How does the world interest rate affect the real exchange rate?

Karine Gente[*]

CEDERS - 14 avenue Jules Ferry, 13621 Aix-en-Provence.

E-mail: kgente@univ-aix.fr.

Tel: 33-4 42 91 48 33

Fax: 33-4 42 91 48 29

Abstract: This paper develops a two goods overlapping generations model of a semi-small open economy. Since generations are not linked, the world interest rate and the domestic rate of time preference need not to be equal. Consequently, this setting represents the real minimal framework to study the effects of a world interest rate shock. We show that both medium and long-run effects of a positive interest rate shock depend on the net financial position of the domestic country vis-à-vis the rest of the world. We have an exchange rate undershooting in the case of a creditor country. As a result, the path is non monotonic whereas the exchange rate simply appreciates in a debtor country.

Key-words: Real exchange rate; overlapping generations; world interest rate shock.

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1. Introduction

How does the world interest rate a®ect the exchange rate? This question has been extensively addressed in traditional open economy macroeconomics. The interest rate parity holding, an increase in the world interest rate makes the current exchange rate of the domestic country depreciate. However, this result is based on a static analysis, and the real equilibrium exchange rate (REER) behavior is not studied.

The real equilibrium exchange rate (REER), de¯ned as the level of price indices and nominal exchange rate consistent with macroeconomic equilibrium, is a very useful indicator for the public decision-maker. Indeed, it can be used to determine whether a nominal exchange rate is sustainable or not. Thus, the REER enables to evaluate the misalignement, that is, short-term deviations of the observed real exchange rate from its long-run equilibrium value [Hinkle and Montiel (1999)]. Consequently, our purpose in this paper will be to develop a model to investigate the REER reaction after a world interest rate shock. Among all characteristics, the main feature of this approach is that we use a real setting to set the REER analysis in the medium to long-run horizon, once monetary neutrality holds.

For the last two decades, most of the exchange rate literature has moved toward an inter-temporal choice theoretical approach where preferences, technology and capital market access are explicitly spelled out [Obstfeld and Rogo® (1996)]. In a non-monetary environment, these models enable to characterize the real exchange rate in a medium to long-run horizon, monetary neutrality holding. Nevertheless, the main ¯nding of this setting is that the real exchange rate is fully determined only on one side of the domestic market. To precise, the real exchange rate is fully explained by capital accumulation when the economy consists of altruistic and identical generations that is to say when a representative agent with in¯nite horizon decides consumption path.

Indeed, these optimal growth models of small open economies require the equality between the world interest rate and the domestic rate of time preference. For this reason, only real exchange rate variations can generate consumption tilts. Otherwise, consumption is constant. Thus, the real exchange rate dynamics result essentially from capital accumulation [Brock (1988), Sen and Turnovsky (1989a) (1989b) (1990), Brock and Turnovsky (1994)]. In a different way, when the economy is made up of “disconnected” generations [Weil (1989)] and supply is fixed, real exchange rate and consumption have the same qualitative paths [Frenkel, Razin and Yuen (1996)]. At the opposite of these two distinct settings, we need for studying the non-trivial REER reaction to a world interest rate shock a framework where the disturbance can affect both savings and investment decisions.

To address theoretically this question, we use the “disconnected generations” assumption [Weil (1989)] according to which new generations are not linked to the previous ones by an altruistic channel. In this setting[1], the domestic rate of time preference and the world interest rate need not to be equal. As a result, we can investigate the REER reaction to a world interest rate shock both through saving and investment decisions. An interesting feature is that the net financial position of the domestic country vis-à-vis the rest of the world depends on the spread between the domestic rate of time preference and the world interest rate.

With these “selfish” generations, our approach is different from the almost real exchange rate literature[2]. Indeed, we focus on the reaction of the REER to an interest rate shock, thus in a medium to long-run horizon. In this sense, this analysis contrasts with Kollmann (1997) and Agénor (1998) who investigate only the short-run behavior of the exchange rate. They both conclude that an interest rate shock leads to a non monotonic

[1] The overlapping generations model without bequests we use is the Blanchard (1985) perpetual youth setting. Several studies have used this framework to investigate the effects of various shocks on the current account like Matsuyama (1987, 1988) or on the real exchange rate as Frenkel, Razin and Yuen (1996). Since ricardian equivalence fails with no bequests, these models are often used to analyze the effects of public deficits on demand, particularly in Persson (1985) and Burgess (1996). However, they do not focus on the effects of a world interest rise on the real exchange rate.

[2] Hinkle and Montiel (1999) survey this literature.

response of the current real exchange rate in a model considering monetary aspects.

Moreover, both Kollmann (1997) and Agénor (1998) models are in line with the altruistic generations setting. Consumer decisions are stemmed from a representative agent with infinite horizon. Hence, the world real interest rate need to be equal to the domestic rate of time preference. This assumption has two main consequences. First, the world interest rate rise has only trivial effects on private savings. Second, the real exchange rate path does not depend both on the time preference and the world interest rate as it is the case in empirical papers [Stein and Paladino (1997)]. Indeed, econometric analysis are used to consider both the world interest rate, the domestic rate of time preference (measured as the ratio between total demand and output), and the productivity of capital as significant variables to explain the real exchange rate.

In contrast with this literature - which deals with the short-run behavior of the real exchange rate - our approach, based on agents with heterogenous wealth, leads to reduced form of the real exchange rate nearer of the ones tested in empirical papers.

Finally, we depart from the two sector setting[3] assuming the country is "semi-small" as in Sen and Turnovsky (1989a) (1989b) (1990). This economy can borrow and lend at a given world real interest rate and purchase imported goods at given world prices, but it faces a downward sloping demand schedule for its exports because they are perceived to be imperfect substitutes for the tradeable goods of other countries[4]. Thus, there is only one sector in this economy and the real exchange rate clears the domestic market. To make the setting relevant, we assume investment is entirely of domestic origin. This assumption is responsible for the non separability of the dynamic system. Thus, various impatience degree of the domestic country can generate different capital stock reactions. Hence, we obtain various responses of the real exchange rate after a world interest rate

[3] Turnovsky (1997) presents the two sector approach.

[4] This concept of a semi-small open economy has become popular in CGE trade modelling literature. Appelbaum and Kohli (1979) provide empirical support for the semi small open economy hypothesis for Canada.

shock. Otherwise, if investment is entirely of imported origin, the model would need a world clearing condition on the market of the imported good. Then, the capital stock adjustment following an interest rate shock would be time preference indepedndent.

In this setting, we obtain the following results. First, the real exchange rate depends both on the demand and supply sides. Second, real exchange rate reaction to a world interest rate shock depends on the net financial position of the domestic country vis-à-vis the rest of the world.

Initially, the real exchange rate reaction depends on the impatience degree of the domestic country. It depreciates when the time preference is high whereas it so much appreciates when the time preference is low that it undershoots its long-run level. In this former case, the real exchange rate goes on appreciating[5] after a positive interest rate shock and then depreciates. Indeed, since the terms of trade deteriorate during the real appreciation, the net foreign assets decrease. As a result, financial wealth and consumption go down. Thus, in the creditor country, the real exchange rate depreciates after it reaches a minimum level. At the opposite, after the initial jump when the time preference is high, the fall in the exchange rate is monotone.

The paper is organized as follows. Section 2 describes the model, presents the dynamics and the steady state. Section 3 investigates the stationary and transitory effects of a permanent unanticipated rise in the world interest rate on the real exchange rate path. Section 4 concludes.

2. The Model

We describe a two goods overlapping generations model of a semi-small economy. We assume as Sen and Turnovsky (1989a, 1989b, 1990) that the country is big enough to influence its exports price but small in the world economy. Thus, the world interest rate r^* is given. The economy consists of heterogeneous agents and a representative firm, which

[5] An appreciation is a decrease of the real exchange rate.

produces a unique commodity from a neoclassical technology F. The agents share their consumption between two substitutable commodities: the good produced domestically x and an imported one y; which price is given. R is the relative price of the imported good in terms of the domestic good. All quantities are expressed in units of the domestic good. Under these conventions, a rise in R means a real effective exchange rate depreciation. Moreover, under perfect capital mobility, the domestic interest rate is defined according to the Interest Rate Parity (IRP) relation: $r = r^* + \dot{R}/R$. The production, realized from capital and labor, is sold domestically for residents consumption x or investment I, and the rest is exported $Z(R)$:

2.1. Heterogeneous Agents

The demographic side of the model follows Blanchard (1985). Each individual household faces a constant probability of death p, which is age independent. Agents have uncertain lifetime and maximize their expected utility. Consequently, the effective individual discount rate is the individual rate of time preference β majored by the instantaneous probability of death. Normalizing the constant population at unity, at each instant p agents die and p new entrants arrive. Without connection between generations' wealth, the system needs an insurance company which secures loans. Free entry equilibrium guarantees that the insurance premium equals the constant risk of death. As a result, the return on financial assets is the world interest rate r^* majored by the insurance premium p.

Savings of an agent born at time s as of time t, $a(s;t)$, can be held into two forms: domestic capital stock $K(t)$ and foreign assets $b(s;t)$. Each agent is born with zero non-human wealth $a(s;s) = 0$ and offers labor inelastically. Instantaneous preferences are defined over the two goods according to:

$$c(x;y) = x^{\alpha} y^{1-\alpha}; 0 < \alpha < 1 \tag{2.1}$$

Therefore, the optimization problem of an agent born at time s as of time $t \geq s$ can be decomposed into an intra- and an inter-temporal problems. First, agent allocates his resources to consumption and savings. Formally, the intertemporal program is:

$$
\begin{aligned}
&\max_{c(s;z)} \int_t^{\infty} \log c(s;z)\, e^{-(p+\beta)(z-t)} dz \\
&s.t.\ \frac{da(s;z)}{dz} = (r(z)+p)\, a(s;z) - \pi(z) c(s;z) + w(z) \qquad \forall z \geq t \\
&\lim_{z\to\infty} a(s;z)\, e^{-(r(z)+p)z} \geq 0; \qquad a(s;t) \text{ given}
\end{aligned}
\tag{2.2}
$$

where $w(z)$ is the age independent wage earned at time z; $c(z)$ is the composite consumption good defined in (2.1) and π is its price index. Second, the agent shares its composite consumption c between the two goods x and y. We show in appendix 1 maximizing the intra-temporal program that $\pi = R^{1-\alpha}\alpha^{-\alpha}(1-\alpha)^{-(1-\alpha)}$; and $x = \alpha\pi c = \frac{\alpha}{1-\alpha} R y$.

The Euler equation of this problem is:

$$
\frac{dc(s;z)}{dz} = \left(r(z) - \frac{\dot{\pi}(z)}{\pi(z)} - \beta \right) c(s;z) \tag{2.3}
$$

with $\frac{\dot{\pi}(z)}{\pi(z)} = (1-\alpha)\frac{\dot{R}(z)}{R(z)}$.

Equation (2.3) is specific to an economy with two goods. Dornbusch (1983) shows that the consumption path depends on fluctuations of the real exchange rate when there are two goods in the economy. With an exogenous world interest rate, consumption is usually smoothed when there is a single consumption good[6]. Instead of, with two commodities and one good produced domestically, consumption cannot be smoothed independently of productivity shocks that affect the supply side. So, consumption swings can emerge out of real exchange rate variations.

This equation gives the individual consumption path resulting from the maximization of the intertemporal objective (2.2). After this trade-off between global consumption and saving, agents share their composite consumption between the two commodities, depending on the real exchange rate.

The spending function πc is obtained by integrating Euler's equation and using the intertemporal budget constraint:

$$
\pi(t)c(s;t) = \gamma\,[a(s;t) + h(t)] \tag{2.4}
$$

[6] In this case, $\dot{\pi} = \dot{R} = 0$ and hence $r(z) = \bar{r}$ in equation (2.3).

where the propensity to consume out of real wealth is $\gamma = \beta + p$

and $h(t) = \int_t^{\infty} w(\tau)e^{-(r+p)(\tau - t)}d\tau$ is the expected human wealth of the consumer at date t.

Equation (2.3) is identical to the one obtained in the context of a representative agent. However, individual consumption has to be aggregated, and macroeconomic consumption dynamics will depend on the gap between the world interest rate and the individual rate of time preference too.

2.2. The Representative Firm

The representative firm produces one good, with a linear homogeneous technology F. This good is sold on the domestic market in quantity X for residents consumption. It is still used for investment I entirely of domestic origin[7]. The rest is exported according to the ad-hoc exports function $Z(R)$ with $Z' > 0$, i.e. a real depreciation increases the quantity of the domestic good exported. The intertemporal objective of the firm at z is:

$$\max_{\{K(z);L(z);I(z)\}} \int_t^{\infty} [F(K(z);L(z)) - W(z)L(z) - I(z)]e^{-r(z)(z-t)}dz$$
$$s.t.: \dot{K}(z) = I(z) - \delta K(z) \qquad \text{for all } z \geq t$$

with $\delta > 0$ the rate of capital depreciation. Taking into account the labor market equilibrium ($L = 1$), first order conditions are:

$$r(t) = F_K(K(t);1) - \delta \tag{2.5}$$

$$W(t) = F_L(K(t);1) \tag{2.6}$$

These conditions are standard. The marginal productivity of capital less depreciation is equal to the domestic interest rate. The marginal productivity of labor is equal to the wage. The capital stock is entirely of domestic origin. but depends on the real exchange rate fluctuations through domestic interest rate $r(t)$.

[7] As we already mentionned, the investment uses a domestic good in order to link the dynamics of capital and consumption. Thus, the dynamic system will be non separable.

2.3. Aggregation

Aggregate variables are obtained by summing individual variables in each cohort, weighted by the number of individuals alive in each cohort at time t : $S(t) = \int_{-\infty}^{t} s(\sigma; t) p e^{-p(\sigma - t)} d\sigma$ where capital letter S represents the aggregated variable s. Thus, the wealth variables are $A(t) = \int_{-\infty}^{t} a(s; t) p e^{-p(s-t)} ds$ and $H(t) = \int_{-\infty}^{t} W(t) p e^{-p(s-t)} ds$ or in the differential form:

$$\begin{aligned} \dot{A} &= rA + W - \pi C \\ \dot{H} &= (r + p) H - W \end{aligned} \tag{2.7}$$

Since the probability of death is constant, propensity to consume is age independent, and (2.4) still holds at the aggregate level:

$$\pi C = \gamma [A + H] \tag{2.8}$$

Since $x = \alpha \pi c$; the demand for the domestic good is:

$$X = \alpha \gamma (A + H) \tag{2.9}$$

Substituting the dynamic equations (2.7) in (2.9), we have :

$$\dot{X} = (r - \beta) X - p \gamma \alpha A \tag{2.10}$$

Since agents are heterogenous, the variation in consumption depends on the financial wealth. Indeed, the last term of equation (2.10) appears in the special case of disconnected generations. The shorter is the probability of death p the less the domestic consumption change. If p approaches to zero, the domestic consumption variation would only depend on the gap between r and β as in the infinitely lived generations setting.

2.4. Macroeconomic equilibrium

From (2.5), the optimal capital stock depends on the domestic interest rate and hence on the real exchange rate through the IRP relation $r(t) = \dot{R}/R + r^{\infty}$:

$$\dot{R} = R [F_K (K; 1) - (\delta + r^{\infty})] \tag{2.11}$$

The equality between uses and resources in domestic good is a second relation linking the optimal capital stock and the real exchange rate. Hence, capital accumulation becomes:

$$\dot{K} = F(K;1) - X - Z(R) - \delta K \tag{2.12}$$

2.5. Dynamics

Financial wealth A consists of foreign assets expressed in terms of domestic goods RB and the capital stock K. Then, we deduce the current account as $\dot{B} = \left[\dot{A} - \dot{K} - \dot{R}B\right]/R$. The dynamic system consists of the domestic equilibrium, the IRP condition, consumption, foreign assets and capital stock accumulation. We substitute the equation (2.5) for the domestic interest rate and we have:

$$\begin{aligned}
\dot{B} &= r^{*}B + \tfrac{1}{R}\left[Z(R) - \tfrac{1-\alpha}{\alpha}X\right] \\
\dot{K} &= F(K;1) - X - Z(R) - \delta K \\
\dot{R} &= R\left[F_K(K;1) - (r^{*} + \delta)\right] \\
\dot{X} &= \left[F_K(K;1) - (\beta + \delta)\right]X - \sqrt{\gamma\alpha}\left[RB + K\right]
\end{aligned} \tag{2.13}$$

This dynamic system is not separable and has four dimensions with two forward variables R and X.

As introduction mentions, the real exchange rate is often explained exclusively by supply determinants like the q-ratio, or only by demand factors in the literature. In contrast, with the system (2.13), the real exchange rate depends both on investment and consumption through capital accumulation. This result emerges because we consider only one sector of production at the opposite of Brock (1988), Brock and Turnovsky (1994). Consequently, the real exchange rate is not only a proxy of the relative return of the two sector of production. In our model, the real exchange rate is a key variable both in the consumer arbitrage between the two goods, and in the share of domestic production between exports and domestic uses (which encompass consumption and investment). Hence, the real exchange rate clears the uses and resources in domestic good and depends both on supply and demand. Thus, as we already mentions, an advantage of this setting is that it provides real exchange rate reduced-form very close to the ones tested in econometric papers. The system (2.13) shows that real exchange rate will depend both on world interest rate and domestic rate of time preference. Moreover, this model is relevant for studying shocks which affect demand or supply, and to analyze their impact on the real exchange rate. That is the reason why we study the effects of a world interest rate shock on the economy without introducing a monetary block.

Appendix 2 determines the linearized system in the neighborhood of the steady state. We can easily show that $\rho < \beta + p$ is a sufficient[8] condition for the system to converge asymptotically. Further, we assume that this condition is always fulfilled. Notice that this restriction enables us to study alternatively the two cases $\rho > \beta$ and $\rho < \beta$.

2.6. Steady State

The long run equilibrium[9] satisfies:

$$X^{*} = \alpha \frac{p\gamma F_L(K^{*};1)}{p\gamma - \rho(\rho - \beta)} \tag{2.14}$$

$$\rho + \delta = F_K(K^{*};1) \tag{2.15}$$

$$R^{*}B^{*} = \frac{(\rho - \beta) F_L(K^{*};1)}{p\gamma - \rho(\rho - \beta)} - K^{*} \tag{2.16}$$

$$Z(R^{*}) = \rho K^{*} + \frac{[p\gamma(1 - \alpha) - \rho(\rho - \beta)] F_L(K^{*};1)}{p\gamma - \rho(\rho - \beta)} \tag{2.17a}$$

[8] This stability condition is usual in Blanchard's overlapping generations model of a small open economy. Indeed, if the world were composed by several small economies, the world balance need that $\beta < \rho < \beta + p$. Otherwise, the most impatient country accumulates all the world's wealth. This result is counter to the small economy assumption.

[9] In the long run, the capital stock K^{*} as given, we have $X^{*} = \rho K^{*} + F_L(K^{*};1) - Z(R^{*})$ and $X^{*} = \frac{p\gamma\alpha[\rho K^{*} - Z(R^{*})]}{\rho(\rho - \beta) - p\gamma(1 - \alpha)}$. These two relations between X^{*} and R^{*} show that the steady state exists as long as $\rho(\rho - \beta) - p\gamma(1 - \alpha) < 0$.

with R^*B^* the foreign assets expressed in units of the domestic good. The star "*" denotes the long-run values. These long-run solutions lead to the following expressions of wealth

$$A^* = \frac{(\bar{r} - \beta)F_L(K^*;1)}{p\gamma - \bar{r}(\bar{r} - \beta)} \quad H^* = \frac{F_L(K^*;1)}{\bar{r}+p} \tag{2.18}$$

As usual in an open economy, long-run capital intensity is fully determined by the world return on capital since domestic and world return on capital have converged: $r(t) = \bar{r}$. The long-run human wealth is the discounted wage. From the long-run capital stock determined by standard marginal productivity conditions, we have wage, supply and human wealth. Then, long-run consumption is a function of the wage and the relative price satisfies the market-clearing condition.

Due to heterogeneity, long-run financial wealth A^* depends both on the probability of death and on the gap between the domestic time preference and the world interest rate. Financial wealth A^* and capital stock K^* being given, net foreign assets expressed in units of domestic good R^*B^* are a residual.

According to the A^* equation in (2.18), the financial wealth can be positive or negative[10] depending on the gap between the world interest rate and the domestic rate of time preference. This property is a characteristic of the disconnected generations framework used here. The stability condition $\bar{r} < \beta + p$ enables us to consider the two cases of a creditor ($\bar{r} > \beta$) and a debtor ($\bar{r} < \beta$) country vis-à-vis the rest of the world.

As in Matsuyama (1987), when the world interest rate is equal to the individual rate of time preference, financial wealth is zero. Consequently, the whole stock of capital is financed by foreign debt:

$$R^*B^* = -K^*$$

More generally, the stock of foreign assets in terms of domestic price is an increasing function of the spread between the world interest rate and the rate of time preference[11].

[10] This result is based on the assumption that the wage is age independent [Matsuyama (1987)].

[11] The long-run financial wealth is positive (negative) when the world interest rate exceeds (is lower

That is to say, if the world interest rate were unchanged, a decrease in β would entail an increase in foreign assets when $\rho > \beta$.

3. A permanent unexpected rise in the world interest rate

This setting with heterogenous agents and no intergenerational link is the minimal real framework to investigate the effects on the real exchange rate path of an exogenous variation in the world interest rate. Indeed, a change in the world interest rate affects the real exchange rate through saving and investment decisions. Since generations are "disconnected" [Weil (1989)] net foreign asset holdings depend on the spread between ρ and β: Therefore, we can analyze the real exchange rate reaction to an interest rate shock according to the net financial position of the country vis-à-vis the rest of the world.

Since the dynamical system has four dimensions, we use numerical simulations (Appendix 5) to examine the variables' reactions to an interest rate shock. Let "0" indicate the initial steady state and the star "$*$" represent the new steady state after the world interest rate increase. Appendix 4 shows that based on the dynamical system (2.13), we can characterize the variables' behavior near the equilibrium by linear combinations of the two stocks $B_0 - B^*$ and $K_0 - K^*$:

$$
\begin{aligned}
B(t) &= B^* + \Gamma_1 (B_0 - B^*) e^{\lambda_1 t} + \eta_1 (K_0 - K^*) e^{\lambda_2 t} \\
K(t) &= K^* + \Gamma_2 (B_0 - B^*) e^{\lambda_1 t} + \eta_2 (K_0 - K^*) e^{\lambda_2 t} \\
R(t) &= R^* + \eta_3 (K_0 - K^*) e^{\lambda_2 t} \\
X(t) &= X^* + \Gamma_4 (B_0 - B^*) e^{\lambda_1 t} + \eta_4 (K_0 - K^*) e^{\lambda_2 t}
\end{aligned}
\tag{3.1}
$$

where λ_1 and λ_2 are the two stable eigenvalues of the system.

Arbitrarily, we will consider an unanticipated permanent rise in the world interest rate. This unanticipated shock influences both capital accumulation and consumption choices - savings become more attractive. This model is forward-looking, so short-term

than) the rate of time preference. More precisely, if $\rho < \beta$ the country is a net debtor. Whereas we always have $\rho > \beta$ when the country is a net creditor vis-à-vis the rest of the world responses to this shock depend on long-run effects. We discuss first the long-run reactions and afterwards the transition to this new steady state.

3.1. Long-run effects

We analyze the effects of an increase in the world interest rate on the foreign assets expressed in units of imported good, B^*; and on the capital stock, K^*. Indeed, we must characterize the stocks' response to the shock that is to say the signs of $K_0 - K^*$ and $B_0 - B^*$ (R and X are the forward variables). We obtain easily the reactions of capital K^* and foreign assets expressed in units of domestic good R^*B^*. However, what matters for the dynamics is the reaction of net foreign assets expressed in units of imported good B^*. Thus, we seek to characterize the long run response of the real exchange rate R^* to obtain the reaction of B^*.

A permanent world interest rate rise leads to an increase in the long-run marginal productivity of capital, and therefore reduces the long-run capital stock according to equation (2.15). As a result, it decreases long-run production, the wage, and thus exerts a negative effect on financial wealth. Since financial wealth is also composed of the foreign assets expressed in domestic currency R^*B^*, we can characterize R^*B^* as soon as we know the financial wealth A^* reaction[12].

Concerning A^*; through the wage, the fall in K^* would tend to decrease financial wealth. This effect may be offset by the direct effect of the world interest rate on the long-run propensity to consume. According to the financial wealth expression in (2.18), these two effects are the following:

$$\frac{\partial A^*}{\partial \rho} = \frac{\partial w^*}{\partial \rho}\frac{A^*}{w^*} + w^* \frac{(\rho - \beta)^2 + \sqrt{\gamma}}{[\sqrt{\gamma} - \rho(\rho - \beta)]^2}$$

Hence, the net financial wealth A^* increases in the long run in the special case of a debtor country with $A^* < 0$. Then, the net foreign assets R^*B^* rise since the capital stock is reduced. Therefore, the real exchange rate reaction is essential to characterize the

[12] We have $R^*B^* = A^* - K^*$.

response of B^*: if the real exchange rate appreciates - that is to say if R^* diminishes -, the net foreign assets expressed in units of imported good B^* will increase. Otherwise, in the case of a real depreciation, we cannot conclude.

Concerning the domestic consumption, an increase in the world interest rate has two opposite effects: a negative income effect - since capital stock and wage are reduced - and a direct effect on domestic consumption which sign depends on the spread between the world interest rate and the domestic rate of time preference. If we assume that $r > \beta/2$ in a debtor country, this direct effect is positive : an increase in r makes the domestic consumption higher[13]. Therefore, the real exchange rate appreciates (appendix 3) since supply is reduced. While R^* goes down, the net foreign assets B^* go up when the domestic rate of time preference is high.

In the case of a creditor country, net financial wealth is reduced. Net foreign assets in domestic good R^*B^* decrease. Since $r > \beta$, the substitution effect is positive and consumption increases. Thus, the real exchange rate appreciates - Appendix 3 show that the exports $Z(R^*)$ are reduced. This fall in R^* leads to an ambiguous reaction of net foreign assets expressed in terms of imported good B^*. Thus, we can only conclude that net foreign assets expressed in domestic good R^*B^* fall.

With realistic parameters (see table 1), in the case of a creditor country, a world interest rate increase leads to a reduction of net foreign assets expressed in imported good B^*. This fall in B^* appears despite the real exchange rate appreciation and the domestic consumption rise.

The following proposition summarizes the above conclusions.

Proposition 1 **Long-run effects of an increase in the world interest rate**

In a debtor country, a world interest rate rise leads to an increase in financial

[13] The domestic good reaction is given by:

$$\frac{\partial X^*}{\partial r} = \underbrace{\frac{p\gamma\alpha}{p\gamma - r(r-\beta)}\frac{\partial w^*}{\partial r}}_{\text{Income Effect}<0} + \underbrace{F_L(K^*,1)\frac{p\gamma\alpha(2r-\beta)}{[p\gamma - r(r-\beta)]^2}}_{\text{Direct Effect}}$$

wealth, a portfolio substitution away from physical capital stock and into net foreign assets, expressed in domestic good. The long-run real exchange rate appreciates and domestic consumption increases. These effects are qualitatively the same for the creditor country except for net foreign assets expressed in domestic good that decrease.

As the proposition 1 indicates, we cannot conclude analytically in the case where the country is a creditor. However, numerical simulations show that the long-run effects of an interest rate shock depend on the net financial position of the country:

$\mu > \beta$	$\mu < \beta$
$B_0 - B^* > 0$	$B_0 - B^* < 0$

We analyze next the medium-run behavior of the real exchange rate. It appears that even the qualitative nature of the convergent paths are not the same whether the country is debtor or creditor vis-à-vis the rest of the world.

3.2. Medium run

According to the system (3.1), the paths all depend on the net foreign assets and capital accumulation. Since investment is only composed of domestic good, available resources to invest are finite[14]. Therefore, the capital stock adjusts gradually to its long-run level. Despite the small open economy assumption, saving and investment are linked. In this way, investment and therefore the capital stock depend on financial wealth as well as on net foreign assets.

Through numerical simulations, we show that the monotonicity of the real exchange rate path depends on the net financial position of the country. We assume a Cobb-Douglas function for production $F(K; l) = K^{\rho} l^{1-\rho}$ and the ad-hoc exports function is $Z(R) = R^{\eta}$: The above table 1 collects the numerical values of parameters used for the numerical simulations[15].

[14] From the equation (2.12), we have $K \leq F(K; 1)$:

[15] For more details, see Appendix 5.

Table 1

¯	r*	®	±	p	½	´
0:04 0:05	0:041	0:55	0:1	0:0125	0:33	3

In order to distinguish the two cases of creditor and debtor countries, we consider two levels for the domestic rate of time preference. The world interest rate after the shock is r* = 0:046: Consequently, when ¯ = 0:04 (resp. ¯ = 0:05) the country is a net creditor (resp. net debtor).

We are interested in describing the transition from state \0" to state \¤" following an unanticipated increase in the world interest rate of 0:5%. The medium run behavior of the real exchange rate results from capital stock and foreign assets dynamics.

On ¯gure 1, continuous lines correspond to the variable path and dotted lines represent the steady state values after the world interest shock. Before time 0, the domestic consumption and the real exchange rate are at their previous steady state levels. At time 0, the interest rate shock entails tilts in X and R. A rise (resp. fall) in R means a real exchange rate depreciation (resp. appreciation). Figure 1 plots the real exchange rate, the domestic consumption and the net foreign assets transitions to the new steady state.

Figure 1 exhibits a non monotonic path for the real exchange rate in the case of a creditor country. As the consumption of the domestic good, the real exchange rate reaction to a world interest rate can be decomposed into three stages. First, the real exchange rate jumps. Then it follows a transitional dynamics and ¯nally reaches its new steady state level. It appears from Figure 1 that even the initial real exchange rate jump depends on the net ¯nancial position of the domestic country vis-a-vis the rest of the world. As a result, these various real exchange rate reactions will be re°ected in both consumption and investment. Finally, we obtain non monotonic paths for the net foreign assets, the capital (Figure 2) and the real exchange rate only in the creditor country case.

Figure 1

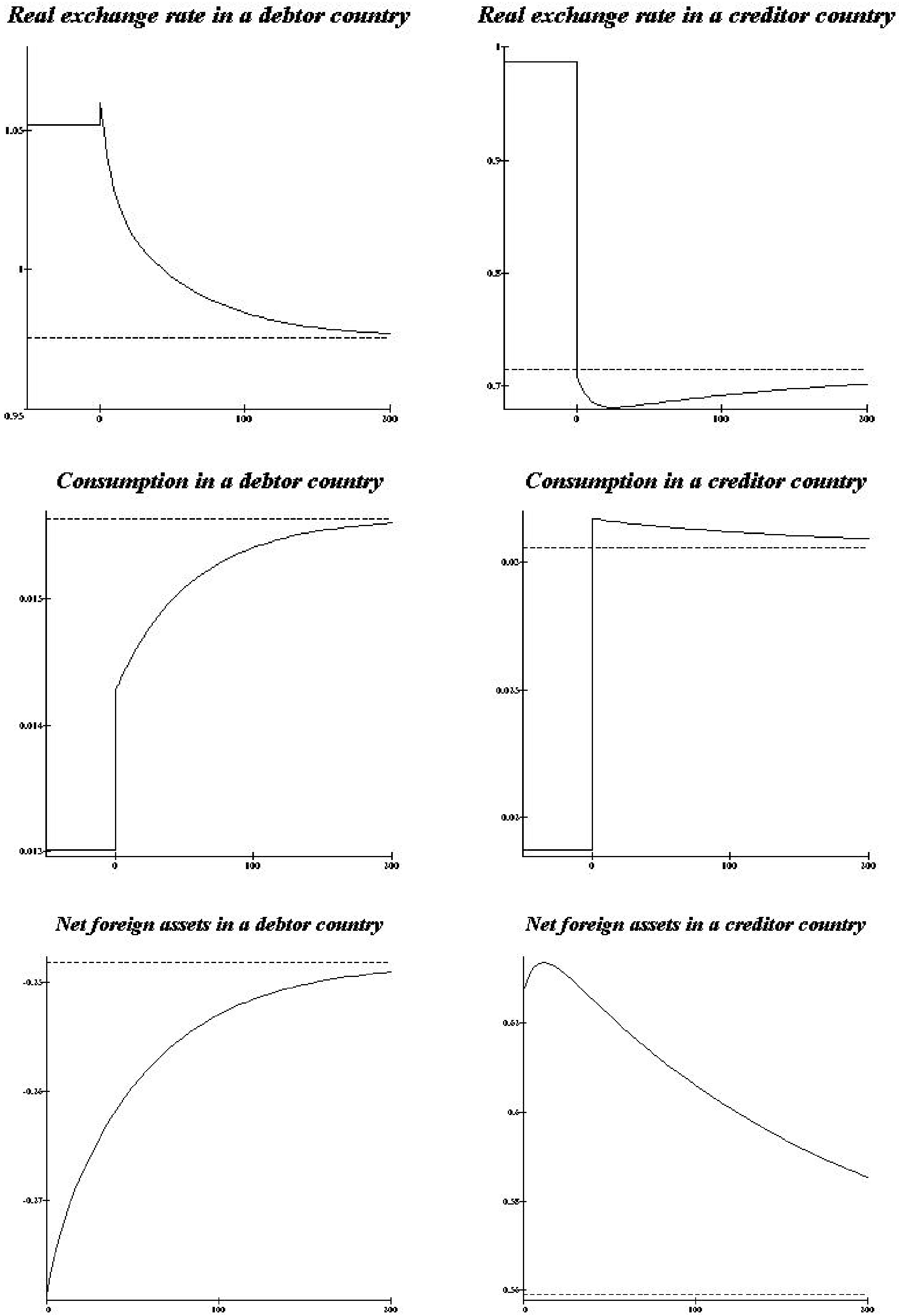
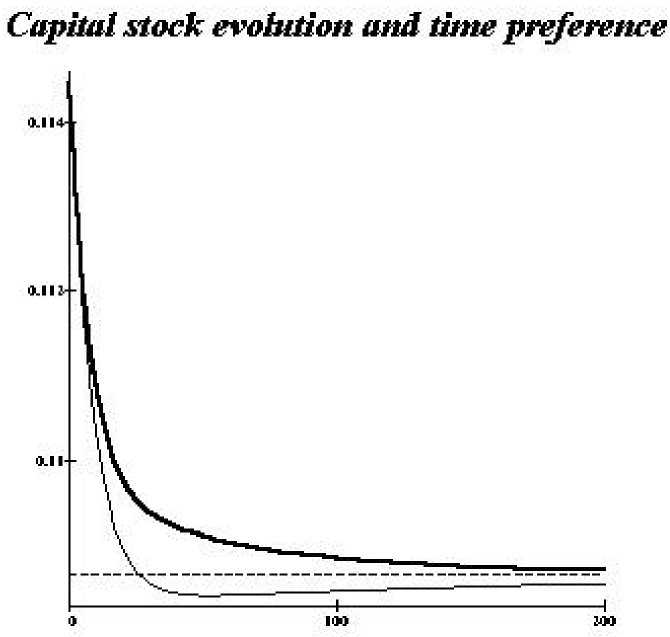

Real exchange rate in a debtor country
Real exchange rate in a creditor country
Consumption in a debtor country
Consumption in a creditor country
Net foreign assets in a debtor country
Net foreign assets in a creditor country

Figure 2 represents the comparative evolution of the capital stock in both the debtor and creditor country cases that is to say whatever the rate of time preference is[16]. The larger line corresponds to the most impatient country - hence the debtor country where the rate of time preference is high - the dotted line indicate the new steady state. Figure 2 exhibits a non monotonic of the capital stock in the case of a creditor country. We will explain this feature after investigating why the initial real exchange rate reaction depends on the time preference level.

Figure 2



As the consumption, the real exchange rate is a forward variable which reacts as soon as the world interest rate increases. However, this reaction depend on the impatient degree of the domestic country. Indeed, the real exchange rate goes up (resp. down) - that is to say it depreciates (resp. appreciates) - when the rate of time preference is high (resp. low).

[16] The former section has shown that the steady state level of the capital stock does not depend on ¯ according to: F (K¤; 1) = r̄ + ±: Hence K_0 is identical whatever the rate of time preference ¯ is and we can compare the two reactions of the capital stock.

Ex ante, an increase in the world interest rate have a negative e®ect on the real exchange rate because the marginal productivity of capital becomes lower than the world return on capital. This ¯rst appreciating e®ect is the same in both creditor and debtor cases and hence tends to increase real wealth whatever ¯ is[17]. Nevertheless, the world interest rate rise causes variaous e®ects which depend on the net ¯nancial position of the domestic country vis-à-vis the rest of the world.

Indeed, a real appreciation leads to a ¯nancial wealth reduction (resp. increase) when the country is a creditor one (resp. debtor one)[18]. Hence this indirect e®ect tends to decrease (resp. to increase) consumption in the creditor country case (resp. in the debtor country case)[19]. Finally, the ex ante real appreciation have two positive e®ects in the case of a debtor country while only the ¯rst one is positive in the case of a creditor country. According to Figure 1, this ¯rst e®ect dominates and the increase in the world interest rate makes initially consumption higher whatever ¯ is. However, this initial jump in consumption is deeper in the case of a creditor country, the real wealth e®ect being more important[20].

Ex-post, this variation in consumption in°uences the real exchange rate. Indeed, an increase in consumption of the domestic good reduces available quantities of domestic good for investment and exportations. Then, the real exchange rate depreciates (resp. appreciates) when the initial jump in consumption is low (resp. high). Hence, an increase in the world interest rate leads to a real exchange rate undershooting: the exchange rate becomes inferior to its long-term level. Consequently, the real exchange rate path is non

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[17] A real appreciation corresponds to a fall in the consumption price index ¼ that increases the real wealth and has a positive e®ect on consumption: $C = ° \frac{A+H}{¼}$:

[18] Financial wealth is given by $A(0) = R(0)B_0 + K_0$ with $\frac{@A(0)}{@R(0)} = B_0$ **?** 0 if ½ **?** ¯:

[19] Another consequence of the ex-ante real appreciation is a substitution e®ect which increases the consumtpion of the imported good. As Figure 1 plots the consumption of the domestic good, this substitution e®ect is not obvious.

[20] The real wealth e®ect given by $\frac{@C}{@¼} = ¡ ° \frac{A+H}{¼^2}$ is higher when the domestic country is creditor ($B_0 > 0$) because $A(0) = R(0)B_0 + K_0$ and K_0 does not depend on the sign on B_0:

monotonic when the time preference is low.

This initial jump in the real exchange rate means that the exportations start decreasing (resp. increasing) in the case of a creditor country (resp. a debtor country). On the other hand, a rise in the world interest rate increases directly the current account when the net financial position of the domestic country is positive (resp. negative). This direct effect explains why the net foreign assets first increase in the case of a creditor country. However, in this former case, the current account deteriorates quickly because of the large initially the exportations fell and the domestic consumption rose sharply. After[21] $t^* = \frac{-\lambda_2}{\lambda_1(\lambda_1-\lambda_2)}\frac{\eta_1}{-1}\frac{K_0-K^*}{B_0-B^*}$; net foreign assets start decreasing and have a negative effect on financial wealth and consumption. At the opposite, in the debtor country case, the initial increase in exportations and the mild rise in consumption lead to a monotonous expansion in net foreign assets, the negative direct effect of an increase in i̇ being offset.

Finally, the initial jump in consumption influences both real exchange rate and investment. Indeed, the sharp increase in consumption in the creditor country case leads to a fall in exportation and investment. Consequently, since investment is lower in the creditor country case, the capital stock adjustment is more abrupt as indicates the Figure 2: the reduction is so much important that capital stock becomes lower than its initial level. After t^*; the decrease in net foreign assets reduces financial wealth and consumption. Hence, there is more domestic good available for investment and capital stock increases until it reaches its new long-run level.

At the opposite, in the debtor country case, the initial jump in consumption is mild. So, investment decreases but at a slower rate. Associated with the monotonous increase in financial wealth and consumption (since net foreign assets are expanding), investment is reducing all the adjustment long and capital stock always decreases.

[21] Deriving B (t) in the system (3.1), we have : $B'(t) = \lambda_1 -_1 (B_0 - B^*)e^{\lambda_1 t} + \lambda_2 \eta_1 (K_0 - K^*)e^{\lambda_2 t}$ and $B'(t^*) = 0$: We note that in a debtor country $t^* < 0$ because $B^* < 0$; and $B_0 - B^* < 0$:

The non monotonic reaction of the capital stock explains why the real exchange first appreciates and then depreciates after the initial state. Indeed, according to (2.11), the real exchange rate follows the same qualitative path as the capital stock.

For the debtor country, the world interest rate rise entails a permanent reduction of the capital stock $K(t) - K^* \geq 0$, whereas for the creditor country, we distinct two stages. First, $K(t) \geq K^*$ and then the real exchange rate appreciates ($\dot{R} < 0$). Second, $K(t) \geq K^*$ and then the real exchange rate depreciates ($\dot{R} > 0$). This feature is characteristic of an economy which uses the same good for exportations, consumption and investment. Otherwise, if the investment good were imported, the dynamic system would become separable and the non monotonic net foreign assets path would not imply such behaviors of capital stock and real exchange rate in the case of a creditor country. In other words, the distinction between an impatient and a patient country would be meaningless in a context where investment is constituted by an imported good.

4. Conclusion

This paper has developed a two goods overlapping generations model of a semi-small open economy. It has examined the REER response to an interest rate shock. Since generations are not linked, the world interest rate and the domestic rate of time preference need not to be equal. Consequently, this setting represents the minimal framework to study the effects of an interest rate shock on the real effective exchange rate.

The semi-small economy can lend or borrow capital on the world market at a fixed interest rate. This paper shows that the real exchange rate is highly dependent on variations of the world interest rate. The finite lifetimes setting permits to distinguish two real exchange rate paths whether the country is a net lender or a net borrower from the rest of the world. The main results are the following. First, the world interest rate increase leads to a real appreciation (resp. real depreciation) when the time preference is low (resp. high). After this initial jump, the real exchange rate appreciates. However, in the special case of a creditor country, the real exchange rate experiences then a depreciating stage to recover its long-run level.

These findings complement those of the exchange rate literature [Hinkle and Montiel (1999)]. Kollmann (1997) and Agénor (1998) have shown, in a monetary framework, that an increase in interest rate causes a non monotonic path of the actual real exchange rate. However, to characterize misalignement, we need to identify the REER response as well. Thus, we point out to the public decision maker the need to consider both the medium and long-run consequences of a world interest rate shock on the REER. Indeed, the central banker can use the REER to evaluate the misalignement of its currency. Thus, investigating the effects of a world interest rate rise, he knows the level of domestic price index consistent with macroeconomic equilibrium in a fixed exchange rate system, world prices being given. Suppose the public decision-maker decides to sustain his nominal exchange rate despite the increase in the world interest rate in his creditor country. Then, he must allow the domestic price index to increase in a first stage. Whereas, in a second stage, the domestic price index should diminish to maintain equilibrium. Otherwise, the drop in consumption will lead to an excess of supply which cannot be exported cause of a deterioration in the terms of trade.

APPENDIX

1. Intra and Inter-temporal Trade-Off

We follow Obstfeld and Rogoff (1996). Instantaneous individual preferences are defined over a domestic good x and an imported good y according to:

$$u(x; y) = y^{1-\alpha} x^{\alpha}$$

where π is the consumer price index defined as the minimal spending $Z = x + Ry$ necessary for buying a unit of composite good c [Obstfeld and Rogoff (1996)]. The variable R is the relative price of imported good in terms of domestic good. Consequently, Z and πC are measured in terms of domestic prices.

Formally, the optimization problem of an agent born at s and still alive at date $t > s$ can be decomposed in intra- and inter- temporal programs. The inter-temporal program is given by (2.2). The Euler equation indicates the global consumption path:

$$\frac{dc(s; z)}{dz} = \left(r(z) - \frac{\dot{\pi}(z)}{\pi(z)} - \beta \right) c(s; z)$$

Integrating Euler's equation, the level of consumption in z is:

$$c(z) = c(t) e^{\int_t^z \rho(\sigma) d\sigma}$$

with $\rho(z) = \left(r - \frac{\dot{\pi}}{\pi} - \beta \right)$. Thus, evaluated at market price[22]:

$$\pi(z) c(z) = \pi(t) c(t) e^{(r-\beta)(z-t)} \tag{1.1}$$

Hence, microeconomic consumption is a constant share of the real wealth, when utility is logarithmic:

$$c(t) = \gamma \frac{a(t) + h(t)}{\pi(t)}$$

[22] To integrate the intertemporal budget constraint, it is better to use individual consumption in current value. The price index is $\pi(z) = \pi(t) e^{\int_t^z \frac{\dot{\pi}}{\pi} d\sigma}$ with $\pi(t)$ the initial price index level.

Beyond this intertemporal arbitrage, agents share their consumption spending between the two goods according to:

$$c = \max_{x;y} x^{\alpha} y^{1-\alpha}$$
$$\text{s.t.: } Ry + x = \pi c$$

This objective being concave, first order conditions are necessary and sufficient:

$$\frac{y}{x} = \frac{1}{R}\frac{1-\alpha}{\alpha}$$

Hence, consumer price index is an increasing function of the real exchange rate: $\pi = \alpha^{-\alpha}(1-\alpha)^{-(1-\alpha)} R^{1-\alpha}$. The optimal consumption share between the two goods is:

$$x = \alpha \pi c$$
$$Ry = (1-\alpha)\pi c$$

2. Dynamical system

The dynamical system is:

$$\dot{B} = \rho B + \tfrac{1}{R}\left[Z(R) - \tfrac{1-\alpha}{\alpha} X\right]$$
$$\dot{K} = F(K;1) - X - Z(R) - \delta K$$
$$\dot{R} = R\left[F_K(K;1) - (\rho + \delta)\right]$$
$$\dot{X} = \left[F_K(K;1) - (\beta + \delta)\right] X - p\gamma\alpha\left[RB + K\right]$$

Around the steady state, the linearized system is:

$$\begin{pmatrix} \dot{B} \\ \dot{K} \\ \dot{R} \\ \dot{X} \end{pmatrix} = \begin{pmatrix} \rho & 0 & \frac{1}{R}\left[Z'(R^*) + \rho B^*\right] & -\frac{1-\alpha}{\alpha}\frac{1}{R^*} \\ 0 & \rho & -Z'(R^*) & -1 \\ 0 & R^* F_K(K^*;1) & 0 & 0 \\ -p\gamma\alpha R & -p\gamma\alpha + F_K(K^*;1)X^* & -p\gamma\alpha B^* & \rho - \beta \end{pmatrix} \begin{pmatrix} B - B^* \\ K - K^* \\ R - R^* \\ X - X^* \end{pmatrix}$$

and Jac denotes the Jacobian matrix. Its determinant is:

$$\det \mathrm{Jac} = F_K(K^*;1) R^* Z'(R^*)(\rho + p)(\rho - \beta - p)$$

There are two backward variables B and K. Consequently, saddle path stability requires that two eigenvalues have negative real parts. Therefore $\det Jac$ must be positive which implies that $\tau < \beta + p$.

3. Steady State

The steady state is given by the system (2.14) (2.15) (2.16) and (2.17a). The proposition 1 is based on the sign of the following derivatives:

$$\frac{\partial A^*}{\partial \tau} = \frac{\partial w^*}{\partial \tau}\frac{A^*}{w^*} + w^* \frac{(\tau - \beta)^2 + p\gamma}{[p\gamma - \tau(\tau - \beta)]^2}$$

$$\frac{\partial Z(R^*)}{\partial \tau} = \frac{\left(F_K(K^*;1) - \delta - \frac{p\gamma\alpha F_{LK}(K^*;1)}{p\gamma - \tau(\tau-\beta)}\right)}{F_{KK}(K^*;1)} - \frac{p\gamma\alpha(2\tau - \beta)F_L(K^*;1)}{p\gamma - \tau(\tau - \beta)} \tag{3.1}$$

With intensive notations and labor market at equilibrium $F(K;1) = f(k)$, we can show that equation (3.1) is:

$$\frac{\partial Z(R^*)}{\partial \tau} = \tau\frac{dk^*}{d\tau} - \frac{\alpha p\gamma(2r - \beta)}{[p\gamma - \tau(\tau - \beta)]^2}\left[f(k^*) - k^* f'(k^*)\right]$$

Thus, we have that:

- for $\tau > \beta/2$, $\frac{\partial Z(R^*)}{\partial \tau} < 0$
- for $\tau < \beta/2$, $\frac{\partial Z(R^*)}{\partial \tau} > 0$
  because $\lim_{\tau \to 0} \frac{\partial Z(R^*)}{\partial \tau} = +\infty$.

4. Paths

The linearized system can be written as:

$$\dot{M}(t) = Jac \cdot M(t)$$

with $M(t) = [B(t) - B^*; K(t) - K^*; R(t) - R^*; X(t) - X^*]^T$.

General solution of the linearized system is: $M(t) = Pe^{Dt}P^{-1}M(0)$ with P the passage matrix and P_{ij} the passage matrix elements, P^{-1} the inverse passage matrix and P_{ij}^{-1} the inverse passage matrix elements. Hence, the diagonal matrix is $D = P^{-1}AP$:

$$D = \begin{pmatrix} \lambda_1 & 0 & 0 & 0 \\ 0 & \lambda_2 & 0 & 0 \\ 0 & 0 & \lambda_3 & 0 \\ 0 & 0 & 0 & \lambda_4 \end{pmatrix}$$

with $\lambda_1 < 0$ and $\lambda_2 < 0$.

We note $P^{-1}M(0) = [\varphi_1(0); \varphi_2(0); \varphi_3(0); \varphi_4(0)]$. The terms in front of $e^{\lambda_3 t}$ and $e^{\lambda_4 t}$ in $Pe^{Dt}P^{-1}M(0)$ must be zero so that the system converges asymptotically toward its steady state:

$$M(t) = Pe^{Dt}\begin{bmatrix} \varphi_1(0) \\ \varphi_2(0) \\ 0 \\ 0 \end{bmatrix}$$

With $\varphi_3(0) = \varphi_4(0) = 0$, we obtain the following system with two equations and two unknown variables $R(0)$ et $X(0)$:

$$\begin{aligned} P_{31}^{-1}[B_0 - B^*] + P_{32}^{-1}[K(0) - K^*] + P_{33}^{-1}[R(0) - R^*] + P_{34}^{-1}[X(0) - X^*] &= 0 \\ P_{41}^{-1}[B_0 - B^*] + P_{42}^{-1}[K(0) - K^*] + P_{43}^{-1}[R(0) - R^*] + P_{44}^{-1}[X(0) - X^*] &= 0 \end{aligned}$$

As a result, all variables can be written as linear combinations of $(B_0 - B^*)e^{\lambda_1 t}$ and $(K_0 - K^*)e^{\lambda_2 t}$. We have:

$$\begin{aligned} B(t) &= B^* + \Gamma_1(B_0 - B^*)e^{\lambda_1 t} + \eta_1(K_0 - K^*)e^{\lambda_2 t} \\ K(t) &= K^* + \Gamma_2(B_0 - B^*)e^{\lambda_1 t} + \eta_2(K_0 - K^*)e^{\lambda_2 t} \\ R(t) &= R^* + \Gamma_3(B_0 - B^*)e^{\lambda_1 t} + \eta_3(K_0 - K^*)e^{\lambda_2 t} \\ X(t) &= X^* + \Gamma_4(B_0 - B^*)e^{\lambda_1 t} + \eta_4(K_0 - K^*)e^{\lambda_2 t} \end{aligned}$$

We notice that ¡$_3$(B$_0$ ¡ B$^¤$) = 0: Indeed, the dynamic equation R neither depend on the foreign assets nor consumption.

5. Numerical simulations

The numerical simulations enable to plot the reaction of the system following a 0:5% increase in the world interest rate. Thus, the world interest rate is r¹$_1$ = 0:046 after the shock. All quantities are expressed in units of domestic good since the domestic good price is normalized at unity. All parameter values are included in Table 1.

Table 1 Numerical values

¯	r¹	®	±	p	½	´
0:04 0:05	0:041	0:55	0:1	0:0125	0:33	3

The real world interest rate r¹ is around 4% to approach as Burgess (1996) the real value of the US interest rate. Nevertheless, we are forced to choose r¹ = 0:041 to ful¯ll the stability condition. For the same reason, we use a = 0:55 instead of the value of 0:5 used by Kollmann (1997). The level of ½ and ± are usual, and we assume that the life expectancy is around 80 years. To compare the creditor and debtor cases, ¯ takes two di®erent values: 4% for the creditor country and 5% for the debtor one.

References

[1] Ag¶nor P. (1998), \Capital in°ows, external shocks, and the real exchange rate", Journal of International Money and Finance, 17, 713-740.

[2] Appelbaum E. and U. Kohli (1979), \Canada-United States trade: tests for the small open economy hypothesis", Canadian Journal of Economics, 12, 1-14.

[3] Blanchard O. (1985), \Debt, de¯cits, and ¯nite horizons", Journal of Political Economy, 91, 589-610.

[4] Burgess D. (1996), \Fiscal de¯cits and intergenerational welfare in almost small open economies", Canadian Journal of Economics, 4, 885-909.

[5] Brock P. (1988), Investment, the current account and the relative prices of nontraded goods in a small open economy, Journal of International Economics, 24, pp. 235-253.

[6] Brock P et S.Turnovsky (1994), The dependent economy model with both traded and nontraded capital goods, Review of International Economics, 2, pp. 306-325.

[7] Dornbusch R. (1983), \Real interest rates, home goods and optimal external borrowings", Journal of Political Economy, 91, 141-153.

[8] Frenkel J., A. Razin and Yuen, (1996), Fiscal Policies and growth in the World Economy, Third edition, Cambridge MA, MIT Press.

[9] Hinkle E. et P. Montiel (1999), Exchange rate misalignment : concept and measurement for developing countries, Oxford University Press.

[10] Kollmann R. (1997), \The exchange rate in a dynamic optimizing current account model with nominal rigidities: a quantitative investigation", IMF Working Paper, 9707.

[11] Matsuyama K. (1987), \Current account dynamics in a ¯nite horizon model", Journal of International Economics, 23, 299-313.

[12] Matsuyama K. (1988), \Terms-of trade, factor intensities and the current account in a life-cycle model", Review of Economics Studies, 55, 247-262.

[13] Obstfeld M. and K. Rogo® (1996), Foundations of International Macroeconomics, MIT Press, Cambridge.

[14] Persson T. (1985), \De¯cits and intergenerational welfare in open economies", Journal of International Economics, 19, 67-84.

[15] Sen P. and S. Turnovsky (1989a),\Deterioration of the terms of trade and capital accumulation: a re-examination of the Laursen-Metzler e®ect", Journal of International Economics, 26, 212-228.

[16] Sen P. and S. Turnovsky (1989b),\Tari®s, capital accumulation and the current account in a small open economy", International Economic Review, 30, 811-831.

[17] Sen P. and S. Turnovsky (1990), \Investment tax credit in a small open economy", Journal of Public Economics, 42, 277-309.

[18] Stein J. and G. Paladino (1997), \Exchange rate misalignements and crises", Working Papers Brown University, WP 98/07.

[19] Turnovsky S. (1997), International Macroeconomic Dynamics, MIT Press, Cambridge.

[20] Weil P. (1989), \Overlapping families of in¯nitely-lived agents", Journal of Public economics, 38, 138-198.