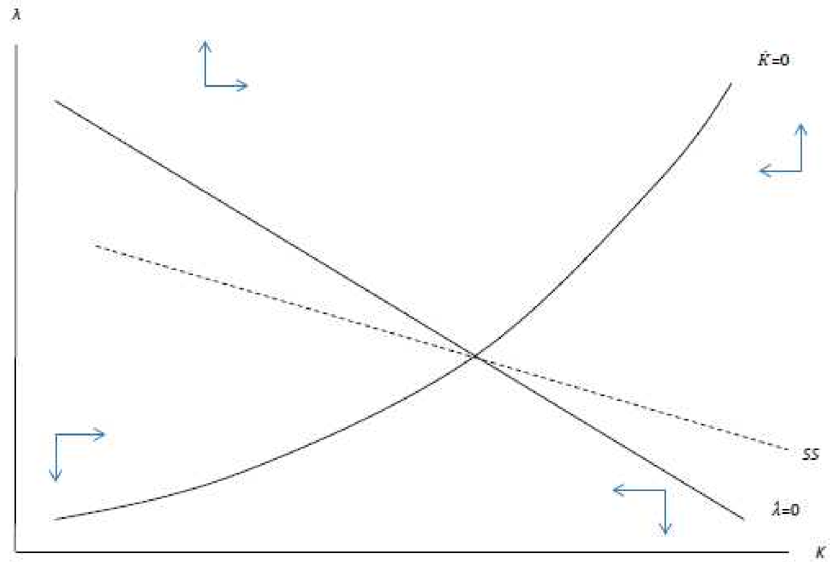

Figure 3: The phase diagram

"highly overvalued" if λ is at a level below both isoclines,

"slightly overvalued" if λ is above the $\dot{K} = 0$ isocline but below the stable arm,

"slightly undervalued" if λ is above the stable arm but below the $\dot{\lambda} = 0$ isocline, and

"highly undervalued" if λ is at a level above both isoclines.

2.3 Policy sans targets

Let's begin the analysis by momentarily deviating from equation (16c) and assuming that policy makers do not have a capital stock target. All that matters is the societal consensus that has assigned weights to labor market objectives. In a setting where policy makers forego specific development goals, following the unique solution path that takes the economy to the steady state asymptotically will involve choosing the point on the stable manifold that corresponds to K_0. This means accumulating capital with continuous, if gradual, appreciation over time. The secular movement of the exchange rate resembles that under the Balassa-Samuelson effect although the underlying mechanism differs (there is no productivity growth here).

Given a finite time horizon, so that $t \in [0, T]$, and beginning at a capital stock such as K_0, policy makers might choose a real exchange rate at the level corresponding to a point A in Figure 4. Investment is negative at this highly overvalued exchange rate, and at any non-infinite terminal time horizon T, the capital stock is optimally run down to a value where high exchange rate appreciation has reduced the shadow value of capital to zero.

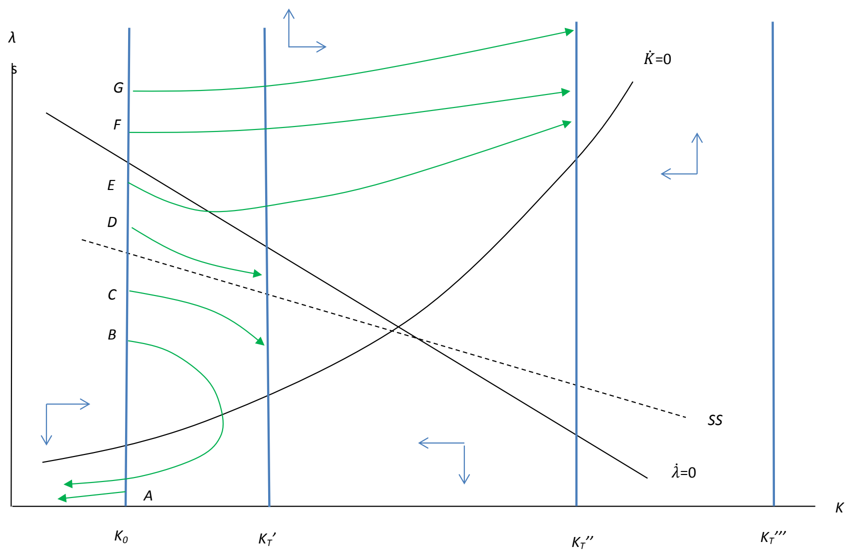

Figure 4: Alternative optimal trajectories under alternative scenarios

Alternatively, given a longer planning horizon, they will pick a higher real exchange rate at a point like B. A slightly overvalued beginning exchange rate at that point leads to a similar end result with the economy consuming away its capital stock after initially experiencing some accumulation and employment generation. The real exchange rate appreciates along the entire path as policy makers, faced with a declining capital stock, lean towards keeping the real wage high and boosting non-tradable employment at each instant. Notice, however, that keeping non-tradable employment high through real appreciation will eventually become unsustainable as the capital stock declines, pulling L_N down with it. Excessive macroeconomic populism may run into hurdles even if the economy is not hit by a crisis of confidence.

2.4 Setting goals

Now let's return to the more interesting case, as captured by equation (16c), where policy makers pursue a capital stock target. This case, of course, is relevant to capital scarce developing countries with long-term development aspirations. As we see below, some targets are beyond reach given economic and political parameters while others may be politically rewarding but too unambitious from a development perspective. There exists a "Goldilocks zone" in our setting, where targets are meaningful and achievable, although politically challenging.

Suppose, as a first pass, that the capital stock target to be reached at time T is a relatively unambitious one such as K_T'. This target can be reached regardless of the degree of real undervaluation, and indeed even with an initially overvalued real exchange rate (at a point like C), as long as the degree of overvaluation is small. This is because, starting with a slightly overvalued exchange rate, the real wage is still low enough to allow for accumulation, even though q will have to be lowered along the trajectory to keep real wages and non-tradable employment relatively high. The optimal paths do, however, depend on the time available and initial overvaluation beyond a point will have to be guarded against even if it is still in the slightly overvalued zone (say at point B). The path starting from point C is similar to one that would emerge from the typical electoral business cycle framework. Given the time horizon, election-focused politicians would be perfectly fine with overvaluation as long as it lets them achieve the employment gains associated with the less ambitious target.

Next, what if the policy makers have a much more ambitious target such as K_T'''? To answer this question, notice that there is no entry from the northwestern quadrant into the northeastern one. Too ambitious a capital stock target is unattainable, regardless of the initial level of λ chosen via the choice of q. There are limits to real exchange rate policy as long as wages are sensitive to the level of employment. One interesting implication, among others, is that an economy that starts with a high initial level of capital stock (and low level of underemployment) may not be able to succesfully employ real exchange rate undervaluation as a tool for capital accumulation. This is consistent with the findings of the literature cited in Section 1. Alternatively, meeting highly ambitious targets may require wage insensitivity to employment that is so high as to rupture any existing social consensus, even if it successfully generates employment.[17]A chasm may sometimes have to be crossed in several small steps.

Finally, let's examine the case where the capital stock target, K_T'', is in the Goldilocks range, neither too unambitious, nor beyond reach. This range is defined by the feature that the targeted level of capital stock is above the steady state associated with the current parameters of the economy (although not high enough for investment to be unprofitable regardless of the level of q). Now meeting the target requires, as a necessary condition, that the chosen real exchange rate level corresponding to K_0 be in the undervalued range. Moreover, it must remain undervalued throughout the time interval $[0, T]$ to compensate for the rising real wage (in terms of non-tradables) along the way. If initially *highly* undervalued, the optimal path involves further real depreciation over time. If the time available is sufficient so that the initial undervaluation puts the exchange rate at the point E in the *slightly* undervalued zone, policy will require initial appreciation to allow for wage growth alongside accumulation, followed by depreciation all the way through as real wages rise. The shorter the policy makers' time horizon, the higher the initial level of undervaluation. For instance, starting at a point like G gets the economy there faster than from starting points E or F. It may also, however, be the hardest path to achieve for political economy reasons.

Ensuring positive and adequately high investment requires initial undervaluation. But why does

[17]Notice that the less sensitive wages are to the level of capital (and hence employment), the less the slope of the $\dot{K} = 0$ isocline, and the more ambitious the feasible target can be. In the extreme case, where the sensitivity is zero, any target can be achieved given an appropriate level of initial undervaluation.

the economy, starting in the undervalued zone, require increasing undervaluation along the way? The intuition lies in the fact that the contribution of capital to the labor market index is declining in the capital stock (i.e., $\partial H/\partial K < 0$).[18] This means that, once a large initial undervaluation begins the capital accumulation process, the real exchange rate must be continuously depreciated in order to raise the shadow value of capital, and keep the process moving in the desired direction.

Now that we have briefly toured various time path scenarios with the help of Figure 4, further direct comparison of the setup here with the electoral business cycle literature may help understand the crucial role of the planning horizon and the discount rate. A plausible assumption in that literature is that of a negative social discount rate, that is, the farther off in the future an observation, the lower the weight it gets. Policy makers, therefore, care most about conditions at the last minute before the elections. Here the opposite holds. Policy makers care about the long-run, but given the discount rate, have to assign higher weights to current outcomes while planning. In contrast to the behavior emerging from the electoral cycle literature, there is no gradual appreciation after the initial undervaluation. Rather, rising wages mean that the real exchange rate has to continue depreciating to constrain unit labor costs in terms of tradables.

In sum, given an adequately short time window, the optimal path in our set-up approaches that of the electoral cycle literature in the short run. Achieving more ambitious (but realistic) targets, on the other hand, will involve consistent and increasing undervaluation.

2.5 The trilemma

We can now summarize our discussion in terms of the policy trilemma mentioned in Section 1. Recall the three vertices: (1) the use of the real exchange rate as a tool of development policy, (2) a time constraint, and (3) maintaining the real exchange rate within a range that avoids political instability. Steinberg and Malhotra [2014](p. 507) note that "all segments of society initially oppose a depreciation;" continuously suppressing the real wage in terms of tradables is unlikely to be the most popular recipe for economic development, even though it is offset over time by rising wages in terms of non-tradables.

Figure 4 and our previous discussion underline the mechanics. Policy makers who want to employ the real exchange rate for development purposes (i.e., to achieve an ambitious capital stock target) must choose between: (a) starting at a point like G, i.e., pursuing a high initial undervaluation followed by further upward movement of the real exchange rate, thus risking loss of popular support and political instability, or (b) starting at a point like E, i.e., relaxing the time constraint, so as to begin with a less undervalued exchange rate and allowing appreciation for part of the cycle. Policy makers who do not have the option of relaxing the time constraint, say because they operate in a democracy with regular elections, may be forced to either risk potential political instability due to large undervaluation, i.e., choose G as the starting point, or surrender the use of the real exchange rate for development, i.e., choose a starting point such as D or C.

The severity of the trade-offs obviously will vary with the structural parameters of the economy. For example, the optimal path of the real exchange rate will depend on factors such as the responsiveness of the non-tradable sector to conditions in the tradable sector, the sensitivity of investors to profitability and that of wages to the stock of capital, and on the relative weights given to various

[18] Note that, owing to rising wages, the contribution of capital to current and future labor market conditions, which declines with the level of λ, has turned negative in this range. If, as mentioned earlier, w were constant, then the $\dot{K} = 0$ isocline will be horizontal, any target stock will be achievable, and continuous depreciation along the optimal path will not be necessary.

policy objectives. The *achievability* of the optimal path, on the other hand, will depend on factors such as the degree of ambition involved, the political power of owners of capital (who invest) versus those of workers and that of the pool of un(der)employed who hope to gain modern sector jobs versus those who already have access to these jobs. More ambitious targets generate trickier trade offs, and the trickier the trade-offs, the more likely any existing societal consensus is to go past the breaking point!

The next section fleshes out these considerations in more detail.

3 Analytics with a simplified linear version

So far we have assumed a societal consensus that allows policy makers to target a capital stock level and explored how changes in the planning horizon or target will define the path followed. How does the optimal path of the real exchange rate differ between economies with different structural features? This section considers the consequences of parametric changes including: (1) a shift in the degree to which capital accumulation affects non-tradable employment, (2) greater policy weight on tradable sector employment, and (3) a change in the extent to which real devaluations are contractionary. In order to explicitly explore the relevant comparative dynamics, I work here with a simplified version of the set-up in Section 2.

I make three main simplifications to the model in the previous section while retaining the overall structure. Suppose that the real wage (in terms of non-tradables) is a linear function of the size of the tradable sector (as proxied by the capital stock).

$$w = \alpha K \tag{24}$$

and that capital accumulation is a linear function of the real wage in terms of tradables, so that,

$$\dot{K} = \psi(q - \alpha K) \tag{25}$$

where α and ψ are non-negative parameters. The equivalent (but now explicit) expression to equation (12) is then given by:

$$L_N = (1 + \psi\alpha)\,\frac{q}{\alpha} - \frac{\psi}{\alpha}\frac{q^2}{K} \tag{26}$$

Non-tradable employment is a positive function of the capital stock, and if, consistent with the version in the previous section, we continue to assume a contractionary impact of devaluations, a negative function of the real exchange rate.[19] In order to derive explicit solutions for our comparative dynamic exercises, I make a third simplification by assuming the following functional form:

$$L_N = \beta K - \delta q^2 \tag{27}$$

where again β and δ are non-negative parameters. Finally, I now ignore the discount rate.

With this simplified set-up, the Hamiltonian based on the problem equivalent to that captured by equation (16a) becomes:

$$H \equiv \phi_1(\alpha K - q) + \phi_2(\beta K - \delta q^2) + \phi_3 K + \lambda\psi(q - \alpha K) \tag{28}$$

[19] The formal condition for devaluations to have a contractionary impact on non-tradable output is: $(2\frac{q}{K} - \alpha) < 1$.

The boundary conditions from (16c) continue to apply, while the first order condition and the standard optimal control approach now yield:

$$\lambda = \frac{\phi_1 + 2\phi_2\delta q}{\psi} \tag{29}$$

$$\dot{\lambda} = -\phi_1\alpha - \phi_2\beta - \phi_3 + \lambda\alpha\psi \tag{30}$$

Unlike the previous section, equations (25), (29) , and (30) can now be solved to deliver explicit steady state solutions.

$$\lambda^*, K^*, q^* = \frac{\phi_1\alpha + \phi_2\beta + \phi_3}{\alpha\psi}, \frac{\phi_2\beta + \phi_3}{2\phi_2\alpha^2\delta}, \frac{\phi_2\beta + \phi_3}{2\phi_2\alpha\delta} \tag{31}$$

In the discussion below, I will present the analysis in $K - q$ space. Now that I can present explicit solutions, talking about the real exchange rate directly simplifies the intuition for some of the thought experiments below. The counterpart equation of motion to equation (30) is:

$$\dot{q} = \alpha\psi q - \frac{\psi}{2\phi_2\alpha}\left[\phi_2\beta + \phi_3\right] \tag{32}$$

Equations (25) and (32) constitute the dynamic system. The general solution to this system, after applying the boundary conditions, is given by:

$$\begin{aligned}\begin{bmatrix} K(t) \\ q(t) \end{bmatrix} = \begin{bmatrix} K^* \\ q^* \end{bmatrix} + \begin{bmatrix} 1 \\ 2\alpha \end{bmatrix} \frac{(K_T - K^*)e^{\alpha\psi t} + (K^* - K_o)e^{-\alpha\psi(T-t)}}{e^{\alpha\psi T} - e^{-\alpha\psi T}} \\ - \begin{bmatrix} 1 \\ 0 \end{bmatrix} \frac{(K_T - K^*)e^{-\alpha\psi t} + (K^* - K_o)e^{\alpha\psi(T-t)}}{e^{\alpha\psi T} - e^{-\alpha\psi T}}\end{aligned} \tag{33}$$

Equation (33) explicitly captures the essence of the trilemma discussed earlier: the higher the target capital stock and the shorter the time available, the greater the political challenge (i.e., the higher the real exchange rate along the optimal path).

Figure 5 captures this information. The main difference from Figure 3 of the previous section is that the $\dot{q} = 0$ isocline (or, alternatively the $\dot{\lambda} = 0$ one) is now horizontal. This is not surprising given that the system is now linear in the state variable, which leads the equation of motion of q to be independent of the capital stock. Again, the system has a saddle path nature, but the stable arm now coincides with the $\dot{q} = 0$ isocline. It is easy to show that, as long as $K_T > K^* > K_0$, that is, as long as the target capital stock is ambitious (greater than the steady state level), $q(T) > q^* > q(0)$, and q rises monotonically with time. Mathematically, from equation (33):

$$q(0) = q^* + 2\alpha\frac{(K_T - K^*) + (K^* - K_o)e^{-\alpha\psi T}}{e^{\alpha\psi T} - e^{-\alpha\psi T}} \tag{34}$$

and,

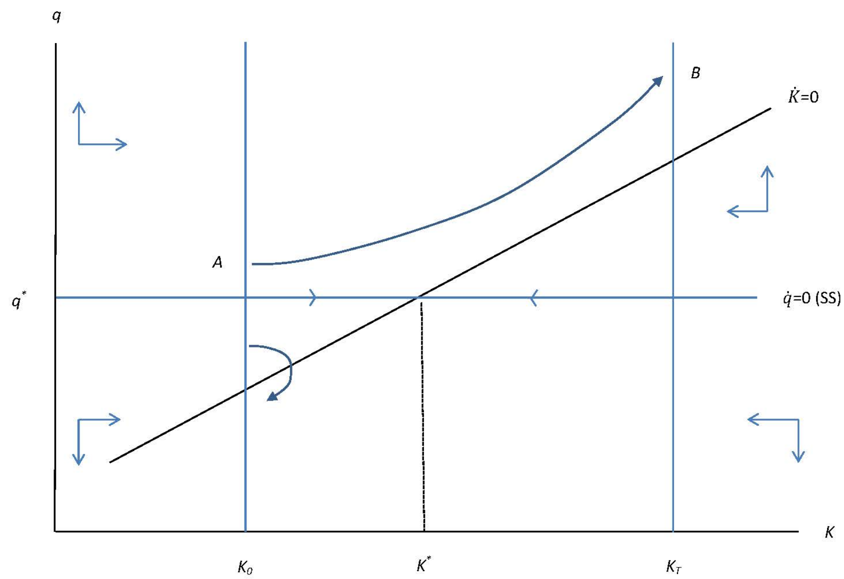

Figure 5: The simplified framework

$$q(T) = q^* + 2\alpha \frac{(K_T - K^*)e^{\alpha\psi T} + (K^* - K_o)}{e^{\alpha\psi T} - e^{-\alpha\psi T}} \tag{35}$$

As with our benchmark non-linear model of the previous section, the real exchange rate must start at an undervalued level when $t = 0$, and the optimal trajectory involves increasing undervaluation. This is illustrated by the path from point A to point B in the figure.

3.1 Increased effect of accumulation on non-tradable employment

Let's first compare two countries where all parameters are identical except for that the responsiveness of non-tradable employment to capital accumulation is greater in one. We can analyze the implications by investigating the effects of an increase in the parameter β. The results are captured by Figure 6. The change shifts the $\dot{q} = 0$ isocline and the stable arm up.[20] We can tell from equation (29) that the relationship between the shadow value of capital and the real exchange rate that satisfies the first order condition is unchanged. Intuitively, the marginal benefit from adding a unit of capital stock has increased.

How does the change in β affect the optimal path of real exchange rate policy? By strengthening the incentive to accumulate capital, the change raises the optimal level of q at $t = 0$. Since the target level of the capital stock and the time allowed to accumulate it is unchanged, the optimal trajectory of the real exchange rate flattens and the final level of q is lower. Mathematically,

[20]Although not of much interest here, the steady state value of K, q, and λ all rise (see equation (31)).

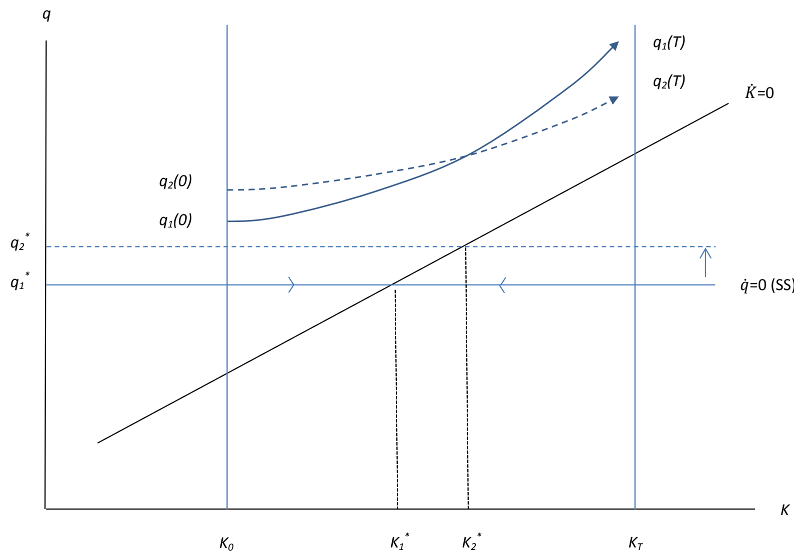

Figure 6: Increased effect of accumulation on non-tradable employment

$$\frac{dq(T) - dq(0)}{d\beta} = \frac{1}{\alpha\delta}\left(\frac{2 - e^{\alpha\psi t} + e^{-\alpha\psi t}}{e^{\alpha\psi t} - e^{-\alpha\psi t}}\right) < 0 \tag{36}$$

Increased non-tradable employment responsiveness to tradable sector expansion makes it easier to pursue the capital stock target at the cost of real wages in the short run. A higher devaluation followed by continuous undervaluation but along a gentler trajectory allows society to reap the benefits of economic expansion sooner. In terms of the figure, the optimal path of the real exchange rate runs from $q_1(0)$ to $q_1(T)$ in the lower β country and from $q_2(0)$ to $q_2(T)$ in the higher β one. Since the level of capital stock is the same in both countries at the end of the day, the low β country starts with a higher real wage but ends up with a lower one in terms of tradables.

In brief, the nature of internal demand generated by tradable/formal sector expansion plays a key role in determining the optimal path of real exchange rate policy.

3.2 Greater focus on tradable sector employment

Next, let's compare two countries that differ in their focus on tradable sector employment. This comparative dynamic exercise involves considering an increase in ϕ_3. A look at eqs. (29), (31), and (32) should convince the reader that the analysis and results are qualitatively similar to those of an increase in β. Moreover, Figure 6 continues to be the relevant illustration.

A country with a greater focus on tradable sector expansion will start with a higher level of q and follow an optimal trajectory that is flatter over time. Avoiding the initial "big push" makes it a steeper incline for the country that places greater immediate weight on real wages. The low ϕ_3 country – the one that starts with a higher real wage in terms of tradables – ends up with a lower one. Greater focus on tradable employment eventually pays off, but is initially riskier politically.

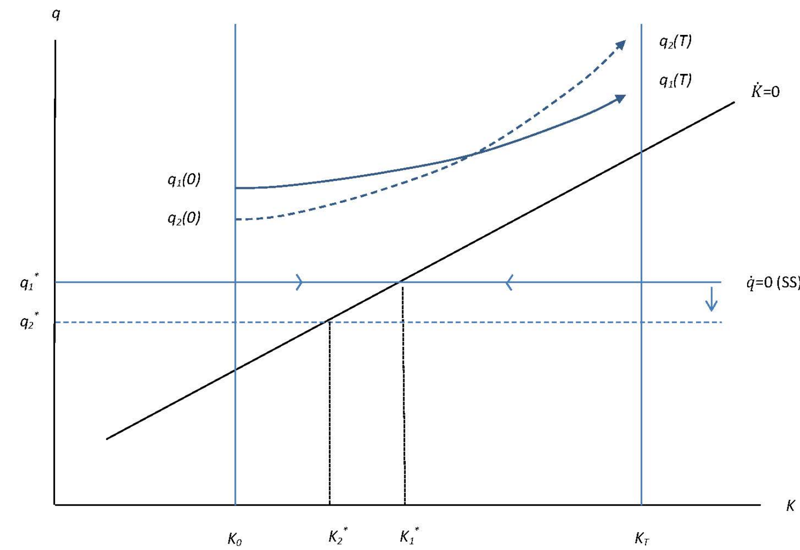

Figure 7: Stronger immediate contractionary impact of devaluations

3.3 Greater contractionary impact of devaluations

Now suppose that the two countries differ in the extent of decline in non-tradable employment that they experience in the immediate aftermath of a real devaluation. Put differently, one of the two countries is a higher δ one.[21] This raises the immediate cost of undervaluation for policy makers.

Figure 7 illustrates the thought experiment involving an increase in δ. The $\dot{K} = 0$ isocline is unmoved while the other isocline shifts downwards. Since a rise in δ makes undervaluation more costly in terms of short-run output and employment, the initial level of undervaluation declines along the optimal trajectory. For a planning horizon with a given fixed end point, this means that the speed of real depreciation over time will have to be higher. In mathematical terms,

$$\frac{dq(T) - dq(0)}{d\delta} = \frac{\phi_2\beta + \phi_3}{\phi_2\alpha\delta^2}\left(\frac{e^{\alpha\psi t} + e^{-\alpha\psi t} - 2}{e^{\alpha\psi t} - e^{-\alpha\psi t}}\right) > 0 \tag{37}$$

In the background, both the initial and terminal shadow price are now higher, although the latter by more so. Raising the cost of undervaluation requires an offsetting rise in the shadow price of capital

The upshot is that the high δ country will start with a less undervalued exchange rate to cushion the effects on employment. Meeting the capital stock target will then require faster devaluation over time. Any tensions that arise from the distributional effects of relative price changes have, like the proverbial can, been kicked down the (uphill?) road.

[21] See Frankel [2005] and Krugman and Taylor [1978], among others, for the causes underlying potentially contractionary short-run effects of devaluations.

4 Concluding Remarks

A body of literature has modeled the interplay between various policy considerations as politicians try to maximize their votes. Confirming some of the resulting predictions, for example, Edwards [1993] studied the timing of 39 large devaluations by democratic regimes in developing countries, finding they tended to occur early on in the term. This literature has, however, focused mostly on short-run cyclical considerations. The focus here, by contrast, has been on the trade-offs between short-run rewards and long-run developmental benefits.

Our framework yields a trilemma whereby policy makers can choose two but not all three options among employing the real exchange rate for development, achieving development targets within a given time, and political stability. The typical political business cycle – involving a rising real wage, expanding non-tradable employment, and falling tradable inflation as the next election cycle approaches – emerges as a special case where policy makers, hard-pressed by time constraints, eschew the use of real undervaluation to pursue ambitious development goals. The problem of course, to borrow a phrase from Dornbusch [1996] – written not surprisingly in the Latin American context – is that "bringing down inflation is not the end of the story; rather, it is the beginning of the next cycle."

How should policy makers maximize the potential long-run benefits of real undervaluation while allowing for rising wages along the way? The major lesson that emerges from our exercise is that a one-shot real undervaluation, although necessary, is not sufficient. For the process to be sustainable, the initial undervaluation should be sufficiently large and sustained, indeed magnified, as wages rise over time. Tight time constraints, if accepted, only exacerbate the resulting political challenge.

Why might some countries be better at successfully implementing relative price signals to pursue capital accumulation? The analysis here suggests that at least part of the explanation lies in the (voluntary or involuntary) choice of vertices. Steinberg and Malhotra [2014] find that tenure security facilitates exchange rate undervaluation by governments. A country where policy makers are less constrained by time bound political horizons may have greater leverage when it comes to the use of the real exchange rate for development. Structural differences between economies may also ease or tighten the trade-offs involved. All (successfully pursued) roads lead to Rome but the ones that are less uphill along the way may require riskier steps at the beginning.

The analysis here abstracts away from a number of complications in order to maintain tractability. Wages in the two sectors are assumed to be identical. More plausibly, one would expect intersectoral wage differentials, especially if the traded sector consists of manufacturing and other modern industries where workers are likely to be more skilled. Labor market segmentation created by different skill intensities, worker bargaining power, and efficiency wage considerations are some of the considerations that we swept under the rug. Landlords, or owners of a fixed factor are likely to play a major role in the political economy of the typical developing economy and a more detailed analysis would benefit from incorporating this angle.[22] We have also eschewed analysis of consumer welfare under different scenarios, which is beyond the scope of the paper. Finally, unlike Rodrik [2008] and Ros and Skott [1998], the tradable sector in our model does not exhibit any "special" characteristics such as external economies of scale. Expanding the tradable sector is desirable in our framework insofar as it promotes non-tradable employment. Furthermore, the analysis here is only relevant to the extent that there is underemployment. Once the modern tradable sector has sufficiently expanded to remove this feature, steady state growth considerations become salient.

[22]See, for example, Razmi et al. [2012].

5 Appendix

5.1 Sufficiency conditions

This sub-section considers the Mangasarian sufficiency conditions in the context of our baseline set-up of Section 2. We already know from equation (18) that λ is positive. Consider now the constraint:

$$f = g\left(1 - \frac{w}{q} - \bar{r}\right) K$$

It can be easily verified that f_{qq}, $f_{KK} < 0$. The remaining condition for f to be concave, that is,

$$w'' \geq \frac{1}{2w}\left(w' - \frac{w}{K}\right)^2$$

is always satisfied for any power function of the form $w = K^n$, where $n \geq 1$.

Next, consider the relevant component of the objective functional:

$$F = \phi_1 \ln\left(\frac{w}{q}\right) + \phi_2 \ln\left[\frac{1 - g\left(1 - \frac{wa}{q} - \bar{r}\right)}{w(K)} qK\right] + \phi_3 \ln(aK)$$

In this case,

$$F_{KK} = \frac{(\phi_1 - \phi_2)}{w}\left[w'' - \frac{(w')^2}{w}\right] - \frac{\phi_2 + \phi_3}{K^2} + \phi_2 \frac{g'}{(1-g)q}\left[w'' - \frac{(w')^2}{w}\frac{w}{q}\frac{g'}{1-g}\right]$$

which is negative as long as $\phi_1 \simeq \phi_2$ (recall that $w'' - \frac{(w')^2}{w} < 0$ by definition, and the assumption of contractionary short-run devaluation implies that $\frac{w}{q}\frac{g'}{1-g} > 0$). Notice that this is a sufficient, not a necessary condition.

$$F_{qq} = \frac{\phi_1 - \phi_2.}{q^2} + \frac{\phi_2}{q^3}\frac{wg'}{1-g}\left(2 - \frac{w}{q}\frac{g'}{1-g}\right)$$

which is negative as long as $\phi_1 \simeq \phi_2$ and $\frac{w}{q}\frac{g'}{1-g} > 2$. Satisfaction of the latter inequality requires that $(q/L_N)(dL_N/dq) < -1$, or in other words, non-tradable employment decline more than proportionately in response to a real depreciation.

The remaining relevant expression that needs to be negative to make F concave is rather involved. Again, assuming $\phi_1 \simeq \phi_2$ to avoid clutter, and simplifying:

$$FqqF_{KK} - (F_{qK})^2 = \frac{\phi_2}{q^3}\frac{wg'}{(1-g)}\left\{-\frac{\phi_2+\phi_3}{K^2}\left(2 - \frac{w}{q}\frac{g'}{(1-g)}\right) + \frac{\phi_2 g'}{(1-g)q}\left[w'' - \left(w'' - \frac{(w')^2}{w}\right)\left(1 - \frac{w}{q}\frac{g'}{(1-g)}\right)\right]\right\}$$

The term in the first square brackets on the right hand side is unambiguously positive, given our assumption about the proportionate response of non-tradable employment to changes in q, while the term in the second square brackets is ambiguously signed. Concavity is satisfied if the two terms add up to a positive term, which is more likely the less convex the wage function.

5.2 Slope of the saddle path

Denoting the negative eigenvalue by υ_1, the slope of the stable manifold is given by:

$$\left.\frac{d\lambda}{dK}\right|_{SS} = \frac{\upsilon_1 - \dot{K}_K}{\dot{K}_\lambda}$$

Given that,

$$\upsilon_1 = \frac{(\dot{K}_K + \dot{\lambda}_\lambda) - \sqrt{(\dot{K}_K + \dot{\lambda}_\lambda)^2 - 4(\dot{K}_K\dot{\lambda}_\lambda - \dot{K}_\lambda\dot{\lambda}_K)}}{2}$$

allows us to derive the expression for the slope:

$$\left.\frac{d\lambda}{dK}\right|_{SS} = -\frac{(\dot{K}_K - \dot{\lambda}_\lambda) + \sqrt{(\dot{K}_K - \dot{\lambda}_\lambda)^2 + 4\dot{K}_\lambda\dot{\lambda}_K}}{2\dot{K}_\lambda} \tag{38}$$

which is negative since $\dot{K}_K < 0$ and $\dot{\lambda}_\lambda > 0$.

5.3 The alternative case where $\dot{\lambda}_\lambda$ is negative.

In this case, as captured by Figure 8, a saddle path solution requires that the $\dot{\lambda} = 0$ locus be steeper. The qualitative results are more or less similar to the case addressed in the main text, although now the optimal path of the real exchange rate that achieves the "Goldilocks" capital stock target (K_T'') invariably requires an initial real undervaluation, followed first by real appreciation and then by real depreciation as the target is approached. Unlike the main text, in other words, there is no optimal control path that involves continuous depreciation all the way. Thus, there is greater real exchange rate volatility. To understand the intuition, recall that this case involves greater policy emphasis on the real wage in terms of tradables, i.e., a high value for φ_1. This, in turn means that policy makers will optimally use real appreciation earlier to raise the real wage and then depreciate to maintain investment once capital accumulation has raised w over time.

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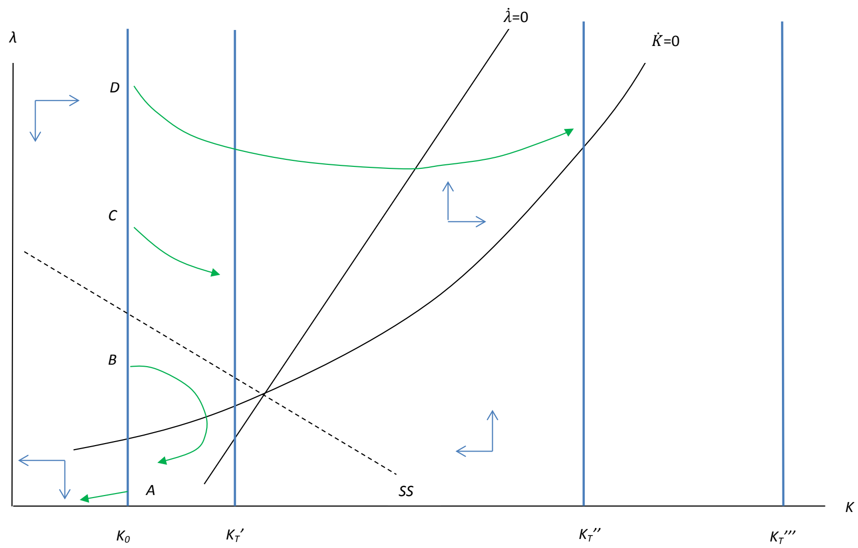

Figure 8: Phase diagram when $\dot{\lambda}_{\lambda} < 0$

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