1. Introduction

1.1. Motivation and methodology

The importance of exchange rate alignments for short-term stabilization has been stressed in post-war economic literature, especially for countries with high incidence of asymmetric (nation-speci…c) shocks (Mundell 1961), and is often regarded as self-evident in current textbooks and seminar papers. However, even without the interference of currency market disturbances and credibility problems, economic stabilization through realignment of the exchange rate is more involved than is often implied. Exchange rate re-alignments are by de…nition a source of sudden and, sometimes, sizable shifts in relative prices, which if anticipated create an incentive for substitution between tradables and non-tradables, as well as intertemporal substitution. This is especially the case for small, open and specialized economies for which prices of tradables are set in foreign markets and are faced with cyclical variations in the terms of trade due demand changes following business cycle movements in the larger economies. For countries in this category, a currency appreciation in the face of a positive export shock could thus be perceived as an omen of a future depreciation, creating an incentive for a consumption binge while the price of tradables is temporarily low.

This tendency for intertemporal substitution has been strongly indicated in natural experiments associated with trade liberalizations under imperfect credibility in less developed economies. Many LDCs have attempted to establish more outward-oriented trade regimes by reducing protection of the import competing sector, although such attempts have failed at least as often as they have succeeded (for further discussion see Michaely et al. 1991). Consequently, when lower tari¤s are announced, the change is considered non-credible and temporary and is followed by a surge in consumer imports inconsistent with plausible values for price and income elasticities of demand, see, e.g., Calvo (1987) and Bu¢e (1995). The consequent reserve loss su¤ered by the central bank is often the main reason for the abandonment of the reforms, in which case failure can be considered self-ful…lling (Bu¢e 1999).

The same dynamics apply to stabilization programs based on a pre-announced path for the nominal exchange rate in the face of high in‡ation, as have been frequent in the Southern-Cone countries of South-America. As a general rule, these programs were not fully credible at time of implementation and as in‡ation raged on, the real exchange rate appreciated and people formed expectations about devaluation and abandonment of the exchange rate target. Consequently, consumption of imported tradables and non-tradables expanded very rapidly at the initial stages of such programs, although at later stages the boom was followed by a recession. Calvo and Vegh (1994) observe; "the business cycle associated with the exchange-rate based stabilization runs counter to conventional wisdom - according to which stabilization is expected to be accompanied by an immediate contraction - and has been a source of confusion and puzzlement for economic theorists and policy makers alike."

The main goal of this thesis is to seek answers as to whether short-term stabilization policy can have non-negligible side e¤ects associated with consumption dislocation across time and commodity groups: Such factors may be able to explain the rather unfortunate experience many resource-based export economies within the OECD had with such policies supported with capital controls, especially in the 70´s and 80´s, the prime examples being, Australia, Iceland, Finland, New Zealand and Norway. In other words, the very same countries that due their asymmetric production structure ought to bene…t the most from exchange rate alignments, according to conventional economic theory.

Although these countries faced substantial external disturbance, the impact of the shocks on aggregate demand, and on imported goods in particular, was both quicker and powerful than one would expect from the direct impact on national income. This led to in‡ationary pressures, consumption volatility and current account movements inversely related to terms of trade changes which is in contrast to classic economic theory of consumption smoothing as de…cits were observed right in the wake of positive export price changes. This occurred in Australia from 1988-9, when the terms of trade improved by 22%, although at the same time the trade de…cit reached a record high 6% of GDP in 1989. Similar things happened in Iceland 1986-88 and in New Zealand 1974-75.

In this thesis I will attempt to capture such dynamics in a simple perfect foresight model, describing a small open economy with a specialized export sector that has to cope with terms-of-trade shocks. The short-term stabilization policy will be characterized as a set of instrumental rules, related to performance in the export sector, which aim to insulate the domestic economy from external shocks. This is only a formal presentation of a classical stabilization policy revolving around terms-of-trade changes and corrections for excess domestic cost increases. However, rather than investigating the policy performance in relation to a single shock in isolation, the time horizon is expanded to include a shock sequence which allows for a more realistic evaluation in countries that are subject to frequent shocks.

The main focus is on the main aggregate variables of macroeconomic importance with the aim of mapping behavioral relationships from micro-based theory. It is clear that in‡ation and unemployment are generally considered undesirable, although no attempt will be made to rank the solutions on the basis of social utility. Moreover, a real comparison will be provided for by picking Iceland out as a source of structural parameters for calibration and simulation. This is done, not only because of the comparative advantages of the author, but also because exchange rate targeting in Iceland was very explicit during 70´s and 80´s with the extreme success of keeping a stable low unemployment rate (below 2%) for two decades, (1970-1990) though at the cost of high in‡ation and volatility of private consumption. Furthermore, due to its small size and almost complete specialization, the economy has many of the stereotypical characteristics of the textbook small open economy. Thus, a set of simplifying assumptions can be credibly imposed on the model without losing reference to reality. Predictability and persistence of the shocks must be a key determinants for the transmission of monetary policy aimed at short-term stabilization.

1.2. Main results

The thesis is organized into three main parts, all describing a completely specialized small open economy. In …rst chapter capital controls are in place and prices are perfectly ‡exible. In the second chapter, delayed labor market clearing is imposed on the same setup and di¤erent assumptions are made about the wage bargaining process. In the third and …nal chapter, the capital controls are lifted and foreign bonds are available to domestic residents.

The general conclusion is that if the shocks are unanticipated and permanent, short-term stabilization works as predicted by conventional economic theory. The exchange rate policy is advantageous in terms of current account and price stability, even though domestic prices are perfectly ‡exible. Not only is the initial blow of the shock considerably softened, the overall nominal change in cash holdings and prices is smaller across steady states. The advantages for output stabilization also become very clear as soon as the nominal wage adjustment process is delayed. The monetary authorities are able to stabilize the labor market with exchange rate interventions, and without too excessive in‡ationary consequences.

When the shocks become multiple and anticipated, (i.e. when they follow a cycle) the policy performance is altered. The policy experiment carried out in all three cases consists of an unanticipated transitory positive shock, followed by an expected transitory negative shock three years down the line. Given this sequence, there should be a strong tendency to save the early windfall in order to sustain consumption in the subsequent, more adverse period, as is the case if the exchange rate is …xed. Then, a signi…cant trade surplus would be observed during the three …rst years, which is then followed by a de…cit. However, the short-term stabilization policy, if expected, weighs counter to these savings incentives. The prospect of a large devaluation in the third year will encourage inter-temporal substitution and dissaving in the periods leading up the adverse shock. Thus, a lower trade surplus is observed and possibly even a de…cit if the degree of inter-temporal substitution is su¢ciently high. The policy rule will promote a pro-cyclical bias in consumption and hence increases its volatility.

The in‡ationary consequences will depend on cross-price elasticity of demand for non-tradables. If the elasticity is low, an increased demand for imported goods will spill into the market for non-tradables, creating a general consumption boom in the three years leading up to the shock. The consequent real exchange rate appreciation will create a need for a relatively large correction through the exchange rate as soon as the terms-of-trade deteriorate. However, if the cross-price elasticity is relatively large, demand will shift from non-tradables to tradables prior to the negative terms-of-trade shocks and hence in‡ation is not very apparent at …rst. However, when the devaluation occurs consumption will shift back towards non-tradables afterwards and thus increasing the in‡ationary impact on domestic markets. In any event, the application of the exchange rate will contain an in‡ationary bias that was not observed when the shocks were permanent and unanticipated.

These dynamics of the current account and private consumption become more pronounced when delayed labor market clearing is introduced. If the labor unions demand instant nominal wage increases in response to anticipated exchange rate interventions, they can e¤ectively prevent the real wage from falling. In that case, the labor market will clear slowly after a massive devaluation and a period of sustained in‡ation. An agreement with unions on a nominal wage freeze is the key to lowering the real wage and controlling in‡ation. However, the large but short-lived fall in the real wage will accelerate consumption in the preceding periods, since higher utility is gained by purchasing consumer goods prior to the shock rather than accumulating cash balances that will signi…cantly decrease in value in subsequent period because of the sharp devaluation. As the result, savings incentives are reversed and significant current account deficits are likely to be observed in the wake of a positive export shock. Moreover, the application of this exchange rate policy combined with minimal nominal wage increases facilitates a drop in real wage that goes far below what is needed in order to clear the labor market and a considerable excess demand is observed. It is clear that the application of the exchange rate rule will prevent cyclical unemployment. Although it should be noted that due to the transitory nature of the shocks, they will not affect employment in a non-interventionist regime as if they were permanent.

When the capital account was closed and cash was the only financial asset available, saving as well dissaving was discouraged since changes in money holdings incurred rising opportunity costs. Swift variations in the current account could occur, although an imbalance would never persist since the cost of holding either too much or too little cash, given the expenditure level, was too large. Therefore, when a negative income shock was expected, a trade surplus or deficit would emerge at a small scale and then rapidly built up to reach a peak just before the shock. When the private agent has the option of holding foreign bonds and the use of money as an asset becomes secondary to transaction services it provides. Money demand and expenditure will therefore tend to move in same direction since dissaving implies a higher expenditure and increasing numbers of transactions and vice versa. Thus, changes in asset holdings are quicker, less costly and a current account imbalance becomes much more persistent.

However, these implications of free capital transactions differ widely between the two regimes. In the non-interventionist regime, the consequence is a complete demand stability. In a interventionist regime, the increased likelihood and greater persistence of a trade deficit prior to a negative shock have the potential of actually increasing demand fluctuations. On the other hand, the counter-cyclical pull of policy interventions on the price level will be weakened because it is less costly to move consumption in time. Consumers will be more sensitive to anticipated price changes and the degree of inter-temporal elasticity becomes more relevant for their decisions. In fact, given a sufficiently high degree of inter-temporal substitution and low degree of cross substitution, a exchange rate appreciation in the wake of a transitory positive shock will actually lead to inflation in the price of non-tradable goods. The final implication is that given a perfect capital mobility, exchange rate interventions run the risk of causing huge portfolio adjustments between domestic and foreign assets, with the corresponding out-or inflow of foreign funds. These results are well in line with the "hot-money" problems which many countries have experienced after capital account liberalization. However, if the exchange rate is fixed, then capital account liberalization is undeniable beneficial as predicted by classical economic theory since economic agents are better able to smooth their consumption by adjusting their assets to meet temporary disturbances in income.

Part I

Chapter one

In this first chapter the model will be laid out in its simplest version with perfect price flexibility. We will furthermore introduce the Icelandic economy as a case study to provide a real comparison. The objective is to recreate patterns similar to those observed in resource based export economies under certain assumptions about monetary policy. The outcomes will then be compared with the benchmark case of non-intervention, and thus obtain information about the micro principles at work behind the stylized facts mentioned in the introduction. Namely, excess volatility of private consumption, inflationary exchange rate appreciations and current account deficits in the wake of transitory positive export shocks. The sections are arranged as follows: First, there is brief description of the Icelandic economy and the policy environment. Second, the model is introduced and solved. Third, policy experiments are carried out and the model is simulated. Section fourth contains concluding remarks.

1.3. Case study: Iceland

> The advantages of maintaining an independent exchange rate remains strong. Iceland is too small ever to have a very diversified export sector, too remote from Europe to use labor mobility as an effective alternative to relative wage adjustment, and has less trade volume than one might expect given its small size. Thus an adjustable exchange rate can serve as a valuable tool of macroeconomic stabilization, and need not impose massive microeconomic costs... There remains a pretty good case for a system in which the currency can be adjusted to cope with adverse export shocks... Krugman (1991)

Iceland is an island, located midst in the Atlantic and is populated by 280,000 people. The island's economy is approximately 1000 times smaller than that of the US in absolute terms, but GDP per capita in the two countries are similar. Iceland is almost a textbook case of a fully specialized economy. The island has no forests, oil, coal, metals, mineral, nor is it possible to harvest common crops such as corn or wheat. In fact, almost all tradable goods consumed in Iceland are foreign made and there is very little import competing production. For example, agriculture (mainly meat and dairy production) is shielded from foreign competition by either a complete ban on imports or very high tariffs. On the other hand, Iceland is richly endowed with energy, both thermal heat and electricity derived from its many waterfalls, and fish which is the main export good. In the context of other OECD countries and its small population, Iceland's foreign trade, exports and imports combined, is a relatively low proportion of total GDP or 75%. However, that raw ratio may be misleading since half-finished goods are largely absent in Iceland´s foreign trade and the foreign sector carries a very large weight in the economy in terms of value added.

Although, the country is blessed with plentiful …shing stocks, the plenty is subject to great variability. The …sh stock is a¤ected by external factors, sea temperature, food supply etc., and therefore the catch ‡uctuates from year to year. Furthermore, a number of other …shing nations in the Atlantic supply the same markets as the Icelanders and their stock variation contributes to a high price volatility in world markets. It is possible to predict these ‡uctuations ahead of time with some accuracy. Marine scientists can make 3-4 year forecasts by measuring the abundance of the young generations of …sh in each stock, which later on will be the staple of the catch. The Icelandic government then issues a quota based on the stock estimates which determines the total allowable catch. The quotas are strictly enforced, perfectly divisible, transferrable and are either owned or rented by individual …rms. This information is public and allows the economic agents to pin-point Iceland's export revenue one year ahead and make somewhat accurate long-range forecasts.

In this paper we will mainly be concerned with the period from 1970-1989, in which the Icelandic monetary regime could be characterized as a managed ‡oat and the Icelandic krona was devalued 25 times and annual price increases averaged about 30-40%. Capital markets were also subjected to heavy restrictions during that time, which in addition to a closed capital account consisted of caps on interest rates and loan rationing. During this time there was a strong correlation between changes in earnings of the …sh industry and economic growth in Iceland, which is perhaps understandable given the fact that of …sh constitutes about 75-80% of good export earnings. Pro…t in the export sector was therefore a bellwether of any external disturbance that was about to be transmitted into the domestic economy. This relationship did foster the perception among Icelanders that the best way to stabilize economic output is to stabilize revenue in the …sh sector by varying the nominal exchange rate. Furthermore, from the standpoint of social policy, the pro…t targeting was seen as a way to transfer rent or "excessive pro…ts" in the …shing industry to consumers through a high real exchange rate and cheap imports.

About 98% of the Icelandic labor force is unionized and wage bargaining is centralized. The unions are territorial and contain the whole labor force in their area, including the jobless. They are therefore sensitive to swelling numbers of unemployed within their ranks and are willing to make real wage concessions to achieve full employment. From 1970 to 1989, the …sh forecasts were a major factor for the wage demands of the labor unions as they were perceived as a good indicator of economic conditions ahead. When an adverse supply shock was expected, the unions were content with minimal wage increases or even a freeze. On the ‡ip side, the unions expected rapid wage increases when prospects looked better. In most cases the wage was quickly bid up by increased demand during economic upturns, as would be expected in an economy with a rather low rate of natural unemployment. The devaluations have frequently been successful in lowering the real exchange rate in medium to short term, since the unions, eager to preserve full employment, will not attempt to compensate for the decrease in purchasing power due to higher import prices. The results are almost contradictory. Because of heavy union and governmental involvement in wage decisions, real wages have been highly pro-cyclical and rapidly adjust to the forces of supply and demand in the labor market.

Table 1. Shocks to the Icelandic export earnings and nominal and real exchange rate responses

Year	Export earnings	Nominal depreciation	Real depreciation	In‡ation Peak
1967-68	-20%	50%	36.3%	21.7%
1874-75	-17%	36.1%	21.9%	49.0%
1979-80	-4.7%	63.3%	11.6	58.5%
1982	-9.7%	65.3%	13.9%	84.3%
1988-90	-13.6%	37.6	21.1%	25.5%

2. The Model

The model developed here, outlines a completely specialized small open economy that produces a non-tradable good Q_n and an export good Q_x. There is no import competing production and domestic consumption of the exported good is negligible and can be ignored. All tradable goods, Q_m, consumed within the economy are therefore imported. The economy is considered to be a price taker since neither its aggregate demand nor supply has any effect on foreign markets. The foreign price of imports P_m^* is assumed to be constant but the foreign price of exports P_x^* is random.

2.1. Prices and sectoral production

$$P_x = eP_x^*, \tag{2.1}$$

$$P_m = e, \tag{2.2}$$

$$P = P_n^{\gamma_n} e^{\gamma_m}, \quad \gamma_n + \gamma_m = 1 \tag{2.3}$$

The domestic price of the imported good P_m is given by the exchange rate, e, since units have been chosen so the fixed world market price equals unity. The general price level of the economy P is constructed as a geometric average of the imported tradable and non-tradable good prices. The respective consumption shares are γ_n and γ_m. Production in each sector requires capital K_i and labor L_i,

$$\bar{Q}_x = F^x(L_x, \bar{K}_x), \tag{2.4}$$

$$Q_n = F^n(L_n, \bar{K}_n), \tag{2.5}$$

$$P_n F_L = w. \tag{2.6}$$

Capital stock is taken to be fixed and sector specific. Total labor supply is inelastic. Both sectors tap into the same labor pool and the same market wage w therefore applies. Both production technologies $F^i(\cdot)$ are continuous and strictly quasi concave and the firms in each sector operate in a competitive environment. Output in the export sector is dependent on a fixed natural resource and more inputs will not expand production further than the given limit. Therefore, export production is fixed.

2.2. The private sector optimization problem

$$\underset{\{E;S\}}{Max} \int_0^\infty \left[V(e;P_n;E) + \phi\left(\frac{M}{P}\right) \right] e^{-\rho t} dt \tag{2.7}$$

s.t.:

$$E = P_x Q_x + P_n Q_n - S \tag{2.8}$$

$$\dot{M} = S \tag{2.9}$$

Decisions about consumption and savings are made by a representative agent who has homothetic preferences and maximizes utility over an infinite lifetime by choosing between spending E and saving S. Money is the only financial asset in the economy and the capital account is closed. The non-pecuniary services rendered by real money balances, such as the facilitation of transactions etc., are accounted for in the $\phi(.)$ component of the utility function. This separable form allows us to substitute an indirect utility function into the maximization problem to represent the utility derived from consumption. The indirect utility function has the usual properties, i.e. $\frac{\partial V}{\partial P_i} < 0$; $\frac{\partial V}{\partial E} > 0$ and $V_{EE} < 0$.

2.3. Market-clearing conditions

$$L_x + L_n = \bar{L}; \tag{2.10}$$

$$D_n(e;P_n;E) = \bar{Q}_n. \tag{2.11}$$

Constant output in the export sector, inelastic total labor supply and full employment in the labor market essentially fixes non-tradable production, since both output Q_x and capital input K_x are constant, the optimal labor input L_x will not vary. Thus a fixed labor supply and market clearing imply that labor input into the non-tradable sector L_n, is fixed. Therefore the supply of non-tradables $\bar{Q}_n$ must be inelastic since the other input, capital K_n is also constant. In the domestic market, the demand for the non-tradable good must be equal to a fixed supply as is stated in equation (2.11). The foreign supply of the imported good and foreign demand for the exported good are infinitely elastic at a given market equilibrium price.

2.4. Monetary policy

The sole source of disturbance in this economy is price volatility in the export sector and the only transmission channel for monetary interventions is through exchange rate interventions. We will attempt to formalize the monetary policies in small export based economies in terms of a simple instrumental rule focusing on profitability in the export sector. Since the business environment is competitive total revenue must be equal to total cost in the export sector,

$$P_x \bar{Q}_x = w\bar{L}_x + r_x \bar{K}_x. \tag{2.12}$$

The rent from the fixed capital stock essentially captures economic profit in the sector and the government must therefore keep r_x constant in order to achieve profit stability. Given this we can log differentiate (2.12) and with a little re-arrangement the following equilibrium relationship is obtained:

$$\hat{P}_x = \theta^x_L \hat{w}. \tag{2.13}$$

The term $\theta^x_L = \frac{wL_x}{Q_x}$ is the cost share of labor in the export sector and for notational ease, a hat superscript denotes a percentage change, i.e. $\hat{x} = \frac{dx}{x}$. If we now log differentiate the domestic export price as represented in equation (2.1) and then insert into the above expression (2.13) we obtain the following reaction function,

$$\hat{e} = \theta^x_L \hat{w} - \hat{P}^*_x. \tag{2.14}$$

The rationale for this rule is twofold. First, this is precisely the monetary policy that was followed by Iceland from 1970-1999, when the government publicly acknowledged that profitability in the marine sector did determine exchange rate interventions. Second, the instrumental rule that appears above displays similar characteristics as one would expect from stabilization policy according to standard economic theory. Negative terms of trade shocks trigger devaluation, as will excess increases in domestic production cost (in this case only wages). Positive developments on the other hand will lead to appreciations. It is worth noting that it is nominal, not real profit that is being targeted, which implies that the government does not respond to inflation directly, unless higher prices prompt increases in the nominal wages.

We wish to evaluate the outcome of the exchange rate rule by comparing it to the case of non-intervention and therefore we will write equation (2.14) as,

$$\hat{e} = Z\left(\theta_L^x \hat{w} - \hat{P}_x^*\right); \qquad (2.15)$$

where Z is a policy parameter which takes the value 0 in the case of the non-interventionist case (i.e. when e is fixed). and is equal to 1 when the exchange rate rule is in place. Since capital stock and output are fixed in the export sector, labor use is fixed as well. Given that labor supply is inelastic and that the wage is perfectly flexible, it follows that employment and output are also constant in the non-tradable sector.

3. Solving the model

To solve the private agent's optimization problem, the following Hamiltonian function is specified,

$$H = e^{-\rho t}\left[V(e; P_n; P_x Q_x + P_n Q_n - S) + \phi\left(\frac{M}{P}\right) - \mu S\right]; \qquad (3.1)$$

where μ is the Lagrangian multiplier associated with the optimization. The first order conditions are,

$$V_E(e; P_n; P_xQ_x + P_nQ_n - S) = \mu; \tag{3.2}$$

$$\dot{\mu} = \rho\mu + \phi'\left(\frac{M}{P}\right)\frac{1}{P}. \tag{3.3}$$

Since Q_x and Q_n are constants, a time differentiation of (3.2) yields,

$$\dot{\mu} = (V_{EN} + V_{EE}Q_n)\dot{P}_n + V_{EM}\dot{e} + V_{EE}Q_x\dot{P}_x - V_{EE}\dot{S}. \tag{3.4}$$

With a little rearrangement, (3.4) can be written,

$$\dot{\mu} = V_{EE}E\left[\left(\frac{V_{EN}}{V_{EE}D_n}\frac{P_nD_n}{E} + \frac{P_nQ_n}{E}\right)\frac{\dot{P}_n}{P_n} + \left(\frac{V_{EM}}{V_{EE}D_m}\frac{eD_m}{E} + \frac{P_xQ_x}{E}\right)\frac{\dot{e}}{e} - \frac{\dot{S}}{E}\right]; \tag{3.5}$$

From Roy's identity $D^i = -\frac{V_i}{V_E}$, a relationship can be derived $\frac{V_{EP_m}}{V_{EE}Q_i} = \nu_i\tau - 1$; where τ is the elasticity of inter-temporal substitution ($\tau = -\frac{V_E}{V_{EE}E}$) and υ_i is the income elasticity of good i: ($\nu_i = \frac{\partial D_i}{\partial E}\frac{E}{D_i}$). If we assume unitary income elasticities of demand, (i.e. $\nu_i = 1$); then (3.5) can be written as,

$$\dot{\mu} = -V_{EE}E\left[\frac{\dot{S}}{E} - \left(\tau\gamma_n\frac{\dot{P}_n}{P_n} + [(\tau - 1)\gamma_m + \alpha_x]\frac{\dot{e}}{e}\right)\right]. \tag{3.6}$$

α_x is the export revenue as a share of total expenditure, i.e: $\alpha_x = \frac{P_xQ_x}{E} = \gamma_m + \frac{S}{E}$. At this stage it should again be noted that since labor input into the non-tradable sector is fixed, there must be a direct relationship between wage changes and changes in the price of non-tradables goods as is specified by equation (2.6). Thus, $\hat{w} = \hat{P}_n$. Given this information the policy equation (2.15) becomes,

$$\hat{e} = Z\left(\theta_L^x\hat{P}_n - \hat{P}_x^*\right). \tag{3.7}$$

Furthermore, on the transition path,

$$\frac{\dot{e}}{e} = Z\theta_L^x\frac{\dot{P}_n}{P_n}. \tag{3.8}$$

After substituting for $\dot{\mu}$ from (3.3)and for $\dot{e}$ from (3.8), equation (3.6) yields,

$$V_{EE}E\left[\tau(\gamma_n + \gamma_m Z\theta^x_L) + (\alpha_x - \gamma_m)Z\theta^x_L\right]\frac{\dot{P}_n}{P_n} - V_{EE}\dot{S} = \rho V_E - \phi'\left(\frac{M}{P}\right)\frac{1}{P}. \quad (3.9)$$

We are still left with the task of solving for changes in P_n in terms of changes in the savings rate S and the exogenous variable P_x^*. In order to do that, the market clearing condition for non-tradables and the budget constraint , can be used. Log differentiation of equations (2.8) and (2.11) yields,

$$\xi_n\hat{P}_n + \xi_m\hat{e} + \hat{E} = 0, \quad (3.10)$$

$$\hat{E} = \alpha_x\hat{P}_x + \gamma_n\hat{P}_n - \frac{dS}{E}. \quad (3.11)$$

Here ξ_i is the uncompensated demand elasticity for good i. The compensated elasticity ε_i, can directly obtain from the Slutsky decomposition, i.e. $-\varepsilon_i = \xi_i + \gamma_i$, where ε_i is assumed to be positive. Furthermore, since there are only two types of goods being consumed, the own and cross price elasticities of the two respective Hicksian compensated demand functions are equal in absolute value, i.e. $\varepsilon_m = \varepsilon_n = \varepsilon.$ Now, keeping in mind that $\hat{P}_x = \hat{e} + \hat{P}_x^*$ and combining equations (3.10) and (3.11) with the policy rule stated in equation (3.7) we obtain the following solution for $\hat{P}_n$,

$$\hat{P}_n = \Psi^{-1}\left([\alpha_x - Z(\varepsilon + \alpha_x - \gamma_m)]\hat{P}_x^* - \frac{dS}{E}\right). \quad (3.12)$$

$$\Psi = \varepsilon(1 - Z\theta^x_L) - Z\theta^x_L(\alpha_x - \gamma_m).$$

On the transition path,

$$\frac{\dot{P}_n}{P_n} = -\frac{\dot{S}}{\Psi E}. \quad (3.13)$$

At this point we can also solve for changes in expenditure and the price level.

$$\hat{E} = \left[\Psi^{-1}[(\alpha_x Z\theta^x_L + \gamma_n)[\alpha_x - Z(\varepsilon + \alpha_x - \gamma_m)]] + (1 - Z)\alpha_x\right]\hat{P}_x^* \quad (3.14)$$
$$- \Psi^{-1}[(\alpha_x Z\theta^x_L + \gamma_n) + \Psi]\frac{dS}{E},$$

$$\hat{P} = \Psi^{-1}[\gamma_m Z\theta_L^x + \gamma_n]\left([\alpha_x - Z(\varepsilon + \alpha_x - \gamma_m)]\hat{P}_x^* - \frac{dS}{E}\right) - Z\gamma_m\hat{P}_x^*. \qquad (3.15)$$

On the transition path,

$$\frac{\dot{P}}{P} = -\Psi^{-1}[\gamma_m Z\theta_L^x + \gamma_n]\frac{\dot{S}}{E}. \qquad (3.16)$$

Equation (3.9) can now be simplified as,

$$-V_{EE}\Psi^{-1}[\tau(\gamma_n + \gamma_m Z\theta_L^x) + (\alpha_x - \gamma_m)Z\theta_L^x + \Psi]\dot{S} = \rho V_E - \phi'\left(\frac{M}{P}\right)\frac{1}{P}. \qquad (3.17)$$

We now have a differential equation which describes the changes in the savings rate over time and will form a two-dimensional dynamic system along with equation (2.9), the growth of money balances. For this system to be solved it needs to be linearized it around a stationary equilibrium, where $\dot{S}$ and the trade balance are initially equal to zero. Taking a first order expansion of (3.17),

$$-V_{EE}\Psi^{-1}[.]\dot{S} = \rho\left[V_{EM}\hat{e} + V_{EN}P_n\hat{P}_n + V_{EE}dE\right]V_E \qquad (3.18)$$
$$-\phi''\frac{M}{P}\left(\hat{M} - \hat{P}\right) + \frac{\phi'}{P}\hat{P}.$$

The solution to the bracketed terms that multiplies ρ, was derived earlier in the course of solving for (3.17). Proceeding as before, (bear in mind that in steady state $\alpha_x = \gamma_m$) we obtain,

$$-V_{EE}\Psi^{-1}[.]\dot{S} = -\rho V_{EE}\Psi^{-1}[\tau(\gamma_n + \gamma_m Z\theta_L^x) + \Psi] - \phi''\frac{M}{P}\left(\hat{M} - \hat{P}\right) + \frac{\phi'}{P}\hat{P}. \qquad (3.19)$$

Moreover, in stationary equilibrium the multiplier μ is constant, i.e. $\dot{\mu} = 0$, and therefore the first order conditions state that $\frac{\phi'}{P} = \rho V_E$. From this, the income elasticity of money demand can be derived, which can be assumed to be unitary,

$$\frac{\hat{M}}{\hat{E}} = \frac{\phi''}{\phi'}\frac{V_E}{V_{EE}E}\frac{M}{P} = 1. \qquad (3.20)$$

This relationship and Roy's identity allows (3.19) to be rewritten,

$$-V_{EE}^{\Psi-1}[\cdot]\dot{S} = -\rho V_{EE}^{\Psi-1}[\tau\gamma_n + \gamma_m Z\theta_L^x) + \Psi] \tag{3.21}$$
$$\left[-\rho V_{EE}^{\Psi-1}(1-\tau)(\gamma_m Z\theta_L^x + \gamma_n)dS + \frac{1}{\chi}dM\right].$$

where $\chi = \frac{M}{E}$. The end result is therefore a linearized differential equation in which $\dot{S}$ is expressed in terms of dS and dM,

$$\dot{S} = \rho\frac{[(\gamma_n + \gamma_m Z\theta_L^x) + \varepsilon(1-Z\theta_L^x)]}{[\tau(\gamma_n + \gamma_m Z\theta_L^x) + \varepsilon(1-Z\theta_L^x)]}dS + \rho\frac{\varepsilon(1-Z\theta_L^x) - Z\theta_L^x(\alpha_x - \gamma_m)}{\chi[\tau(\gamma_n + \gamma_m Z\theta_L^x) + \varepsilon(1-Z\theta_L^x)]}dM. \tag{3.22}$$

or more compactly,

$$\dot{S} = AdS + BdM. \tag{3.23}$$

Where;

$$A \equiv \rho\frac{[(\gamma_n + \gamma_m Z\theta_L^x) + \varepsilon(1-Z\theta_L^x)]}{[\tau(\gamma_n + \gamma_m Z\theta_L^x) + \varepsilon(1-Z\theta_L^x)]}$$
$$B \equiv \rho\frac{\varepsilon(1-Z\theta_L^x) - Z\theta_L^x(\alpha_x - \gamma_m)}{\chi[\tau(\gamma_n + \gamma_m Z\theta_L^x) + \varepsilon(1-Z\theta_L^x)]}$$

We now have a two dimensional simultaneous dynamic system,

$$\begin{bmatrix}\dot{S}\\ \dot{M}\end{bmatrix} = \begin{bmatrix}A & B\\ 1 & 0\end{bmatrix}\begin{bmatrix}S\\ M - M^*\end{bmatrix}. \tag{3.24}$$

The eigenvalues of the system are

$$\lambda_1, \lambda_2 = \frac{A \pm \sqrt{A^2 + 4B}}{2}. \tag{3.25}$$

while the eigenvectors are obtained from,

$$\begin{bmatrix}A & B\\ 1 & 0\end{bmatrix}\begin{bmatrix}Z_{1j}\\ Z_{2j}\end{bmatrix} = \begin{bmatrix}\lambda_j Z_{1j}\\ \lambda_j Z_{2j}\end{bmatrix}; \quad j = 1,2; \; i = 1,2. \tag{3.26}$$

Normalizing by setting $Z_{2j} = 1$ gives $Z_{1j} = \lambda_j$. The general solution for the system is therefore,

$$S_t = \lambda_1 h_1 e^{\lambda_1 t} + \lambda_2 h_2 e^{\lambda_2 t}. \tag{3.27}$$

$$M_t - M^* = h_1 e^{\lambda_1 t} + h_2 e^{\lambda_2 t}. \tag{3.28}$$

Since $B > 0$; one eigenvalue, λ_1; is positive and the other, λ_2; negative. Thus, there is a saddlepath solution for the system.

4. Policy experiments: Permanent shocks with and without exchange rate interventions

4.1. Comparative analysis

It is fairly conventional for economic textbooks to assume supply shocks to be uncorrelated and permanent surprises and that does indeed hold true in the first policy experiment. The price shock occurs without notice at time $t = 0$ and is permanent. Since the dynamic system is saddle point stable, the solution path follows "the stable arm" to the new stationary equilibrium. In this case, the constant h_1, associated with the positive eigenvalue λ_1 equals zero. Thus the solution to the dynamic system can be written to only on terms of one unknown constant h_2,

$$S(t) = \lambda_2 h_2 e^{\lambda_2 t}; \tag{4.1}$$

$$M(t) - M^* = h_2 e^{\lambda_2 t}. \tag{4.2}$$

The money stock is pre-determined and the additional information needed to solve for h_2 can be obtained from initial conditions, which relate the change in steady state money holdings to the unknown constant. At $t = 0$; (4.2) yields,

$$M_0 - M^* = h_2. \tag{4.3}$$

Since income elasticity of money demand is assumed to be unitary, the change in steady state expenditure and money balances must be directly related, i.e. $\hat{E}_{ss} = \hat{M}_{ss}. \Rightarrow M^* - M^0 = M_0 \hat{E}_{ss}$. The change in steady state expenditure, as given by equation (3.14), can therefore give a solution for the change in money balances across steady states. Thus we now have an explicit expression for h_2;

$$h_2 = -(M^* - M^0) = -M_0 \ast \hat{P}_x^*. \tag{4.4}$$

$$\Lambda = \frac{[Z\theta_L^x\gamma_m + \gamma_n][\gamma_m - Z\varepsilon] + (1 - Z)\gamma_m\varepsilon(1 - Z\theta_L^x)}{\varepsilon(1 - Z\theta_L^x)}$$

The solution paths for S and M can now be written as,

$$S(t) = -\lambda_2 M_0 \Lambda \hat{P}_x^* e^{\lambda_2 t}. \tag{4.5}$$

Furthermore, we want to use an expression for change from the initial stationary equilibrium M_0, that is,

$$M(t) - M_0 = M_0\Lambda(1 - e^{\lambda_2 t})\hat{P}_x^*. \tag{4.6}$$

In order to determine the transitional dynamics we need to pin down the stationary equilibrium. The exchange rate rule targets economic profit in the export sector, in other words e is adjusted to keep $\theta_L^x\hat{w} - \hat{P}_x^*$ at zero. Since $\hat{P}_n = \hat{w}$, the net change in e caused by an export price shock can be derived by combining the policy rule (3.7) and the solution (3.12) for $\hat{P}_n$,

$$\hat{e} = \frac{1}{(1 - \theta_L^x)}\left(1 - \frac{\alpha_x\theta_L^x}{\varepsilon}\right)\hat{P}_x^*. \tag{4.7}$$

Equation (4.7) defines the terms under which a negative shock will lead to a lower profit in the export sector and thus prompting a devaluation. If cross price substitutability is sufficiently low and the cost share of labor in the export sector is sufficiently large, then $1 < \frac{\alpha_x\theta_L^x}{\varepsilon}$ and a decrease in the export price will actually lead to higher profits and an appreciation of the currency. Therefore we can state the following necessary and sufficient condition for the nominal exchange rate to depreciate as the result of a negative shock,

$$\varepsilon > \alpha_x\theta_L^x. \tag{4.8}$$

The importance of condition (4.8) is well illustrated if the impact on P_n from an export price shock is considered. By combining equations (3.10) and (3.11) we can define the market equilibrium for non-tradables,

$$\varepsilon\hat{P}_n = \varepsilon\hat{e} + \alpha_x\hat{P}_x^*. \tag{4.9}$$

Using policy equation (2.15) we obtain a solution for P_n,

$$\hat{P}_n = \frac{\alpha_x - \varepsilon}{\varepsilon(1 - \theta_L^x)}\hat{P}_x^*. \qquad (4.10)$$

The relative sizes of α_x and ε, are of pivotal importance. If $\varepsilon > \alpha_x$; then imports and non-tradables are gross substitutes. In that case, a decrease in P_x^* and induced change in the exchange rate will raise the demand for non-tradables and increase P_n. Thus we have the following necessary and sufficient condition for the exchange rule to increase aggregate domestic demand in the face of an adverse shock,

$$\varepsilon > \gamma_m. \qquad (4.11)$$

If (4.11) does not hold, we can turn to the weaker condition (4.8) which if satisfied ensures that the exchange rate policy will soften the deflationary impact of shock, although not eliminate it.

The conclusion is that the exchange rate rule is beneficial in terms of current account and price stability if condition (4.8) holds and a negative shock will indeed trigger a net devaluation. For Iceland, $\gamma_m = 40\%$ and cost ratio of labor in the fish sector, $\theta_L^x = 40\%$; the substitutability ε has to be lower than 0.16 for (4.8) to fail

4.2. Transitional dynamics

The comparison of closed form solutions for the transition period is complicated by the fact that the eigenvalues of the two respective policy regimes differ. However, certain inferences can be drawn on their relative sizes. Firstly, note that $\lambda_2 = \frac{1}{2}\left(A - \sqrt{A^2 + 4B}\right)$ and information on the size of parameter B is sufficient to reach conclusion on how the two eigenvalues rank with regard to each other. Secondly, a comparison (see equation 3.23) reveals that B is always larger in an non-interventionist regime λ_N. Therefore the eigenvalue associated with the interventionist regime λ_I, must always be smaller in absolute value, i.e. $\frac{\lambda_2^N}{\lambda_2^I} > 1.$

The rate of adjustment is therefore faster in the non-interventionist regime, as prices are perfectly flexible. The exchange rate intervention, on the other hand, softens the initial blow and hence delays the adjustment if condition (4.8) holds. This is evident if the initial and most severe impact of the shock at $t = 0$ are compared. The following solution apply for the current account in the transition period. For relatively small changes starting from the stationary equilibrium where $\alpha_x = \gamma_m$,

$$\frac{S(t)}{E} = -\lambda_2 \chi \Lambda \hat{P}_x^{*} e^{\lambda_2 t}. \tag{4.12}$$

Since λ_2 is negative and Λ is positive in a non-interventionist regime, an adverse supply shock will always cause trade deficits, the persistence of which will be defined by the absolute value of λ_2 in the time component; $e^{\lambda_2 t}$. The outcome for the exchange rate regime in the transition period is determined by same condition as we have defined for steady state changes. If condition (4.11) holds ($\varepsilon > \gamma_m$) and imports and non-tradables are gross substitutes, then $\Lambda < 0$; and a devaluation in the wake of an adverse supply shock will lead to a trade surplus. Otherwise, a weaker sufficiency condition on ε can be obtained through a direct comparison between the two regimes, i.e. under which condition on ε equation (4.12) gives lower absolute value when $Z = 1$ as compared with the case when $Z = 0$,

$$\varepsilon \geq \gamma_m \frac{\theta_L^x \left(\gamma_m \frac{1}{\lambda_N} + \gamma_n \right) + \gamma_n \left(\frac{1}{\lambda_N} - 1 \right)}{\gamma_n \frac{1}{\lambda_N} + \gamma_m + \gamma_m \theta_L^x \left(\frac{1}{\lambda_N} - 1 \right)}. \tag{4.13}$$

Condition (4.13) ensures that an exchange rate adjustment will reduce the deficit in the initial period, although not eliminate it. This is weaker constraint on ε than (4.8) since $\lambda_N > \lambda_I$. However, as $\tau \to 0$; λ_N approaches λ_I, and (4.13) converges to (4.8) ($\varepsilon \geq \gamma_m \theta_L^x$).

A very similar story can be told about the price dynamics. The jump in the price of non-tradables in the initial period, at time $t = 0$ is,

$$\hat{P}_n \Big|_{t=0} = \frac{[\alpha_x - Z\varepsilon] - \lambda_2 \chi \Lambda}{\varepsilon (1 - Z\theta_L^x)} \hat{P}_x^{*}, \tag{4.14}$$

and thereafter

$$\frac{\dot{P}_n}{P_n} = \frac{-\lambda_2 \chi^*}{\varepsilon(1 - Z\theta_L^x)} \hat{P}_x^* e^{\lambda_2 t}. \tag{4.15}$$

If non-tradables and tradables are gross substitutes then P_n will increase as the result of an exchange rate intervention. Conversely, by comparing the outcome from the two policy regimes as specified by equation (4.14), a weaker constraint on ε can be defined that suffices to ensure that the exchange rate rule will lessen the deflationary impact of a negative shock in the initial period,

$$\varepsilon > \gamma_m \theta_L^x + \frac{1}{\hat{P}_x^*} \left((1 - \theta_L^x) \left[\frac{S(0)}{E}\right]_N - \left[\frac{S(0)}{E}\right]_I \right). \tag{4.16}$$

Or more specifically,

$$\varepsilon > \gamma_m \theta_L^x + \chi[(1 - \theta_L^x) \lambda_N \ast_N - \lambda_I \ast_I]. \tag{4.17}$$

Condition (4.17) is either slightly stronger or weaker than (4.8), depending on the savings rate response and labor intensity of export production, θ_L^x. The jump in the CPI in the initial period, at time $t = 0$ is,

$$\hat{P}\big|_{t=0} = [\gamma_m Z \theta_L^x + \gamma_n] \left(\frac{[\alpha_x - Z\varepsilon] - \lambda_2 \chi^*}{\varepsilon(1 - Z\theta_L^x)} \right) \hat{P}_x^* - Z\gamma_m \hat{P}_x^*, \tag{4.18}$$

and the change thereafter

$$\frac{\dot{P}}{P} = \left(\frac{-\lambda_2 \chi^* [\gamma_m Z \theta_L^x + \gamma_n]}{\varepsilon(1 - Z\theta_L^x)} \right) \hat{P}_x^* e^{\lambda_2 t}. \tag{4.19}$$

If relatively weak sufficiency conditions are satisfied, then the exchange rate rule is advantageous for the economy in terms of current account and price stability, unless ε is very high and a serious inflation results. Not only is the initial blow of the shock considerably softened, the overall nominal change in money stock and prices is smaller across steady states. The analysis so far almost replicates the classical results concerning the benefit of short-term stabilization. However, this represents only one scenario, the one of very persistent shocks. Furthermore, economic agents have no time to adjust their behavior in anticipation of a coming policy measures since the shock occurs at the very beginning and. The devaluation is a one time a¤air which is not connected to what happened before t = 0 or to what happens next time when the steady state is disrupted.

4.3. Simulations

4.3.1. Parameter values

The model will be calibrated with Icelandic parameters, to the degree that they are known. There are no estimates available for two parameters; the elasticity of inter-temporal substitution, ¿; and cross price elasticity, ": These parameters may vary from country to country. Ogaki & Reinhart (1998) estimate, by taking durable goods into account, that the inter-temporal substitution in the US is in the range 0:32 ¡ 0:45. Others have produced similar or slightly higher estimates, see e.g. Hu (1993) for estimates for G-7 countries. By focusing speci…cally on import consumption in the US Ceglowski (1988) …nds estimates of ¿ that are close to one. Therefore in this paper we let ¿ vary in the range 0:25 ¡ 0:8

The division of consumption into tradable and non-tradable goods is also somewhat arti…cial since most …nal goods are composites. In general, compensated demand elasticities for broadly aggregated goods cannot be expected to be very large. However, in the literature, values ranging from 0:10 and up to 0:7 have been reported for broadly aggregated compensated demand elasticities (See for example Deaton & Muellbauer (1980) or a survey by Blundell (1988)) In light of this we feel justi…ed to let the value of " range from 0:15 ¡ 0:75.

The values for other parameters are relatively straightforward. Icelandic foreign trade mainly consists of …nal goods and therefore the share of imported goods to GDP is an accurate indicator of tradable goods consumption; $°_m = 40\%$ and $°_n = 1 ¡ °_m = 60\%$: The cost ratio of labor in the Icelandic …sh sector: $µ_L^x = 40\%$. The ratio of High-powered money over expenditure: $\frac{M}{E} = 15\%$. The time preference rate, $\rho = 7\%$.

4.4. Results

If the shocks are permanent and unexpected, then the results are not sensitive to the degree of inter-temporal substitution. Therefore we will set $\tau = 0.45$ and only the cross price elasticity ε will vary in the simulations. In a non-interventionist regime, a negative shock will result in a lower level of steady state nominal money balances and prices. The downward adjustment occurs because a lower income reduces the need for transaction services provided by cash balances. In the exchange rate regime, the policy outcome is sensitive to values assigned to the cross price elasticity, ε. If condition (4.8) does not hold and $\varepsilon = 0.15$; a negative price shock will not lead to a net nominal devaluation because lower wages will compensate for lower revenue and profit in the export sector is not eroded. In that case, given the policy rule, there is no cause for a devaluation and the effect of the shock on the two regimes will be fairly identical (see as graphs $1a - c$): However, if condition (4.8) does indeed hold and $\varepsilon = 0.35$; then trade deficits and price volatility are significantly reduced (see figures $2a - c$) by the employment of the exchange rate rule. The inflationary side effects are pretty mild since overall price level will only increase by 2% in the first year, compared with a 6% deflation that would occur without an exchange rate intervention.

Now, if the cross price elasticity is indeed higher so that condition (4.11) holds and tradables and non-tradables are gross substitutes then trade deficits are completely eliminated and the demand for non-tradables actually increases as the result a negative price shock and induced devaluation (see figures $3a - c$ where $\varepsilon = 0.45$). In terms of the CPI, the two regimes come close to mirror each other. The intervention leads to about 5% inflation compared with 4.5% deflation under non-intervention. Inflation may be a greater concern if the substitutability becomes much higher, such as shown in figures $4a - c$ where $\varepsilon = 0.65$. In that case, the trade surplus following an exchange rate intervention becomes quite significant and the CP I does increase by 8% in the in the …rst period.

The simulations therefore support the conclusion already reached by a comparison of closed form solutions. Given the current assumption about openness (40%) and the domestic cost ratio (40%) in the export sector, the exchange rate regime does seem to outperform the non-interventionist regime unless degree of substitutability between tradables and non-tradables is either very low or very high.

5. Temporary and anticipated shocks

5.1. Solution paths

We will incorporate expectations and temporality into our analysis by increasing the number of shocks. The …rst shock, at the very start, comes as a surprise as before. It is now followed by two other shocks which are fully anticipated. More speci…cally, the sequence of shocks is as follows: In the beginning, at $t = 0$, there is 10% price increase, then at $t = t_1$ there will be a 20% price decrease and lastly at $t = t_2$ the price reaches the initial level by a 10% price increase. In other words, the shocks are temporary and the economy follows a full cycle with a return to the initial terms-of-trade at the last shock. In fact, for a low or zero discount rate the shock induces a very little change to life-time earnings.

We will argue that this is more in line with the real-life experience of most small open economies, whose export prices depend on demand conditions in the larger economies. However, the temporality adds to the mathematical complications in retrieving the solution, since di¤erent systems govern dynamics during each phase of the price cycle.

The …rst path The …rst shock occurs in the beginning at t_0. It only lasts until t_1 and does not imply a …xed end point that pins down a convergent path to a new saddle point equilibrium. Instead, dynamic optimization will create a non-convergent path that is qualitatively different from that of a permanent price change. The following equations characterize the period from t_0 to t_1. Since the path is non-convergent the constant associated with the positive eigenvalue, h_1; can not be assumed to be zero,

$$S_t = \lambda_1 h_1 e^{\lambda_1 t} + \lambda_2 h_2 e^{\lambda_2 t}; \; t \leq t_1; \tag{5.1}$$

$$M_t - M^* = h_1 e^{\lambda_1 t} + h_2 e^{\lambda_2 t}; \; t \leq t_1: \tag{5.2}$$

M^* is the new steady state for monetary balances implied by price change at t_0. However, for later convenience, the steady state change in money stock will be expressed in terms of the initial stationary equilibrium, which will subsequently prevail at the end. Thus (5.2) becomes,

$$\Rightarrow M_t - M^0 = \left(M^* - M^0\right) + h_1 e^{\lambda_1 t} + h_2 e^{\lambda_2 t} = M^0 \ast P_x^* + h_1 e^{\lambda_1 t} + h_2 e^{\lambda_2 t}: \tag{5.3}$$

The second path The second shock occurs at t_1 and is also temporary. There will be another shift as the economy links up to a second path. Money stock is pre-determined and therefore the change occurs with a jump in the savings rate at t_1. The new path is not convergent either since the third price change is expected at t_2. This period can be characterized in the same way as before except for the fact that the constants have changed. The new constants are h_3 and h_4, neither of which can be assumed to be zero,

$$S_t = \lambda_1 h_3 e^{\lambda_1 t} + \lambda_2 h_4 e^{\lambda_2 t}; \tag{5.4}$$

$$M_t - M^{**} = h_3 e^{\lambda_1 t} + h_4 e^{\lambda_2 t}; \tag{5.5}$$

$$\Rightarrow M_t - M^0 = M \ast \hat{P}_x^* + h_3 e^{\lambda_1 t} + h_4 e^{\lambda_2 t}: \tag{5.6}$$

$$t_1 \leq t \leq t_2$$

Third path The last shock at time t_2 and is permanent. As it occurs the savings rate jumps again and the economy links to the third path which is convergent. In other words, since the shock is permanent utility maximization will imply a "stable arm" path to a saddle point stable equilibrium. Therefore, from t_2 to infinity, the constant h_5 associated with the positive eigenvalue is zero,

$$S_t = \lambda_2 h_6 e^{\lambda_2 t}; \; t \geq t_2; \tag{5.7}$$

$$M_t - M' = h_6 e^{\lambda_2 t}, \; t \geq t_2. \tag{5.8}$$

5.2. Solutions

To solve for the five unknowns $h_1; h_2; h_3; h_4$ and h_6; 5 restrictions are needed on the transition path. Firstly, the initial conditions on the stock of nominal money balances can be exploited. As M is pre-determined, equation (5.2) can be used at $t = 0$ to describe the relationship between the change in steady state money stock and the two unknown constants h_1 and h_2,

$$M' - M^* = h_1 + h_2;$$

$$\Rightarrow \; h_1 = -(M_0 * P_x^* + h_2). \tag{5.9}$$

Secondly, at $t = t_1$ the equations (5.2) and (5.6) both report nominal money stock at the same moment in time and must give the same solution,

$$-M' * P_x^* + h_1 e^{\lambda_1 t_1} + h_2 e^{\lambda_2 t_1} = M * P_x^* + h_3 e^{\lambda_1 t_1} + h_4 e^{\lambda_2 t_1};$$

$$\Rightarrow \; h_1 e^{\lambda_1 t_1} + h_2 e^{\lambda_2 t_1} - h_3 e^{\lambda_1 t_1} - h_4 e^{\lambda_2 t_1} = 2M * P_x^*. \tag{5.10}$$

Thirdly, the same condition applies at $t = t_2$; when the next shift occurs and equations (5.6) and (5.8) must give the exact same information for the level of nominal money stock,

$$h_6 e^{\lambda_2 t_2} = -M * \hat{P}_x^* + h_3 e^{\lambda_1 t_2} + h_4 e^{\lambda_2 t_2}; \tag{5.11}$$

$$\Rightarrow h_3 e^{\lambda_1 t_2} + h_4 e^{\lambda_2 t_2} - h_6 e^{\lambda_2 t_2} = -M \, P_x^*. \tag{5.12}$$

However, two other restrictions are still needed. They arrive from the fact that S will jump at time t_1 and again at t_2, as the economy links to a new path. The magnitude of the jump amounts to the difference in how the two respective equations report the savings rate immediately before and after the shocks occurs. If we call J_1 the jump at t_1, and J_2 the jump at t_2, the following must hold,

$$J_1 = \lambda_1 h_3 e^{\lambda_1 t_1} + \lambda_2 h_4 e^{\lambda_2 t_1} - \lambda_1 h_1 e^{\lambda_1 t_1} + \lambda_2 h_2 e^{\lambda_2 t_1}; \tag{5.13}$$

$$J_2 = \lambda_2 h_6 e^{\lambda_2 t_2} - \lambda_1 h_3 e^{\lambda_1 t_2} - \lambda_2 h_4 e^{\lambda_2 t_2}. \tag{5.14}$$

The two jumps can be determined by the fact that the multiplier μ is constant at $t = t_1$ and at $t = t_2$, since no new information will arrive after $t = 0$ and our representative agent is equipped with a perfect foresight. Therefore, the first order conditions, earlier derived, will determine by how much S is affected by changes in P_x^*,

$$V_E(P_n, P_m, E) = \mu.$$

Then by total differentiation,

$$\Rightarrow \tau \gamma_n \hat{P}_n + (\tau - 1)\gamma_m \hat{e} + \alpha_x \hat{P}_x - \frac{dS}{E} = d\mu = 0.$$

Now substitute (3.7) in for e,

$$\Rightarrow \tau(\gamma_n + Z\theta_L^x \gamma_m)\hat{P}_n + \hat{P}_x^*(\alpha_x - Z\tau\gamma_m) - \frac{dS}{E} = d\mu = 0.$$

Finally, if we use equation (3.12) to solve for $\hat{P}_n$ and rearrange terms we obtain a complete description of the relationship between the change in export price and savings,

$$\frac{dS}{E} = \frac{\tau(\gamma_n + Z\theta_L^x\gamma_m)[\gamma_m - Z\varepsilon] + \varepsilon\gamma_m(1 - Z\theta_L^x)(1 - Z\tau)}{\varepsilon(1 - Z\theta_L^x) + \tau(\gamma_n + Z\theta_L^x\gamma_m)}\hat{P}_x^*. \tag{5.15}$$

Now we have established five equations that can give a complete solution for the five unknowns, i.e. h_1, h_2; h_3, h_4, and h_6. The solutions are as follows,

$$h_1 = -\frac{e^{\lambda_1 t_1} J_1 + e^{\lambda_1 t_2} J_2 + \lambda_2 \left[e^{\lambda_1 t_1} - 2e^{\lambda_1 t_2} \right] M^* \hat{P}_x^*}{e^{\lambda_1 t_1} e^{\lambda_1 t_2} (\lambda_1 - \lambda_2)}; \tag{5.16}$$

$$h_2 = \frac{e^{\lambda_1 t_2} J_1 + e^{\lambda_1 t_1} J_2 - \lambda_2 \left(2M^* \hat{P}_x^* e^{\lambda_1 t_2} - e^{\lambda_1 t_1} \right)}{e^{\lambda_1 t_1} e^{\lambda_1 t_2} (\lambda_1 - \lambda_2)} - M^* \hat{P}_x^*; \tag{5.17}$$

$$h_3 = -\frac{J_2 + \lambda_2 M^* \hat{P}_x^*}{e^{\lambda_1 t_2} (\lambda_1 - \lambda_2)}; \tag{5.18}$$

$$h_4 = -\frac{e^{\lambda_1 t_1} \left(e^{\lambda_1 t_2} J_1 - e^{\lambda_2 t_1} J_2 - M^* \hat{P}_x^* \left[2e^{\lambda_1 t_2} \lambda_1 + e^{\lambda_2 t_1} \lambda_2 \right] \right)}{e^{\lambda_1 t_1} e^{\lambda_2 t_1} e^{\lambda_1 t_2} (\lambda_1 - \lambda_2)} - M^* \hat{P}_x^* + \frac{e^{\lambda_2 t_1} e^{\lambda_1 t_2} \left(2\lambda_2 M^* \hat{P}_x^* - J_1 \right)}{e^{\lambda_1 t_1} e^{\lambda_2 t_1} e^{\lambda_1 t_2} (\lambda_1 - \lambda_2)}; \tag{5.19}$$

$$h_5 = \frac{e^{\lambda_1 t_1} \left(e^{\lambda_2 t_1} \left(e^{\lambda_2 t_2} (J_2 + \lambda_2) - e^{\lambda_1 t_2} \left(J_2 + \lambda_1 M^* \hat{P}_x^* \right) \right) \right)}{e^{\lambda_1 t_1} e^{\lambda_2 t_1} e^{\lambda_1 t_2} e^{\lambda_2 t_2} (\lambda_2 - \lambda_1)} \\ \frac{e^{\lambda_1 t_2} e^{\lambda_2 t_2} \left(e^{\lambda_2 t_1} \left(J_1 - 2M^* \hat{P}_x^* \lambda_2 \right) + e^{\lambda_1 t_1} \left(2M^* \hat{P}_x^* - J_1 \right) \right)}{e^{\lambda_1 t_1} e^{\lambda_2 t_1} e^{\lambda_1 t_2} e^{\lambda_2 t_2} (\lambda_2 - \lambda_1)} + M^* \hat{P}_x^*. \tag{5.20}$$

At this point, a comparison of closed form solutions is not feasible and we will have to refer to numerical simulations.

5.3. Simulations

5.3.1. The Current account

In the non-interventionist regime, export price decreases are purely income shocks and consumer optimization is the elementary problem of consumption smoothing. Thus, there should be strong tendency to save the early windfall in order to sustain consumption in the subsequent, more adverse period. Therefore a significant trade surplus would be expected during the three first years along with a strong deflationary pull due to lower demand. Exchange rate interventions, on the other hand, will alter the relative price of tradables and non-tradables, and thus encourage inter-temporal substitution and dissaving, which contradicts consumption smoothing. Larger values of ε and τ will, as expected, increase the gains from inter-temporal substitution and thus lead to a lower trade surplus and possibly even a trade deficit if the degree of intertemporal substitution is sufficiently high ($\tau \geq 0.8$), as can be seen in figure 10a.

5.3.2. Prices

Since this is a two good economy, compensated demand and cross price elasticity are identical. The price paths of the two regimes are close to converging for low values of ε, although the outcome is not very appealing in terms of price stability, as can be seen from figure 5c. This is in line with sufficiency condition (4.8), which determines the lower bound $\varepsilon > 0.16$ for the exchange rate policy to be effective. Higher values of ε will universally lead to a better policy performance in terms of price stability in the non-interventionist regime since demand is more flexible to price changes. However, the results are more mixed for the exchange rate regime. As long as tradables and non-tradables are not gross substitutes and sufficiency condition (4.11) is not fulfilled, i.e. $\varepsilon < \gamma_m = 0.4$; then higher values of ε will enhance policy performance. If $\varepsilon > \gamma_m = 0.4$, then substitution dominates and a higher degree of price elasticity leads to a greater price instability.

Policy performance is very sensitive to τ; as larger values will make economic agents more tolerant to dents in consumption and weaken the incentive save in anticipation of a negative income shock. A low degree of inter-temporal substitution will make appreciation more effective in stabilizing prices in the three years leading up to a devaluation, although then the devaluation itself becomes more inflationary. The reason for this almost contradictory result is that the agents expect the price of non-tradables as well as tradables to rise in the wake of a devaluation. If the value of τ is large there is an incentive to consume non-tradables prior as well prior to the shock. Therefore the price of non-tradables will have greater tendency to increase in the three …rst years and the devaluation itself is less in‡ationary. This is really an example of how in‡ation expectations can create certain inertia for current economic policy.

5.3.3. Real exchange rates

The …rst shock, which is unanticipated, produces very similar response in both regimes in terms of relative prices, i.e. $\frac{\hat{P}_n}{\hat{e}}$. However, the subsequent and anticipated shocks do produce di¤erent responses. In fact, the exchange rate rule leads to a downward swing in relative prices when the adverse shock hits, which is much larger than is observed in a non-interventionist regime. The same phenomenon is displayed when the anticipated positive shock occurs that the exchange rate regime leads to a much higher upward movement in relative prices. This is result which is quite robust and holds almost irrespective of parameter values. Flexible exchange rates will create greater real exchange rate volatility.

6. Conclusion

The most striking result is that short-term stabilization policy may deliver very desirable short-term results in terms of price stability as in‡ation is postponed until the external trade environment is reversed. If " > °$_m$; so that tradables and non-tradables are gross substitutes, then a double digit in‡ation will result from the devaluation at time $t = 3$ when the negative shock occurs. The results thus indicate that an active monetary policy that involves temporary counter-cyclical exchanges rates changes may in e¤ect have a considerable in‡ationary bias, which is revealed after some lag. Furthermore, it is clear that the exchange rate policy will promote greater current account stability, although the tendency for a current account de…cits to appear in the wake of positive supply shocks is clearly displayed. From a microeconomic point of view, this constitutes a distortion or a welfare loss since variation in the current account are an inherent feature of consumption smoothing. The results are overall in line with the Icelandic experience.

Part II

Chapter 2

In the previous chapter, perfect price ‡exibility was assumed. This may be an unreasonable assumption, especially in economies that are heavily unionized. Workers, negotiating as one body, are likely to resist nominal pay cuts until concerns about their job security are rendered su¢ ciently realistic by unemployment within their ranks. Thus, following a negative shock, there is a time span with excess supply in labor market while the real wage is slowly being bid down. Flexible exchange rates have long been considered an alternative way of clearing the labor market in small open economies. Currency depreciation has the potential to lower the real wage in a swift and decisive way, without the painful adjustment process associated with a downward nominal price adjustment. However, the question is how much do expectations and labor market structure a¤ect this equation. If the labor unions anticipate a coming devaluation, they can possibly neutralize it by demanding nominal wage increases which prevent the real wage from decreasing, or alternatively they can cooperate with the government by keeping the nominal wage …xed and facilitate a sharp drop in the real wage. This paper seeks to investigate this interplay between monetary policy and patterns in the labor market by mapping down how the two di¤erent responses from unions a¤ect macroeconomic variables, both before and the policy intervention. The analysis is built on the model previously introduced in chapter one, with the addition of a delayed adjustment of the nominal wage with regard to changes in the labor market. The most striking result is that although a currency depreciation will, regardless of the union response, eliminate excess labor supply other macroeconomic variables, e.g. the current account or inflation, are greatly affected by the degree of labor market cooperation.

As before, our discussion will revolve around the monetary policy practiced by Iceland 1970-90. The Icelandic business cycle is essentially driven by external shocks which invariably are changes in export earnings. Profit in the export sector is thus a bellwether of the disturbance which is about to be transmitted into the domestic economy. The monetary authorities are therefore able to launch pre-emptive strikes against unemployment and control the real wage by adjusting the exchange rate to maintain constant profitability in the export sector. The success of this policy is best displayed by the fact that the unemployment rate was kept below 2% for 20 years in Iceland, from 1970 to 1990, despite considerable volatility in export earnings and almost complete unionization of the workforce. During this time, nominal wages never decreased. The adjustment came solely through real wage cuts brought about with a currency depreciation.

7. Model reconfiguration

7.1. Delayed clearing

Delayed labor market clearing will be incorporated into the model by assuming that wages do not instantly adjust to changes in labor demand. In the long run wages are determined by changes in the price index and the natural rate of unemployment prevails, but the adjustment to new condition may take some time, during which the unemployment rate might deviate from the natural rate. We can characterize the adjustment process as,

$$\frac{\dot{w}}{w} = \frac{\dot{P}}{P} + g(l_x + l_n - \bar{L}); \tag{7.1}$$

where l_x and l_n are the respective shares of the labor force employed by each sector and the parameter g determines the responsiveness of the nominal wage to the unemployment rate, $\bar{L} - l_x - l_n$. The long-run total labor supply, $\bar{L}$, is normalized at unity. Expression (7.1) can also be written in terms of the real wage,

$$\frac{\dot{\omega}}{\omega} = g(l_x + l_n - 1); \tag{7.2}$$

where $\omega = \frac{w}{P}$. Since the nominal wage w is predetermined, the real wage jumps instantly with the price level when a shock occurs. It is assumed, as before, that the capital stock is fixed in both sectors in the medium to short run, which is the time horizon under investigation. Moreover, the export sector is dependent on a limited, fully utilized natural resource which essentially fixes export production. Thus l_x, the share of labor supply employed in the export sector is also fixed. Previously, the assumptions of inelastic labor supply, perfectly flexible wage adjustment and instantaneous market clearing implied that output in the non-tradable sector was also fixed. Now, with the possibility of open unemployment, production in the non-tradable sector can vary as the result of a delayed wage adjustment. It is assumed that the unemployment rate can for a short-time dip below the natural level and the total labor supplied can be in excess of unity for short periods of time, e.g. through increases in hours worked by currently employed workers.

7.2. Production of non-tradables

Given the short time-span under consideration, firms in the non-tradable sector are only free to vary their labor input. The first order condition resulting from the profit maximization under perfect competition is therefore,

$$P_n F_L^n = w. \tag{7.3}$$

This can be rewritten in terms of the real wage and the relative price of the non-traded good:

$$F_L^n = \omega \frac{P}{P_n} = \omega \left(\frac{e}{P_n} \right)^{\gamma_m}. \tag{7.4}$$

Taking the inverse of F_L, equation (7.4) yields the labor demand function,

$$l_n = L\left[\varpi\left(\frac{e}{P_n}\right)^{\gamma_m}\right]. \tag{7.5}$$

Total differentiation then gives,

$$\hat{l}_n = -\eta_n\left(\hat{\varpi} + \gamma_m(\hat{e} - \hat{P}_n)\right), \tag{7.6}$$

where η_n is the wage elasticity of labor demand in the non-tradable sector ($\eta_n = -\frac{dl_n}{dw}\frac{w}{l_n} > 0$). The policy equation defining exchange rate adjustments is,

$$\hat{e} = Z(\theta_L^x \hat{w} - \hat{P}_x^*). \tag{7.7}$$

Therefore eq. (7.6) can be rewritten as,

$$\hat{l}_n = -\eta_n\left(\hat{\varpi} + \gamma_m Z(\theta_L^x \hat{w} - \hat{P}_x^*) - \gamma_m \hat{P}_n\right). \tag{7.8}$$

Note that $\hat{\varpi} = \hat{w} - \hat{P}$, the change in the nominal wage can therefore be expressed as

$$\hat{w} = \frac{\hat{\varpi} + \gamma_n \hat{P}_n - \gamma_m Z \hat{P}_x^*}{1 - \gamma_m Z \theta_L^x}. \tag{7.9}$$

Substituting this into (7.8) and collecting terms gives,

$$\hat{l}_n = \frac{-\eta_n}{1 - \gamma_m Z \theta_L^x}\left(\hat{\varpi} - (1 - Z\theta_L^x)\gamma_m \hat{P}_n - \gamma_m Z \hat{P}_x^*\right). \tag{7.10}$$

A higher real wage will, as expected, decrease labor demand in the non-tradable sector and higher price of non-tradables will do the opposite. What is less obvious is that a higher export price will, through exchange rate intervention, directly increase demand for labor in the non-tradable sector. Although, of course, the total effect on labor demands depends on how P_x^* will affects P_n and ϖ. In other words, the effect of the nominal exchange rate on labor demand is now an additional transmission mechanism for monetary interventions in this model.

7.3. Prices

To solve for the equilibrium prices in this economy, combine the market clearing constraint

$$-(\varepsilon+\gamma_n)\hat{P}_n+(\varepsilon-\gamma_m)\hat{e}+\hat{E}=\hat{Q}_n; \tag{7.11}$$

The supply response in the non-tradable sector

$$\hat{Q}_n=\theta_L^n\hat{\ell}_n=-\frac{\theta_L^n\kappa_n}{1-\gamma_m Z\theta_L^n}\left[\hat{\varpi}-[1-\gamma_m Z\theta_L^x]\gamma_n\hat{P}_n\right] \tag{7.12}$$

the budget constraint

$$\hat{E}=\alpha_x(\hat{e}+\hat{P}_x^*)+\gamma_n\hat{P}_n+\gamma_n\hat{Q}_n-\frac{dS}{E}; \tag{7.13}$$

and the policy rule for exchange rate

$$\hat{e}=Z\left[\frac{\theta_L^x\left(\hat{\varpi}+\gamma_n\hat{P}_n\right)-\hat{P}_x^*}{[1-\gamma_m Z\theta_L^x]}\right]. \tag{7.14}$$

This yields the following solution for $\hat{P}_n$ and $\hat{e}$:

$$\begin{aligned}\hat{P}_n &= \Phi^{-1}\left\{[\theta_L^x Z(\varepsilon+\alpha_x-\gamma_m)+\theta_L^n\kappa_n\gamma_m]\hat{\varpi}-(1-\gamma_m Z\theta_L^x)\frac{dS}{E}\right\} \\ &\quad +\Phi^{-1}[(\gamma_m-\alpha_x-\varepsilon)Z+\alpha_x[1-\gamma_m Z\theta_L^x]-\kappa_n\theta_L^n\gamma_m\gamma_m Z]\hat{P}_x^*; \end{aligned} \tag{7.15}$$

$$\hat{e}=Z\Phi^{-1}\left\{[\varepsilon+\theta_L^n\kappa_n\gamma_m]\theta_L^x\hat{\varpi}-\gamma_n\theta_L^x\frac{dS}{E}+[\alpha_x\theta_L^x\gamma_n-\gamma_m\kappa_n\theta_L^n\gamma_m-\varepsilon]\hat{P}_x^*\right\}. \tag{7.16}$$

where,

$$\Phi=[(\varepsilon+\gamma_m\kappa_n\theta_L^n\gamma_m)(1-Z\theta_L^x)-(\alpha_x-\gamma_m)Z\theta_L^x\gamma_n]$$

The results are somewhat predictable. A higher real wage will, other things constant, raise the price of non-tradables as well as trigger devaluation to compensate the export sector for higher labor costs. However, the direct effect of an export price change on $\hat{P}_n$ is ambiguous since there is a conflict between income effect directly leading from $\hat{P}_x^*$ and substitution between tradables and non-tradables which the resulting exchange rate adjustment brings about.

To map the transition period in the wake of an external shock, equations, (7.15), (7.16) and (??) can be expressed as differential equations,

$$\frac{\dot{P}_n}{P_n} = \Phi^{-1}\left[[\theta_L^x Z(\varepsilon + \alpha_x - \gamma_m) + \theta_L^n \kappa_n \gamma_m] \frac{\dot{\varpi}}{\varpi} - (1 - \gamma_m Z \theta_L^x) \frac{S}{E} \right]. \tag{7.17}$$

$$\frac{\dot{e}}{e} = \frac{Z}{\Phi}\left[[\varepsilon + \kappa_n \gamma_m \theta_L^n] \theta_L^x \frac{\dot{\varpi}}{\varpi} - \theta_L^x \gamma_n \frac{S}{E} \right] \tag{7.18}$$

8. Solving the model

8.1. The path of savings

As before, we can express the private agent's optimization problem as,

$$\underset{\{E,S\}}{Max} \int \left[V(e, P_n, E) + \phi\left(\frac{M}{P}\right) \right] e^{-\rho t} dt \tag{8.1}$$

$$s.t.$$

$$E = P_x Q_x + P_n Q_n - S \tag{8.2}$$

$$\dot{M} = S \tag{8.3}$$

For which the following Hamiltonian function is specified,

$$H = e^{-\rho t}\left[V(e, P_n, P_x Q_x + P_n Q_n - S) + \phi\left(\frac{M}{P}\right) - \mu S \right], \tag{8.4}$$

where μ is the Lagrangian multiplier associated with the optimization. The first order conditions are,

$$V_E(e, P_n, P_x Q_x + P_n Q_n - S) = \mu, \tag{8.5}$$

$$\dot{\mu} = \rho\mu + \phi'\left(\frac{M}{P}\right)\frac{1}{P}. \tag{8.6}$$

As before Q_x can be treated as a constant, and time differentiation of (8.5) yields:

$$\dot\mu = (V_{EN} + V_{EE}Q_n)\dot P_n + V_{EM}\dot e + V_{EE}P_n\dot Q_n + V_{EE}Q_x\dot P_x - V_{EE}\dot S. \qquad (8.7)$$

With a little rearrangement we can write (8.7) as

$$\dot\mu = V_{EE}E\left[\left(\frac{V_{EN}}{V_{EE}D_n}\frac{P_nD_n}{E} + \frac{P_nQ_n}{E}\right)\frac{\dot P_n}{P_n} + \frac{P_nQ_n}{E}\frac{\dot Q_n}{Q_n} + \left(\frac{V_{EM}}{V_{EE}D_m}\frac{eD_m}{E} + \frac{P_xQ_x}{E}\right)\frac{\dot e}{e} - \frac{\dot S}{E}\right]. \qquad (8.8)$$

From Roy's identity $D^i = -\frac{V_i}{V_E}$, we can derive the relationship $\frac{V_{EPm}}{V_{EE}Q_i} = \gamma_i\tau - 1$; where τ is the elasticity of inter-temporal substitution ($\tau = -\frac{V_E}{V_{EE}E}$) and υ_i is the income elasticity of good i: ($\gamma_i = \frac{\partial D_i}{\partial E}\frac{E}{D_i}$). If we assume unitary income elasticities of demand, i.e. $\gamma_i = 1$. Moreover, for small changes in the neighborhood of the steady equilibrium, $\alpha_x = \gamma_m$; thus (8.8) can be written as,

$$\dot\mu = V_{EE}E\left[\tau\gamma_n\frac{\dot P_n}{P_n} + \tau\gamma_m\frac{\dot e}{e} + \gamma_n\frac{\dot Q_n}{Q_n} - \frac{\dot S}{E}\right]. \qquad (8.9)$$

Now, substitute for $\frac{\dot Q_n}{Q_n}$; $\frac{\dot e}{e}$ and $\frac{\dot P_n}{P_n}$ using equations (7.12), (7.18) and (7.17),

$$V_{EE}\Phi^{-1}\left(EA\frac{\dot\varpi}{\varpi} - B\dot S\right) = \rho V_E - \phi'\left(\frac{M}{P}\right)\frac{1}{P}; \qquad (8.10)$$

where,

$$A = [\tau\theta_L^x Z\varepsilon + \theta_L^n\kappa_n(\tau\gamma_m(\gamma_n + \gamma_m Z\theta_L^x) - \varepsilon\gamma_n(1 - Z\theta_L^x))]$$

$$B = [\tau\gamma_n + (\varepsilon + \gamma_m\kappa_n\theta_L^n)(1 - Z\theta_L^x)]$$

Finally, use eq.(7.2) to substitute for $\frac{\dot\varpi}{\varpi}$ and we have a differential equation describing the path of the savings rate,

$$\dot S = \frac{-\Phi}{BV_{EE}}\left(\rho V_E - \phi'\left(\frac{M}{P}\right)\frac{1}{P}\right) + \frac{A}{B}Eg(l_x + l_n - 1). \qquad (8.11)$$

8.2. Linearization

Differential equation (8.11) will solved through a linearization around the initial stationary equilibrium. Differentiation of the first term on the right hand side of eq. (8.11) yields

$$\dot{S} = \frac{1}{B}\left[-\rho\left(A\frac{l_n}{\theta_L^n\gamma_n}d\varpi - BdS\right) + \Phi\rho E\left[(\tau - 1)\hat{P} + \hat{M}\right]\right] + (): \tag{8.12}$$

Now using eq. (??) to substitute for $\hat{P}$ we obtain,

$$\dot{S} = \frac{\rho}{B}\left[[\Phi + \gamma_n]dS - [\gamma_n(\varepsilon - \gamma_m) - [(Z\gamma_n + 1)\varepsilon + \gamma_m\gamma_m]Z\theta_L^x]\frac{\kappa_n l_n}{\gamma_n}d\varpi + \frac{\Phi}{\chi}dM\right] + (): \tag{8.13}$$

The linearization of the second term on the right in eq. (8.11) yields,

$$\dot{S} = () + \frac{A}{B}Eg\,dl_n: \tag{8.14}$$

From eq.(7.10),(7.14) and (7.15) we have an expression for changes in the labor input depending on savings decisions and the real wage,

$$dl_n = \frac{-\kappa_n l_n}{\varepsilon + \gamma_m\kappa_n\theta_L^n\gamma_m}\left[\varepsilon\varpi + \gamma_m\frac{dS}{E}\right]: \tag{8.15}$$

Thus eq. (8.14) becomes,

$$\dot{S} = () - \frac{A}{B}\frac{\kappa_n l_n g}{\varepsilon + \kappa_n\gamma_m\theta_L^n\gamma_m}\left[\frac{\varepsilon l_n}{\theta_L^n\gamma_n}d\varpi + \gamma_m dS\right]: \tag{8.16}$$

Lastly, the linearization of differential equation (8.11) is complete if equations (8.16) and (8.13) are combined,

$$\dot{S} = C_1 dS + C_2 d\varpi + C_3 dM: \tag{8.17}$$

$$C_1 = \frac{1}{B}\left[\rho[(\varepsilon + \gamma_m\kappa_n\theta_L^n)(1 - Z\theta_L^x) + \gamma_n] - \frac{\varepsilon\gamma_m\kappa_n l_n g A}{\varepsilon + \kappa_n\gamma_m\theta_L^n\gamma_m}\right]$$

$$C_2 = \frac{1}{B}\left[[(Z\gamma_n + 1)\varepsilon + \gamma_m\gamma_m]Z\theta_L^x - \gamma_n(\varepsilon - \gamma_m) - \frac{A\varepsilon l_n g}{\theta_L^n(\varepsilon + \kappa_n\gamma_m\theta_L^n\gamma_m)}\right]\frac{\kappa_n l_n}{\gamma_n}$$

$$C_3 = \frac{1}{B}[(\varepsilon + \kappa_n\gamma_m\theta_L^n\gamma_m)(1 - Z\theta_L^x)]\frac{\rho}{\chi}$$

8.3. The real wage

The path of the real wage is described by di¤erential equation (7.2), which also has to be linearized around the initial stationary equilibrium. Simple di¤erentiation yields,

$$\underline{\$} = \$ g d l_n : \qquad (8.18)$$

Now using eq. (8.15) we write (8.18) as,

$$\underline{\$} = \frac{\text{¡} g \cdot_n}{(" + \cdot_n {°}_m µ^n_L {°}_m)} \left(l_n " d\$ + {°}_m µ^n_L {°}_n dS\right); \qquad (8.19)$$

Or written more conveniently,

$$\underline{\$} = C_4 dS + C_5 d\$: \qquad (8.20)$$

$$C_4 = \frac{\text{¡} g \cdot_n {°}_m µ^n_L {°}_n}{(" + \cdot_n {°}_m µ^n_L {°}_m)}$$

$$C_5 = \frac{\text{¡} " g \cdot_n l_n}{(" + \cdot_n {°}_m µ^n_L {°}_m)}$$

Equations (8.20), (8.17), along with (8.3) will form a three dimensional simultaneous dynamic system.

$$\begin{bmatrix} \dot{S} \\ \underline{\$} \\ \dot{M} \end{bmatrix} = \begin{bmatrix} C_1 & C_2 & C_3 \\ C_4 & C_5 & 0 \\ 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} S \\ \$ \text{ ¡ } \$^{¤} \\ M \text{ ¡ } M^{¤} \end{bmatrix} : \qquad (8.21)$$

The general solution to (8.21) can be written as follows,

$$\begin{bmatrix} S \\ \$ \text{ ¡ } \$^{¤} \\ M \text{ ¡ } M^{¤} \end{bmatrix} = \begin{bmatrix} Z_{11} & Z_{12} & Z_{13} \\ Z_{21} & Z_{22} & Z_{23} \\ Z_{31} & Z_{32} & Z_{33} \end{bmatrix} \begin{bmatrix} k_1 e^{¸_1 t} \\ k_2 e^{¸_2 t} \\ k_3 e^{¸_3 t} \end{bmatrix}, \quad \begin{matrix} i = 1; 2; 3 \\ j = 1; 2; 3 \end{matrix} \qquad (8.22)$$

where Z_{ij} are the eigenvectors, $¸_i$ the eigenvalues associated with the solution and k_i are constants determined by the initial conditions. The nominal wage is predetermined, but the real wage can jump instantaneously through the exchange rate or price adjustment. Thus, of the three variables in question, only M is a state variable, and both S and \$ are jump variables. For the system to be saddlepoint stable, two eigenvalues have to be positive, one negative. The solutions for the eigenvectors are obtained from

$$\begin{bmatrix} C_1 & C_2 & C_3 \\ C_4 & C_5 & 0 \\ 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} Z_{1j} \\ Z_{2j} \\ Z_{3j} \end{bmatrix} = \begin{bmatrix} Z_{1j}\lambda_j \\ Z_{2j}\lambda_j \\ Z_{3j}\lambda_j \end{bmatrix}; \; j = 1;2;3 \tag{8.23}$$

Any scalar multiple of an eigenvector is also an eigenvector and we are therefore free to set one component in each eigenvector equal to unity. Thus $Z_{1j} = \lambda_i$, $Z_{2j} = \frac{C_4}{(\lambda_j - C_5)}$ and $Z_{3j} = 1$, for $j = 1;2;3$.

9. Permanent and unexpected shocks

9.1. Solution paths

If the dynamic system is hit by a permanent export price shock, then the economy will traverse the unique saddlepath leading to the new equilibrium; on which the constants associated with the positive eigenvalues are zero, (i.e. $k_2 = k_3 = 0$): Therefore we can write the solution for all three variables in terms of just one unknown constant k_1:

$$S(t) = \lambda_1 k_1 e^{\lambda_1 t}: \tag{9.1}$$

$$\$(t) - \$^* = k_1 \frac{\lambda_1 C_4}{(\lambda_1 - C_5)} e^{\lambda_1 t}: \tag{9.2}$$

$$M(t) - M^* = k_1 e^{\lambda_1 t}: \tag{9.3}$$

The additional information needed to solve for the unknown constant can be obtained from initial conditions, which relate the change in steady state money holdings to k_1. At $t = 0$;(9.3) yields,

$$M_0 - M^* = k_1: \tag{9.4}$$

Since we have assumed that income elasticity of money demand is unitary, the change in steady state expenditure and money balances must be directly related, i.e. $\hat{E}_{ss} = \hat{M}_{ss}$. $\Rightarrow$ $M^* - M^0 = M_0\hat{E}_{ss}$. The delayed wage adjustment only affects the transitional path and not production in the long run. Thus the change in steady state money holdings remains unchanged from the earlier case of perfect price adjustment. The constant k_1 can therefore be expressed as,

$$k_1 = -(M^* - M^0) = -M_0\Lambda\hat{P}_x^*. \tag{9.5}$$

$$\Lambda = \frac{[Z\theta_L^x\gamma_m + \gamma_n][\gamma_m - Z\varepsilon] + (1 - Z)\gamma_m\varepsilon(1 - Z\theta_L^x)}{\varepsilon(1 - Z\theta_L^x)}$$

The solution paths for S, ϖ and M can now be written,

$$S(t) = -\lambda_1 M_0\Lambda\hat{P}_x^* e^{\lambda_1 t}; \tag{9.6}$$

$$\varpi(t) - \varpi_0 = -\lambda_1\frac{M_0\Lambda_1 C_4}{(\lambda_1 - C_5)}\hat{P}_x^* e^{\lambda_1 t} + \varpi_0\left(\frac{\varpi^* - \varpi_0}{\varpi_0}\right). \tag{9.7}$$

$$M(t) - M_0 = M^0\Lambda(1 - e^{\lambda_1 t})\hat{P}_x^*. \tag{9.8}$$

Since there is no change in labor input across stationary equilibrium, it is clear from eq. (7.6) that,

$$\hat{l}_n = -\eta_n\left(\hat{\varpi} + \hat{P} - \hat{P}_n\right) = 0;$$

That is, in the long-run $\hat{w} = \hat{P}_n$; and the permanent change in the real wage depends on the relative movements of the CPI and P_n as the result of an export price change,

$$\hat{\varpi} = \hat{P}_n - \hat{P} = \gamma_m(\hat{P}_n - \hat{e}). \tag{9.9}$$

Thus, by using the long-run versions of equations (7.15) and (7.16),

$$\frac{\varpi^* - \varpi_0}{\varpi_0} = \frac{\gamma_m\gamma_m}{\varepsilon}\hat{P}_x^*. \tag{9.10}$$

Given that we can express eq. (9.7) as,

$$\varpi(t) - \varpi_0 = \left(\frac{\gamma_m^2}{\varepsilon}\varpi_0 - \lambda_1\frac{M_0\Lambda_1 C_4}{(\lambda_1 - C_5)}e^{\lambda_1 t}\right)\hat{P}_x^*. \tag{9.11}$$

9.2. Simulations

9.2.1. The choice of parameters

The choice of parameters is the same as in the previous chapter. However, a number of new ones now appear in association with non-tradable sector and the degree of wage stickiness. About 85% of the workforce is employed in the non-tradable sector in Iceland and the labor cost ratio is about 75%. Moreover, the wage elasticity of labor demand is between 1.5. Lastly, the degree of wage stickiness is more di¢cult to assess. However, since there are three years between the shocks in the policy experiments, the values chosen for g will create an adjustment (0.25-0.5) process which is roughly three years.

Parameter name	Notation	Value
Consumption share; imported goods	$°_m$	40%
Consumption share; non-tradable goods	$°_n$	60%
Labor cost ratio in the export sector	$µ_L^x$	40%
Labor cost ratio in the non-tradable sector	$µ_L^n$	75%
The ratio of highpowered money to E	$\frac{M}{E}$	15%
Time preference rate	½	7%
The elasticity of intertemporal substitution	¿	0.1-0.8
Cross price elasticity	"	0.15-0.75
Wage elasticity of labor demand in the non-tradable sector	$·_n$	1.5
The degree of wage stickiness	g	0.25-0.5
The share of the labor force employed in the non-tradable sector	l_n	85%

9.2.2. Numerical solutions

Broadly stated, the simulations reveal that the application of the exchange rate rule delivers results which are qualitatively di¤erent from that of non-intervention, almost regardless of parameter values. When the economy is hit with a 10% permanent, unexpected and negative shock, an exchange rate intervention will lead to a trade surplus as opposed a de…cit (see …gures 14d and 15d), a burst of in‡ation instead of de‡ation (see …gures 13f and 14f) and an immediate decrease in the real wage (see …gures 14b and 15b) compared with increase which would occur in the case of a non-intervention. Thus, unemployment is averted (…gures 14e and 15e) or at least signi…cantly decreased (…gure 13e). These results are typical as to what exchange rate interventions are usually expected to accomplish in a macroeconomic context. As would be expected the force of the cross price substitution between tradables and non-tradables will be a determining factor for the e¤ect of the exchange rate intervention. If " is rather high, demand for labor will increase in the aftermath of the devaluation and signi…cant in‡ation will result. Policy makers who are not extremely averse to in‡ation would be inclined to favor the exchange rate policy to laissez faire, since e.g. when " = 0:45 and ¿ = 0:45; an exchange rate intervention would deliver 4% in‡ation (see …gure 14f) and no unemployment compared with 4% cyclical unemployment (see …gure 14e)and 2% de‡ation under non-intervention.

10. Temporary and anticipated shocks

10.1. Wage bargaining and expectations

In order to factor in the e¤ects of transitory shocks and expectations, we will now increase the number of shocks. The initial shock comes as a surprise, but is now followed by two subsequent shocks that are known with certainty. More speci…cally, the sequence of shocks is as follows: In the beginning, at $t = 0$, there is a 10% export price increase; then three years later at $t = t_1 = 3$ the price falls 20% and lastly six years down the road at $t = t_2 = 6$; the export price returns to its initial level by rising 10% increase. In other words, the shocks are temporary and the economy follows a full cycle returning to the initial supply conditions with the last shock.

We have also introduced collective wage bargaining and delayed labor market clearing. Therefore the anticipated shocks raise the issue of how the trade unions will value full employment versus purchasing power stability, and thus how they will react to the devaluation at t_1 that is known beforehand. Unless there are some binding long term contracts that limit nominal wage increases, the possibility exists that the unions will instantly o¤set a devaluation with nominal wage demands. In other words, the questions hinges on whether the union will allow the real wage to jump downward when the shock occurs. That decision might depend on the labor market conditions at the time the shock occurs, e.g. a tight market where excess demand is observed rather than excess supply may translate into in‡exibility and vice versa. Moreover, the overall structure of wage bargaining has to be a factor. If the unions are centralized into one bargaining team, as is mostly the case in Iceland, they are more willing to acknowledge the need for a lower real wage in order to preserve employment.

In the simulations we will allow for the these two possibilities. If the labor unions are cooperative in the sense they allow the real wage to fall in the event of a devaluation, the nominal wage is pre-determined as the shock occurs and the real wage is a jump variable. By second choice, if the unions are not willing to accept the sharp decrease in purchasing introduced by a devaluation, then the nominal wage is not predetermined and the real wage will not jump. This distinction is crucial for the outcome, as it turns out.

10.2. Transitional paths

The transitional period can be divided into three distinct time periods, each marked by di¤erent constants, k, determined by the three shocks.

The …rst path The …rst shock occurs in the beginning at t_0. Since it is not permanent and lasts only until t_1; the economy is not constrained to follow a convergent path to a new saddle point equilibrium. Instead, dynamic optimization will imply a non-convergent path that may be qualitatively different from a permanent price change, since the temporary price shock will not imply a fixed end point that pins down the equilibrium path. This initial shock is unexpected and therefore there will be a jump in both the savings rate and real wage because the nominal wage is pre-determined due to the surprise. The following equations characterize the period from t_0 to t_1. Since the path is non-convergent the two constants associated with the positive eigenvalues cannot be assumed to be zero,

$$S_t = \lambda_1 k_1 e^{\lambda_1 t} + \lambda_2 k_2 e^{\lambda_2 t} + \lambda_3 k_3 e^{\lambda_3 t}; \tag{10.1}$$

$$\varpi_t - \varpi_0 = \varpi^* - \varpi_0 + C_4 \left[\frac{\lambda_1 k_1}{\lambda_1 - C_5} e^{\lambda_1 t} + \frac{\lambda_2 k_2}{\lambda_2 - C_5} e^{\lambda_2 t} + \frac{\lambda_3 k_3}{\lambda_3 - C_5} e^{\lambda_3 t} \right]; \tag{10.2}$$

$$M_t - M_0 = M^* - M_0 + k_1 e^{\lambda_1 t} + k_2 e^{\lambda_2 t} + k_3 e^{\lambda_3 t}. \tag{10.3}$$

where the star notation acknowledges the new stationary equilibrium implied by the respective export price change as if it would be permanent.

The second path The second shock occurs at t_1 and is also temporary. There will be a shift as the economy links to another path and since the money stock is pre-determined the change occurs with a jump in the savings rate and possibly the real wage at t_1; depending on the unions' response to the anticipated devaluation. The new path is not convergent either since the third price change is expected at t_2 and utility maximization does not imply adjustment to a permanent end point. We can characterize this period in the same way as before except for the fact that the constants have changed, none which can be assumed to be zero;

$$S_t = \lambda_1 k_4 e^{\lambda_1 t} + \lambda_2 k_5 e^{\lambda_2 t} + \lambda_3 k_6 e^{\lambda_3 t} \tag{10.4}$$

$$\varpi_t - \varpi_0 = \varpi^{**} - \varpi_0 + C_4 \left[\frac{\lambda_1 k_4}{\lambda_1 - C_5} e^{\lambda_1 t} + \frac{\lambda_2 k_5}{\lambda_2 - C_5} e^{\lambda_2 t} + \frac{\lambda_3 k_6}{\lambda_3 - C_5} e^{\lambda_3 t} \right] \tag{10.5}$$

$$M_t - M^0 = M^{**} - M_0 + k_4 e^{\lambda_1 t} + k_5 e^{\lambda_2 t} + k_6 e^{\lambda_3 t} \tag{10.6}$$

$$t_1 \le t \le t_2$$

If we denote M^{**} and $\$^{**}$ as being the new steady state associated with the negative export price shock at t_1; and since $\hat{P}_x^*(t_0) = -2\hat{P}_x^*(t_1)$; then $M^{**} - M_0 = -dM$ and $\$^{**} - \$_0 = -d\$$

Third path The last shock occurs at time t_2 and is permanent. As it hits the savings rate and possibly the real wage jump again and the economy links to a third and final path which is convergent. In other words, since the shock is permanent, utility maximization will imply a "stable arm" path to a saddle point stable equilibrium. Therefore, from t_2 to infinity, the two equations below describe the dynamic system and the constant k_7 associated with the positive eigenvalue is zero.

$$S_t = \lambda_1 k_7 e^{\lambda_1 t} \tag{10.7}$$

$$\$_t - \$_0 = \frac{\lambda_1 k_7 C_4}{\lambda_1 - C_5} e^{\lambda_1 t}; \tag{10.8}$$

$$M_t - M^0 = k_7 e^{\lambda_1 t}, \tag{10.9}$$

10.2.1. Restrictions

To solve for the seven unknowns constants we need an equal number of boundary conditions. Firstly, we can exploit the initial conditions on the stock of nominal money balances in the same way as earlier derived for the permanent shock. Since M is pre-determined, equation (10.3) can be used at $t = 0$ to describe the relationship between the change in steady state money stock and the three first constants,

$$-(M^* - M^0) = k_1 + k_2 + k_3$$

$$\Rightarrow k_1 = -(dM + k_2 + k_3) \tag{10.10}$$

Secondly, at $t = t_1$ equations (10.3) and (10.6) both report nominal money stock at the same moment in time and must therefore give the same solution:

$$k_4 e^{\lambda_1 t_1} + k_5 e^{\lambda_2 t_1} + k_6 e^{\lambda_3 t_1} - k_1 e^{\lambda_1 t_1} - k_2 e^{\lambda_2 t_1} - k_3 e^{\lambda_3 t_1} = 2dM \qquad (10.11)$$

Thirdly, the same condition applies at $t = t_2$, when the next shift occurs and equations (10.6) and (10.9) must give the exact same information for the level of nominal cash balances:

$$k_4 e^{\lambda_1 t_2} + k_5 e^{\lambda_2 t_2} + k_6 e^{\lambda_3 t_2} - k_7 e^{\lambda_1 t_2} = dM \qquad (10.12)$$

Four other restrictions are still needed and they can be derived from the fact that S, and possibly ϖ, will jump at time t_1 and again at t_2. The magnitude of the jumps amounts to the difference in how the above system of equations reports the savings rate and the real wage immediately before and after the shocks. Thus the jump in S at t_1, which is noted as J_1, can be defined by subtracting eq. (10.1) from eq. (10.4) and similarly the savings jump at t_2, which is noted as J_2, must be the difference between (10.4) and (10.7),

$$J_1 = \lambda_1 k_4 e^{\lambda_1 t_1} + \lambda_2 k_5 e^{\lambda_2 t_1} + \lambda_3 k_6 e^{\lambda_3 t_1} - \lambda_1 k_1 e^{\lambda_1 t_1} - \lambda_2 k_2 e^{\lambda_2 t_1} - \lambda_3 k_3 e^{\lambda_3 t_1} \qquad (10.13)$$

$$J_2 = \lambda_1 k_7 e^{\lambda_2 t_2} - \lambda_1 k_4 e^{\lambda_1 t_2} - \lambda_2 k_5 e^{\lambda_2 t_2} - \lambda_3 k_6 e^{\lambda_3 t_2}. \qquad (10.14)$$

In similar fashion, using the equational pairs (10.2), (10.5) and (10.5), (10.8) respectively, the two jumps in ϖ at same time points, noted as J_3 and J_4, can be characterized as,

$$J_3 = -2d\varpi + C_4 \left[\frac{\lambda_1 (k_4 - k_1)}{\lambda_1 - C_5} e^{\lambda_1 t_1} + \frac{\lambda_2 (k_5 - k_2)}{\lambda_2 - C_5} e^{\lambda_2 t_1} + \frac{\lambda_3 (k_6 - k_3)}{\lambda_3 - C_5} e^{\lambda_3 t_1} \right] \qquad (10.15)$$

$$J_4 = d\varpi + C_4 \left[\frac{\lambda_1 (k_7 - k_4)}{\lambda_1 - C_5} e^{\lambda_1 t_2} - \frac{\lambda_2 k_5}{\lambda_2 - C_5} e^{\lambda_2 t_2} - \frac{\lambda_3 k_6}{\lambda_3 - C_5} e^{\lambda_3 t_2} \right] \qquad (10.16)$$

10.3. Explicit solutions: Getting expressions for J_1-J_4

This is a utility optimization under the assumption of a perfect foresight. No new information arrives after $t = 0$ and the multiplier μ must therefore be constant after an initial jump. Given this fact, the first order conditions derived from utility maximization can be used to determine the immediate impact on S by a change in P_x^* at $t = t_1$ and at $t = t_2$.

$$V_E(P_n, P_m, E) = \mu. \tag{10.17}$$

By total differentiating (10.17) and applying similar transformations as before we obtain,

$$\tau\gamma_n\hat{P}_n + (\tau\gamma_m + \alpha_x - \gamma_m)\hat{e} + \gamma_n\hat{Q}_n + \alpha_x\hat{P}_x^* - \frac{dS}{E} = d\mu = 0$$

Then equations (7.15) and (7.16) can be used to eliminate $\hat{P}_n$ and $\hat{e}$ and we obtain the following solutions,

$$\frac{dS(t)}{E} = N_3^{-1}\left[N_1\hat{\varpi}(t) + N_2\hat{P}_x^*(t)\right] \tag{10.18}$$

$$N_1 = (\tau[\varepsilon Z\theta_L^x + \gamma_m\kappa_n\theta_L^n(\gamma_n + \gamma_m Z\theta_L^x)] - \gamma_n\varepsilon\kappa_n\theta_L^n(1 - Z\theta_L^x))$$

$$N_2 = \tau[\gamma_n\gamma_m - Z\varepsilon - \kappa_n\theta_L^n\gamma_m\gamma_m Z] + \gamma_m[\varepsilon + \kappa_n\gamma_m\theta_L^n](1 - Z\theta_L^x)$$

$$N_3 = [\tau\gamma_n + (\varepsilon + \gamma_m\kappa_n\theta_L^n)(1 - Z\theta_L^x)]$$

The determination of J_3 and J_4 depends on the labor market response to the anticipated devaluations at t_1 and t_2. If the unions demand nominal wage changes to avoid jumps in the real wage, we can safely conclude that $J_3 = J_4 = 0$. However, on the other hand, if the nominal wage is fixed as the shock occurs, then the jumps can be determined directly from the change in the price level. If we assume that the nominal wage is predetermined as the shocks occur, i.e. $J_3, J_4 \geq 0$, then the jump in the real wage will amount the change in general price level as result of export price change,

$$\hat{\varpi}(t_j) = -\hat{P}(t_j).\ j = 0, 1, 2. \tag{10.19}$$

From equations, (7.15) and (7.16), substituting for $\hat{P}$ in (10.19) given the relationship between changes in the real wage, savings and the export price,

$$\hat{\varpi}(t) = [\varepsilon + \gamma_m \eta_n \theta_L^n]^{-1} \left\{ \gamma_n \frac{dS(t)}{E} - [\gamma_m \gamma_n - Z\varepsilon - \eta_n \theta_L^n \gamma_m \gamma_m Z] \hat{P}_x^*(t) \right\} \quad (10.20)$$

Now given that $\hat{P}_x^*(t_1) = -2\hat{P}_x^*(t_2)$, and thus $J_1 = -2J_2$ and $J_3 = -2J_4$, we have sufficient information from equations (10.20) and (10.18) to quantify the four jumps if the unions will refrain from nominal wage increases as the shocks occur,

$$J_i = \left\{ \frac{N_2[\varepsilon + \gamma_m \eta_n \theta_L^n] - N_1[\gamma_m \gamma_n - Z\varepsilon - \eta_n \theta_L^n \gamma_m \gamma_m Z]}{N_3[\varepsilon + \gamma_m \eta_n \theta_L^n] - N_1 \gamma_n} \right\} \hat{P}_x^*(t_i), \; i=1,2. \quad (10.21)$$

$$J_3 = [\varepsilon + \gamma_m \eta_n \theta_L^n]^{-1} \left[\gamma_n J_1 - [\gamma_m \gamma_n - Z\varepsilon - \eta_n \theta_L^n \gamma_m \gamma_m Z] \hat{P}_x^*(t_1) \right] \quad (10.22)$$

$$J_4 = [\varepsilon + \gamma_m \eta_n \theta_L^n]^{-1} \left[\gamma_n J_2 - [\gamma_m \gamma_n - Z\varepsilon - \eta_n \theta_L^n \gamma_m \gamma_m Z] \hat{P}_x^*(t_2) \right] \quad (10.23)$$

Otherwise, if the unions do not refrain from demanding nominal wage adjustments in response to exchange rate interventions and the real wage does not jump then,

$$J_i = \frac{N_2}{N_3} \hat{P}_x^*(t_i), \; i = 1, 2., \quad (10.24)$$

$$J_3 = J_4 = 0. \quad (10.25)$$

11. Simulation results

11.1. The current account

In the case of non-intervention, the specter of future unemployment and income losses will increase the incentives to save during the three good years preceding the three bad years in order to smooth consumption. Thus we observe annual trade surpluses which amount to 3 – 6% of total GDP until the negative shock occurs at $t = 3$ and significant deficits appear, as can e.g. be seen in figures 16d and 17d. This is to be expected. However, more surprising is how much the current account is a¤ected by the interplay between actions in the labor market and monetary interventions. If the unions cooperate, then the general incentive to save in anticipation of a negative shock is decreased and relatively large current account de…cits my appear (see e.g. …gure 20d). This result can be traced to the fact that the real wage will jump downwards when the negative shock hits at $t = 3$; due to currency depreciation and predetermined nominal wage. However, the low level of purchasing power is short-lived and the real wage will rise relatively fast in the subsequent periods (see e.g. …gure 20b). For the representative agent, the question is whether to save and accumulate cash balances in anticipation of the temporary slump in purchasing power or to simply substitute consumption across time. If the degree of inter-temporal substitution is high, the consumers will be less inclined to accumulate monetary assets, in the periods prior to the shocks to sustain consumption over the sharp drop in the real wage. As the result, signi…cant trade de…cits appear in the …rst three years which are much larger than in the previous case of a perfect price ‡exibility documented in chapter 1. The pro-cyclical tendency of the current account is much less pronounced when the unions are not cooperative, (see e.g. …gure 19d). This is a remarkable, as it suggests that actions that might seem as prudent, such as organized labor market cooperation to prevent nominal wage increases, might actually have imprudent e¤ects on the spending and saving decisions of private agents.

11.2. Prices

Prices are generally more stable in the non-interventionist regime, as would be expected. In‡ation never ventures above 10% (9% being the maximum, see …gure 24f)and for most cases not higher than 5%. The exchange rate policy is more in‡ationary, although the policy authorities are able to dampen the in‡ationary e¤ects of currency depreciation by negotiating a nominal wage freeze. Conversely, when cooperation is lacking, considerably more in‡ation is observed, partly because larger nominal exchange rate adjustments are needed to reach the stated policy goals and partly because domestic prices are not anchored down in the same manner as was the case with full union cooperation (see e.g. figures 16f and 18f). Generally stated, about 20% nominal depreciation and10% inflation results when the negative shock occurs at $t = 3$ when the unions are cooperative, compared with 30% depreciation and 20% inflation when the cooperation is lacking.

11.3. Unemployment and wages

One of the main stated advantage of exchange rate alignments is to clear any potential excess supply in the labor market due to nominal wage inflexibility, in the event of a negative shock. However, it should be noted that the need for such an adjustment is less pronounced when the shocks are transitory and anticipated, than would be the case if people are caught by surprise and are unable to save in advance to meet the temporary income shortfall. This evident from the multiple shock simulations. They reveal that a 20% transitory export price decrease at $t = 3$ results in $2 - 3\%$ unemployment if $\varepsilon \geq 0.25$ (compare e.g. figures 22e and 21e) which is a significantly lower rate than was earlier observed for 10% permanent price decrease (see figure 14f). In other words, the proposed benefit from an exchange rate adjustment in terms of preventing excess supply is less apparent when the shocks are temporary.

The exchange rate policy is unsuccessful in lowering the real wage if it is not supported by labor market agreement on halted nominal pay increases. In other words, since the unions foresee the currency alignment they will neutralize it with instant nominal wage increases as the devaluation occurs. The resulting change in the exchange rate will be larger (see figures 18d-24d) and the shock is felt more as a shift in the relative price of tradables versus non-tradables and less as an income shock. As the result, there is a greater substitution away from non-tradables and into tradables, possibly with some increase in unemployment during the three first periods leading up to the shock (see figure 19e). This is subsequently reversed after $t = 3$ and the increased demand for non-tradables after the devaluation is sufficient to sustain a labor market clearing with an almost unchanged real wage.On the other hand If the unions accept a nominal wage freeze, the real wage will drop sharply and the shock is felt mainly as a decrease in overall purchasing power.

12. Conclusion

If the conventional assumptions hold, the shocks are permanent and the exchange rate interventions are unanticipated, then familiar things appear with the incorporation of nominal wage constraints to the model. The export sector is the only source of disturbance in this economy and therefore it is sensible to make that sector the center of attention for monetary policy. The monetary authorities are able with interventions built on that premise to stabilize the labor market and the current account, without excessive inflationary consequences. When the shocks become multiple and anticipated, this picture is changed. The shocks do not affect employment as much because of their transitory nature. On the other hand, interventions in this shifting environment bring with them considerable side effects, which are highly dependent on the labor market structure. If the labor unions are not cooperative, they will demand instant nominal wage increases in response to anticipated exchange rate interventions, which effectively prevent the real wage from falling. In that case the labor market does clear in the event of a negative shock, but only after a massive devaluation, price increases and huge shift in the relative price of tradables versus non-tradables. An agreement with unions on a nominal wage freeze is the key to lowering the real wage and prevent excess inflation. However, the effects of such price controls are much wider than usually is acknowledged.

The agents will expect a short-lived but a large fall in the real wage towards the end of every economic upturn and they will use the temporary high purchasing power to stock up on imported goods to sustain consumption during the brief period of low purchasing power. As the result, savings incentives are reversed and signi…cant current account de…cits are observed in the wake of a positive export shock. This is in line with the Icelandic experience, where movements in the current account have been contrary to terms of trade shocks a¤ecting the country. Moreover, the application of this exchange rate policy combined with minimal nominal wage increases facilitates a drop in real wage that goes far below what is needed in order to clear the labor market and a considerable excess demand is observed. This feature of the of model bears a strong resemblance to the situation in Iceland from 1970-90, during which time excess demand for labor seems to have been quite chronic, as unemployment never rose above 2% for 20 years and stayed below 1% in most years. Thus it can be concluded that the model at this stage has a real ability to map out the underlying structural and behavioral dynamics the underwrite movements in Icelandic macroeconomic variables, and possible other small open economies.

Part III

Chapter three

12.1. Economic stability and …nancial ‡ows

In recent years there has been a growing trend towards capital account liberalization and integration of small open economies into world …nancial markets. According to classical economic theory, access to foreign capital should increase economic stability since economic agents are better able to adjust their assets in order to smooth consumption. However, at the same time, easier borrowing also translates into a more forceful inter-temporal substitution in response to expected changes in relative prices. Thus while counter-cyclical exchange rate policy and free capital transactions might work separately to promote economic stability, the combined results might be less advantageous and possibly counter-productive. Free capital transactions have been reputed to create economic volatility and it is an open question as to what goals exchange rate targeting, either explicit or implicit, can deliver under increasing …nancial mobility. In this third and …nal chapter I conduct the exact same policy experiments, analyzing the same export shocks in the same policy regimes; the only thing which di¤ers is that the capital account is now open

12.2. Capital transactions

In order to incorporate capital account transactions in the simplest possible manner, we will assume that world market interest rate r equals the time preference rate ½ to rule out in…nite borrowing. We will also assume that the government's foreign exchange reserves are invested in foreign bonds and that interest income from the bonds is rebated to the public in a lump sum fashion. Let F denote private sector holdings of foreign bonds, G the government's foreign exchange reserves and A the asset portfolio of the representative agent. Then we can write budget and wealth constraints as follows,

$$E = P_x Q_x + P_n Q_n - S + re(F + G); \tag{12.1}$$

$$A = M + eF: \tag{12.2}$$

Money creation depends on government reserve accumulation; from the central bank's balance sheet we have;

$$M = eG: \tag{12.3}$$

M is no longer predetermined since each agent can instantaneously swap M and F through capital account adjustments. It is the sum of the assets, M + eF; which is now predetermined since total foreign assets can only change by either current account surpluses or de…cits. Observe also that asset swaps do not change real income because variations in F and G are o¤setting at any given point in time. It should also be noted that exchange rate adjustments do not directly affect the money supply since variations in e only change the valuation of reserves accumulated earlier and do not affect M. We can therefore state the current account as,

$$S = e(G + \dot{F}). \tag{12.4}$$

Time differentiation of (12.2) yields an expression for the asset dynamics,

$$\dot{A} = \dot{M} + e\dot{F} + \omega eF; \tag{12.5}$$

where $\omega = \frac{\dot{e}}{e}$. If equations (12.4) and (12.5) are combined we simply obtain an expression stating that nominal wealth accumulation equals nominal savings plus capital gains or losses brought about by changes in the nominal exchange rate,

$$\dot{A} = S + \omega eF. \tag{12.6}$$

12.3. The optimization problem

The new optimization problem can be written as follows

$$\underset{\{E;S;F\}}{\text{Max}} \int \left[V(e; P_n; E) + \phi\left(\frac{M}{P}\right) \right] e^{-\rho t} dt$$

Subject to;

$$(12.1); (12.2) \text{ and } (12.6)$$

After substituting for E and M; we can write the Hamiltonian;

$$H = e^{-\rho t}\left[V(e; P_n; P_xQ_x + P_nQ_n - S + re(F + G)) + \phi\left(\frac{A - eF}{P}\right) + \mu(S + \omega eF) \right]$$

The first order conditions are

$$V_E(e; P_n; P_xQ_x + P_nQ_n - S + re(F + G)) = \mu; \tag{12.7}$$

$$r + \omega = \frac{\phi'}{PV_E}; \tag{12.8}$$

The co-state equation reads,

$$\dot{\mu} = \rho\mu - \frac{\phi'}{P};$$

$$\Rightarrow \dot{\mu} = (\rho - r - \omega)V_E = -\omega V_E \tag{12.9}$$

Now if we combine the budget constraint (12.1) and nominal asset changes (12.6) we obtain the following description of the current account dynamics;

$$S = \dot{A} - \omega eF = P_xQ_x + P_nQ_n + re(F + G) - E \tag{12.10}$$

Furthermore, with the aid of (12.5) we can write;

$$\dot{M} + e\dot{F} = P_xQ_x + P_nQ_n + re(F + G) - E \tag{12.11}$$

Finally if we differentiate the Central Bank's balance sheet identity (12.3) we can substitute for $e\dot{G}$ and obtain a solution for the current account measured in foreign currency;

$$\dot{G} + \dot{F} = \frac{1}{e}(P_xQ_x + P_nQ_n + re(F + G) - E) \tag{12.12}$$

13. Permanent shocks

When capital controls were in place, cash balances were the only asset available as a vehicle for savings. Consequently, dissaving, led to lower money holdings and rising opportunity costs stemming from foregone transaction services. However, under perfect capital mobility, the interest rate is fixed. The private agent has the option of holding foreign bonds and the use of money as an asset becomes secondary to transaction services it provides. Money demand and expenditure will therefore tend to move in same direction since dissaving implies a higher expenditure and increasing numbers of transactions and vice versa. Moreover, since the private agents can instantaneously swap M and F, there is nothing to prevent instantaneous adjustment to a new equilibrium in response to an external change. Intuition therefore suggests that permanent changes in the export price will lead to an immediate adjustment of choice variables in line with either a gain or loss in real income without affecting savings or the current account balance.

To verify that this is indeed the right solution, suppose that μ jumps immediately to its new steady state level and stays there throughout the adjustment process. Since $\omega = 0$ (e jumps at $t = 0$ but does not change thereafter), equation (12.9) then implies that $\dot{\mu} = 0$. Given this, (12.7) and the market clearing condition for the non-tradables sector must imply that the paths E and P_n are flat after an instant reaction to the change in the export price. Equation (12.11) then states that the current account only remains at zero if $d(\frac{E}{e}) = Q_x dP_x^*$. In other words, since the change in the export price is discrete and final the change in the exchange rate must also be discrete and final. After this line of reasoning it is clear that according eq. (12.8) the path of M will stay flat after an initial jump.

We can therefore conclude that a capital account liberalization will only alter the speed of adjustment since the stationary equilibrium is determined by economic fundamentals and external conditions. The variables in question E, e, P_n, F and M will just jump from one stationary equilibrium to the next in response to external changes without any transitional dynamics.

14. Temporary shocks

14.1. Transitional dynamics

When the shocks are transitory the variables are not tied down by economic fundamentals and policy expectations can influence spending and savings decisions. However, the same logical reasoning previously applied for permanent shocks can be used to determine the transitional dynamics. If $\omega = 0$ then according to eq. (12.9) the multiplier μ is constant over the entire time horizon after a possible jump at $t = 0$. Given that, the first order condition (12.7) clearly dictates that the paths of E, P_n and e are flat apart from instantaneous and discrete reactions to changes in P_x^*. Equation (12.8) establishes the same result for M. This discreteness simplifies the current account dynamics. If we time differentiate the budget constraint (12.1) we obtain,

$$\dot{S} = re(\dot{F} + \dot{G}). \tag{14.1}$$

Furthermore, if we use the Central bank's balance sheet (12.3) to substitute for $e\dot{G}$ and the expression for the current account balance (12.4) then the following first order differential equation emerges which describes the path of the savings rate:

$$\dot{S} = r(e\dot{F} + \dot{M}) = rS. \tag{14.2}$$

The general solution to (14.2) can be written as follows;

$$S(t) = ce^{rt} \tag{14.3}$$

Where c is an arbitrary constant which has to be determined by the initial conditions. Given the three exogenous shocks, the time path is marked by three distinct intervals with t_1 and t_2 as the dividing points. Each interval is defined by its own restrictions and therefore the solution in (14.3) applies with three different arbitrary constants:

14.2. Solving for the path of savings

It can first be observed that since the final shock at $t = t_2$ is permanent S must be zero after that point in time as other variables jump to a new steady state. Therefore we can write the equations defining the three intervals as follows

$$S(t) = c_1 e^{rt}; \ 0 \leq t \leq t_1 \tag{14.4}$$

$$S(t) = c_2 e^{rt}; \ t_1 \leq t \leq t_2 \tag{14.5}$$

$$S(t) = 0, \ t_2 \leq t \tag{14.6}$$

The three paths are connected by jumps in S which are caused by export price shocks. These jumps can be used to establish the restrictions that are necessary to pin down the values of the arbitrary constants c_1 and c_2, that is by specifying the relationship between the three equations at the dividing points t_1 and t_2. Let Γ denote the parameter defining the reduced form relationship between changes in S and P_x^*, i.e. $\frac{dS}{E} = \Gamma \hat{P}_x^*$. An explicit solution for Γ can be determined from the first order conditions, keeping in mind that the sum of F and G is predetermined and the multiplier μ remains fixed after a possible jump in the initial period. Total differentiation of (12.7) yields the following relationship at $t = t_2$;

$$V_{EP_m}de + V_{EP_N}dP_n + V_{EE}\left[Q_x dP_x + Q_n dP_n - dS + r(F+G)de\right] = 0 \qquad (14.7)$$

Roy's identity can be used derive the relationship $\frac{V_{EPm}}{V_{EE}Q_i} = \nu_i \tau - 1$; where τ is the elasticity of inter-temporal substitution ($\tau = \frac{V_E}{V_{EE}E}$) and υ_i is the income elasticity of good i: ($\nu_i = \frac{\partial D_i}{\partial E}\frac{E}{D_i}$). If we assume unitary income elasticities of demand, i.e. $\nu_i = 1$, then (14.7) can be written as:

$$V_{EE}E\left[(\tau - 1)\gamma_n \hat{P}_n + (\tau - 1)\gamma_m \hat{e} + \alpha_x \hat{P}_x + \gamma_n \hat{P}_n - \frac{dS}{E} + \frac{er(F+G)}{E}\hat{e}\right] = 0 \qquad (14.8)$$

To substitute for the term $er(F+G)$; we can use the initial steady state identity for the current account equilibrium;

$$P_m D_m - P_x Q_x = re(F+G) \qquad (14.9)$$

Or expressed as a ratio of current expenditure,

$$\gamma_m - \alpha_x = i \qquad (14.10)$$

Where i is the ratio of foreign interest payments to expenditure, i.e. $i = \frac{re(F+G)}{E}$. If the net foreign position is positive then the interest revenue will allow the representative agent to consume more imported goods than the corresponding exports and $\gamma_m > \alpha_x$. If the country is indebted, the reverse holds true. Using (14.10) and substituting for $\hat{e}$ from the policy rule we can simplify (14.8) as

$$(\gamma_n + \gamma_m Z\theta_L^x)\,\tau \hat{P}_n + (\alpha_x - \tau\gamma_m Z)\,\hat{P}_x^* = \frac{dS}{E} \qquad (14.11)$$

The solution for $\hat{P}_n$ can be found by combining the budget constraint (12.1), eq. (14.9) and the market clearing condition for non-tradables;

$$\hat{P}_n = \frac{(\alpha_x - \varepsilon Z)\hat{P}_x^* - \frac{dS}{E}}{\varepsilon(1 - Z\theta_L^x)} \tag{14.12}$$

In the same way, a solution can be found for changes in expenditure

$$\hat{E} = \frac{[\alpha_x(\varepsilon + \gamma_n) - Z\varepsilon + (\gamma_m - \varepsilon)\alpha_x Z\theta_L^x]\hat{P}_x^* - (\gamma_n + \varepsilon + (\gamma_m - \varepsilon)Z\theta_L^x)\frac{dS}{E}}{\varepsilon(1 - Z\theta_L^x)} \tag{14.13}$$

Finally if we combine (14.11) and (14.12) we have a solution for Γ;

$$\frac{dS}{E} = \Gamma\hat{P}_x^* \tag{14.14}$$

Where,

$$\Gamma = \alpha_x - Z\frac{\tau\varepsilon}{\varepsilon(1 - Z\theta_L^x) + \tau(\gamma_n + \gamma_m Z\theta_L^x)}$$

At this point we have enough information to solve for c_1 and c_2. When $t = t_2$, the difference between the savings rate reported by equations (14.5) and (14.6) immediately before and after the export price shock occurs must equal the jump in S in response to the shock:

$$S(t_2^+) - S(t_2^-) = \Gamma E\hat{P}_x^* \tag{14.15}$$

Since $S(t_2^+) = 0$ and $S(t_2^-) = c_2 e^{rt_2}$; (14.15) implies that;

$$c_2 = -e^{-rt_2}\Gamma E\hat{P}_x^* < 0 \tag{14.16}$$

The export price shock at t_1 has been defined to be the double negative sum of the shock occurring at t_2 and the jump in the savings rate at t_2 is therefore $-2\Gamma\hat{P}_x^*$: Thus we can determine c_1 by using the analogous relationship between the jump and constants c_1 and c_2 at t_1;

$$S(t_1^+) - S(t_1^-) = -2\Gamma E\hat{P}_x^* \tag{14.17}$$

$$\Rightarrow c_2 e^{rt_1} - c_1 e^{rt_1} = -2 - E\hat{P}_x^* \quad (14.18)$$

Now by substituting in for c_2 we have a solution for c_1;

$$-\left[-\hat{P}_x^* e^{-rt_2} + c_1\right] e^{rt_1} = -2 - E\hat{P}_x^* \quad (14.19)$$

$$\Rightarrow c_1 = \left[2 - e^{r(t_1 - t_2)}\right] e^{-rt_1} - E\hat{P}_x^* > 0 \quad (14.20)$$

As the shocks become more persistent the absolute value of the constants get smaller. At the extreme, when $t_1; t_2 \to \infty$ then $c_1 = c_2 = 0$ and the current account dynamics disappears.

14.3. The transition path

14.3.1. Current account dynamics

Utility optimization in the non-interventionist regime is purely a problem of consumption smoothing under real income volatility. The shocks are temporary, symmetric and do not affect permanent income in a significant way. In the case of a current positive shock and future negative shock, the current account dynamics is characterized by surpluses and accumulation of foreign assets, which are then symmetrically reversed during the adverse period. It is therefore optimal to save the entire early income gain to completely meet the later shortfall in revenue. Thus, the temporary income changes cancel each other out and consumption remains unchanged. This response is invariant to substitution patterns. In fact, apart from the external variables; r and P_x^*; the only relevant variables in a non-interventionist regime are the openness of the economy γ_m and shock duration, since $- = \alpha_x$ when $Z = 0$.

In the interventionist regime the agents anticipate exchange rate adjustments and relative price changes. This weakens the incentive to save prior to an adverse shock to income, since the relative price of imported goods is much cheaper in the current period than in the future. It is clear from eq. (14.14) that as long as $\tau > 0$ and $\varepsilon > 0$; the savings response is more pro-cyclical in non-interventionist regime, i.e. $\Gamma_{non-intervention} > \Gamma_{intervention}$: A closer look at (14.14) also reveals the savings response can be qualitatively different, i.e. negative, given certain range in parameter values. In other words, the current account worsens in the wake of a favorable price shock if,

$$\alpha_x < \frac{\tau\varepsilon}{\varepsilon(1 - \theta_L^x) + \tau(\gamma_n + \gamma_m\theta_L^x)} \tag{14.21}$$

To simplify sufficiency condition (14.21) it is useful to express the demand elasticity, ε, in terms of elasticity of substitution, β. Since there are only two goods that enter the demand function and we have assumed homothetic preference we can write the own price elasticity as

$$\varepsilon = \beta\gamma_m. \tag{14.22}$$

where β is the elasticity of substitution,Thus we can write sufficiency condition (14.21) as

$$\frac{\tau}{(1 - \theta_L^x) + \frac{\tau}{\beta}\left(\frac{\gamma_n}{\gamma_m} + \theta_L^x\right)} > \alpha_x \tag{14.23}$$

In the benchmark case when $\tau = \beta$

$$\tau > \frac{\alpha_x}{\gamma_m} = 1 - \frac{\Gamma}{\gamma_m}; \tag{14.24}$$

as $\alpha_x = \gamma_m + \Gamma$

14.3.2. Price dynamics

Given the fixed nominal expenditure in the non-interventionist regime, prices must also be constant. This conclusion is confirmed by the explicit solution for the non-tradable price change at the three given time points;

at t_0

$$\hat{P}_n|_{t=0} = \frac{(\alpha_x - \varepsilon Z) - \left[2 - e^{r(t_1 - t_2)}\right] e^{-rt_1} -}{\varepsilon(1 - Z\theta_L^x)} \hat{P}_x^*; \tag{14.25}$$

at t_1

$$\hat{P}_n|_{t=0} = \frac{(\alpha_x - \varepsilon Z) + e^{-rt_2}}{\varepsilon(1 - Z\theta_L^x)} - \hat{P}_x^*; \tag{14.26}$$

and at t_2

$$\hat{P}_n|_{t=0} = 0. \tag{14.27}$$

14.3.3. The capital account

Since nominal money balances are constant while P_x^* is constant, the capital account is equal but opposite in sign to the current account over the intervals $(0; t_1)$ and $(t_1; t_2)$. There are discrete changes in capital account balances, however, at $t = 0$, t_1 and t_2 when changes in the export price and the exchange rate induce the private agent to swap foreign bonds for domestic money or vice versa. To determine the impact on capital flows at these three dates, differentiate the first order condition (12.8) and solving for the change in money holdings,

$$d\omega = \frac{1}{V_E}\left[\frac{\phi''}{P}\frac{M}{P}\left(\hat{M} - \hat{P}\right) - \frac{\phi'}{P}\hat{P} - \frac{\phi' V_{EE} E}{V_E^2 P}(\tau - 1)\left(\gamma_m \hat{e} + \gamma_n \hat{P}_n\right) + \hat{E}\right]; \tag{14.28}$$

where ω is now interpreted as the foreseen percentage change in the exchange rate at times t1 and t2 ($\omega = \frac{e(t_1^+) - e(t_1^-)}{e(t_1^-)}$ at t_1, for example). As before $\frac{\phi''}{\phi'}\frac{M}{P}\frac{V_E}{V_{EE}E} = 1$ under the assumption that the elasticity of money demand with respect to expenditure equals unity. Given this and the facts that $\hat{P} = \gamma_m \hat{e} + \gamma_n \hat{P}_n$ and $\frac{\phi'}{\rho V_E} = r$, the solution in (14.28) simplifies drastically to

$$\hat{M}|_{t=0} = \hat{E}|_{t=0} \tag{14.29}$$

$$\hat{M}|_{t=t_j} = \hat{E}(t_j) - \frac{\tau}{r}\hat{e}(t_j); \; j = 1; 2 \tag{14.30}$$

Higher expenditure, of course, calls for an increase in transaction services rendered by cash balances. On the other hand, money holdings are also determined by the rates of return from other alternative investments. The term $\frac{\hat{e}(t_j)}{r}$ is in effect the percentage change in the rate of return for foreign assets, as the result of exchange rate adjustments. Thus, the interest elasticity of money demand is equal to the elasticity of intertemporal substitution; ¿: World market interest rates are usually in the single digits and exchange rate adjustments can sharply alter relative returns and be a cause of signi…cant portfolio adjustments. Changes in money holdings are therefore likely to be dominated by variation in the rate of return on foreign assets in domestic currency, unless ¿ is very small.

15. Simulations

15.1. Parameter values

The simulations will use Icelandic structural parameters, to the degree that they are known. There is uncertainty about the precise values of the two demand parameters; the compensated demand elasticity " and the elasticity of inter-temporal substitution ¿; and they are therefore allowed to vary within a given range. Iceland's foreign asset position is negative. Net foreign debts are about 60% of GDP and they bear on average 6 ¡ 7% interest in annual terms. Foreign interest payments therefore amount to about 3 ¡ 4% of GDP in each year. The shock sequence is the same as before. Initially, there are three years in which the export price is 10% higher than equilibrium value and another three years follow when $P_x^{¤}$ is 10% below the same value before there is return to normalcy at $t = 6$.

Parameter name	Notation	Value
Consumption share; imported goods	$°_m$	40%
Consumption share; non-tradable goods	$°_n$	60%
Labor cost ratio in the export sector	$µ_L^x$	40%
The ratio of highpowered money to E	$\frac{M}{E}$	15%
Time preference rate	½	7%
The elasticity of intertemporal substitution	¿	0.1-0.8
Cross price elasticity	"	0.15-0.75
Elasticity of substitution	¯	0.38-1.88
The ratio of exports to expenditure	$®_x$	43.5%
Net foreign asset position as % of E	$\frac{F+G}{E}$	-50%
World market interest rate	r	7%
Ratio of foreign interest payments to E	i	-3.5%

The initial foreign asset position at $t = 0$ will a¤ect the consumption level of imported goods, but has no direct impact on the dynamics of the main variables, $\hat{E}$, $\hat{P}_n$, $\hat{M}$ or $\hat{e}$. The net foreign interest payments constitute a …xed factor in the consumer budget and capital account, which does not otherwise a¤ect savings decisions.

15.2. Current account dynamics

In the non-interventionist regime, the export shocks are just temporary income changes, with no e¤ect on prices or expenditure. Simulation results are therefore considerably simpli…ed since the two demand parameters, " and ¿; do not a¤ect saving decisions. However, given the …xed choice of other parameters, the current account is characterized by a trade surplus, which accumulated over three years amounts to 14:5% of GDP. However, after the adverse shock hits a de…cit appears which is symmetric to the surplus previously observed.

In the interventionist regime, the agents will have a devaluation on their mind as well as future income loss when they make decisions. A greater degree of substitution, whether between goods or time periods, will weaken the incentive to save during the three first years in order to prepare for negative export price shock, which both constitutes an income loss as well as a change in relative prices. However, unless substitutability is zero ($\varepsilon = 0$ or $\tau = 0$), the trade surplus in the three first years is always lower than in the non-interventionist regime. The current account dynamics are characterized in terms these two parameters, in table 1.

Table 1	
Parameter values	Current account balance in the first year (as % of E)
$\tau\varepsilon < 0.04$ or $\beta\tau < 0.1$	2% < surplus
$0.04 < \tau\varepsilon < 0.2$ or $0.1 < \beta\tau < 0.5$	$1 - 2\%$ surplus
$0.2 < \tau\varepsilon < 0.3$ or $0.5 < \beta\tau < 0.75$	$0 - 1\%$ surplus
$0.3 < \tau\varepsilon < 0.6$ or $0.75 < \beta\tau < 1.5$	$0 - 2\%$ Deficit
Range; $0.1 < \tau < 0.8$; $0.15 < \varepsilon < 0.75$ or $0.375 < \beta < 1.875$	

The simulations display that the exchange rate policy will promote greater current account stability, given the parameter range, though at the expense of a higher variability of consumer expenditure. Moreover, if the degree of substitutability is moderately large (i.e. $0.3 < \tau\varepsilon$) then the there is a qualitative difference in the current account between the two regimes, as trade deficit is observed in the interventionist case and consumption thus becomes more volatile than income.

15.3. The capital account and the balance of payments

When the capital account was closed and cash was the only financial asset available, saving as well dissaving was discouraged since changes in money holdings incurred rising opportunity costs. Swift variations in the current account could occur, although an imbalance would never persist since the cost of holding either too much or too little cash, given the expenditure level, was too large. Therefore, when a negative income shock was expected, a trade surplus or deficit would emerge at a small scale and then rapidly built up to reach a peak just before the shock. When foreign bonds are available at fixed rate of interest, changes in asset holdings are much less costly and a current account imbalance becomes much more persistent. Otherwise, the implications of free capital transactions differ widely between the two regimes.

In the non-interventionist regime, changes in foreign bond holdings are just a mirror image of the current account dynamics, as money holdings remain unchanged. The agent will save in anticipation of a temporary shortfall in income and accumulate foreign assets and therefore a trade surplus appears, totalling 14:5% of GDP during the three first years, which will improve the foreign asset position. However, after the shock has occurred at $t = 3$; foreign bonds are sold off to finance current account deficits which mirror the surpluses in periods before, and maintain a fixed level of consumption during the three adverse years, until the former equilibrium level in foreign asset holdings has been reached. The overall balance of payments remains unchanged in the non-interventionist regime since none of these flows will affect government reserves or nominal money holdings.

In the interventionist regime, the option of trading foreign assets will increase the likelihood of persistent current account deficits in the wake of a positive export price shocks. Therefore, ceterus paribus, free capital transactions can increase demand volatility since inter-temporal substitution is encouraged. However, current account variations are minor disturbance to balance of payments in the interventionist regime compared with the incentive for arbitrage trading between foreign and domestic assets that exchange rate alignments create. This is essentially a frictionless economy, and the resulting asset changes can be quite dramatic. Tables 2a-2c list the elasticity of money demand with regard to export price changes at the three time periods in question, t_0, t_1 and t_2.

Table 2a:Elasticity of money demand, $\frac{\hat{M}}{\hat{P}_x^{¤}}$ at t_0					
°$_m$ = 0:4	" = 0:75	" = 0:65	" = 0:45	" = 0:25	" = 0:05
¿ = 0:8	0.142	0.130	0.103	0.0656	0.0157
¿ = 0:65	0.278	0.257	0.206	0.135	0.0334
¿ = 0:45	0.520	0.488	0.404	0.279	0.0739
¿ = 0:25	0.879	0.840	0.733	0.534	0.1705
¿ = 0:1	1.283	1.255	1.170	0.996	0.4245

Table 2b:Elasticity of money demand, $\frac{\hat{M}}{\hat{P}_x^{¤}}$ at t_1					
°$_m$ = 0:4	" = 0:75	" = 0:65	" = 0:45	" = 0:25	" = 0:05
¿ = 0:8	2.917	2.804	2.489	1.873	2.092
¿ = 0:65	2.587	2.48	2.183	1.600	2.017
¿ = 0:45	2.170	2.075	1.804	1.267	1.904
¿ = 0:25	1.793	1.78	1.489	1.012	1.749
¿ = 0:1	1.560	1.509	1.347	0.968	1.493

Table 2c:Elasticity of money demand, $\frac{\hat{M}}{\hat{P}_x^{¤}}$ at t_2					
°$_m$ = 0:4	" = 0:75	" = 0:65	" = 0:45	" = 0:25	" = 0:05
¿ = 0:8	2.526	2.441	2.175	1.565	2.939
¿ = 0:65	2.160	2.057	1.758	1.185	2.133
¿ = 0:45	1.865	1.768	1.513	1.118	1.743
¿ = 0:25	1.693	1.614	1.420	1.227	1.306
¿ = 0:1	1.612	1.550	1.421	1.361	1.740

The tables indicate well the implication exchange rate expectations. At t_0 (table 2c) the exchange rate change is unanticipated and the change in money demand is determined by changes in expenditure. However, at t_1, the exchange rate appreciation is anticipated and the private agents will swap domestic currency for foreign bonds and therefore much higher elasticities are observed (table 2b). It should be noted again that the interest elasticity of money demand is equal to ¿; the elasticity of inter-temporal substitution. Therefore, the sensitivity of money demand towards export price changes and resulting exchange rate adjustments will thus be hugely a¤ected by higher values of ¿. This highlights the importance of maintaining foreign exchange reserves, although in the this experiment the task is made easier by the fact that a large in‡ow will precede the out‡ow.

15.4. Price changes

When the exchange rate is …xed and capital movements are free, complete price stability is achieved. That is a signi…cant improvement from the earlier case of closed capital account. Greater price stability is also achieved in the interventionist regime, in all cases (see tables 4a-4d) unless the degree of substitutability becomes very high, i.e. "¿ > 0:5. Prices become more stable because free capital transactions make it less costly to move income back and forth in time. The agents are able, by trading foreign bonds, to steer their purchases away from periods where prices are expected to be high. Thus, the budget constraint within in the period becomes less binding for consumers' decisions and the spikes in the price level are signi…cantly reduced. In this sense, demand becomes more autonomous or self-regulating with the aid of foreign funds. This, however, also implies that current policy actions become less e¤ective in controlling demand or pushing against in‡ation using the exchange rate. In fact, the simulation results con…rm that if cross price elasticity is su¢ciently low then exchange rate appreciation will actually lead to increases in the price of non-tradable goods.

16. Extensions;openness

16.1. Exposure to foreign trade

Imports constitute about 40% of GDP in Iceland and are for the most part, goods for …nal consumption. This ratio of imports to total output may be larger in gross terms in other relatively small countries, although in most cases a large fraction of that trade is in intermediates or half-…nished goods meant for re-export rather than …nal consumption. However, for various reasons, many resource based small economies are relatively closed to foreign trade. This may be because such economic systems are prone to get infected by the Dutch disease whose symptoms are displayed as a diminished share of foreign trade relative to GDP. In the less developed countries trade restrictions or policies aimed at import substitution have in the past repressed consumption of imported goods. In any case, it is likely that foreign trade shares will be increasing in most countries in the near future, whether the reason is the liberalization of trade in the respective country or just the fact that the growth of foreign trade has exceeded economic growth in the vast majority of world's economies in the last decade. Therefore, it is worth considering the implications of di¤erent degrees of openness for monetary policy. Higher trade shares may, as McKinnon (1963) has maintained, lead to a weaker but more distortionary e¤ects of monetary policy. In light of this, the model will be re-calibrated with the share of imports equal to 15% of total GDP, as opposed to 40% before.

16.2. Current account dynamics

As the trade shares are smaller, the real income e¤ect of export price shocks will of course decrease. The implication is very clear cut in a non-interventionist regime; less counter-cyclical savings variation is needed to stabilize consumption. The same symmetric shock sequence (three years when the export price is 10% above average followed by another three years when it is 10% below average) results in a 5:4% accumulated positive trade balance over the three …rst years when the imports share is a mere 15%, compared with 14:5% before when imports constituted about 40% of GDP.

The outcome in the interventionist regime is more complicated and is reported in tables 5a-5d. Since the income e¤ects of the shock are much reduced, the expected relative price change can potentially have a greater e¤ect. Although at the same time, the possibility of cross substitution must be more limited since imports constitute a much smaller portion of the consumer budget. The elasticity of substitution is directly proportional to the import share, i.e. $\epsilon = \beta\gamma_m$; and it is doubtful that the cross price elasticity, ϵ; between the two goods can be presumed to be large when γ_m is small. However, even when correcting for that and assuming the same value for the elasticity of substitution, the simulations clearly show that there is a greater tendency to dissave in the wake of a transitory positive shock as the national economy is more closed. Therefore, it is likely that a rapid liberalization which is followed by exchange rate variations may lead to greater demand volatility. The portfolio choice between money and foreign bonds is not much affected by a smaller trade share, as would be expected. Although, a lower income variation means that the sensitivity of money demand towards changes in the foreign rates of return is increased.

16.3. Price dynamics

Given the same level of cross price elasticity, ϵ, it is clear that price volatility will increase as the economy gets more closed, as is clear from table 6a-6d.. However, that may be an unreasonable comparison given the vastly different implication for 15% trade versus 40% trade share for cross price substitution.. If we correct for the different trade share and make the comparison in terms of the elasticity of substitution, then the result appears that price volatility will actually decrease by a factor of 1 or 2. This is perhaps not surprising. Exchange rate policy will have a less direct effect on the national economy if its main lever, the price of foreign goods in domestic currency, has a little weight in consumer decisions. Thus, an appreciation will be less effective in decreasing demand for non-tradables or keeping the price level down. On the other hand, the possible adverse effects are also reduced. Since there is a very low likelihood that a temporary appreciation can actually inflationary.

17. Conclusion

The conclusion is that capital account liberalization will stabilize the economy in a non-interventionist regime as predicted by classical economic theory since economic agents are better able to smooth their consumption by adjusting their assets to meet temporary disturbances in income. The outcome is more mixed in the interventionist regime. Overall, an open capital account has four major implications in this model. First, the speed of an adjustment will be faster since the agents can instantaneously adjust both expenditure and money balances. Second, the current account volatility will increase and be more persistent. In the case of a non-interventionist regime, the consequence is complete demand stability. In interventionist regime, the increased likelihood and greater persistence of a trade deficit prior to a negative shock have the potential of actually increasing demand fluctuations. Third, the counter-cyclical pull of policy interventions on the price level will be weakened because it is less costly to move income in time. Consumers will therefore be more sensitive to anticipated price changes and the degree of inter-temporal elasticity becomes more relevant for agents' decisions. In fact, given a sufficiently high degree of inter-temporal substitution and low degree of cross substitution, exchange rate appreciation in the wake of a transitory positive shock will actually lead to inflation in the price of non-tradable goods. The fourth and final implication is that exchange rate interventions run the risk of causing huge portfolio adjustments between domestic and foreign assets, with the corresponding out-or inflow of foreign funds. These results are well in line with the "hot-money" problems which many countries have experienced after capital account liberalization.

If the simulations are repeated assuming smaller trade shares, the effect of the exchange rate policy on prices will be more muted. This is as expected since the exchange rate will less directly affect consumer demand. What is surprising is that the potential current account problems in terms of a pro-cyclical trade deficits are likely to become worse. This occurs since the income e¤ect of a negative shock will decrease, there is a greater incentive to dissave before the devaluation occurs.

18. Conclusion

This thesis provides a rational explanation for the observed tendency of many resource based economies to embark on a "consumption binge" in the wake of a transitory positive terms-of-trade shock, even though the rationale of consumption smoothing should give an incentive for increased savings prior to an anticipated lower income in the future. There is no speci…c reason to expect the foreign shocks a¤ecting small open economies to have permanent e¤ects. Indeed, most of the supply shocks a¤ecting small countries are variations in the terms of trade, perhaps caused by demand changes in larger economies. When the shocks are temporary, spending and savings decisions are not tied down solely by economic fundamentals; they also depend on policy expectations. Therefore, in a monetary regime bent on short-term stabilization, a transitory positive shock is seen as a signal of current appreciation and future devaluation. Thus, savings incentives are reversed, pro-cyclical demand volatility is increased, an inverse relationship between the current account balance and terms-of-trade appears and exchange rate interventions display a strong in‡ationary bias.

The thesis also indicates that free capital movements might in e¤ect make short-term stabilization infeasible in the classic Keynesian sense, or at least exacerbate its side e¤ects, especially if the degree of intertemporal substitution is high. On the other hand, free capital movements o¤er the private sector an increased opportunity for smoothing consumption through borrowing on foreign …nancial markets, if international transactions are secured with a …xed exchange rate.

The calibration with Icelandic parameters provides results that mimic the cyclic behavior of the Icelandic economy in many crucial aspects, as described above. In the model that features delayed labor market clearing and consensus nominal wage freeze of the labor unions in response to devaluations, (common in Iceland) the above dynamics exacerbated and chronic excess demand in the labor market is observed. This could at least partly explain why 30-40% in‡ation rate and 1% unemployment rate prevailed for two decades 1970-1990. Furthermore, comparison with the benchmark case of a …xed exchange rate and non-intervention also reveals that the country could have been better o¤ in terms of demand stability without short-term stabilization policies. And, as a matter of a fact, the country moved towards …xing the exchange rate in 1990 and hence lowering the in‡ation rate to single digits. Further research is needed before a similar policy recommendation is made for other resource based economies, though this could give an indication of the issues at hand in other countries with similar structure, including many less developed economies.

Many extensions can be considered for a further research. Relatively modest changes can be made to increase the realistic appearance of the model. First, by imposing a delayed labor market on the case of open capital account. Second, a more thorough insight can be obtained of the demand dynamics by including capital in production relations and investment spending in aggregate demand. Most capital goods are imported in small open economies, and thus the e¤ect of expected exchange rate movements on investment could be substantial. Third, by allowing for durable goods it is likely the potential incentive for acceleration of consumer purchases is increased. In addition, the research can be extended to include welfare analysis of the micro costs associated with the excess ‡uctuations.

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Tables 4a-4 Accumulative price changes in an exchange rate regime

Table 4a. Accumulative price changes, intervention					
¿ = 0:8		$\frac{\hat{P}_n}{\hat{P}_x^*}$		$\frac{\hat{P}}{\hat{P}_x^*}$	
		Capital account:		Capital account:	
"	Time	Open	Closed	Open	Closed
0:15	t_0 ¡ t_1	0.024355	-0.1088	-0.02149	-0.12267
	t_1 ¡ t_2	-0.04871	0.6596	0.04298	0.5813
	t_2 ¡ 1	0.024355	0.34654	-0.02149	0.2234
0:25	t_0 ¡ t_1	0.009235	-0.06221	-0.03298	-0.08728
	t_1 ¡ t_2	-0.01847	0.10135	0.06596	0.2244
	t_2 ¡ 1	0.009235	0.08507	-0.03298	0.02465
0:45	t_0 ¡ t_1	-0.0148	-0.02738	-0.05125	-0.06081
	t_1 ¡ t_2	0.0296	0.01746	0.1025	0.09326
	t_2 ¡ 1	-0.0148	-0.02661	-0.05125	-0.06085
0:75	t_0 ¡ t_1	-0.04064	-0.02167	-0.07089	-0.05647
	t_1 ¡ t_2	0.08128	0.01620	0.1418	0.09231
	t_2 ¡ 1	-0.04064	-0.05565	-0.07089	-0.08145

Table 4b. Accumulative price changes, intervention					
¿ = 0:65		$\frac{\hat{P}_n}{\hat{P}_x^*}$		$\frac{\hat{P}}{\hat{P}_x^*}$	
		Capital account:		Capital account:	
"	Time	Open	Closed	Open	Closed
0:15	t_0 ¡ t_1	0.01884	-0.0813	-0.02569	-0.1018
	t_1 ¡ t_2	-0.03767	0.6728	0.05137	0.5913
	t_2 ¡ 1	0.01884	0.3253	-0.02569	0.2098
0:25	t_0 ¡ t_1	0.001553	-0.07174	-0.03882	-0.0945
	t_1 ¡ t_2	-0.003106	0.2119	0.07764	0.2410
	t_2 ¡ 1	0.001553	0.07611	0.07764	0.0168
0:45	t_0 ¡ t_1	-0.02487	-0.05065	-0.0589	-0.0784
	t_1 ¡ t_2	0.04974	0.05102	0.1178	0.1188
	t_2 ¡ 1	-0.02487	-0.02123	-0.0589	-0.0561
0:75	t_0 ¡ t_1	-0.05191	0.02586	-0.07945	-0.08088
	t_1 ¡ t_2	0.1038	0.05457	0.1589	0.1215
	t_2 ¡ 1	-0.05191	-0.05899	-0.07945	0.00904

Table 4c. Accumulative price changes, intervention					
¿ = 0:45		$\frac{\hat{P}_n}{\hat{P}^*_x}$		$\frac{\hat{P}}{\hat{P}^*_x}$	
		Capital account:		Capital account:	
"	Time	Open	Closed	Open	Closed
0:15	t_0 ¡ t_1	0.01064	-0.04943	-0.03191	-0.07757
	t_1 ¡ t_2	-0.02128	0.6900	0.06382	0.6044
	t_2 ¡ 1	0.01064	0.2934	-0.03191	0.1829
0:25	t_0 ¡ t_1	-0.00943	-0.08604	-0.04717	-0.1054
	t_1 ¡ t_2	0.01887	0.2417	0.09434	0.2637
	t_2 ¡ 1	-0.00943	0.06982	-0.04717	0.01306
0:45	t_0 ¡ t_1	-0.03846	-0.08623	-0.06923	-0.1055
	t_1 ¡ t_2	0.07692	0.09448	0.13846	0.1518
	t_2 ¡ 1	-0.03846	-0.02853	-0.06923	-0.06168
0:75	t_0 ¡ t_1	-0.06627	-0.09209	-0.09036	-0.1100
	t_1 ¡ t_2	0.13253	0.10124	0.18072	0.15694
	t_2 ¡ 1	-0.06627	0.006822	-0.09036	-0.09038

Table 4d. Accumulative price changes, intervention					
¿ = 0:25		$\frac{\hat{P}_n}{\hat{P}^*_x}$		$\frac{\hat{P}}{\hat{P}^*_x}$	
		Capital account:		Capital account:	
"	Time	Open	Closed	Open	Closed
0:15	t_0 ¡ t_1	-0.01786	0.01393	-0.05357	-0.02941
	t_1 ¡ t_2	0.03572	0.7400	0.10714	0.6424
	t_2 ¡ 1	-0.01786	0.2206	-0.05357	0.1277
0:25	t_0 ¡ t_1	-0.04412	-0.1332	-0.07353	-0.1413
	t_1 ¡ t_2	0.125	0.3275	0.14706	0.3289
	t_2 ¡ 1	-0.04412	0.04014	-0.07353	0.01567
0:45	t_0 ¡ t_1	-0.0761	-0.17356	-0.09782	-0.1719
	t_1 ¡ t_2	0.1522	0.2041	0.1956	0.2351
	t_2 ¡ 1	-0.0761	-0.04525	-0.09782	-0.07439
0:75	t_0 ¡ t_1	-0.10156	-0.1766	-0.1172	-0.1164
	t_1 ¡ t_2	0.20312	0.2071	0.2344	0.2374
	t_2 ¡ 1	-0.10156	-0.0860	-0.1172	-0.1053

Tables 5a-5d The accumulated current account balance during the three …rst years as % of GDP

The accumulated current account balance during the three first years as % of GDP				
$\tau = 0.8$			Share of imports in GDP	
ε	$\beta/\gamma_m = 0.4$	$\beta/\gamma_m = 0.15$	$\gamma_m = 40\%$	$\gamma_m = 15\%$
0.05	0.13	0.33	0.1240	0.0357
0.15	0.38	1.00	0.0876	0.0027
0.25	0.63	1.67	0.0566	-0.0259
0.35	0.88	2.33	0.0298	-0.0510
0.45	1.13	3.00	0.0064	-0.0731
0.65	1.63	4.33	-0.0324	-0.1103
0.75	1.88	5.00	-0.0487	-0.1262

The accumulated current account balance during the three first years as % of GDP				
$\tau = 0.65$			Share of imports in GDP	
ε	$\beta/\gamma_m = 0.4$	$\beta/\gamma_m = 0.15$	$\gamma_m = 40\%$	$\gamma_m = 15\%$
0.05	0.13	0.33	0.1242	0.0359
0.15	0.38	1.00	0.0892	0.0039
0.25	0.63	1.67	0.0602	-0.0230
0.35	0.88	2.33	0.0358	-0.0459
0.45	1.13	3.00	0.0150	-0.0658
0.65	1.63	4.33	-0.0186	-0.0983
0.75	1.88	5.00	-0.0323	-0.1118

The accumulated current account balance during the three first years as % of GDP				
$\tau = 0.45$			Share of imports in GDP	
ε	$\beta_{\gamma_m = 0.4}$	$\beta_{\gamma_m = 0.15}$	$\gamma_m = 40\%$	$\gamma_m = 15\%$
0.05	0.13	0.33	0.1246	0.0363
0.15	0.38	1.00	0.0924	0.0067
0.25	0.63	1.67	0.0676	-0.0167
0.35	0.88	2.33	0.0478	-0.0357
0.45	1.13	3.00	0.0316	-0.0514
0.65	1.63	4.33	0.0069	-0.0758
0.75	1.88	5.00	-0.0027	-0.0855

The accumulated current account balance during the three first years as % of GDP				
$\tau = 0.25$			Share of imports in GDP	
ε	$\beta_{\gamma_m = 0.4}$	$\beta_{\gamma_m = 0.15}$	$\gamma_m = 40\%$	$\gamma_m = 15\%$
0.05	0.13	0.33	0.1257	0.0372
0.15	0.38	1.00	0.0994	0.0125
0.25	0.63	1.67	0.0818	-0.0045
0.35	0.88	2.33	0.0693	-0.0169
0.45	1.13	3.00	0.0599	-0.0263
0.65	1.63	4.33	0.0467	-0.0398
0.75	1.88	5.00	0.0419	-0.0447