Nominal growth of a small open economy*

Peter Benczur[†]and Istvan Konya[‡]

September 2006

Abstract

This paper develops a flexible price, two-sector nominal growth model, in order to study the nominal aspects of capital accumulation (convergence). We adopt a classical model of a small open economy with traded and nontraded goods, and enrich its structure with gradual investment and a preference for real money holdings. We find that (i) the choice of exchange rate regime influences the transition dynamics of a small open economy, (ii) a one-sector model does not adequately capture the channels through which the nominal side interacts with real variables, and (iii) as a consequence, sectoral asymmetries are important for understanding the effects of the exchange rate regime on capital accumulation.

JEL Classification Numbers: F32, F41, F43

Keywords: two-sector growth model, small open economy, capital accumulation, household portfolios, real effects of nominal shocks.

1 Introduction

The nominal exchange rate is one of the most important prices for a small open economy. There are strong linkages among permanent or temporary exchange rate movements, the external position, the growth rate and fluctuations of the economy, the latter often showing sectoral asymmetries as well. In this paper we show that the exchange rate is not only important for the business cycle, but it can also significantly influence the growth process of a small open economy. We argue that the choice of the exchange rate regime is not neutral, and the *capital accumulation path depends on the nominal regime.*

As suggested by consumption smoothing, converging economies should be borrowing against their future income, while they also build up their asset holdings. As we will document below, a

*We are grateful to Andrew Blake, Ágnes Csermely, Michal Kejak, Miklós Koren and participants of the conference celebrating the 50th anniversary of IE-HAS, a seminar at MNB, the 4th Workshop on Macroeconomic Research, the IE-HAS Summer Workshop, and the 2006 EEA Congress, for comments and suggestions. All the remaining errors are ours.

[†]Magyar Nemzeti Bank and Central European University. Corresponding author, email: benczurp@mnb.hu

[‡]Magyar Nemzeti Bank and Central European University; email: konya@mnb.hu

large fraction of these assets are local currency bank deposits and bonds, the value of which move together one in one with nominal exchange rates. This implies that the evolution of the nominal exchange rate will influence the asset accumulation process. Moreover, whether exchange rates are flexible, fixed or "frozen" (like in a currency board arrangement) also determines how much nominal asset accumulation can be achieved by nominal appreciation and how much requires household savings from income. Such a link then has repercussions for capital accumulation, growth and sectoral (tradables versus nontradables) reallocations. Our objective is to develop a simple but sufficiently rich framework, which is capable of addressing the aggregate and sectoral features of such a nominal convergence.

The structure of the model is the following. We consider a small open economy, with a traded and a nontraded sector. The source of growth is capital accumulation. We assume that the initial capital stock is below the steady state level, so the country experiences capital accumulation and excess growth along its convergence path. We adopt the now classic *Tobin-q* approach to capture gradual capital flows. We introduce an asset accumulation motif by assuming that households derive utility directly from holding (real) money balances (*money in the utility*). As the income of consumers grow, they want to consume more and also to hold more money.

After setting up the model we turn to the analysis of the nominal growth process. We first show that in case of flexible exchange rates, the nominal economy behaves identically to the real economy without money: capital accumulation increases labor income, leading to a gradual increase in money holdings, which is implemented by an appreciating nominal exchange rate. This is a formal version of the popular phrase that FDI inflows put an appreciating pressure on nominal exchange rates.[1] Equivalently, even with exchange rates fixed, the right amount of money creation by the central bank can implement the real path.

The nominal and the real paths differ, however, when both the exchange rate is fixed and money growth is exogenous. This is the case, for example, when the country operates a currency board economy (zero money growth), or chooses the euro conversion rate (joining a monetary union). Historically, the gold standard shared the same features. Under these assumptions any increase in the domestic money stock must come from abroad. This necessitates either a trade surplus or foreign borrowing. Since borrowing is costly (debtors face a positive risk premium), the growth path differs from that of an economy where money plays no role.

There are two channels through which demand dynamics influence investment decisions. First, when the interest rate is debt-dependent, the opportunity cost of investment is different from the subjective rate of time preference along the transition path (*interest rate channel*). Second, the relative price of nontradables is influenced by demand conditions. When the capital

[1] Strictly speaking, our benchmark model does not have FDI; instead, domestic investment is financed by foreign borrowing.

intensity of the two sectors differs, demand for capital and hence investment decisions are also affected (*relative price channel*). While the interest rate channel is present in a one-sector model, the relative price channel only operates when there are two (or more) sectors. We show that the addition of the relative price channel has interesting implications for the behavior of investment and the capital stock.

An application of our framework is the comparison of two nominal (currency board) paths which differ only in the level of the exchange rate. Different nominal exchange rates lead to relatively small but highly persistent deviations: from identical capital stocks, foreign bond and local currency holdings, a stronger nominal exchange rate means a higher foreign currency value of local currency holdings. As tradable prices are fixed in foreign currency, this is a positive wealth shock.

The clearest case for such a comparison is when a country decides over its entry rate into a monetary union; but a realignment of a fixed exchange rate also shares these features as long as money supply is not completely flexible. An important application of our model is thus the choice of the euro conversion rate for EMU aspirants. As the role of money and bank deposits is larger in these economies than in previous EMU entrants, we can expect a stronger real impact of this choice. The historical episode of converting the East German currency into Dmarks also highlights the importance of the wealth effect of currency conversion and its persistent real effects; but one could also look back at the restoration of the gold standard in the UK after WWI.

The paper is organized as follows. The next section puts the model into context. Section 3 describes the model. Section 4 explains the mechanics and the main results for the flexible exchange rate case, while Section 5 discusses the currency board regime. Section 7 offers some quantitative policy simulations, and Section 8 concludes. The Appendix contains an illustrative episode of the symptoms of excessive household wealth and all the detailed calculations.

2 The context of the model

2.1 Theory

Usual explanations for nominal shocks having lasting real effects build on staggered price or wage contracts. An early example is Taylor (1980). Recently, state- or time-dependent pricing models constitute as the workhorse for analyzing nominal scenarios (see chapter 3 of Woodford (2003) for a general discussion). While pricing problems are clearly important to understand business cycle frequency developments, we believe that they should have limited impact over the growth horizon. Motivated by this, we depart from this literature by focusing on the effect of nominal shocks through nominal wealth accumulation (captured by money-in-the-utility).[2] The major building blocks of our model are *money-in-the-utility* (a nominal effect), a debt-dependent interest rate, gradual investment (a real friction) and sectoral technology differences (capital-labor intensities).

We use money-in-the-utility to capture the fact that some assets are denominated in local currency (see section 2.2 for details). As nominal exchange rate movements revalue this stock, our approach is closely related to the recent literature on the revaluation channel of external adjustment (Lane and Milesi-Ferretti, 2004, Gourinchas and Rey, 2005). Tille (2005) also analyzes the real effects of such a revaluation. In our case, this revaluation happens automatically as the price of tradable goods is fixed in foreign currency.

Many current papers point to the importance of gradual investment in shaping business cycle properties, inflation or real exchange rate behavior. Eichenbaum and Fisher (2006) argue that the empirical fit of a Calvo-style sticky price model substantially improves with firm-specific capital (and a nonconstant demand elasticity). Christiano et al (2001) present a model in which moderate amounts of nominal rigidities are sufficient to account for observed output and inflation persistence, after introducing variable capital utilization, habit formation and capital adjustment costs. Chapter 4 of the Obstfeld and Rogoff (1996) textbook contains an exposition of a two-sector growth model (the standard Balassa-Samuelson framework), with gradual investment in some of the sectors. We depart from these approaches by dropping staggered price setting, but – unlike Obstfeld and Rogoff – still allowing for a nominal side of the economy.

The presence of a traded and a nontraded sector allows us to merge trade theory insights with a monetary framework: for example, the presence of nontraded goods means that a redistribution of income between countries will affect their relative wages (the classical transfer problem, like in Krugman (1987)), or the Stolper-Samuelson theorem, linking changes in goods prices with movements in factor rewards. It is also essential to introduce the relative price channel described in the introduction

Huffman and Wynne (1999) develop a multisector real model with investment frictions (sector-specific investment goods and costs of adjusting the product mix in the investment sector). Their objective is, however, to match the *closed economy comovements* of real activity across sectors (consumption and investment). In our model, the two sectors have a completely different nature (traded and nontraded). These two sectors do not necessarily move together, as indicated by the countercyclicality or acyclicality of net exports (see Fiorito and Kollintzas (1994) for G7 countries, Aguiar and Gopinath (2004) for emerging economies). Aguiar and

[2] Devereux and Sutherland (2006) consider a somewhat similar mechanism: under incomplete asset markets, monetary policy (or nominal shocks in general) can influence the return structure of nominal bonds, thus yielding real effects.

Gopinath (2004) also construct a *one-sector real model* to explain the countercyclicality of net exports and the excess volatility of consumption. Balsam and Eckstein (2001) develop a real model with traded and nontraded goods, aimed at explaining the procyclicality of Israel's net exports and excess consumption volatility.

The growth literature also employs multisector models, but the two sectors there differ in the investment good they produce (physical versus human capital). Examples include Rebelo (1991) and Lucas (1988). Ventura (1997) is an example of a multisector growth model with an explicit trade framework. His model of growth in interdependent economies clearly illustrates the importance of merging trade and growth theory. The implications of a nontraded sector, however, are not addressed by that paper.

Our framework is closely related to that of Rebelo and Végh (1995), who also build a two-sector, flexible price open economy model where money serves to lower transaction costs. They use the model to examine the effects of (large) devaluations. Our contribution relative to Rebelo and Végh (1995) is threefold. First, we seek to answer a more general question: what are the conditions under which nominal factors have a persistent effect on the real side of an economy, and investment behavior in particular. In Rebelo and Végh (1995) money lowers *real* transaction costs, and thus influences intertemporal decisions unless the nominal interest rate is zero. This means that even perfectly flexible prices and a floating exchange rate do not implement the nonmonetary economy. Since in our model money has a less central role, its influence on real variables does not follow from a single assumption, but rather from the interplay of various factors. We thus believe that our framework delivers novel insights into the linkages between the nominal and real sides of the economy.

Second, we view the motive for nominal asset accumulation as more general than just lowering transaction costs. While this distinction is not very important methodologically, it makes the interpretation of the stylized facts presented below much easier. In particular, we think that transaction costs alone cannot explain the fact that households keep a large fraction of their wealth in nominal, local currency denominated assets. Although money-in-the-utility does not explain why this is the case, it serves as a useful device to condense the various roles of money into a single assumption.

Finally, since we assume an endogenous risk premium on foreign assets, our model has a well defined steady state for all variables. We thus avoid the unit root problem in Rebelo and Végh (1995) that makes the linear approximation method imprecise and potentially unreliable.

2.2 Stylized facts

We start by documenting the specifics of EU and OECD household financial balance sheets. Figure 1 plots the three-year average household asset per GDP position for 27 countries, for years 2002-04.[3] It is immediate from the graph that new member and candidate states exhibit much lower asset holdings. This is somewhat less true for previous catching-up countries like Spain, Portugal, or Korea. Figure 2 plots the same measure of household liabilities, again showing that new member states and, to a smaller degree, less developed economies lag behind industrial economies in this respect. Finally, as Figure 3 shows, a similar though somewhat less pronounced pattern holds for overall household net worth.

It is also important to look at the time series behavior of these statistics. We use three countries as illustrations: two early catching-up countries, Spain and Portugal, plus Hungary (Figure 4). Spain exhibited a strong increase in assets and roughly constant liabilities until the late nineties, and then – likely driven by easier access to international credit – liabilities started to grow, while assets even decreased. In Portugal, both assets and liabilities were increasing, leading to an overall decline in net wealth. Finally, Hungary had an increase in assets throughout the entire period 1990-2004, while liabilities started to grow only after 2000, leading to a reversal in net wealth as well. We indeed see a general increasing trend both in assets and liabilities, mixed with cyclical and one-time effects like easing international borrowing constraints; while the development of net wealth is ambiguous.

Switching now to the composition of household balance sheets, Figure 5 shows that apart from Estonia, new member states have at least 40% share of currency, bank deposits and bonds (securities other than shares) in their asset holdings. Spain and Portugal also have such high numbers; while Austria, Japan, Korea and to a smaller extent, Belgium, Germany and Italy are more surprising examples of industrialized countries with a very high share. All other developed countries have substantially smaller shares, though it always exceeds 20%.

This distinction remains true if one looks at the entire nineties: with the above exceptions (plus Finland for the early nineties), developed economies rarely had a share higher that 40%, while new member states (with the exception of Estonia and Lithuania) never had a share below 40%. A similar pattern emerges when we look at the ratio of net deposit-type holdings (net currency, deposit and bond holdings minus bank loans) to net wealth (Figure 6): apart from Estonia, new members states are at the high end of the distribution, together with Austria, Belgium, Italy, Japan and Korea.[4]

We now discuss some stylized facts relating to the results of our model. It gives important predictions about employment, price and wage dynamics after nominal exchange rate shocks. In

[3] The countries are: Australia, Canada, Japan, Korea and the US; Austria, Belgium, Denmark, Finland, France, Germany, Italy, the Netherlands, Norway, Portugal, Spain, Sweden and the UK; Bulgaria, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania (data exists only for 1999), Slovakia and Slovenia. Data are from the Eurostat and OECD.

[4] These observations remain valid if we exclude bond holdings (item 3 of financial accounts statistics), and consider cash, bank deposits and loans only. In fact, the pattern is even more clear-cut; with Austria, Japan and Korea being the sole set of exceptions among industrial countries.

particular, a nominal appreciation leads to (1) an increase in wages; (2) a reallocation of labor from manufacturing to services; (3) a marked sectoral asymmetry in investment behavior: increase in service sector investment, fall in manufacturing; (4) an increase in the nontraded-traded relative price; (5) an overall consumption boom, accompanied by a deteriorating trade balance; (6) a temporary increase in real GDP. A depreciation would produce exactly the opposite of these effects.

In particular, our model matches the recent experience of Hungary (1999-2003), showing all the symptoms from above. While there were many different impulses coming from both monetary and fiscal policy, most of these impulses point in the same direction. In the language of the model, most changes were shocks to nominal wealth. Since our model has the same predictions for any such shock, it is not important (and also not feasible) to separate out the impact of nominal appreciation. Thus while the exact contribution of each shock is unclear, we feel confident that the final picture is consistent with the model's predictions about an economy with excessive nominal wealth ("overvaluation"). The Appendix offers a detailed coverage of this episode.

At a more general level, these predictions are in line with the performance of exchange-rate based disinflations, and its reverse conclusions are relevant to price and wage dynamics after large devaluations. Rebelo and Végh (1995) find the following main stylized facts of exchange rate based stabilization programs: (1) high economic growth, (2) which is dominantly fuelled by consumption, (3) slow price adjustment,(4) deteriorating trade balance. They also show some indicative evidence of a superior nontradable performance for Uruguay, Mexico, and cite Bufman and Leiderman (1995) as evidence for Israel. Burstein et al (2005) analyze large *devaluation* episodes, and find that (1) inflation is low relative to the depreciation, (2) the relative price of nontradables falls, (3) and export and import prices (goods that are truly traded and not just tradable) track more closely with the exchange rate than the full CPI.

3 The model

3.1 Consumers

Consumers solve the following problem:

$$\begin{aligned} \max U_0 &= \sum_{t=0}^{\infty}\left(\frac{1}{1+\rho}\right)^t\left[\log C_t+\gamma\log\frac{H_t}{P_t}\right] \\ \text{s.t.}\quad S_tB_t+H_t &= (1+\tau_t)\,H_{t-1}+(1+i_{t-1})\,S_tB_{t-1}+ \\ & \quad W_tL+R_tS_tK_{t-1}-P_tC_t-S_t\left(1+\frac{\delta}{2}\frac{I_t}{K_{t-1}}\right)I_t \\ K_t &= K_{t-1}+I_t, \end{aligned}$$

where S is the nominal exchange rate, B is foreign bond holdings (denominated in foreign currency), H is the stock of money, τH is a government transfer,[5] W is the wage rate, L is labor (supplied inelastically), R_t is the real rental rate of capital, K is the stock of capital, P is the consumption price index, C is the consumption aggregate, and I is investment. Consumers consume a Cobb-Douglas mix of tradables (C^T) and nontradables (C^N), so C is defined as $C = \left(C^T\right)^{\lambda}\left(C^N\right)^{1-\lambda}$. The law of one price holds for tradables, which implies that after normalizing the foreign price of tradables to unity, the domestic price simply equals the exchange rate. For future reference, we define foreign currency household wealth as $A = B + H/S$.

We assume that households own the capital stock which they rent out to firms on a competitive market. Households also make investment decisions. Investment is subject to quadratic adjustment costs, which ensures that the convergence to the steady state is not too fast. For convenience we assume that capital and investment only require tradables, and that capital does not depreciate.

Part of wealth is held as money, and the rest is invested (or borrowed) in foreign bonds. Foreign bonds and the rental rate on capital are measured in foreign currency, while all other variables are in local currency. To ensure the long-run existence of a well-defined steady state, we assume a debt-dependent bond rate $i_t = i\left(B_t\right)$, as in Schmitt-Grohe and Uribe (2003). The particular form is $1+i\left(B\right) = 1+\rho+d(B)$,where $d(\cdot)$ is a risk premium which is decreasing in its argument, and $d(\bar{B}) = 0$. We work with the same functional form as Schmitt-Grohe and Uribe (2003): $d\left(B\right) = \psi\left[e^{-(B-\bar{B})}-1\right]$. We assume that individual households do not internalize the effect of their borrowing or lending on $i(\cdot)$, i.e. the debt premium depends on average (country level) bond holdings.

The form of the utility function allows a sequential solution of the consumer problem: we first calculate the share of tradables and nontradables given current nominal expenditures (intratemporal step), and then we determine the optimal evolution of expenditures (intertemporal step). The usual intratemporal optimization conditions imply that:

$$
\begin{aligned}
PC &= SC^T + P^N C^N \\
\frac{SC^T}{P^N C^N} &= \frac{\lambda}{1-\lambda} \\
P &= \lambda^{-\lambda}\left(1-\lambda\right)^{\lambda-1} S^{\lambda}\left(P^N\right)^{1-\lambda}.
\end{aligned}
$$

The intertemporal problem is solved by writing down the Lagrangian, where we choose the

[5] What we assume here is that consumers get a transfer *proportional to their money holdings.* This makes sure that whether we implement the real model by flexible exchange rates or perfectly elastic money supply would be completely equivalent. One could also work with an exogenous transfer T. Then the choice of nominal implementation would have an effect on real money growth and the utility derived from money holdings, but all other real variables would be the same. We chose to work with τH.

dynamic multipliers as Λ_t and $Q_t S_t \Lambda_t$:

$$\begin{aligned}
\mathfrak{L} &= \sum_{t=0}^{\infty} (1+\rho)^{-t} \Bigg\{ \log C_t + \gamma \log \frac{H_t}{P_t} + Q_t S_t \Lambda_t \left(K_t - K_{t-1} - I_t\right) + \\
&\quad \Lambda_t \left[W_t L + S_t R_t K_{t-1} - P_t C_t - S_t I_t \left(1 + \frac{\delta}{2}\frac{I_t}{K_{t-1}}\right) + \right. \\
&\quad \left. H_{t-1} + \tau_t H_{t-1} + (1+i_{t-1}) S_t B_{t-1} - S_t B_t - H_t \right] \Bigg\},
\end{aligned}$$

and the first-order conditions are given by

$$\begin{aligned}
\frac{1}{C_t} &= \Lambda_t P_t \\
\Lambda_t S_t &= \frac{1+i_t}{1+\rho} \Lambda_{t+1} S_{t+1} \\
\frac{\gamma}{H_t} &= \Lambda_t - \frac{1+\tau_t}{1+\rho} \Lambda_{t+1} \\
Q_t &= \left(1 + \delta \frac{I_t}{K_{t-1}}\right) \\
Q_t &= \frac{1}{1+\rho} \left(R_{t+1} + Q_{t+1}\right) \frac{S_{t+1}\Lambda_{t+1}}{S_t \Lambda_t}.
\end{aligned}$$

Eliminating Λ_t and I_t yields

$$\begin{aligned}
\frac{S_t}{P_t C_t} &= \frac{1+i_t}{1+\rho} \frac{S_{t+1}}{P_{t+1} C_{t+1}} \\
\frac{\gamma}{H_t} &= \frac{1}{P_t C_t} - \frac{1+\tau_t}{1+\rho} \frac{1}{P_{t+1} C_{t+1}} \\
Q_t &= \frac{1}{1+\rho} \left(R_{t+1} + Q_{t+1}\right) \frac{S_{t+1} P_t C_t}{S_t P_{t+1} C_{t+1}} \\
K_t &= \left(1 + \frac{Q_t - 1}{\delta}\right) K_{t-1} \\
S_t B_t + H_t &= (1+\tau_t) H_{t-1} + (1+i_{t-1}) S_t b_{t-1} + W_t L + R_t S_t K_{t-1} - P_t C_t + S_t K_{t-1} \frac{Q_t^2 - 1}{2\delta}.
\end{aligned}$$

3.2 Producers

Production functions are given by

$$\begin{aligned}
Y^T &= \left(L^T\right)^{\beta} \left(K^T\right)^{1-\beta} \\
Y^N &= \left(L^N\right)^{\alpha} \left(K^N\right)^{1-\alpha}.
\end{aligned}$$

Since capital and labor are assumed to be mobile across sectors, profit maximization implies

$$\begin{aligned}
W &= S\beta \left(L^T\right)^{\beta-1} \left(K^T\right)^{1-\beta} = P^N \alpha \left(L^N\right)^{\alpha-1} \left(K^N\right)^{1-\alpha} \\
R &= (1-\beta) \left(L^T\right)^{\beta} \left(K^T\right)^{-\beta} = P^N / S \, (1-\alpha) \left(L^N\right)^{\alpha} \left(K^N\right)^{-\alpha}.
\end{aligned}$$

Aggregate capital is predetermined at the beginning of time t, while its sectoral allocation and labor can adjust within a period. Thus K always correspond to time $t-1$, while K^T, K^N, L^T, L^T, W, and R are of time t.

We would not argue that the sectoral mobility of capital is a fully realistic assumption. One could also set up a model with sector-specific capital. This would not change the qualitative results, but the interpretation of the mechanisms becomes less transparent.

3.3 Equilibrium

There are three market clearing conditions, for the capital, labor and the nontradable goods markets:

$$\begin{aligned} K_t^T + K_t^N &= K_{t-1} \\ L_t^T + L_t^N &= L \\ Y_t^N &= C_t^N. \end{aligned}$$

Let us introduce nominal expenditures: $X = PC$. The full dynamic system can be then written as

$$\frac{S_t}{X_t} = \frac{1+i_t}{1+\rho} \frac{S_{t+1}}{X_{t+1}} \tag{1}$$

$$\frac{\gamma}{H_t} = \frac{1}{X_t} - \frac{1+\tau_t}{1+\rho} \frac{1}{X_{t+1}} \tag{2}$$

$$Q_t = \frac{1}{1+\rho} \left(R_{t+1} + Q_{t+1}\right) \frac{S_{t+1} X_t}{S_t X_{t+1}} \tag{3}$$

$$K_t = \left(1 + \frac{Q_t - 1}{\delta}\right) K_{t-1} \tag{4}$$

$$S_t B_t + H_t = (1+\tau_t) H_{t-1} + (1+i_{t-1}) S_t B_{t-1} + W_t L + R_t S_t K_{t-1} - X_t + S_t K_{t-1} \frac{Q_t^2 - 1}{2\delta} \tag{5}$$

(1) - (5) is a system of five equations for seven variables: K, Q, B, X, H, S and τ (W and R are functions of these seven). The final two equations are given by policy. In what follows, we consider three alternative regimes: flexible exchange rates (and fixed money supply: $\tau = 0, H_t \equiv H$), perfectly elastic money supply (and fixed exchange rates: $S_t \equiv \bar{S}, H_t/H_{t-1} = 1 + \tau_t$), and a currency board (fixed exchange rates and no exogenous money growth). The next section develops the flexible exchange rate and the elastic money supply regimes in detail and shows that the path of real variables is identical to a model where money has no role ($\gamma = 0$). For the currency board $S_t \equiv \bar{S}$ and $\tau = 0$ in every period. As the government does not print money and there is no change in the external value of the local currency, any increase in money demand must be financed through a money inflow from the rest of the world. It can happen through

borrowing or a trade surplus. As we will demonstrate, this leads to deviations from the real model, which is not the case for the two flexible regimes.

We assume that steady state bond holdings are zero: $\bar{B} = 0$. To solve for the other steady state conditions, note that

$$\begin{aligned}
\bar{Q} &= 1 \\
\bar{R} &= \rho \\
\bar{H} &= \gamma \bar{X} \frac{1+\rho}{\rho}
\end{aligned}$$

Expressing sectoral capital and labor employment from income shares:

$$\begin{aligned}
\bar{K}^T &= \frac{(1-\beta)\lambda \bar{X}}{\bar{S}\rho} \\
\bar{K}^N &= \frac{(1-\alpha)(1-\lambda)\bar{X}}{\bar{S}\rho} \\
\bar{L}^N &= \frac{\alpha(1-\lambda)\bar{X}}{\bar{W}} \\
\bar{L}^T &= \frac{\beta\lambda\bar{X}}{\bar{W}}.
\end{aligned}$$

Plugging the latter two into labor market clearing:

$$\bar{W} = \frac{\alpha(1-\lambda)+\beta\lambda}{L}\bar{X},$$

so

$$\begin{aligned}
\bar{L}^T &= \frac{\alpha(1-\lambda)}{\alpha(1-\lambda)+\beta\lambda}\bar{L} \\
\bar{L}^N &= \frac{\beta\lambda}{\alpha(1-\lambda)+\beta\lambda}\bar{L}.
\end{aligned}$$

The last thing we need is to determine X:

$$\begin{aligned}
\lambda\bar{X}/\bar{S} &= \left(\bar{L}^T\right)^{\beta}\left(\bar{K}^T\right)^{1-\beta} = \left[\frac{\alpha(1-\lambda)}{\alpha(1-\lambda)+\beta\lambda}L\right]^{\beta}\left[\frac{(1-\beta)\lambda\bar{X}}{\bar{S}\rho}\right]^{1-\beta} \\
\bar{X} &= \frac{\bar{S}L}{\lambda}\left[\frac{\alpha(1-\lambda)}{\alpha(1-\lambda)+\beta\lambda}\right]\left(\frac{1-\beta}{\rho}\right)^{\frac{1-\beta}{\beta}}.
\end{aligned}$$

This condition pins down the euro value of nominal expenditures, which then determines the euro value of all supply and demand-side variables. The determination of local currency values depends on the monetary regime. In a currency board or a fixed exchange rate with flexible money supply, $S = \bar{S}$; while for flexible exchange rates, $\bar{H} = H_0$ pins down $\bar{S}$.

4 Flexible monetary regimes

Let us assume that foreigners are unwilling to hold domestic currency. One monetary arrangement is flexible exchange rates, where the central bank is not committed to any exchange rate behavior. In other words, the central bank is unwilling to take an open position in the local currency, which implies that the money stock is constant ('money growth targeting'). An alternative is to assume that the exchange rate is fixed, and the central bank distributes as much money as consumers demand ('exchange rate targeting').

We start with the case when money is constant: setting $\tau = 0$ and $H_t \equiv H$ in (1)-(5), the dynamic system becomes

$$\frac{S_t}{X_t} = \frac{1+i_t}{1+\rho}\frac{S_{t+1}}{X_{t+1}} \tag{6}$$

$$\frac{\gamma}{H} = \frac{1}{X_t} - \frac{1}{1+\rho}\frac{1}{X_{t+1}} \tag{7}$$

$$Q_t = \frac{1}{1+\rho}\left(R_{t+1} + Q_{t+1}\right)\frac{S_{t+1}X_t}{S_t X_{t+1}} \tag{8}$$

$$K_t = \left(1 + \frac{Q_t - 1}{\delta}\right) K_{t-1} \tag{9}$$

$$S_t B_t = \left(1 + i_{t-1}\right) S_t B_{t-1} + W_t L + R_t S_t K_{t-1} - X_t + S_t K_{t-1}\frac{Q_t^2 - 1}{2\delta}, \tag{10}$$

while the steady state conditions remain the same. Apart from the money equation, the nominal exchange rate can be completely eliminated from this system by introducing $X_t^* = X_t/S_t$ and $W_t^* = W_t/S_t$. Alternatively for fixed exchange rates, using again X_t^* and W_t^*, and setting $S_t = \overline{S}$ and $H_t = (1+\tau) H_{t-1}$, (5) becomes identical to (10).

Dropping (7) from (6)-(10) yields an entirely real system. This is the same as the nonmonetary version of the model, where consumers solve

$$\begin{aligned} \max U_0 &= \sum_{t=0}^{\infty}\left(\frac{1}{1+\rho}\right)^t \log C_t \\ s.t.\ B_t &= W_t^* L + \left[1 + \rho + d\left(B_{t-1}\right)\right] B_{t-1} + R_t K_{t-1} - P_t^* C_t - I_t\left(1 + \frac{\delta}{2}\frac{I_t}{K_{t-1}}\right) \\ K_t &= K_{t-1} + I_t. \end{aligned}$$

The traded good is used as the numeraire, and P^* is the appropriate price index.

It is easy to see that the first-order conditions are

$$\begin{aligned}
\frac{1}{X_t^*} &= \Lambda_t \\
\Lambda_t &= \frac{\Lambda_{t+1}}{1+\rho}(1+i_t) \\
Q_t &= \frac{1}{1+\rho}(R_{t+1}+Q_{t+1})\frac{X_t^*}{X_{t+1}^*} \\
K_t &= \left(1+\frac{Q_t-1}{\delta}\right)K_{t-1} \\
B_t &= [1+\rho+d(B_{t-1})]B_{t-1}+W_t^*L-X_t^*+K_{t-1}\frac{Q_t^2-1}{2\delta}+.
\end{aligned}$$

The production and investment side remains the same as in the nominal case, while the Euler equation can be written as

$$X_t^* = X_{t+1}^*\frac{1+\rho}{1+\rho+d(B_t)}.$$

As all the other static and dynamic equations remain the same, this establishes our first general result:

Proposition 1 *Both he flexible exchange rate and the elastic money supply economy implement the real version of the model.*

To determine the evolution of S under flexible exchange rates, remember that

$$\frac{\gamma}{H} = \frac{1}{X_t} - \frac{1}{1+\rho}\frac{1}{X_{t+1}}.$$

If we are looking for a solution where the nominal exchange rate is constant in the long run (a 'no bubble' condition), then there is a constant steady state level of $\bar{X} = \frac{\gamma H \rho}{1+\rho}$, thus we have

$$\rho\left(\frac{1}{\bar{X}} - \frac{1}{X_t}\right) = \frac{1}{X_t} - \frac{1}{X_{t+1}}.$$

In order to have $X_t \to \bar{X}$, we must have $X_t \equiv \bar{X} = H\frac{\rho}{\gamma(1+\rho)}$.[6] The equilibrium nominal exchange rate path is such that nominal expenditures remain constant in local currency. Assuming that the euro value of expenditures increases during convergence, an equilibrium nominal appreciation follows, which proves our second result:

Proposition 2 *Convergence implies an equilibrium nominal appreciation.*

[6] If $X_t > \bar{X}$ then $X_{t+1} > X_t$, so it remains higher than $\bar{X}$ and thus increases without bounds; while it decreases without bounds if it starts below $\bar{X}$.

Under exchange rate targeting, $S = \overline{S}$ and

$$\begin{aligned}
\frac{\gamma}{H_t} &= \frac{1}{X_t} - \frac{1+\tau}{1+\rho}\frac{1}{X_{t+1}} \\
\frac{\gamma(1+\rho)}{H_t} &= \frac{1+\rho}{X_t} + \frac{H_{t+1}}{H_t X_{t+1}} \\
\frac{H_{t+1}}{X_{t+1}} &= (1+\rho)\left(\frac{H_t}{X_t} - \gamma\right) \\
\frac{H_{t+1}}{X_{t+1}} - \frac{\gamma(1+\rho)}{\rho} &= (1+\rho)\left[\frac{H_t}{X_t} - \frac{\gamma(1+\rho)}{\rho}\right];
\end{aligned}$$

so again, if we rule out explosive money growth paths, we must have $X = \frac{\gamma(1+\rho)}{\rho}H = \bar{X}$. The dynamics of real money (the foreign currency value of local currency) is thus the same under the two monetary arrangements.[7]

What happens to the equilibrium real exchange rate (which equals the relative price of nontradables) during convergence? One can show that the initial relative price gap depends positively on the initial gap in expenditures and also on the capital gap (if the nontraded sector is more labor-intensive).[8] So if all gaps are negative, the relative price must increase.

5 The currency board

To understand the mechanics of the currency board regime, recall that consumer wealth (measured in domestic currency) is defined as $A_t \equiv H_t + S_t B_t$, which in turn can be written as

$$S_t B_t + H_t = (1+\tau) H_{t-1} + (1+i_{t-1}) S_t B_{t-1} + W_t L + R_t S_t K_{t-1} - P_t C_t - S_t \left(1 + \frac{\delta}{2}\frac{I_t}{K_{t-1}}\right) I_t.$$

Under the currency board arrangement, the government is prohibited from printing money, so $\tau = 0$, and naturally, S is fixed. The change in money can be thus written as

$$H_t - H_{t-1} = (1+i_{t-1}) S B_{t-1} - S B_t + W_t L + R_t S K_{t-1} - P_t C_t - S\left(1 + \frac{\delta}{2}\frac{I_t}{K_{t-1}}\right) I_t.$$

Just like in the flexible exchange rate case, we assume that foreigners cannot use the local currency for their transactions, so they do not accept it at all. How can consumers still increase the domestic money stock? They receive foreign currency (euros) for their trade surplus and foreign investment income (the current account balance), which they take to their own central

[7] This is where the assumption of exogenous money transfers would make a difference. The reason is that consumers in a flexible exchange rate economy do realize that the euro value of their money holdings will change over time; while consumers in the fixed exchange rate regime take money growth as exogenous. The nonmonetary part of consumer welfare is still the same in the two implementations, but the monetary part differs.

[8] Based on the appendix, the loglinearized relative price can be written as $p^N - s = 1/(L^N K^T(1-\beta) + K^T L^T + \beta K^N L^T)[(\alpha-\beta) K L^T k + (\beta-\alpha)^2 \lambda(1-\lambda)\bar{X}^2/\left(\bar{S}\bar{W}\rho\right)(x-s)]$.

bank. The central bank takes the euros, adds them to its foreign reserves, and issues domestic money in return. An alternative is to borrow from the rest of the world $(SB_{t-1} - SB_t)$ in euros and again, exchange it to domestic money through the central bank. In both ways the rest of the world does not need to take any positions in the currency board country's local currency.

Now we compare the dynamic system describing the currency board case to the flexible exchange rate model (the real equilibrium). Equations (1), (2), (3) and (4) are the same in the two cases (6, 7, 8 and 9 in the real model). The only difference is (5). Using that $\tau = 0$ and S is constant, it now becomes

$$B_t = W_t^* L + R_t K_{t-1} - X_t^* - I_t \left(1 + \frac{\delta}{2} \frac{I_t}{K_{t-1}}\right) + \left[1 + \rho + d\left(B_{t-1}\right)\right] B_{t-1} - \left(H_t^* - H_{t-1}^*\right), \quad (11)$$

with $H^* = H/S$. Recalling that

$$\frac{\gamma}{H_t^*} = \frac{1}{X_t^*} - \frac{1}{1+\rho} \frac{1}{X_{t+1}^*},$$

it is immediate that (10) and (11) differ. Thus we get our third result:

Proposition 3 *The currency board dynamic system is different from the flexible exchange rate regime.*

What does a revaluation (a decline in S) do in a currency board economy? Just before the revaluation, consumers hold B_{t-1} foreign bonds and H_{t-1} units of local currency. Evaluated at the initial exchange rate, household wealth is $A_{t-1} = B_{t-1} + H_{t-1}/S$; while after the revaluation, it becomes $A'_{t-1} = B_{t-1} + H_{t-1}/S' > A_{t-1}$. Consequently, a revaluation (or a stronger conversion rate) is equivalent to a wealth shock of $H/\Delta S$. As wealth is a regular state variable, a wealth shock leads to a full dynamic response of real variables.

In a perfectly elastic money supply regime, the same wealth shock is immediately neutralized by a change in the per period money transfer; while if a central bank of a flexible exchange rate economy prints money, that is immediately offset by a currency depreciation. This is summarized in our fourth result:

Proposition 4 *The level of the exchange rate or the size of the money stock has a real effect in a currency board regime; while it is neutral in the nominal implementation of the real model.*

It is important to clarify whether a change in the exchange rate is sensible within a currency board framework. Literally speaking, a currency board cannot revalue its currency (unless it receives foreign grants to increase its reserves). It can nevertheless devalue and set aside some of the previous reserves. The question is now what they do with those excess funds. One possibility is to buy import goods from that directly – or give to the government who could again do the same. In this case the extra funds are given to foreigners, in return for imported goods.

If those excess funds are converted to local currency, then there is no change in the euro value of the local currency, just a reshuffling of who owns the money. If the unused reserves are distributed in proportion to local currency holdings, there is no change at all, while if the mechanism is different, there is again redistribution within the country. In a representative agent world (where a redistribution is neutral on aggregates), all these cases imply no real effects at all.

A more interesting example is the conversion rate around German unification – as most East Germans had their savings in local currency (cash or bank deposits), this was purely a transfer/wealth effect, exactly in the spirit of our model. Not surprisingly, the East German economy showed strong symptoms of overvaluation, in response to a very strong conversion rate. The return of the UK to the gold standard after WWI and the euro conversion rate are similar examples.

We believe that around a currency changeover, the wealth effect analyzed by our framework is a more important source of real effects than pricing rigidities: firms can always use the need to post prices in the new currency as an occasion to reoptimize their prices. Hobijn, Ravenna and Tambalotti (2006) documents that this was clearly the case in the restaurant sector of the euro area in January 2002.

Let us stress that one cannot use this framework to calculate an optimal conversion rate. In terms of consumer welfare (no matter whether we take into account the money part of it or not), the stronger the entry rate, the better. Again, this is due to the pure wealth transfer. In reality, there should be constraints on how much foreign currency the rest of the world is willing to give for a local currency, but such considerations are not part of our framework. Besides, governments might care for certain subgroups (like exporters), which would again limit the case for a strong entry rate. Nevertheless, our model does produce lasting and sizable real consequences of different entry rates.

6 Role of certain assumptions

Now that we have established our main analytical results, it is interesting to briefly discuss the role of some assumptions in generating the real effects under a currency board. These assumptions are (i) the endogenous risk premium, (ii) the domestic (as opposed to foreign) ownership of capital, and (iii) the presence of two sectors.

As mentioned in the introduction, the nominal side interacts with the real side through two channels: the interest rate channel and the relative price channel. The first of these channels depends on the presence of a debt-dependent risk premium (which also serves to pin down the steady state net foreign asset position). As long as capital is owned by households, the opportunity cost of investment differs from the subjective rate of time preference (ρ). Thus a nominal shock that changes the foreign currency value of wealth (and hence the risk premium) will have a real effect on investment behavior.

The second channel only operates in the two-sector framework. A (positive) shock to nominal wealth increases the demand for both tradables and nontradables. Nontradable production, however, can only increase through a reallocation of labor, since capital is fixed in the short run. This means that the transformation curve between tradables and nontradables is nonlinear, and hence the relative price of nontradables must go up. As long as $\alpha \neq \beta$, this changes the rate of return on capital; when $\alpha > \beta$ (the nontradable sector is more labor intensive), R goes down (the Stolper-Samuelson theorem). Finally, the change in R leads to a change in investment behavior through the capital/bond arbitrage condition.[9]

In our setup both of these channels are operational. To separate their effects, we will examine two alternative specifications. First, when $\alpha = \beta$ (which is equivalent to a one-sector economy), the relative price channel does not operate, since the relative price of nontradables is identically 1 (the transformation curve becomes linear). Second, when capital is held by foreigners who can borrow at the interest rate ρ, the interest rate channel disappears, as the opportunity cost of investment equals the subjective rate of time preference.[10]

A key difference between the two channels is in the behavior of investment. A nominal appreciation (more wealth) leads to more investment through the interest rate channel, and less investment through the relative price channel (if the nontradable sector is more labor intensive). In the former case, more wealth means a lower nominal interest rate premium, so future capital income is discounted less. In the latter, higher wealth implies a higher demand for nontradables, which leads to a higher nontradable price, and a fall in the price of capital (through the Stolper-Samuelson mechanism). Since the net effect is analytically ambiguous, we will return to this issue when we discuss our numerical results.

[9] Benigno (2003) and part 3.2.5 of Woodford (2003) also highlight the role of sectoral asymmetries, though not in the context of traded versus nontraded goods.

[10] One could also set up the model without a premium term. Though this would lead to technical difficulties, as the steady state becomes path-dependent, the relative price channel still remains functional. In terms of model equations, the mechanism is now through the steady state and the intertemporal budget constraint, and not first order conditions or per period equilibrium conditions. The logic is the following: based on the Appendix, one can show that $c_1 k + c_2 l_N = x = 0$, so $l_N = -\frac{c_1}{c_2} k$, and all other conditions depend only on k. This means that wealth does not enter the loglinearized system. There is still a link: the steady state wealth level (and the present discounted value of wages along the convergence path) influence the constant level of X, which affects $\bar{L}_N$, and that influences $\bar{K}$. A wealth shock changes $\bar{K}$, so even without changing K_0, its percentage deviation from the new steady state changes.

7 Policy exercises

Due to the high dimensionality of our dynamic system, we cannot sign impulse responses analytically. Instead, we proceed with a numerical illustration. Besides showing that our model delivers sizable real effects under plausible parameter values, it also evaluates the relative importance of the interest rate and the relative price channels.

7.1 Choice of parameters

For illustrative purposes, let us fix all the parameters:

$\alpha = 0.8$ – labor intensity of the nontraded sector.

$\beta = 0.5$ – labor intensity of the traded sector. All this starting assumption does is to assume that $\alpha > \beta$, which is a standard choice, though it might not hold in certain countries.[11] To explore its role in delivering results, we also run two additional simulations with $\alpha = 0.5$ and 0.3.

$\lambda = 1/3$ – expenditure share on tradables. This is a reasonable assumption, particularly if we take into account that traded prices also have large service components.

$\rho = r^* = 0.05$ – required real rate of return on capital. Assuming that one year is a unit time interval, then it means 5% annually.

$\delta = 5$ – the investment adjustment cost parameter. This number can be chosen to match a priori expectations about the speed of capital adjustment. Our choice means that the half-life of a proportional innovation to the capital stock in the real model ($\hat{K} < 0$, $db = 0$) is 25 years.

$\psi = 0.01$. This risk premium parameter is higher than the choice (0.000742) of Schmitt-Grohe and Uribe (2003). In case of an emerging economy, it is not unreasonable to assume a risk premium that is more responsive to foreign debt than in an industrial economy. Under our parameter choices, annual GDP is 7.1429, so for a level of excess foreign debt of $B - \bar{B} = -0.5$ (7% of GDP) the risk-adjusted interest rate becomes $\rho + \psi\left(e^{0.5} - 1\right) \approx 0.05 + 0.0065 = 0.0565$. The contribution of the risk premium is overall reasonable. For our purposes, the most important consequence of choosing ψ is the speed of adjustment following a wealth shock. In the real model with exogenous labor and capital income ($\hat{w} = \hat{r} = 0$), and no investment, the wealth-expenditure block becomes a saddle-path stable system with an eigenvalue of .7916 (a half-life of 3 years).[12]

$\gamma = 0.05$ – the relative weight of real money in the per period utility function. Based on the steady state relationship $\frac{\bar{H}}{\bar{X}} = \frac{\gamma(1+\rho)}{\rho} = 1.05$, our parameters mean that steady state money

[11] The equilibrium nominal appreciation result and the impact of a nominal appreciation within a currency board economy is independent from the ranking of α and β. The equilibrium real appreciation result is sensitive to this assumption.

[12] Adopting the appropriate loglinearized equations from the Appendix: $b_t = -\bar{X}x_t + (1+\rho)\, b_{t-1}$ and $x_t - x_t = x_{t+1} - s_{t+1} + \frac{\psi}{1+\rho} b_t$.

holdings are equal to 105% of annual expenditure. The choice of γ also influences the speed of adjustment following a wealth shock in the *nominal* model. Again with exogenous capital and labor income and no investment, the half-life of a wealth shock becomes roughly 5 years.[13] This is somewhat higher than for the real model, but the overall contribution of the nominal friction is reasonable.

$\bar{B} = 0$ – this means that the country has a zero net foreign asset position in the long-run,100% of its assets are local (money), and total assets equal 105% of annual national income.

$K_0 = 0.5\bar{K}$ – initial capital stock.[14]

$A_0 = \bar{A}/2 = 2.625$ – this means that initial wealth is 50% of its long-run level. Since $\bar{B} = 0$, we have $\bar{A} = \bar{H}/\bar{S} = (1+\rho)\,\bar{Y}/\bar{S}$, so A_0 is 52.5% of steady state GNP. Under our parameter choice, $Y_0/S_0 \approx 0.75\bar{Y}/\bar{S}$ in both models, so initial wealth is roughly 66.6% of initial GNP.

7.2 Real and nominal convergence paths

7.2.1 The real path

Let us start with results corresponding to the real equilibrium path. Convergence implies an appreciating nominal exchange rate regardless of the relative intensities of the two sectors. If the nontraded sector is more labor-intensive, there is also an increase in the relative price of nontradables (a real appreciation). If labor intensities are equal across sectors, then capital accumulation has no impact on the equilibrium relative price of nontradables; while if the nontraded sector is less labor-intensive, we observe a fall in the relative price of nontradables.

These findings are fully consistent with international trade theory: as long as capital is scarce, it has a high factor price. This implies a high relative price of the sector which uses capital more intensively (inverse Stolper-Samuelson theorem). Therefore, if the nontraded sector is more labor-intensive, the NT relative price must increase along the convergence path. It means a positive but vanishing excess inflation.

Figure 7 shows the evolution of real GDP (measured in the consumption basket), capital stocks, asset holdings, the nominal exchange rate and the nontraded relative price. As argued before, there is an increase in the relative price: under our choice of parameters, there is a 16% initial price gap due to the low stock of capital. Since money is fixed, the required increase in real money holdings is implemented by a gradual strengthening of the nominal exchange rate

[13] Writing the current account and the Euler equation in terms of $a = b + \bar{H}h$, the system becomes $a_t = -\bar{X}\,(x_t - s_t) + (1+\rho)\,a_{t-1} - \rho\bar{H}\,(h_{t-1} - s_{t-1})$, $x_t - s_t = x_{t+1} - s_{t+1} + \frac{\psi}{1+\rho}\left(a_t - \bar{H}\,(h_t - s_t)\right)$ and $h_t - s_t = \frac{\rho}{\rho+\psi\bar{h}}\,(x_{t+1} - s_{t+1}) + \frac{\psi}{\rho+\psi\bar{h}}a_t, h_{t-1} - s_{t-1} = \frac{\rho}{\rho+\psi\bar{h}}\,(x_t - s_t) + \frac{\psi}{\rho+\psi\bar{h}}a_{t-1}$.

[14] Clearly such a large deviation from steady state is inconsistent with the loglinear approximation. Given that the numerical solution of the exact system is problematic (due to its saddle path nature), we still believe that our numerical exercises are good illustrations of the theoretical results.

(a total of 33%). Though the economy starts from debt, consumers still borrow more, and they start repayments after 4-5 periods. An even lower level of initial wealth would eliminate the initial increase in foreign debt.

7.2.2 Comparing the currency board and the real path

Next we compare the results of the currency board case and the real equilibrium path. Both trajectories start from the same initial conditions for capital (K_0 and A_0). Figure 8 depicts the difference of the evolution of various variables under the two scenarios. The curves show the difference of the currency board economy from the real path relative to the steady state.

The differences between the two convergence processes are quite substantial. In general, the nominal economy is initially "overvalued" relative to the flexible case: relative prices are initially higher, and production leans towards nontradables. Even though the price difference is small (0.25%), there is substantial sectoral reallocation. The nontraded sector employs more than 0.5% more labor and almost 2% less capital.

Investment is higher in the currency board. This results from two opposing forces: the rental rate is lower (the relative price channel), but foreign debt is smaller, pushing the interest rate down (the interest rate channel). Although the difference in aggregate capital stocks appears only gradually, sectoral capital-labor ratios are higher from the start, as suggested by higher wages and lower rental rates. This follows from the fact that the more labor-intensive nontraded sector is larger in the currency board economy.

After around 5-10 periods, the currency board economy shifts to undervaluation, and it now features an asymmetry in favor of tradables. Investment and q turns around. Wealth accumulation, on the other hand, is faster in the flexible regime during the entire convergence period, and it also exhibits a higher share of money.

The general difference can be traced to an extra saving motif for consumers in a currency board, namely to build up their money stock. When we want to implement the real model within a flexible exchange rate framework, the required increase in money is achieved by an appreciating nominal exchange rate. Hence consumers can spend more, which then pushes resources (capital and labor) from tradables to nontradables. This is what we observe in later stages of convergence, when the currency board economy is already undervalued.

The effect on savings is even more complex: though currency board households do need to allocate more resources from their labor income to money holdings, flexible exchange rate households also have nonlabor income (the exchange rate gain) to save from, plus they face a higher overall return on money (the marginal utility plus the exchange rate gain). This second feature explains why they have a higher share of money in their portfolio. Finally, there are also dynamic effects: lower capital and wealth stocks increase the savings and investment of the economy in the future.

The difference in portfolio allocations is key in understanding the initial overvaluation: consumer wealth is the same in both cases, but as the total return on money is higher in the flexible exchange rate economy, it has a bigger portfolio share. Consequently, currency board households hold less foreign debt, which leads to a lower interest rate. The Euler equation then commands a more front-loaded expenditure path and less savings. This is what generates the initial overvaluation. Later on, their lower wealth holdings make them consume less, which causes the switch from over- to undervaluation.

7.2.3 The effect of a 10% revaluation

Figure 9 compares two currency board economies, one having a 10% stronger exchange rate. With the exception of wealth and bond holdings, all figures are differences divided by steady state values; while those two are absolute differences (subtracting values corresponding to the weaker exchange rate economy from those of the stronger exchange rate economy). For example, the relative price of nontradables is higher by 0.003, meaning that there is only a 97% passthrough into nontradables. The more revalued economy is shifted towards nontradables, and real GDP is higher. Though price differences are relatively small, factor reallocations are quite substantial.

A revaluation worsens the current account (savings) by 1.4% of steady state GDP (7.1429), since the windfall in wealth is gradually consumed. During this process, there is an initial increase in both money and foreign bond holdings, followed by a reversal. As expected, consumption of both tradables and nontradables goes up. Overall, the figures show that there is a sizable and highly persistent real effect of the choice of the conversion rate or a revaluation.

As we have argued before, the behavior of investment is determined by two opposing forces. Just like in the comparison between the flexible exchange rate and the currency board economy, the interest rate channel leads to more investment, while the relative price channel works in the opposite direction. The combined effect turns out to be positive in our numerical example, meaning that a revaluation in fact stimulates investment. Notice that there is an asymmetry across sectors: nontraded investment booms (both channels go in its favor), while traded investment collapses (here again, the two channels point in opposite directions).

Though such an aggregate investment response is not entirely unreasonable,[15] one would have expected a revaluation to hurt investment. A first observation is that a one-sector economy cannot produce such an effect, since the relative price channel is missing there. We have experimented with our model framework to match that feature. One possibility is to assume that capital is completely owned by foreigners, in which case the interest rate channel is no longer operational. Another is to weaken the interest rate channel by decreasing the risk premium: if

[15] Rebelo and Végh (1995) report that many exchange-rate based stabilizations featured accelerating investment.

ψ moves from 0.01 to 0.0001, investment responds negatively to a revaluation. Unfortunately, such a ψ generates implausibly high persistence.

A realistic alternative is to assume that the risk premium is much smaller on investment loans than on consumer loans. Setting up very carefully, the assumption of zero premium on investment loans is in fact equivalent to full foreign ownership. The complication is that one needs to prohibit corporations from channelling cheap investment loans to consumers via paying out dividends.

8 Some concluding comments

The paper presented a simple theoretical model that addresses the growth process of a small trading economy with a traded and a nontraded sector. Overall, the model highlighted that capital and financial wealth accumulation (real and nominal convergence) are deeply interconnected. In particular, we showed that the choice of monetary regime influences the capital accumulation path of the economy. We also discussed the channels of this influence, which are operational except in the empirically implausible case of a one-sector economy without risk premium.

We think our results are relevant for a broad range of issues in addition to the question of capital accumulation on a convergence path. Any unexpected shock that changes nominal wealth will lead to the effects described in the paper, as long as the exchange rate is not fully flexible or the central bank does not fully accommodate changes in money demand. Examples to such scenarios include: (i) exchange rate de- or revaluations, (ii) joining a monetary union, (iii) fiscal policy shocks, (iv) valuation changes in a country's foreign assets.

There are several interesting questions that we did not address. First, as we stressed previously, our framework cannot be used to study the optimality of either the exchange rate regime or the level of the exchange rate. Doing so would require either explicitly modelling the foreign side, or introducing consideration for other than consumer welfare (such as the current account). Second, we assumed that prices are fully flexible. While studying the medium-run interaction of wealth effects and sticky prices/wages may lead to interesting results, we leave this line of investigation for further research.

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Appendix

A The Hungarian episode

To illustrate a specific example to the symptoms of a wealth shock ("overvaluation"), we present some recent evidence from Hungary. Looking at Hungarian data between 1999-2003, we find the following:[16] (1) a drop in real corporate investment around 1999, and a flattening of the total investment to GDP ratio (Panels A and B of Figure 10); (2) a strong increase in the consumption to GDP ratio since 2000 (Panel B); (3) a strong comovement of corporate investment and the stock market index – the 1999 episode is mixed here with the Russian crisis, but from 2000, the U-shaped pattern of investment and the stock market is common (Panel C); (4) massive real wage growth episodes around 1999, 2000, partly driven by public sector wages (Panel D); (5) a general increase in the nontraded-traded relative price, with historical highs since 2000-2001 (Panel E); (6) a shift of (total) investment from industry towards services and real estate (Panel F);[17] (7) a tilt of employment towards the service sector (Panel G); (8) and an overall high current account deficit, particularly deteriorating since 1998, with a temporary reversal in 2001 and 2002 (Panel H).

[16] There was no apparent extra GDP growth – but the fact that there was no slowdown among the international stagnation of the 2000s can be interpreted in such a way. By 2003, GDP growth indeed declined.

[17] This change in total investment shares is mostly driven by a constant industry share within corporate investment, and an overall increase in public investment (dominantly services) and household investment (dominantly real estate).

The policy environment can be summarized as (1) a correction in the public versus private sector wage ratio, around the beginning of 1999; (2) a large increase in minimum wage legislation, around the beginning of 2001; (3) investment subsidies to SMEs and (4) subsidized real estate loans, from around 1999; (5) a large nominal appreciation (monetary restriction), in the form of widening the exchange rate band in May 2001, (6) followed by a massive fiscal expansion, partly in the form of public sector wage increases (end of 2002). The exact timing of this latter fiscal expansion is somewhat unclear: the rise in public sector wages unambiguously came after the monetary contraction, but the fiscal stance before and after the monetary developments is subject to heated political debates in Hungary.

B Loglinearization

In this section we briefly derive the log-linearized version of the model. For convenience, we set $\tau_t = 0$; the resulting equations still contain the flexible exchange rate regime and the currency board regime as special cases (by setting $h = 0$ in the former case and $s = 0$ in the latter). Lowercase variables indicate log deviations from the steady state, except for di and b, which are absolute differentials.

Households

- Euler equation

$$di_t = (1+\rho)\left(E_t x_{t+1} - x_t + s_t - E_t s_{t+1}\right)$$

- Money demand

$$\rho h_t = (1+\rho)\, x_t - E_t x_{t+1}$$

- Capital accumulation

$$k_t = k_{t-1} + \frac{1}{\delta} q_t$$

- Trade-off between capital and bonds

$$q_t = \frac{\rho}{1+\rho} E_t r_{t+1} + \frac{1}{1+\rho} E_t q_{t+1} + E_t(s_{t+1} - s_t) - E_t\left(x_t - x_{t+1}\right)$$

- Demand for tradables

$$c_t^T = x_t - s_t$$

- Demand for nontradables

$$c_t^N = x_t - p_t^N$$

Production

- Production function for nontradables

$$y_t^N = \alpha l_t^N + (1-\alpha)\, k_t^N$$

- Production function for tradables

$$y_t^T = \beta l_t^T + (1-\beta)\, k_t^T$$

- Labor share in N

$$w_t + l_t^N = p_t^N + y_t^N$$

- Labor share in T

$$w_t + l_t^T = s_t + y_t^T$$

- Capital share in N

$$r_t + s_t + k_t^N = p_t^N + y_t^N$$

- Capital share in T

$$r_t + k_t^T = y_t^T$$

Equilibrium

- Labor market clearing

$$\bar{L}^T l_t^T + \bar{L}^N l_t^N = 0$$

- Capital market clearing

$$\bar{K}^T k_t^T + \bar{K}^N k_t^N = \bar{K} k_t$$

- Nontradable market clearing

$$y_t^N = c_t^N$$

- Interest premium

$$di_t = -\psi b_t$$

- Current account

$$b_t - (1+\rho)\, b_{t-1} + \bar{H}/\bar{S}\,(h_t - s_t - (h_{t-1} - s_{t-1})) = \bar{Y}^T \left(y_t^T - c_t^T\right) - \frac{\bar{K}}{\delta} q_t$$

C Figures

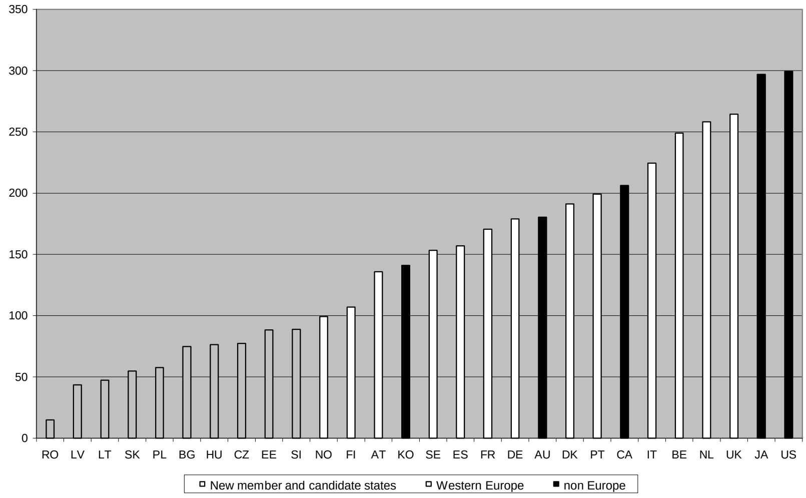


Figure 1: Household assets per GDP

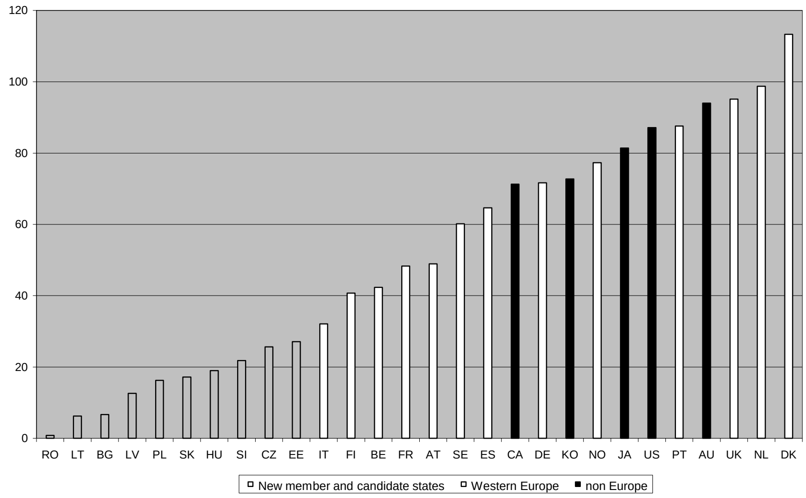


Figure 2: Household liabilities per GDP

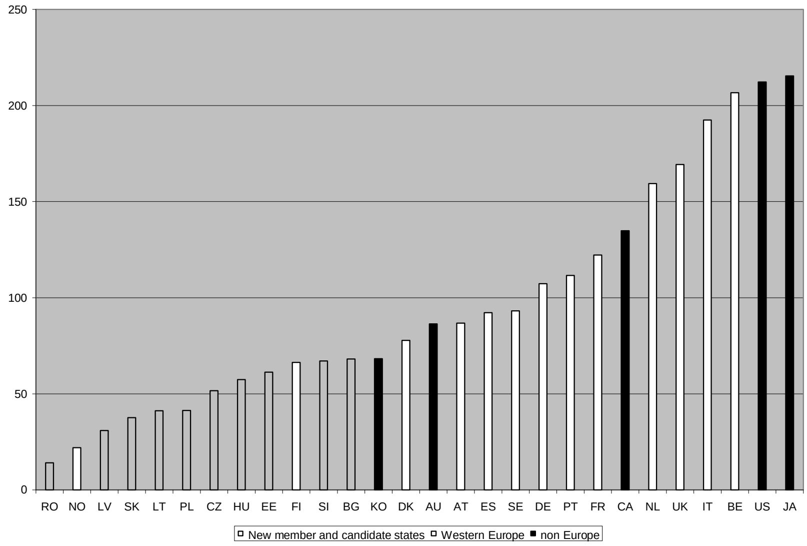
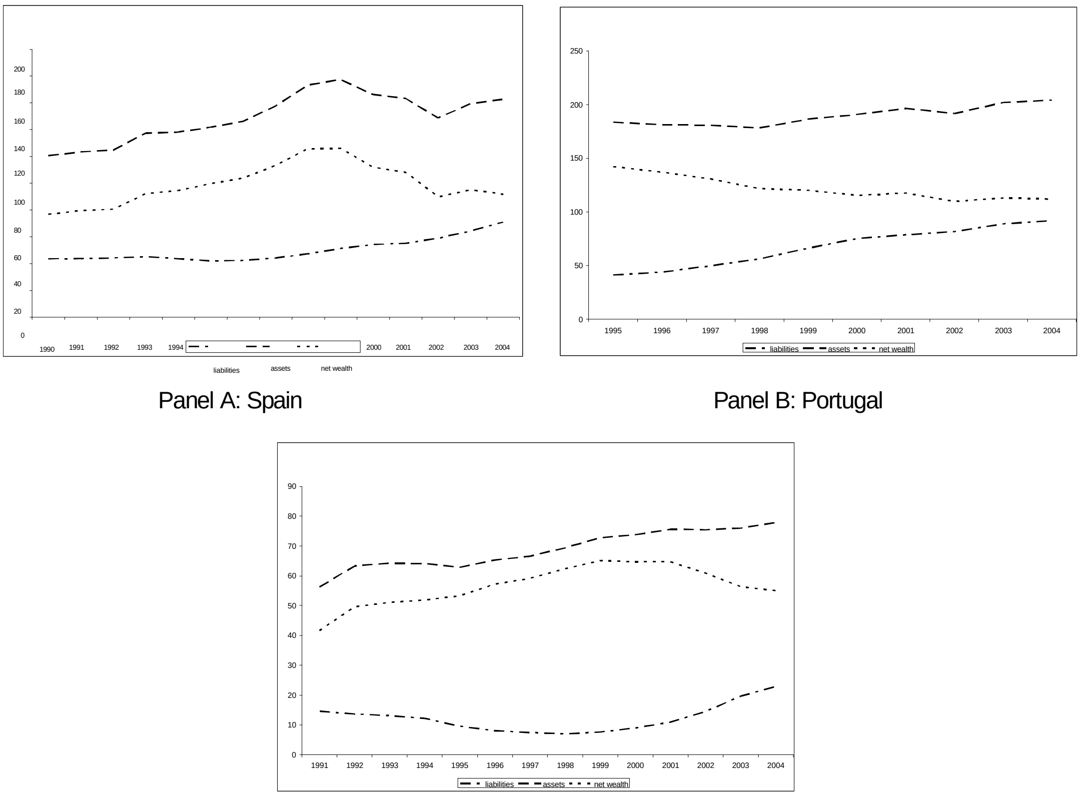


Figure 3: Household net wealth per GDP



Panel A: Spain

Panel B: Portugal

Panel C: Hungary

Figure 4: Time series evolution of household balance sheets

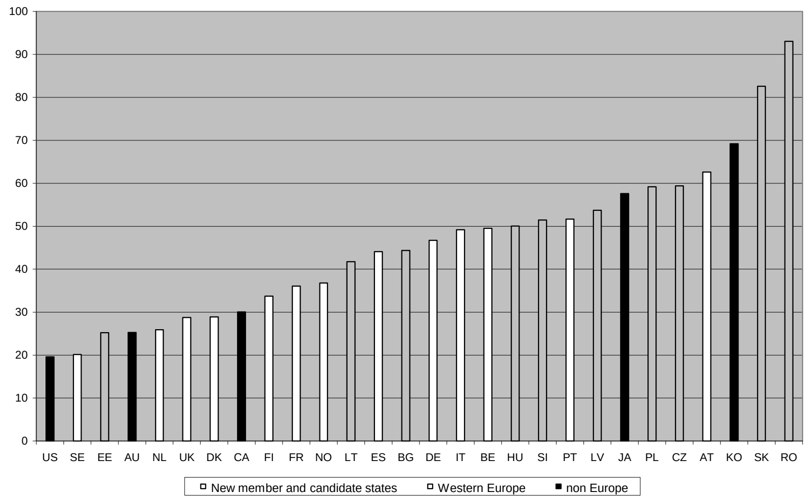


Figure 5: Currency, bank deposits and securities other than shares per household assets

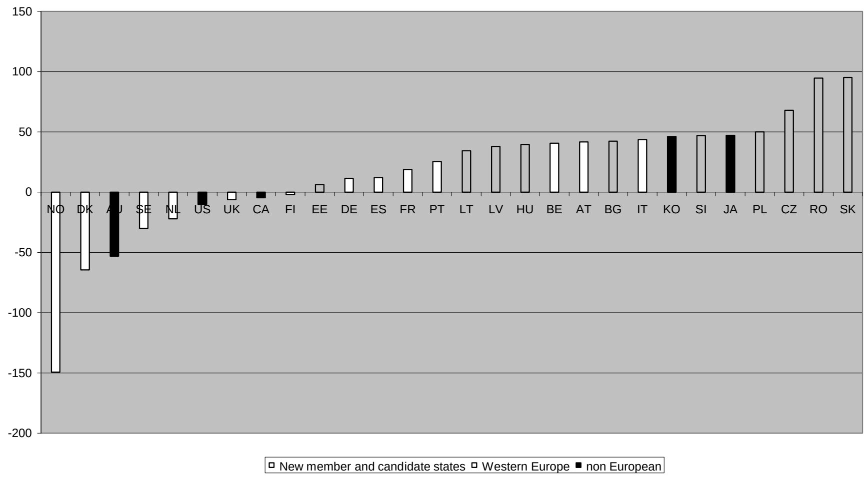


Figure 6: Net currency, bank deposits, loans and securities other than shares per household wealth

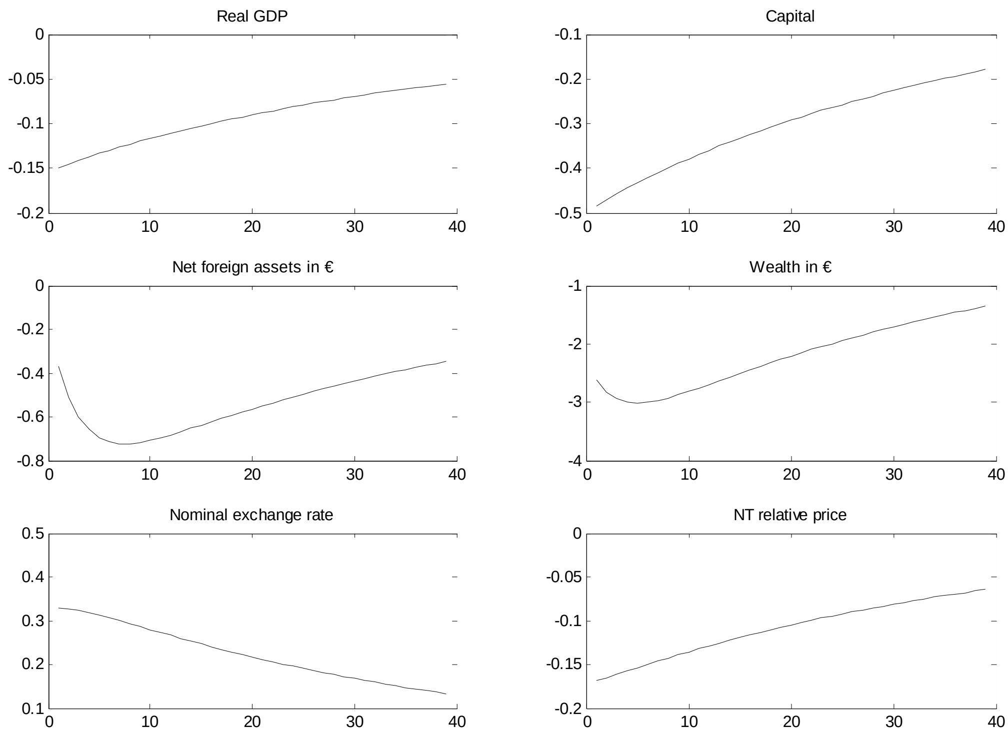


Figure 7: The real convergence process

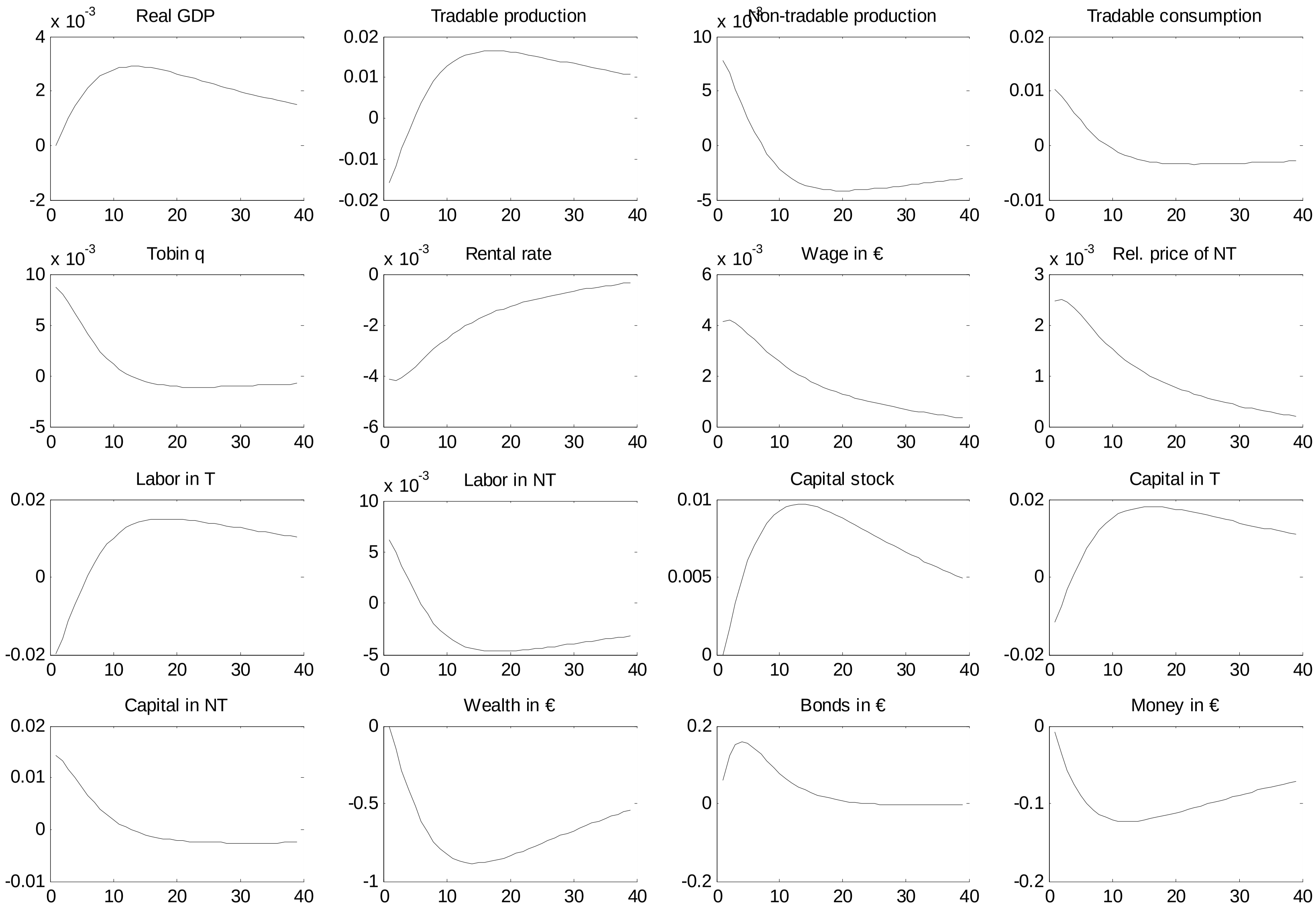


Figure 8: Differences between the nominal and the real model

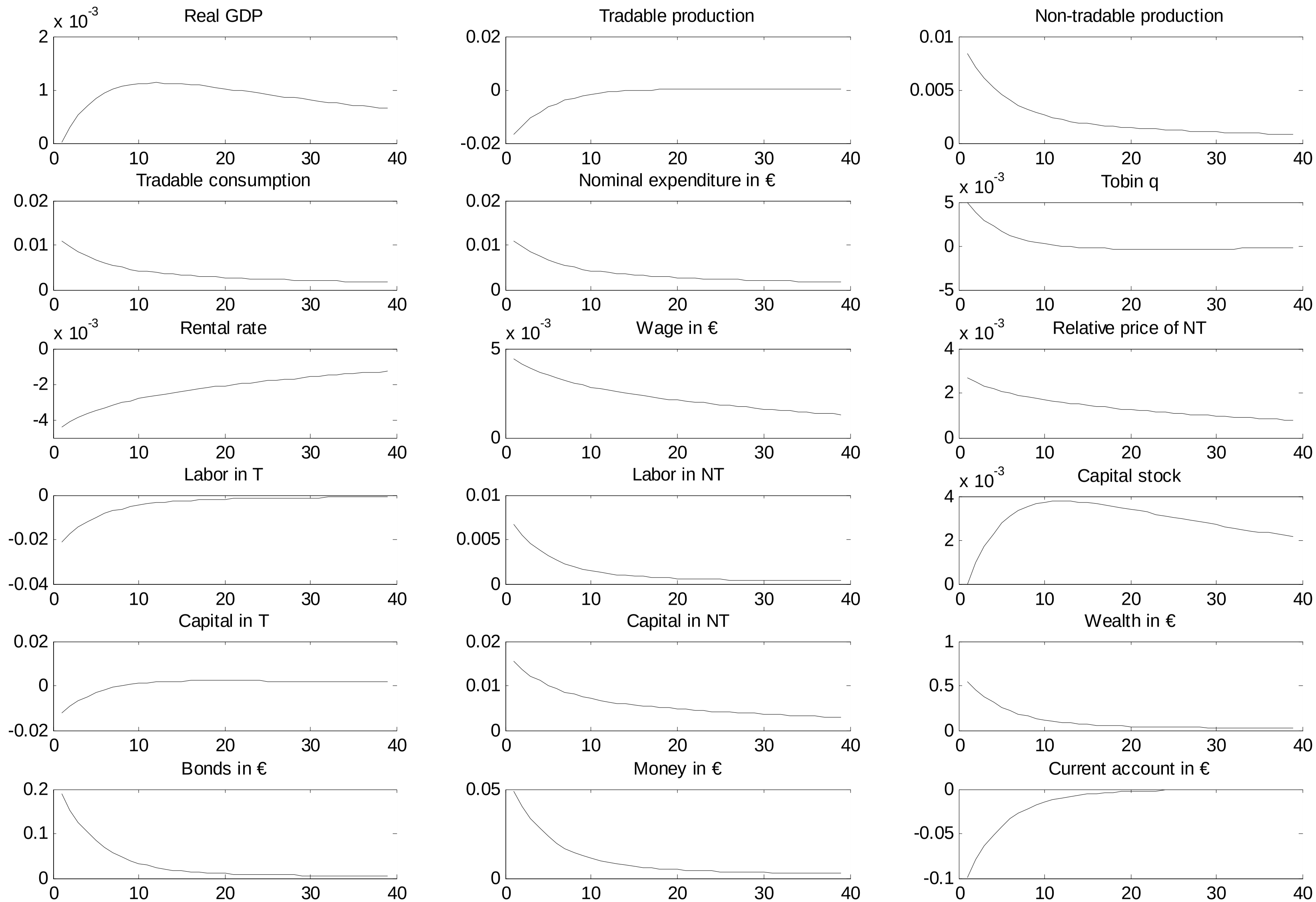
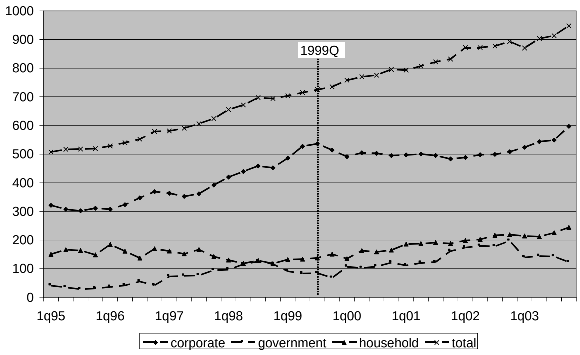
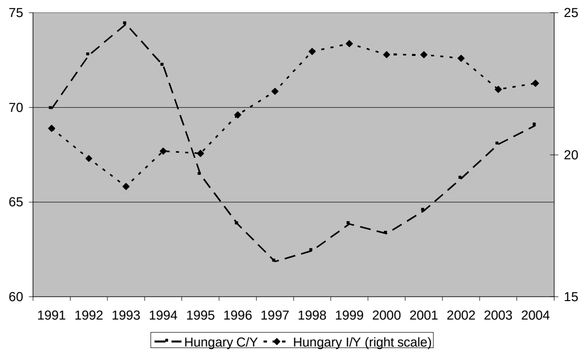


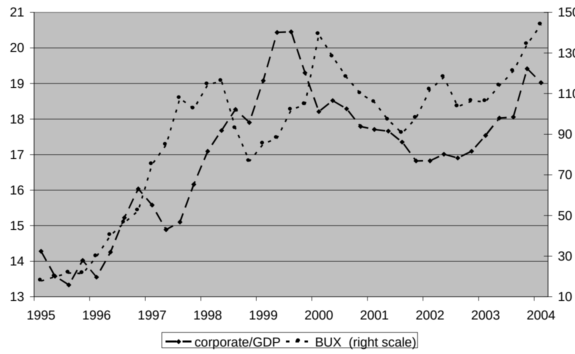
Figure 9: Real effects of a 10% stronger conversion rate



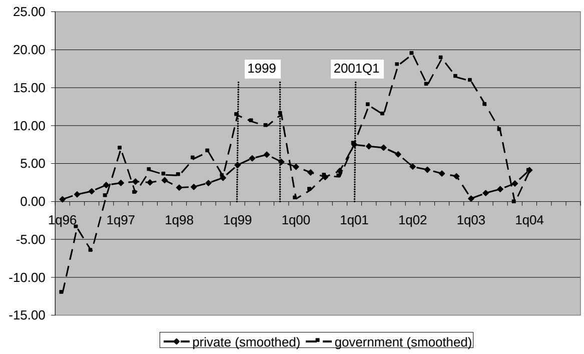
Panel A: Investment (real)



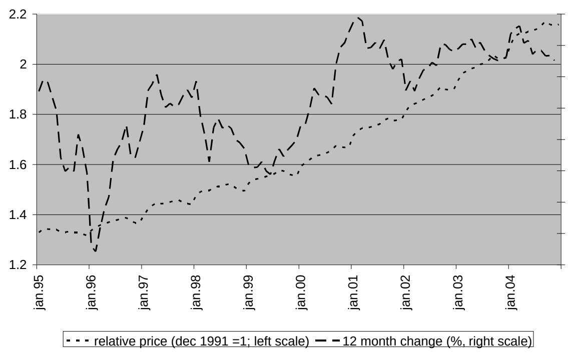
Panel B: Investment and consumption ratios



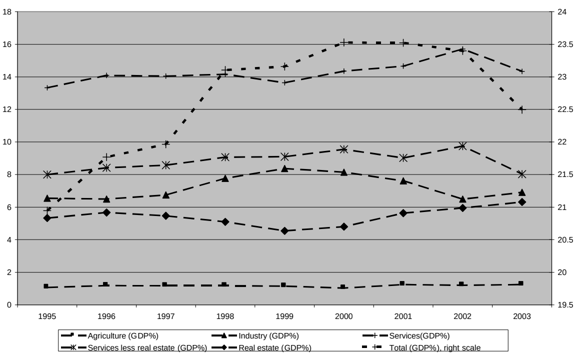
Panel C: Investment and the stock index



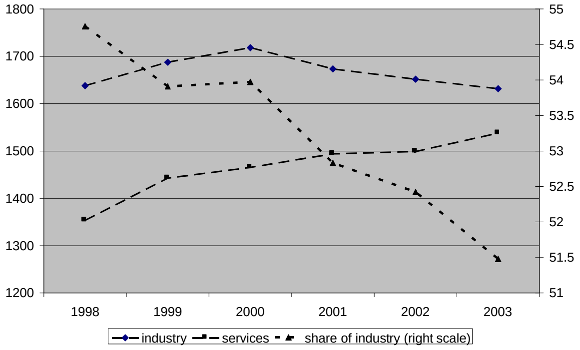
Panel D: Real wages



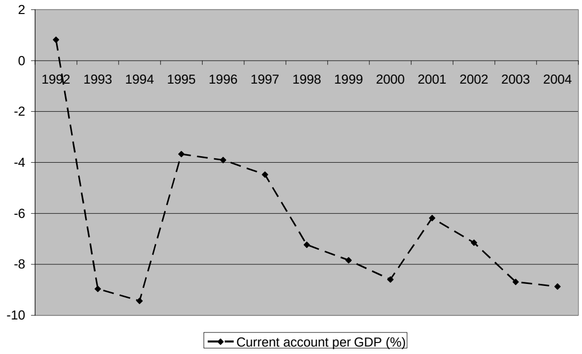
Panel E: The nontraded-traded relative price



Panel F: Investment by sectors



Panel G: Employment in the private sector



Panel H: The current account

Figure 10: Hungary in the late nineties