Competitive exchange rate and infrastructure in a macrodynamic of economic growth

Antonio Soares Martins Neto
Department of Economics
University of São Paulo, Brazil
martinsneto.as@gmail.com

Gilberto Tadeu Lima
Department of Economics
University of São Paulo, Brazil
giltadeu@usp.br

Abstract: We develop a dual open-economy model which incorporates infrastructure as a factor of production to investigate effects of a competitive exchange rate policy under different levels of investment in infrastructure. It is suggested that an exchange rate policy coordinated with an infrastructure policy should produce better results. By increasing productivity in the tradable sector and by reducing inflationary pressures, this policy contributes to the success of an economic growth strategy led by a competitive currency.

Keywords: Exchange rate policy, infrastructure, development.

J.E.L. Classification Codes: H54, O41, O24.

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1 Introduction

Within a developmental approach, a competitive, undervalued exchange rate appears as a key factor to foster economic growth. Although there is not a consensus about the channel through which the exchange rate interacts with growth – by the alleviation of the balance-of-payment constraints, increase in aggregate savings and investment (see Glüzmann et al., 2012 and Razmi et al. 2012b), or gains in productivity in the tradable sector (for example, Rodrik 2008) –, recent empirical studies found robust evidence that a competitive exchange rate positively affects economic growth.

Rodrik (2008), observing that an exchange rate devaluation stimulates growth, found evidence that these results are especially valid for developing countries. Razmi et al. (2012a) find that currency devaluation is a major inducer of investment, with the evidence suggesting that the effect of undervaluation is larger and more robust for developing economies. Several other studies reinforce the role of competitive exchange rates in episodes of growth (Hausman et al. 2005, Gala 2008 and Razmi et al. 2012a) and exchange overvaluation as responsible for episodes of stagnation (Johnson et al., 2006).

Recent episodes of sustainable growth experienced by Korea, Taiwan, Singapore and, most recently, China, corroborate the role of a competitive exchange rate as inducer of growth. Similarly, countries that sustained their currency overvalued have experienced low growth trajectories, as were the cases of Brazil and Argentina during the 1990s (ECLAC, 2001).

Additionally to the aforementioned empirical results, the theoretical literature has more recently focused on aspects related to the coordination of policies that influence the feasibility of a growth strategy led by a competitive exchange rate, the effect of exchange rate policy in an environment of heterogeneous preferences on the exchange rate, and the importance of the tradable sector for the success of this strategy.

The importance of the tradable sector is analyzed in Rodrik (2008). After empirically verifying the positive relationship between episodes of growth led by competitive exchange rates and capacity expansion of the tradable sector, the author builds a formal model that evaluates the process. Rodrik assumes that in developing countries the tradable sector suffers disproportionately from existing distortions, and an exchange rate policy is a way to compensate such disturbances. Developing countries achieve better results when they are able to alter relative profitability in favor of the tradable sector, especially industry.

Lima and Porcile (2013) use a dynamic model of capacity utilization and growth – where agents have heterogeneous preferences regarding the real exchange rate – to investigate how the latter is related to the functional income distribution and aggregate demand. By incorporating interclass and intraclass conflicts over the preferred real exchange rate, the authors incorporate the possibility of a contractionary devaluation. A competitive exchange rate policy can lower the share of wages in income and reduce aggregate demand, capacity utilization and economic growth.

Rapetti (2013) uses a dual economy model to explore how aggregate demand and its effect on inflation can block the growth response of an exchange rate policy. Within the proposed framework, currency devaluation changes the relative profitability of the tradable sector, which is characterized by increasing returns. Especial attention is given to the inflationary pressures from non-tradables and wages, which may prevent the tradable sector from developing. The author concludes that policies' coordination, especially on domestic demand and wage growth, makes the strategy viable.

However, the literature on competitive exchange rate and economic growth has paid scant attention to the importance of supply policies. The existence of an appropriate production structure, especially concerning infraestructure, is essential to promoting sustainable growth. Nurkse (1953), Rosenstein-Rodan (1957), and Hirschman (1961), for instance, emphasized the important role of infrastructure in the emergence of supply-side externalities and the enhancement of other activities. Lewis (1979), in his Nobel Prize lecture, highlighted that "growth requires physical infrastructure and trained manpower even when its purpose is only to export primary produce". In recent contributions, Barro (1990), Turnovsky and Fisher (1995), Agénor (2012), and Glomm and Ravikumar (1994) theoretically investigated the positive effects of public spending on infrastructure. Several empirical studies found evidence of such positive effects, such as Aschauer (1989a and 1989b), Munnel (1992), Gramlich (1994), and Rivas (2003).

In recent years, however, investment in infrastructure has been reduced in many developing countries, mostly Latin America's economies (see for example Perrotti and Sánchez, 2011). This increasing gap in infrastructure has affected the productivity of these countries and accounted for a considerable part of the increasing output gap in Latin America, relative to Asian and developed countries (Calderón and Servén, 2003).

Along with a decreasing investment in infrastructure, the debate about the importance of a competitive exchange rate has become more intense in those countries. Understood as a key determinant of competitiveness, an undervalued exchange rate is frequently considered as a policy to trigger a process of rapid growth. Even though the issue of competitiveness includes several aspects, the focus on the exchange rate has sometimes been disproportionate, which may compromise its success. Within a process of rapid development, several other circumstances and policies can determine the path of an economy.

This paper contributes to the existing literature by investigating, by means of a theoretical model, some effects of exchange rate policy in environments characterized by different levels of investment in infrastructure. While Rapetti (2013) − from which the model herein draws a great deal − focuses on the importance of conducting an exchange rate policy along with aggregate demand policies, we aim to explore some channels through which supply policies can facilitate the success of a competitive exchange rate policy. It is suggested that the complementarity between an exchange rate policy and an infrastructure policy may generate better outcomes. By increasing productivity in the tradable sector through additional investment in infrastructure, the economy may require a lower devaluation in order to start an acceleration of growth, which reduces the extent of exchange rate pass-through consequences. At the same time, enhanced productivity in the non-tradable sector increases its supply of goods, which prevents domestic inflation from eroding the external competitiveness of the economy.

The remainder of the paper is organized as follows. Section 2 describes the structure of the model, while Section 3 analyses its dynamic behavior. Section 4 analyses the coordination of infrastructure and exchange rate policies. The paper closes with a summary of the main conclusions derived along the way.

2 The Model

Consider a small open economy with two sectors, tradable (T) and non-tradable (N), populated by three types of agents: households, firms and government. The economy is open to trade and finance, and since the exchange rate is credibly fixed[1], the interest parity condition imposes that:

[1] In the context of fixed exchange rates in which surprise devaluations increase output, credibility becomes an essential attribute. When the outcome of a devaluation is likely to be expansionary, credibility will be assured only if policymakers are significantly concerned with inflation. Our assumption, thus, implies that the market trusts the government's commitment to avoid inflation.

$$i = i^* \tag{1}$$

where i is the domestic interest rate and i^* is the international one. This assumption also implies that as the balance of payments always adjust to imbalances in the current account, the external balance is not explicitly modeled. For simplicity, population (which is equal to the available labor force) is assumed to remain constant:

$$L = L_T + L_N + U \tag{2}$$

where L_T and L_N are the labor force employed in the tradable sector and non-tradable sector, respectively, and U is unemployment. The tradable sector operates with a production function with increasing returns due to infrastructure externalities:

$$Y_T = G^{\chi} K^{\alpha} L_T^{1-\alpha} \tag{3}$$

where $\alpha \in$ (0,1) and $\chi \in$ (0,1), K is the private capital stock, G denotes non-tradable infrastructural goods and services provided by the government and L_T is the corresponding labor input. Therefore, these public infrastructural goods and services allow the tradable sector to operate under increasing returns to scale. Unlike Agénor and Canuto (2012), for instance, we do not distinguish between basic and advanced infrastructure. As it turns out, infrastructure is broadly defined to include roads, ports, airports, electricity, basic telecommunications, advanced information, and communication technologies. However, it is likely that within a process of development, more advanced infrastructure is prioritized.

As in Park and Philippopoulos (2004), we assume that the government taxes the firms' capital stock carried over from the previous period. The government taxes the capital stock of the tradable sector at a constant rate $\tau \in$ (0,1) and its budget constraint is given by:

$$G = \tau K \tag{4}$$

Using equation (4), equation (3) can be rewritten as:

$$Y_T = \tau^{\chi}(1-\tau)^{\alpha} K^{\alpha+\chi} L_T^{1-\alpha} \tag{5}$$

The price of the traded good is internationally determined:

$$P_T = E P_T^* \tag{6}$$

where E is the nominal exchange rate, defined as the price of the foreign currency in terms of the domestic currency, P_T is the domestic price, and P_T^* is the foreign price.

Given the stock of capital and wage, and assuming atomistic competition and hence price-taking behavior, the representative firm in the tradable sector exerts a demand for labor at any moment by standard profit-maximizing criteria:

$$L_T = (1-\tau)\tau^{\frac{\chi}{\alpha}} \left[\frac{(1-\alpha)}{w_T}\right]^{\frac{1}{\alpha}} K^{\frac{\chi+\alpha}{\alpha}} \tag{7}$$

where $w_T \equiv \frac{W_T}{P_T}$ is the tradable product wage.

As the infrastructural input is external to firm's decisions, profits in the tradable sector can be obtained by substituting (7) into the first order condition of the choice of capital:

$$r = \alpha(1-\tau)\tau^{\frac{\chi}{\alpha}} K^{\frac{\chi}{\alpha}} \left[\frac{1-\alpha}{w_t}\right]^{\frac{1-\alpha}{\alpha}} \tag{8}$$

The non-traded good is produced under conditions of non-increasing returns and its price is locally determined. Assuming a typically low capital intensity in this sector, we consider a simple production function with labor as the only input. As a first approximation, we neglect the effects of infrastructure in the non-tradable sector to facilitate the understanding of the various effects of this policy. It can be assumed in this case that the government prioritizes investment in ports and airports, which have negligible effects over non-tradable products. Later on this assumption will be relaxed and the effect of infrastructure in this sector will be considered. Formally:

$$Y_N = BL_N^{\sigma} \tag{9}$$

where B is a fixed factor and $\sigma \in$ (0,1). The demand for labor in this sector arises from profit maximization by the owners of the fixed factor. Hence:

$$L_N = \left[\frac{\sigma B}{w_N}\right]^{\frac{1}{1-\sigma}} \tag{10}$$

where $w_N \equiv \frac{W}{P_N}$ is the non-tradable product wage.

Considering a Cobb-Douglas utility function, consumers maximize consumption such that the relative private consumption is:

$$\frac{C_T}{C_N} = \frac{\phi}{1-\phi}\left(\frac{P_N}{P_T}\right) \tag{11}$$

where $\phi \in$ (0,1) and 1 - ϕ are the share of consumers' income spent on tradable and non-tradable goods, respectively.

Assuming that workers do not save while capitalists in the tradable sector and owners of the fixed factor in the non-tradable sector save a share s of their profits and rents, we can set the following goods market equilibrium condition:

$$P_N C_N + P_T C_T = W(L_T + L_N) + (1-s)r(1-\tau)K + (1-s)\Pi_N \tag{12}$$

where W is the nominal wage and Π_N are the rents of the owners of the fixed factor B. Since we do not distinguish between importables and exportables, depending on the balance between domestic production and demand, the country either will be an exporter or importer of the traded good. Also, since non-tradables are used only for domestic consumption, the market equilibrium condition requires that output equal expenditure:

$$Y_N = C_N \tag{13}$$

3 Dynamic Behavior

The rate of capital accumulation is assumed to be a positive function of the profit rate minus the cost of finance, given by i, and depreciation, δ:

$$\hat{K} = r - (i + \delta) \tag{14}$$

where a hat (ˆ) represents proportionate rates of growth.[2] Note that domestic savings need not equal domestic investment, as determined by equation (14). It is assumed, thus, that capital is internationally mobile.

Substituting (8) into (14), we have:

$$\hat{K} = \alpha(1-\tau)\tau^{\frac{\chi}{\alpha}} K^{\frac{\chi}{\alpha}} \left[\frac{1-\alpha}{w_t}\right]^{\frac{1-\alpha}{\alpha}} - (i+\delta) \tag{15}$$

Wages are defined through a bargaining process between workers (from both sectors and with the same aspirations) and capitalists, which is represented by workers' demand for a desired wage. Workers demand wages as a result of both expectations about inflation and the difference between the prevailing wage and the desired one, according to the following equation (Lima and Porcile, 2010):

$$\hat{W} = \frac{w^d - w}{w} + \hat{P}^E \tag{16}$$

where w^d is workers' desired real wage, $\frac{W^d}{P}$, $w = \frac{W}{P}$, $P = P_T^{\phi} P_N^{1-\phi}$ and the superscript E means "expected". The desired wage is defined endogenously as a result of variations in the rate of employment:

$$w^d = m(1-e)^{-\xi} \tag{17}$$

where, assuming L = 1, e is the rate of employment (L_T + L_N), $\xi \in$ (0,1), and m is a positive constant which reflects labor market regulations (such as collective negotiations, degree of unionization, unemployment benefits, and minimum wages). For instance, a higher (lower) minimum wage increases (decreases) the desired wage.

Price expectation is given by the weights of tradable and non-tradable prices in the private consumption basket. Since P_T is given and E is fixed, expected inflation (which is assumed to be equal to the actual inflation rate) is proportional to non-tradable prices inflation:

$$\hat{P}^E = (1-\phi)\hat{P}_N \tag{18}$$

As $P_N \equiv \frac{W}{w_N}$ by denifition, we have:

$$\hat{P}_N = \hat{W} - \hat{w}_N \tag{19}$$

Substituting from equations (16)-(19), we have (see appendix A):

$$\hat{W} = \frac{1}{\rho\phi} \left\{ \frac{w^d - w}{w} - (1-\phi) \left[\frac{(\alpha+\chi)(\sigma-1)}{\alpha} \hat{K} \right] \right\} \tag{20}$$

where $\rho \equiv \left[1 - \frac{(1-\phi)(\sigma-1)}{\phi\alpha}\right] > 0$.

From (15) is clear that $\hat{K}$ increases with K and falls with w_T, thus we need to focus on the first term in the right-hand side of (20).[3] We know from (22) and (7) that L_T and L_N increase with K and

[2] A possible extension of the model is to make physical capital depreciation a function of the investment in infrastructure. Better conditions of roads and a stable supply of energy are clear examples of how infrastructure can reduce depreciation. In the simple case in which depreciation is a linear and negative function of infrastructure, this extension does not change the following qualitative results.

[3] As P_T is assumed constant, $\hat{W}$ = $\hat{w}_T$ at any point in time. We can thus use both terminologies to define the dynamic equation for wages.

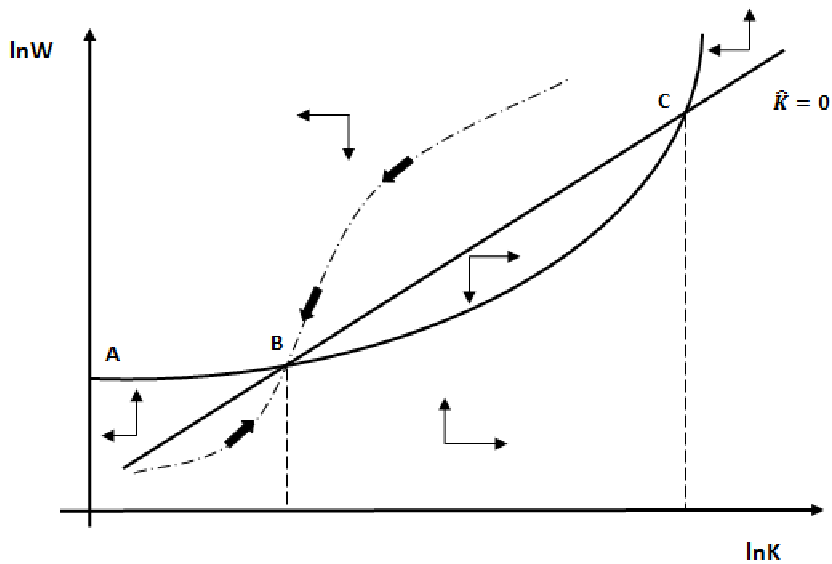

Figura 1: Model in (lnW,lnK) space

fall with w_T. Thus, the employment rate e varies positively with K and negatively with w_t. Finally, we know from (30) that w_N varies negatively with K and positively with w_T. As a result, the desired wage varies positively with K and negatively with w_T.

Equations (15) and (20) form a two-dimensional system of autonomous differential equations, which we present below in a reduced form. While the derivation of the $\hat{K}$ = 0 locus is straightforward, appendix B presents the derivation of the $\hat{W}$ = 0 locus. An important condition for multiple equilibria is to have a relatively small effect of infrastructure, otherwise the trajectory would be explosive (see appendix C for more details). Our subsequent discussion assumes that all conditions for multiple equilibria are met.

$$\hat{K} = f(K, W; \tau)$$

$$\hat{W} = g(K, W; \tau)$$

where $f_K > 0$, $f_W < 0$, $g_K > 0$, $g_W < 0$.

Figure 1 shows the phase diagram with its two steady states (besides equilibrium point A where K = 0), represented by equilibrium points B and C. Equilibrium point B is a steady state of low stock of capital and, therefore, low per capita income, while equilibrium point C has a higher stock of capital. Equilibrium point B is a saddle point, with the positively sloped saddle path dividing the plane in two regions. To the left of the saddle path the behavior of the system is moving this economy towards equilibrium point A, while at any point at the right of the saddle path the economy is moving towards equilibrium point C, which is stable. It is only in the case that the economy happens to be exactly in the saddle path that it will be moving towards equilibrium point B.

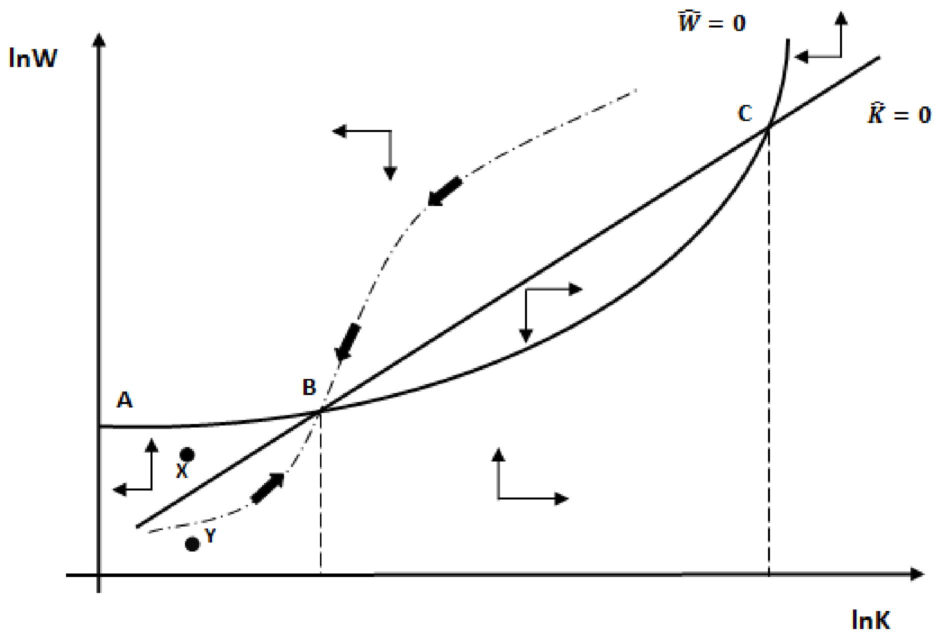

Figura 2: Exchange rate policy

4 The role of exchange rate policy and the importance of infrastructure

4.1 The role of exchange rate policy

An exchange rate policy puts a downward pressure on real wages in the short-run, which promotes the expansion of the tradable sector via price incentives. In the medium run, this high profitability in the tradable sector promotes higher investment, which increases K. An increase in K brings in a positive feedback through G, which induces a virtuous cycle between productivity increases and the desire to invest. However, as a result of this process, the absorption of workers by the tradable sector rises. This higher demand for labor by the tradable sector reduces the relative supply of non-tradable goods and increases the bargaining power of workers, resulting in higher prices and wages. This subsequent rise in wages has a negative impact on the development process, and hence the possibility of a virtuous process depends on the forces of these ambiguous mechanisms.

Figure 2 shows a case where a devaluation moves the economy from point X to Y, shifting it from a trajectory of underdevelopment to a trajectory towards equilibrium with higher development (from the left side to the right side of the saddle path). This result is in accordance with the empirical literature (see Rodrik and McMillan 2011) in which an exchange rate policy induces a process of structural change (understood as a change towards sectors of higher productivity) in developing economies, and with the results found in Razmi et al. (2012a) and Rodrik (2008).

Resource reallocation is the main driver of this process. In parts of Africa, for instance, where the employment share of agriculture is still significant, this process could be understood as a movement from agriculture towards industry. In Latin American countries where the share of low productivity services has been increasing, the shift could be mostly from services to manufacture. In both cases, the increase in total employment correlates with increases in the overall productivity of the economy, boosting employment, investment and growth.

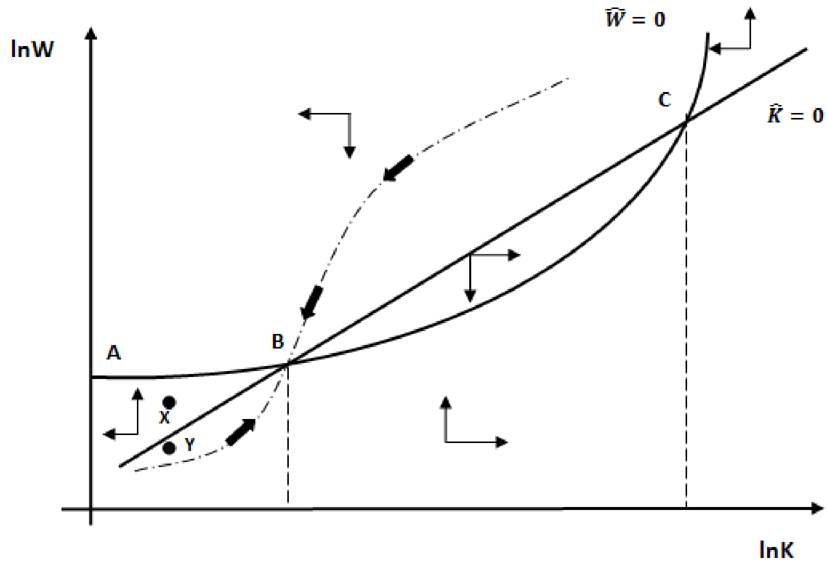

Figura 3: Exchange rate policy: the case of an insufficient devaluation

But a feasible devaluation is not necessarily successful. Excessive devaluation might affect the credibility of the fixed exchange rate and, additionally, has a high reversion due to rapid pass-through on non-tradable prices and wages, which is in accordance with the results of Taylor et al. (2001).[4] These asymmetries in terms of the size of the devaluation may result from "menu costs"associated with changing prices: small exchange rate variations can be absorbed by firms and only changes exceeding a threshold are passed through prices (see Aron et al. 2014 for a survey of exchange rate pass-through studies).

Figure 3 shows a case in which a feasible devaluation is not sufficient. Suppose a country situated at point X, on the left of the saddle path. A devaluation moves the economy to point Y. In contrast to the preceding case, despite an initial stimulus, the spur in capital accumulation and the productivity gains would not last long enough to induce a process of steady development. Our next step is to understand how different investment rates in infrastructure as a complementary policy to exchange devaluation can change this result.

4.2 The role of infrastructure

Suppose again an economy situated at point X and represented by the black isoclines in Figure 4. As in the previous case, a devaluation shifts this economy to point Y, still in the trajectory of total underdevelopment. Let us now assume that this economy raises its investment in infrastructure (a higher τ). As we can see from equation (15), the rate of capital accumulation is an inverted U-shaped function in τ which, as it can be checked, has a maximum at $\tau = \frac{\chi}{\alpha+\chi}$. We assume herein that any

[4]A devaluation can alter the inflationary expectations of the public. If credibility is lost, private agents will expect that the Central Bank will deviate again from its exchange rate commitment, triggering an inflationary cycle. Additionally, in the case of significant inflationary pressures, a policy response (a further devaluation) may hinder the process, as pointed out by Rapetti (2013, p.18): "in a context in which nominal devaluations instead of generating a RER depreciation lead to rises in domestic prices, engaging in further devaluations is likely to accelerate the rate of inflation".

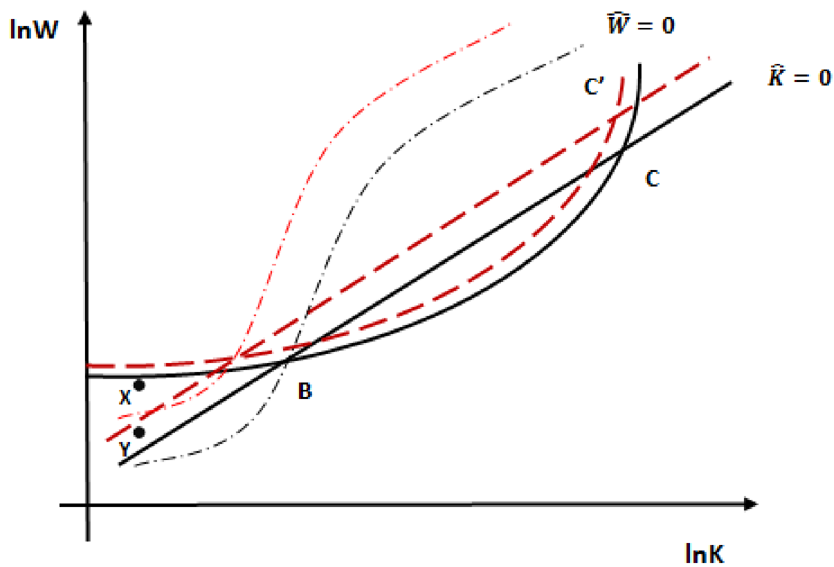

Figura 4: The role of infrastructure

change in τ takes place with τ remaining to the left of such maximum value.[5] Thus, any increase in τ induces an upwards shift in the isocline $\hat{K}$ = 0. Another important assumption concerns the shift in the $\hat{W}$ = 0 isocline, which also shifts upwards. In order to ensure that this shift does not eliminate the positive effect of $\hat{K}$ = 0, we must assume that ξ is not too large and that the share of tradables in private consumption is sufficiently large, as already assumed. In Figure 4, the upward shift of isoclines $\hat{W}$ = 0 and $\hat{K}$ = 0 is represented by the dashed red isoclines.

Note that in this case point Y lies in the trajectory of higher development (on the right side of the new saddle path) and thus the feasible devaluation is sufficient to bring a process of development as a result of the complementarity between the exchange rate and infrastructure policies. The intuition for the complementarity between theses policies is straightforward. A higher investment in infrastructure provides higher productivity for the tradable sector, which then requires a lower devaluation in order to expand. An increase in τ provides a better productive environment for the economy, which increases production possibilities. In this new environment, the odds of an exchange rate policy succeeding are higher, and this is so also because a lower devaluation reduces the exchange rate pass-through to prices and wages, which could undo the positive impact of the currency devaluation.

On the other hand, the financing of infrastructure is a challenge for most developing economies, especially in this environment. Rapetti (2013) shows how the implementation of domestic demand policies, including the reduction of government spending, can be important to accomplish a successful exchange rate policy. The right balance between types of expenditure must be found, opting

[5]In our setting, taxation favors tradable sector firms up to a maximum value. Under this assumption, there is not a political economy constraint, which introduces two questions. The first one is why the private sector itself does not supply infrastructure, while the second question is why the government is not able to tax optimally. The former question can be answered by appealing to a typical free rider problem, in which the provision of a public good will not be optimal in the presence of free riders. As for the second question, a possible constraint that prevents the government from choosing the ideal tax is the existence of imperfect information, which is a plausible assumption for developing economies with poor data and a lack of skilled government officials. Under these circumstances, we assume that the government is not capable to optimize taxation. In a more inclusive model in which workers and owners of the fixed factor are taxed as well (which we opted for not taxing for the sake of simplicity), political economy constraints may emerge.

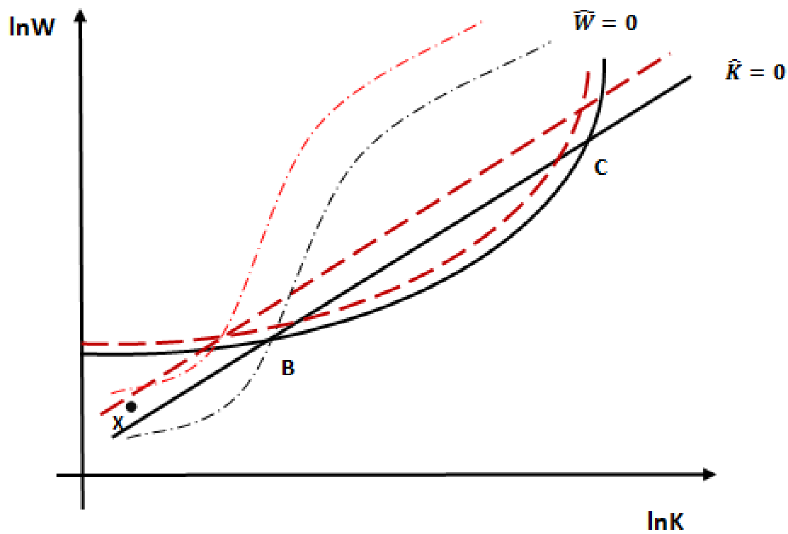

Figura 5: Infrastructure policy separately

for the reduction in non-productive expenditure. Moreover, a greater involvement of private investors can mitigate such problems. In this sense, the increasingly popular public-private partnership is a good prospect, as it can divert resources and efficiency patterns of the private sector to boost infrastructure finance. Additionally, as mentioned earlier, it is expected that in the process of development investment in advanced infrastructure is prioritized. In fact, the scarcity of investment of this type can lock an economy in a middle-income trap (see Agénor and Canuto 2012).

Even though we have focused on the complementarity of infrastructure and exchange rate policies, we could also consider infrastructure policy separately. In fact, the movement towards point C can be achieved through a higher investment in infrastructure, instead of a currency devaluation (see Figure 5). In this case, there is not a shift from X to Y, but a shift upward of the isoclines $\hat{W} = 0$ and $\hat{K} = 0$, such that point X is now to the right of the saddle path and hence moving towards the long-run equilibrium with higher stock of capital. Similarly to the case of an insufficient devaluation, this upward movement can fail to alter positively the trajectory of the economy.

The possibility of obtaining the same results through an infrastructure policy leads one to wonder which one is the best policy. This is evidently a broad question, which we can briefly discuss from the perspective of income distribution. Both policies, when successful, lead to higher employment. However, there is a relevant difference in terms of distribution. Suppose that an economy opts for a devaluation (see Figure 3), shifting from X to Y. Note that at this point, wages are lower, and the equilibrium with higher development remains at equilibrium point C. In the case of an infrastructure policy, however, the new relevant isoclines are the dotted red ones, with which the initial real wage is the same and the equilibrium with higher development has a higher real wage (see equilibrium point C' in Figure 5). Given the possibility of choosing between policies, the exchange rate policy has worse distributive consequences. In the case of complementarity between policies, a higher investment in infrastructure has better distributive consequences.

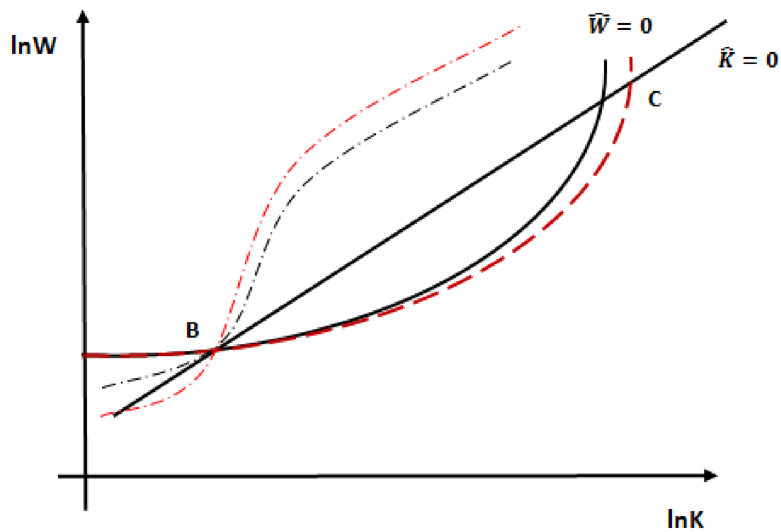

Figura 6: Infrastructure and inflation

4.3 Infrastructure and inflation

We have so far focused on the positive effects of an increase in investment in infrastructure on the productivity of the tradables sector. As seen above, the complementarity of policies can result in a successful exchange rate policy, thus leading the economy to a path of development. However, an important consequence of an appropriate supply of infrastructure is the impact on prices.

In order to preserve the simplicity of the model, let us make some further assumptions. In the baseline version, the available infrastructure does not participate in the production of the non-tradable sector. In order to further our analysis and include some effects of infrastructure on domestic prices, let us then assume an alternative production function for the non-tradable sector:

$$Y_N = BG^{\eta} L_N^{\sigma} \tag{21}$$

where $\eta < \chi$ and $\eta + \sigma < 1$. All the other assumptions remain intact, so that we are dropping solely the assumption that infrastructure does not participate in the production of non-tradable goods. The assumption that η is lower than χ is based on the fact that since the non-tradable sector does not use capital (or uses less capital, in the real world), this sector benefits less from infrastructure.

The introduction of infrastructure in the non-tradable sector changes the $\hat{W} = 0$ isocline in two different ways.[6] First, it changes the slope of the isocline, as represented in Figure 6 by the dashed red lines. This change is a consequence of a lower rate of inflation in the economy, since the process of development goes along with an increase in productivity of the non-tradable sector. Therefore,

[6]We can solve the model in the same way, the only difference being that now infrastructure affects the demand for labor in the non-tradable sector and hence the slope of the $\hat{W} = 0$ isocline. Mathematically, the difference is a change in equation (34), where the new condition for multiple equilibria is:

$$\frac{\chi}{1-\alpha} > \frac{(\chi+\alpha)\phi(1-\sigma) - \phi\alpha\eta}{\alpha(1-\phi) + (1-\sigma)\phi}$$

Note also that with a higher η it is more likely that this condition will hold.

the relative supply of non-tradable goods falls at a slower pace during the migration of labor force to the tradable sector. This implies not only a dynamic of lower inflation, but also a stable long-run equilibrium with higher stock of capital.

The second effect occurs when we increase the tax rate, as discussed in the previous case of complementarity of policies. Even though both isoclines will move upward as represented in Figure 4, the shift in the $\hat{W} = 0$ isocline is expectedly smaller. This result comes from the lower impact of τ on the intercept, since now part of its effect on domestic prices is positive.

The complementarity of infrastructure should include a broad range of services that favor both tradable and non-tradable sectors. While infrastructure is important to boost productivity in the tradable sector, infrastructure is equally important to avoid a relatively lower supply of non-tradable goods resulting in inflationary pressures that erode price competitiveness. Therefore, the process of development involves avoiding the rise of a dual economy with large differences in sectoral productivities.

5 Summary

As of late, a competitive exchange rate policy has been often claimed to be growth-enhancing. In fact, there is considerable empirical and theoretical support for such claims, including the relatively recent episodes of growth experienced by Asian economies. However, the literature has paid insufficient attention to the possibility that the feasibility and success of an exchange rate policy as economic growth enhancer can be improved by its coordination with supply policies.

This paper develops a dual economy model to explore the implications of different levels of infrastructure as complementary to exchange rate policy. In the model, an exchange rate devaluation favors the profitability in the tradable sector and bring the economy to the track of development. The government taxes the capital stock endowed by firms in the tradable sector and invests all the resulting tax collection towards the provision of infrastructure.

The model shows that (i) a higher investment in infrastructure results in higher productivity in the tradable sector, so that a lower currency devaluation than otherwise is required to increase the economic growth rate; (ii) a higher investment in infrastructure leads to lower inflation in the economy, since the process of development goes along with an increase in productivity in the non-tradable sector, and (iii) when there is a choice between an exchange rate policy and an infrastructure policy, one relevant issue to consider is that the latter has better distributive consequences.

All in all, the prospects for a competitive exchange rate to be both feasible and successful as a growth-enhancing development policy are improved when the exchange rate policy is pursued in conjunction with a suitable complementary infrastructure policy.

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Appendix A

In order to find the wage locus, we first have to express L_N as a function of L_T. Using equation (12), along with substituting from (11) and defining profits and rents as a function of wages, we obtain:

$$\frac{P_N C_N}{1-\mu} = W(L_T + L_N) + (1-s)(1-\tau_T)\frac{\alpha}{1-\alpha}WL_T + (1-s)\frac{1-\sigma}{\sigma}WL_N \tag{22}$$

Substituting from (9) and imposing the market clearing condition from (13), we obtain:

$$L_N = \lambda L_T \tag{23}$$

where $\lambda \equiv \frac{\left[\frac{1+\alpha(s\tau - s - \tau)}{1-\alpha}\right]}{\left[\frac{1}{\sigma(1-\mu)}-1\right]}$.

We now need to find $\hat{w}_N$. In order to find it, we recall from (8) that:

$$w_N = \sigma B L_N^{\sigma-1} \tag{24}$$

Substitution of (23) into (24) yelds:

$$w_N = \sigma B \left[\lambda(1-\tau)\tau^{\frac{\chi}{\alpha}}\left(\frac{(1-\alpha)}{w_T}\right)^{\frac{1}{\alpha}} K^{\frac{\chi+\alpha}{\alpha}}\right]^{\sigma-1} \tag{25}$$

Taking natural logs, differentiating with respect to time and considering that $\hat{W}$ = $\hat{w}_T$ (since P_T is constant), and using equations (16)-(19), we obtain:

$$\hat{W} = \frac{1}{\rho\phi}\left\{\frac{w^d - w}{w} - (1-\phi)\left[\frac{(\alpha+\chi)(\sigma-1)}{\alpha}\hat{K}\right]\right\} \tag{26}$$

where $\rho \equiv \left[1 - \frac{(1-\phi)(\sigma-1)}{\phi\alpha}\right] > 0$.

Substituting (17) into (26), we obtain:

$$\hat{W} = \frac{1}{\rho\phi}\left\{\left[\frac{m(1-e)^{-\xi}}{w_T^{1-\phi} w_N^{\phi}} - 1\right] - (1-\phi)\left[\frac{(\alpha+\chi)(\sigma-1)}{\alpha}\hat{K}\right]\right\} \tag{27}$$

Appendix B: Derivation of the $\hat{w}_t$ = 0 locus

We already know from (15) that $\frac{\mathrm{d}log w_T}{\mathrm{d}log K}\mid_{\hat{K}=0}$ is positively sloped, so that we can focus on the first term of the right hand side of (27) in order to find the $\hat{w}_t$ = 0 locus. In order to do that, we must have:

$$\frac{w^d}{w_T^{1-\phi} w_N^{\phi}} - 1 = 0 \tag{28}$$

We know from previous equations how each term of (28) varies with w_t and K. From (25) we know that w_N rises with w_T and falls with K. From (7), (23), and (17) we know that w^d rises with K and falls with w_T. Equation (28) can thus be expressed as an implicit function on K, w_T and τ:

$$G(K, w_T, \tau) = w^d w_T^{\phi-1} w_N^{-\phi} - 1 = 0 \tag{29}$$

Hence, we find that:

$$\frac{\partial w_t}{\partial K} = -\frac{w_T^{\phi-1}[-\phi w_N^{-\phi-1} w_{N_K} w^d + w_N^{-\phi} w_K^d]}{[(\phi-1) w_T^{\phi-2} w_N^{-\phi} - \phi w_T^{\phi-1} w_N^{-\phi-1} w_{N_{w_T}}] w^d + w_T^{\phi-1} w_N^{-\phi} w_{w_T}^d} > 0 \tag{30}$$

Since $w_{N_K} < 0$, $w_{N_{w_T}} > 0$, $w_{w_T}^d < 0$, and $w_K^d > 0$, we find that equation (30) $>$ 0, i.e., the w^d = $w_T^{\phi-1} w_N^{-\phi}$ is positively sloped, and so it is the $\hat{w_T} = 0$ locus.

Appendix C: Multiple Equilibria

Consider first the the $\hat{K}$ = 0 locus. From (14), we know that the condition is that r = i + δ. Substituting it into (15), taking logs and totally differentiating, we obtain:

$$\frac{\mathrm{d}log w_T}{\mathrm{d}log K} = \frac{\chi}{1-\alpha} \tag{31}$$

To find the locus of w^d = $w_T^{\phi-1} w_N^{-\phi}$, we need to substitute (25) and (17) into (29). Taking logs and totally differentiating,

$$\frac{\mathrm{d}log K}{\mathrm{d}log w_T} = (\chi + \alpha) \frac{\phi(1-\sigma) + \xi \frac{e}{1-e}}{\alpha(1-\phi) + (1-\sigma)\phi + \xi \frac{e}{1-e}} \tag{32}$$

Multiple equilibria will arise when these two locus intercept more than once. As we can see from (32), the locus is not constant, and in fact depends on the employment rate, as K varies. From (7) and (23) we can see how the employment rate responds to a variation in K. We thus have two cases:

(1) As K $\to \infty$, the locus is:

$$\frac{\mathrm{d}log K}{\mathrm{d}log w_T} = \chi + \alpha \tag{33}$$

(2) As K $\to$ 0, the locus is:

$$\frac{\mathrm{d}log K}{\mathrm{d}log w_T} = (\chi + \alpha) \frac{\phi(1-\sigma)}{\alpha(1-\phi) + (1-\sigma)\phi} \tag{34}$$

For the first case, the slope of w^d = $w_T^{\phi-1} w_N^{-\phi}$ will be greater than $\hat{K}$ = 0 if and only if:

$$\chi + \alpha < 1$$

In the latter case, already assuming the previous condition, the slope of w^d = $w_T^{\phi-1} w_N^{-\phi}$ will be smaller than that of $\hat{K}$ = 0 if:

$$\frac{\chi}{1-\alpha} > \frac{\phi(1-\sigma)}{\alpha(1-\phi) + (1-\sigma)\phi}$$

The first condition states that the positive effect of infrastructure needs to be modest, otherwise the model dynamic would be explosive. The second condition, similarly to the model in Rapetti

(2013), is more likely to hold the higher the values of α, σ and ϕ, i.e., the more capital intensive is the tradable production, the more elastic the supply of non-tradables and the higher the share of tradables in private consumption. Our following analysis will assume that both conditions hold.