Chapter 2

1. Introduction

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 in‡ation, are greatly a¤ected 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. Pro…t 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 preemptive strikes against unemployment and control the real wage by adjusting the exchange rate to maintain constant pro…tability 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.

2. Model reconfiguration

2.1. 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,

$$\frac{\dot{w}}{w} = \frac{\dot{P}}{P} + \gamma(l_x + l_n - \bar{L}); \tag{2.1}$$

where l_x and l_n are the respective shares of the labor force employed by each sector and the parameter γ 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 (2.1) can also be written in terms of the real wage,

$$\frac{\dot{\omega}}{\omega} = \gamma(l_x + l_n - 1); \tag{2.2}$$

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.

2.2. 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,

$$P_n F_L^n = w. \tag{2.3}$$

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

$$F_L^n = \omega \frac{P}{P_n} = \omega \left(\frac{e}{P_n}\right)^{\gamma_m}. \tag{2.4}$$

Taking the inverse of F_L, equation (2.4) yields the labor demand function,

$$l_n = L\left[\omega\left(\frac{e}{P_n}\right)^{\gamma_m}\right]. \tag{2.5}$$

Total differentiation then gives,

$$\hat{l}_n = -\eta_n\left(\hat{\omega} + \gamma_m(\hat{e} - \hat{P}_n)\right), \tag{2.6}$$

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,

$$\hat{e} = Z(\theta_L^x \hat{w} - \hat{P}_x^*). \tag{2.7}$$

Therefore eq. (2.6) can be rewritten as,

$$\hat{l}_n = -\eta_n\left(\hat{\omega} + \gamma_m Z(\theta_L^x \hat{w} - \hat{P}_x^*) - \gamma_m \hat{P}_n\right). \tag{2.8}$$

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

$$\hat{w} = \frac{\hat{\omega} + \gamma_n \hat{P}_n - \gamma_m Z \hat{P}_x^*}{1 - \gamma_m Z \theta_L^x}. \tag{2.9}$$

Substituting this into (2.8) and collecting terms gives,

$$\hat{l}_n = \frac{-\eta_n}{1 - \gamma_m Z \theta_L^x}\left(\hat{\omega} - (1 - Z\theta_L^x)\gamma_m \hat{P}_n - \gamma_m Z \hat{P}_x^*\right). \tag{2.10}$$

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.

2.3. Prices

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

$$-(\varepsilon + \gamma_n)\hat{P}_n + (\varepsilon - \gamma_m)\hat{e} + \hat{E} = \hat{Q}_n; \tag{2.11}$$

The supply response in the non-tradable sector

$$\hat{Q}_n = \theta_L^n \hat{l}_n = -\frac{\theta_L^n \kappa_n}{1 - \gamma_m Z \theta_L^n}\left[\hat{\varpi} - [1 - \gamma_m Z \theta_L^x]\gamma_n \hat{P}_n\right] \tag{2.12}$$

the budget constraint

$$\hat{E} = \alpha_x(\hat{e} + \hat{P}_x^*) + \gamma_n \hat{P}_n + \gamma_n \hat{Q}_n - \frac{dS}{E}; \tag{2.13}$$

and the policy rule for exchange rate

$$\hat{e} = Z\left[\frac{\theta_L^x\left(\hat{\varpi} + \gamma_n \hat{P}_n\right) - \hat{P}_x^*}{[1 - \gamma_m Z \theta_L^x]}\right]. \tag{2.14}$$

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

$$\begin{aligned}\hat{P}_n = {} & \Phi^{-1}\left[[\theta_L^x Z(\varepsilon + \alpha_x - \gamma_m) + \theta_L^n \kappa_n \gamma_m]\hat{\varpi} - (1 - \gamma_m Z \theta_L^x)\frac{dS}{E}\right] \\ & + \Phi^{-1}[(\gamma_m - \alpha_x - \varepsilon)Z + \alpha_x[1 - \gamma_m Z \theta_L^x] - \kappa_n \theta_L^n \gamma_m \gamma_m Z]\hat{P}_x^*;\end{aligned} \tag{2.15}$$

$$\hat{e} = Z\Phi^{-1}\left[[\varepsilon + \theta_L^n \kappa_n \gamma_m]\theta_L^x \hat{\varpi} - \gamma_n \theta_L^x \frac{dS}{E} + [\alpha_x \theta_L^x \gamma_n - \gamma_m \kappa_n \theta_L^n \gamma_m - \varepsilon]\hat{P}_x^*\right]. \tag{2.16}$$

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, (2.15), (2.16) and (??) can be expressed as differential equations,

$$\frac{\dot{P}_n}{P_n} = \Psi^{-1}\left[\left[\theta_L^x Z(\varepsilon + \alpha_x - \gamma_m) + \theta_L^n \eta_n \gamma_m\right]\frac{\dot{\$}}{\$} - (1 - \gamma_m Z \theta_L^x)\frac{\dot{S}}{E}\right]. \tag{2.17}$$

$$\frac{\dot{e}}{e} = \frac{Z}{\Psi}\left[\left[\varepsilon + \eta_n \gamma_m \theta_L^n\right]\theta_L^x \frac{\dot{\$}}{\$} - \theta_L^x \gamma_n \frac{\dot{S}}{E}\right] \tag{2.18}$$

3. Solving the model

3.1. The path of savings

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

$$\underset{\{E,S\}}{Max} \int \left[V(e, P_n, E) + \phi\left(\frac{M}{P}\right)\right] e^{-\rho t} dt \tag{3.1}$$

$$s.t.$$

$$E = P_x Q_x + P_n Q_n - S \tag{3.2}$$

$$\dot{M} = S \tag{3.3}$$

For which the following Hamiltonian function is specified,

$$H = e^{-\rho t}\left[V(e, P_n, P_x Q_x + P_n Q_n - S) + \phi\left(\frac{M}{P}\right) - \mu S\right], \tag{3.4}$$

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

$$V_E(e, P_n, P_x Q_x + P_n Q_n - S) = \mu, \tag{3.5}$$

$$\dot{\mu} = \rho\mu + \phi'\left(\frac{M}{P}\right)\frac{1}{P}. \tag{3.6}$$

As before Q_x can be treated as a constant, and time differentiation of (3.5) yields:

$$\dot{\mu} = (V_{EN} + V_{EE} Q_n)\dot{P}_n + V_{EM}\dot{e} + V_{EE} P_n \dot{Q}_n + V_{EE} Q_x \dot{P}_x - V_{EE}\dot{S}. \tag{3.7}$$

With a little rearrangement we can write (3.7) as

$$\dot{\mu} = V_{EE}E\left[\left(\frac{V_{EN}}{V_{EE}D_n}\frac{P_nD_n}{E}+\frac{P_nQ_n}{E}\right)\frac{\dot{P}_n}{P_n}+\frac{P_nQ_n}{E}\frac{\dot{Q}_n}{Q_n}+\left(\frac{V_{EM}}{V_{EE}D_m}\frac{eD_m}{E}+\frac{P_xQ_x}{E}\right)\frac{\dot{e}}{e}-\frac{S}{E}\right]. \tag{3.8}$$

From Roy's identity $D^i = -\frac{V_i}{V_E}$, we can derive the relationship $\frac{V_{EP_m}}{V_{EE}Q_i} = \nu_i\tau - 1$; 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: ($\gamma_i = \frac{\partial D_i}{\partial E}\frac{E}{D_i}$). If we assume unitary income elasticities of demand, i.e. $\nu_i = 1$. Moreover, for small changes in the neighborhood of the steady equilibrium, $\alpha_x = \gamma_m$; thus (3.8) can be written as,

$$\dot{\mu} = V_{EE}E\left[\tau\gamma_n\frac{\dot{P}_n}{P_n}+\tau\gamma_m\frac{\dot{e}}{e}+\gamma_n\frac{\dot{Q}_n}{Q_n}-\frac{\dot{S}}{E}\right]. \tag{3.9}$$

Now, substitute for $\frac{\dot{Q}_n}{Q_n}$; $\frac{\dot{e}}{e}$ and $\frac{\dot{P}_n}{P_n}$ using equations (2.12), (2.18) and (2.17),

$$V_{EE}\Omega^{-1}\left(EA\frac{\dot{\varpi}}{\varpi}-B\dot{S}\right)=\rho V_E-\phi'\left(\frac{M}{P}\right)\frac{1}{P}; \tag{3.10}$$

where,

$$A = [\tau\theta^x_L Z\varepsilon + \theta^n_L\kappa_n(\tau\gamma_m(\gamma_n+\gamma_m Z\theta^x_L) - \varepsilon\gamma_n(1 - Z\theta^x_L))]$$

$$B = [\tau\gamma_n + (\varepsilon + \gamma_m\kappa_n\theta^n_L)(1 - Z\theta^x_L)]$$

Finally, use eq.(2.2) to substitute for $\frac{\dot{\varpi}}{\varpi}$ and we have a differential equation describing the path of the savings rate,

$$\dot{S} = \frac{-\Omega}{BV_{EE}}\left(\rho V_E - \phi'\left(\frac{M}{P}\right)\frac{1}{P}\right)+\frac{A}{B}Eg(l_x + l_n - 1). \tag{3.11}$$

3.2. Linearization

Differential equation (3.11) will solved through a linearization around the initial stationary equilibrium. Differentiation of the first term on the right hand side of eq. (3.11) yields

$$\dot{S} = \frac{1}{B}\left[-\rho\left[A\frac{l_n}{\theta^n_L\gamma_n}d\varpi - BdS\right] + \Omega\rho E\left[(\tau-1)\hat{P}+\hat{M}\right]\right] + (). \tag{3.12}$$

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

$$\dot{S} = \frac{½}{B}\left[[© + °_n]dS \; ¡ \; [°_n(" \; ¡ \; °_m) \; ¡ \; [(Z°_n + 1)" + °_m°_m]Zµ_L^x]\frac{\cdot_n l_n}{°_n}d\$ + \frac{©}{Â}dM \right] + (): \tag{3.13}$$

The linearization of the second term on the right in eq. (3.11) yields,

$$\dot{S} = () + \frac{A}{B}Egdl_n: \tag{3.14}$$

From eq.(2.10),(2.14) and (2.15) we have an expression for changes in the labor input depending on savings decisions and the real wage,

$$dl_n = \frac{¡ \cdot_n l_n}{" + °_m \cdot_n µ_L^n °_m}\left["\$ + °_m\frac{dS}{E} \right]: \tag{3.15}$$

Thus eq. (3.14) becomes,

$$\dot{S} = () \; ¡ \; \frac{A}{B}\frac{\cdot_n l_n g}{" + \cdot_n °_m µ_L^n °_m}\left[\frac{"l_n}{µ_L^n °_n}d\$ + °_m dS \right]: \tag{3.16}$$

Lastly, the linearization of di¤erential equation (3.11) is complete if equations (3.16) and (3.13) are combined,

$$\dot{S} = C_1 dS + C_2 d\$ + C_3 dM: \tag{3.17}$$

$$C_1 = \frac{1}{B}\left[½[(" + °_m \cdot_n µ_L^n)(1 \; ¡ \; Zµ_L^x) + °_n] \; ¡ \; \frac{"°_m \cdot_n l_n gA}{" + \cdot_n °_m µ_L^n °_m} \right]$$

$$C_2 = \frac{1}{B}\left[[(Z°_n + 1)" + °_m°_m]Zµ_L^x \; ¡ \; °_n(" \; ¡ \; °_m) \; ¡ \; \frac{A"l_n g}{µ_L^n(" + \cdot_n °_m µ_L^n °_m)} \right]\frac{\cdot_n l_n}{°_n}$$

$$C_3 = \frac{1}{B}[(" + \cdot_n °_m µ_L^n °_m)(1 \; ¡ \; Zµ_L^x)]\frac{½}{Â}$$

3.3. The real wage

The path of the real wage is described by di¤erential equation (2.2), which also has to be linearized around the initial stationary equilibrium. Simple di¤erentiation yields,

$$\dot{\$} = \$gdl_n: \tag{3.18}$$

Now using eq. (3.15) we write (3.18) as,

$$\dot{\omega} = \frac{-g\eta_n}{(\epsilon + \eta_n\gamma_m\theta_L^n\gamma_m)}(l_n\epsilon d\omega + \gamma_m\theta_L^n\gamma_n dS); \tag{3.19}$$

Or written more conveniently,

$$\dot{\omega} = C_4 dS + C_5 d\omega: \tag{3.20}$$

$$C_4 = \frac{-g\eta_n\gamma_m\theta_L^n\gamma_n}{(\epsilon + \eta_n\gamma_m\theta_L^n\gamma_m)}$$

$$C_5 = \frac{-\epsilon g\eta_n l_n}{(\epsilon + \eta_n\gamma_m\theta_L^n\gamma_m)}$$

Equations (3.20), (3.17), along with (3.3) will form a three dimensional simultaneous dynamic system.

$$\begin{bmatrix} \dot{S} \\ \dot{\omega} \\ \dot{M} \end{bmatrix} = \begin{bmatrix} C_1 & C_2 & C_3 \\ C_4 & C_5 & 0 \\ 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} S \\ \omega - \omega^* \\ M - M^* \end{bmatrix}: \tag{3.21}$$

The general solution to (3.21) can be written as follows,

$$\begin{bmatrix} S \\ \omega - \omega^* \\ M - M^* \end{bmatrix} = \begin{bmatrix} Z_{11} & Z_{12} & Z_{13} \\ Z_{21} & Z_{22} & Z_{23} \\ Z_{31} & Z_{32} & Z_{33} \end{bmatrix} \begin{bmatrix} k_1 e^{\lambda_1 t} \\ k_2 e^{\lambda_2 t} \\ k_3 e^{\lambda_3 t} \end{bmatrix}, \quad \begin{matrix} i = 1;2;3 \\ j = 1;2;3 \end{matrix} \tag{3.22}$$

where Z_{ij} are the eigenvectors, λ_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 ω 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

$$\begin{bmatrix} C_1 & C_2 & C_3 \\ C_4 & C_5 & 0 \\ 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} Z_{1j} \\ Z_{2j} \\ Z_{3j} \end{bmatrix} = \begin{bmatrix} Z_{1j}\lambda_j \\ Z_{2j}\lambda_j \\ Z_{3j}\lambda_j \end{bmatrix}; \quad j = 1;2;3 \tag{3.23}$$

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 $j = 1;2;3$.

4. Permanent and unexpected shocks

4.1. 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:

$$S(t) = \lambda_1 k_1 e^{\lambda_1 t}. \tag{4.1}$$

$$\varpi(t) - \varpi^* = k_1 \frac{\lambda_1 C_4}{(\lambda_1 - C_5)} e^{\lambda_1 t}. \tag{4.2}$$

$$M(t) - M^* = k_1 e^{\lambda_1 t}. \tag{4.3}$$

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 $t = 0$, (4.3) yields,

$$M_0 - M^* = k_1. \tag{4.4}$$

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. $\hat{E}_{ss} = \hat{M}_{ss}$. $\Rightarrow M^* - M' = M_0 \hat{E}_{ss}$. 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,

$$k_1 = -(M^* - M') = -M_0 \Lambda \hat{P}_x^*. \tag{4.5}$$

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

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

$$S(t) = -\lambda_1 M_0 \Lambda \hat{P}_x^* e^{\lambda_1 t}, \tag{4.6}$$

$$\varpi(t) - \varpi_0 = -\lambda_1 \frac{M_0 \Lambda_1 C_4}{(\lambda_1 - C_5)} \hat{P}_x^* e^{\lambda_1 t} + \varpi_0 \left(\frac{\varpi^* - \varpi_0}{\varpi_0} \right). \tag{4.7}$$

$$M(t) - M_0 = M' \Lambda (1 - e^{\lambda_1 t}) \hat{P}_x^*. \tag{4.8}$$

Since there is no change in labor input across stationary equilibrium, it is clear from eq. (2.6) that,

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

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,

$$\hat{\varpi} = \hat{P}_n - \hat{P} = \gamma_m(\hat{P}_n - \hat{e}): \tag{4.9}$$

Thus, by using the long-run versions of equations (2.15) and (2.16),

$$\frac{\varpi^* - \varpi_0}{\varpi_0} = \frac{\gamma_m \gamma_m}{\varepsilon}\hat{P}_x^*: \tag{4.10}$$

Given that we can express eq. (4.7) as,

$$\varpi(t) - \varpi_0 = \left(\frac{\gamma_m^2}{\varepsilon}\varpi_0 - \lambda_1\frac{M_0\Delta_1 C_4}{(\lambda_1 - C_5)}e^{\lambda_1 t}\right)\hat{P}_x^*: \tag{4.11}$$

4.2. Simulations

4.2.1. 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 difficult 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%

4.2.2. 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.

5. Temporary and anticipated shocks

5.1. 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.

5.2. Transitional paths

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

The first path The first 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,

$$S_t = \lambda_1 k_1 e^{\lambda_1 t} + \lambda_2 k_2 e^{\lambda_2 t} + \lambda_3 k_3 e^{\lambda_3 t}; \tag{5.1}$$

$$\varpi_t - \varpi_0 = \varpi^* - \varpi_0 + C_4 \left[\frac{\lambda_1 k_1}{\lambda_1 - C_5} e^{\lambda_1 t} + \frac{\lambda_2 k_2}{\lambda_2 - C_5} e^{\lambda_2 t} + \frac{\lambda_3 k_3}{\lambda_3 - C_5} e^{\lambda_3 t} \right]; \tag{5.2}$$

$$M_t - M_0 = M^* - M_0 + k_1 e^{\lambda_1 t} + k_2 e^{\lambda_2 t} + k_3 e^{\lambda_3 t}: \tag{5.3}$$

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;

$$S_t = \lambda_1 k_4 e^{\lambda_1 t} + \lambda_2 k_5 e^{\lambda_2 t} + \lambda_3 k_6 e^{\lambda_3 t} \tag{5.4}$$

$$\varpi_t - \varpi_0 = \varpi^{**} - \varpi_0 + C_4 \left[\frac{\lambda_1 k_4}{\lambda_1 - C_5} e^{\lambda_1 t} + \frac{\lambda_2 k_5}{\lambda_2 - C_5} e^{\lambda_2 t} + \frac{\lambda_3 k_6}{\lambda_3 - C_5} e^{\lambda_3 t} \right] \tag{5.5}$$

$$M_t - M^0 = \left(M^{**} - M_0\right) + k_4 e^{\lambda_1 t} + k_5 e^{\lambda_2 t} + k_6 e^{\lambda_3 t} \tag{5.6}$$

$$t_1 \le t \le t_2$$

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.

$$S_t = \lambda_1 k_7 e^{\lambda_1 t} \tag{5.7}$$

$$\$_t - \$_0 = \frac{\lambda_1 k_7 C_4}{\lambda_1 - C_5} e^{\lambda_1 t}; \tag{5.8}$$

$$M_t - M^0 = k_7 e^{\lambda_1 t}, \tag{5.9}$$

5.2.1. 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 (5.3) can be used at $t = 0$ to describe the relationship between the change in steady state money stock and the three first constants,

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

$$\Rightarrow k_1 = -(dM + k_2 + k_3) \tag{5.10}$$

Secondly, at $t = t_1$ equations (5.3) and (5.6) both report nominal money stock at the same moment in time and must therefore give the same solution:

$$k_4 e^{\lambda_1 t_1} + k_5 e^{\lambda_2 t_1} + k_6 e^{\lambda_3 t_1} - k_1 e^{\lambda_1 t_1} - k_2 e^{\lambda_2 t_1} - k_3 e^{\lambda_3 t_1} = 2dM \tag{5.11}$$

Thirdly, the same condition applies at $t = t_2$; when the next shift occurs and equations (5.6) and (5.9) must give the exact same information for the level of nominal cash balances:

$$k_4 e^{\lambda_1 t_2} + k_5 e^{\lambda_2 t_2} + k_6 e^{\lambda_3 t_2} - k_7 e^{\lambda_1 t_2} = dM \tag{5.12}$$

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. (5.1) from eq. (5.4) and similarly the savings jump at t_2, which is noted as J_2, must be the difference between (5.4) and (5.7),

$$J_1 = \lambda_1 k_4 e^{\lambda_1 t_1} + \lambda_2 k_5 e^{\lambda_2 t_1} + \lambda_3 k_6 e^{\lambda_3 t_1} - \lambda_1 k_1 e^{\lambda_1 t_1} - \lambda_2 k_2 e^{\lambda_2 t_1} - \lambda_3 k_3 e^{\lambda_3 t_1} \tag{5.13}$$

$$J_2 = \lambda_1 k_7 e^{\lambda_2 t_2} - \lambda_1 k_4 e^{\lambda_1 t_2} - \lambda_2 k_5 e^{\lambda_2 t_2} - \lambda_3 k_6 e^{\lambda_3 t_2}. \tag{5.14}$$

In similar fashion, using the equational pairs (5.2), (5.5) and (5.5), (5.8) respectively, the two jumps in ϖ at same time points, noted as J_3 and J_4,can be characterized as,

$$J_3 = -2d\varpi + C_4 \left[\frac{\lambda_1(k_4 - k_1)}{\lambda_1 - C_5} e^{\lambda_1 t_1} + \frac{\lambda_2(k_5 - k_2)}{\lambda_2 - C_5} e^{\lambda_2 t_1} + \frac{\lambda_3(k_6 - k_3)}{\lambda_3 - C_5} e^{\lambda_3 t_1} \right] \tag{5.15}$$

$$J_4 = d\varpi + C_4 \left[\frac{\lambda_1(k_7 - k_4)}{\lambda_1 - C_5} e^{\lambda_1 t_2} - \frac{\lambda_2 k_5}{\lambda_2 - C_5} e^{\lambda_2 t_2} - \frac{\lambda_3 k_6}{\lambda_3 - C_5} e^{\lambda_3 t_2} \right] \tag{5.16}$$

5.3. 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 $t = t_2$.

$$V_E(P_n, P_m, E) = \mu. \tag{5.17}$$

By total differentiating (5.17) 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 (2.15) and (2.16) can be used to eliminate $\hat{P}_n$ and $\hat{e}$ and we obtain the following solutions,

$$\frac{dS(t)}{E} = N_3^{-1}\left[N_1\varpi(t) + N_2\hat{P}_x^*(t)\right] \tag{5.18}$$

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

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

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

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,

$$\varpi(t_j) = -\hat{P}(t_j).\; j = 0,1,2. \tag{5.19}$$

From equations, (2.15) and (2.16), substituting for $\hat{P}$ in (5.19) given the relationship between changes in the real wage, savings and the export price,

$$\varpi(t) = \left[\varepsilon + \gamma_m\kappa_n\theta_L^n\right]^{-1}\left[\gamma_n\frac{dS(t)}{E} - \left[\gamma_m\gamma_n - Z\varepsilon - \kappa_n\theta_L^n\gamma_m\gamma_m Z\right]\hat{P}_x^*(t)\right] \tag{5.20}$$

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 (5.20) and (5.18) to quantify the four jumps if the unions will refrain from nominal wage increases as the shocks occur,

$$J_i = \left[\frac{N_2\left[\varepsilon + \gamma_m\kappa_n\theta_L^n\right] - N_1\left[\gamma_m\gamma_n - Z\varepsilon - \kappa_n\theta_L^n\gamma_m\gamma_m Z\right]}{N_3\left[\varepsilon + \gamma_m\kappa_n\theta_L^n\right] - N_1\gamma_n}\right]\hat{P}_x^*(t_i);\; i=1,2. \tag{5.21}$$

$$J_3 = \left[\varepsilon + \gamma_m\kappa_n\theta_L^n\right]^{-1}\left[\gamma_n J_1 - \left[\gamma_m\gamma_n - Z\varepsilon - \kappa_n\theta_L^n\gamma_m\gamma_m Z\right]\hat{P}_x^*(t_1)\right] \tag{5.22}$$

$$J_4 = \left[\varepsilon + \gamma_m\kappa_n\theta_L^n\right]^{-1}\left[\gamma_n J_2 - \left[\gamma_m\gamma_n - Z\varepsilon - \kappa_n\theta_L^n\gamma_m\gamma_m Z\right]\hat{P}_x^*(t_2)\right] \tag{5.23}$$

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,

$$J_i = \frac{N_2}{N_3}\hat{P}_x^*(t_i);\; i = 1,2.; \tag{5.24}$$

$$J_3 = J_4 = 0. \tag{5.25}$$

6. Simulation results

6.1. 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 signi…cant de…cits appear, as can e.g. be seen in …gures 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.

6.2. 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. ...gures 16f and 18f). Generally stated, about 20% nominal depreciation and10% in‡ation results when the negative shock occurs at $t = 3$ when the unions are cooperative, compared with 30% depreciation and 20% in‡ation when the cooperation is lacking.

6.3. 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 in‡exibility, 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 " ¸ 0:25 (compare e.g. ...gures 22e and 21e) which is a signi...cantly lower rate than was earlier observed for 10% permanent price decrease (see ...gure 14f). In other words, the proposed bene...t 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 ...gures 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 ...rst periods leading up to the shock (see ...gure 19e). This is subsequently reversed after $t = 3$ and the increased demand for non-tradables after the devaluation is su¢cient 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.

7. 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 in‡ationary consequences. When the shocks become multiple and anticipated, this picture is changed. The shocks do not a¤ect employment as much because of their transitory nature. On the other hand, interventions in this shifting environment bring with them considerable side e¤ects, 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 e¤ectively 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 in‡ation. However, the e¤ects 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.