CENTRAL BANK OF ICELAND

WORKING PAPERS No. 18

SMALL OPEN ECONOMY MODEL WITH DOMESTIC RESOURCE SHOCKS: MONETARY UNION VS. FLOATING EXCHANGE RATE

by

Tor Einarsson

November 2002

CENTRAL BANK OF ICELAND

Economics Department

Central Bank of Iceland Working Papers are published by the Economics Department of the Central Bank of Iceland. The views expressed in them are those of their authors and not necessarily the views of the Central Bank of Iceland.

Also available on the Central Bank of Iceland World Wide Web site (http://www.sedlabanki.is)

ISSN: 1028-9445

Small Open Economy Model with Domestic Resource Shocks: Monetary Union vs. Floating Exchange Rate*

Tor Einarsson
University of Iceland

First version: September 2001

This version: November 2002

Abstract

This paper developes a small open economy model in which domestic resource shocks play a vital role in driving the dynamics of the major macroeconomic aggregates. Households rent capital and labour to firms and have access to an international bond market. The model is calibrated to recent Icelandic data and simulated under two alternative exchange rate regimes: floating rates, and monetary union membership. It is found that by entering a larger currency area, the volatility of the real exchange rate, real wages and consumption are sharply reduced, but output and employment are seen to be more volatile. Smoother consumption renders monetary union marginally Pareto superior to floating. Under monetary union and low inflation, slight nominal wage reductions may be required at times to absorb adverse resource shocks. [JEL Codes: E32, E42, F31, F41. Key words: domestic resource shocks, exchange rate regime, stabilization, welfare costs.]

*I wish to thank Mar Gudmundsson, Thorarinn G. Petursson, and seminar participants at the Central Bank of Iceland for useful comments and suggestions.

1. Introduction

In his paper on optimal currency areas, Robert Mundell (1961) proposed several conditions under which a monetary union between two or more regions would define a feasible regime of exhange rates. First, factors of production, capital and labour, should be highly mobile across regions. With one region facing an adverse demand shock, say, moving factors from that region would bring markets back into equilibrium. Second, macroeconomic shocks should be synchronized, i.e. a shock hitting one region should hit other regions in same direction. Third, nominal factor prices, including wages, should be flexible, in order to restore equilibrium in the factor markets after a shock. For a currency area to function smoothly, at least one of these conditons should be met. This general proposition has been applied at the national level, bringing up the issue whether a particular economy is suitable for joining a larger currency area, of which the European Monetary Union (EMU) is a recent example. Several advantages have been listed from joining such a union. First, the reduction of transaction costs that are incurred in exchanging from one currency to another. Second, the elimination of exchange rate risk, reducing real interest rate uncertainty, and in turn, the accompanying premium. Third, more transparity in prices across countries. These effects are likely to improve market efficiency in general, enhancing economic activity and growth. Among the disadvantages from entering a monetary union are: first, a loss of a degree of freedom, the nominal exchange rate, as a means of reacting to macroeconomic shocks. Second, the surrender of national sovereignty, as the monetary authority no longer conducts an independent monetary policy.

Since the emergence of EMU, there has been an ongoing debate in Iceland whether or not to join, mostly in the general media. However, some scholarly contributions have also been made. Buiter (2000) compares the late 1990's regime of price stability (coupled with a fairly flexible exchange rate) adopted in Iceland and monetary union membership. He concludes that, on balance, neither regime overwhelmingly dominates the other. The lack of real factor mobility and nominal price rigidities would not be major obstacles to EMU membership, but the current arrangement might provide better macroeconomic stabilization in face of temporary real shocks. Gudmundsson et. al. (2000) conclude that Iceland does not meet the optimal currency area criteria for EMU-membership. Economic fluctuations are, according to them, rooted mainly in real supply shocks, largely uncorrelated with shocks in other economies. However, they discuss the limitations of these criteria, and conclude that the feasibility of joining the EMU remains an open issue. Finally, due to the nature of the fluctuations and the inherent difficulty of maintaining a unilateral stable exchange rate policy, they conclude that Iceland should adopt a floating exchange rate, so long as it keeps its own currency. Agnarsson et.al. (2000) conclude that adopting the euro currency would limit the Icelandic economy's ability to absorb adverse supply shocks, at least on the scale seen in the past. However, they point out the potential for more monetary discipline from EMU membership, which might contribute to more flexibility in the labour market.

This paper focuses on the suitability of alternative exchange rate regimes in Iceland, from the viewpoint of macroeconomic stability. To that end we develop a simple small open economy model that builds on the real business cycle (RBC) literature. Early examples of such modelling include Cardia (1991) and Mendoza (1991) (single consumer good), and Einarsson (1992) (two consumer goods). These studies focus on certain statistics pertaining to open economies, such as the current account and the correlation between savings and investment, under some given exchange rate regime, typically fixed rates. Among more recent examples is Fernandez and Kehoe (2000), who develope a model with one traded and one nontraded good to examine the effects of Spain's abolition of capital controls in the late 1980's and early 1990's. Cooley and Quadranini (2001) develop a model with one home produced and one imported intermediate good and compare the welfare implications of adopting the U.S. dollar in the Mexican economy to monetary independence. They conclude that a 'dollarization' may not be Pareto superior to an independent monetary policy. Mendoza (2001) formulates a model with a traded and a nontraded good, with households facing a potential borrowing constraint in an international bond market. He concludes that 'dollarization' may entail significant welfare benefits for emerging economies such as Mexico's: first, by eliminating price and wealth distortions induced by the lack of credible stabilization policies; second, by improving the efficiency of financial markets by reducing frictions originating in information structure or institutions. Schmitt-Grohé and Uribe (2001) consider a small open economy model with households who have access to an international bond market. Two types of goods are produced, exportables and nontradeables, and three goods are absorbed, exportables, importables, and nontradeables. Two sources of nominal rigidities are assumed: 'sticky' prices of nontradeables, and transaction costs that are decreasing in households' money balances. Calibrating the model to Mexican quarterly data, it is found that 'dollarization' is slightly Pareto inferior to the alternative regimes examined, including constant money growth and inflation targeting.

In the model constructed here, households consume two goods, a home good and a foreign good, both being tradeable and imperfect substitutes for one another. Total spending on consumption is constrained by the amount of money balances carried over from the previous period, a standard cash-in-advance constraint. This motivates households to hold money balances on grounds of liquidity services. The households undertake all investment in physical capital, which is rented out to the firms, along with labour services. Households also have access to an international bond market, onto which they can channel savings (or incur debt). There are two production sectors in the model. One producing a single non-fish output that can be used for consumption and investment at home, or exported. Another sector, the fisheries sector, transforms an exogenously given fish catch into an exportable good, fisheries exports. [1] Two regimes on exchange rates are considered: a floating or flexible rates, and a monetary union membership, a form of a credible currency peg. While neither case fully matches the historical regime (or the regimes) adopted

[1]For an other example in which a product serves as an exportable only, see e.g Conzaga and Terra (1997).

in Iceland, we take the floating rate case to be the closer approximation. Calibrating the model to recent Icelandic data indicates that entering a monetary union will tend to stabilize some macroeconomic quantities and destabilize others. Among the former are the real exchange rate, real wages and consumption. In the latter category we have output and employment. Therefore, the model provides no reason to expect 'across the board' stabilization from switching between exchange rate regimes. However, concerning the welfare costs of business cycles in Iceland, it is found that with lower volatility of both consumer goods, monetary union membership marginally dominates floating exchange rates.

The model is set out in Section 2. The calibration is described in Section 3, and the simulation exercies are presented in Section 4. Section 5 concludes the paper.

2. The Model

The model consists of five sectors: households, non-fish producers, a fisheries sector, a foreign sector, and a monetary authority. Households rent capital and labour services to the non-fish producers, and purchase two types of consumer goods, one domestic, one foreign. They hold three types of assets: physical capital, foreign bonds, and money. The expenditure on the two consumption goods is constrained by a standard cash-in-advance constraint. The non-fisheries sector produces a single output which can be consumed, invested in physical capital, or exported. The fisheries sector transforms fish catch into a good that is solely used for exports. Two exchange rate regimes are assumed in the model: a floating rate, and a permanent peg to the foreign currency. There are three sources of aggregate shocks in the model: one to total factor productivity, one to fish catch, and one to export demand.

2.1 Households

The representative household seeks to maximize expected life utility, or

$$\max_{\{c_{Dt},c_{Ft},l_t,n_t,k^d_{t+1},b^d_{t+1},M^d_{t+1}\}} \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t U(c_{Dt}, c_{Ft}, l_t), \qquad \beta \in (0,1) \tag{1}$$

where period utility is derived from consuming the home and the foreign good, c_{Dt}, and c_{Ft} respectively, and leisure, l_t, according to the utility function, U, assumed to possess standard properties, i.e. differentiabilty and strict concavity. β is the discount factor, and E_0 the expectations operator, conditional on all period 0 information.

The household's budget constraint is given by:

$$P_t c_{Dt} + E_t c_{Ft} + P_t[k^d_{t+1} - (1-\delta)k^d_t] + E_t b^d_{t+1} + M^d_{t+1}$$

$$\leq P_t R_t k^d_t + W_t n_t + R_{Ft} E_t b^d_t + M^d_t + \phi J_t, \qquad \phi \in \{0,1\} \tag{2}$$

where: P_t is the domestic output price; E_t is the unit price of foreign currency in terms of home currency; k^d_{t+1} is the end of period stock of capital; b^d_{t+1} and M^d_{t+1} are the stocks of one period foreign bonds and money respectively, with negative values of b_{t+1} amounting to foreign debt incurred by households; n_t denotes the amount of labour services; R_t and W_t are the rental rates of capital and labour respectively; R_{Ft} denotes the gross interest rate on the foreign bond; J_t is a lumpsum transfer from the monetary authority in the case of floating exchange rate, $\phi = 1$; in the case of monetary union, we set $\phi = 0$. By normalizing the foreign price level to unity, we do not distinguish between real and nominal quantities in the foreign sector.

In nominal terms, household's consumption purchases are further subjected to a standard cash-in-advance constraint:

$$P_t c_{Dt} + E_t c_{Ft} \leq M^d_t + A_t \tag{3}$$

where M^d_t are the beginning of period money balances, and $A_t = J_t$ under floating, or $A_t = V_t$, the balance of payments, under monetary union (see Section 2.4.)

The household allocates its time to leisure and labour services in each period:

$$l_t + n_t \leq 1 \tag{4}$$

with total time normalized to one.

Finally, b^d_0, k^d_0, and M^d_0 are given.

A recursive representation

To express the maximization problem recursively, it is neccessary to convert the model to a stationary form. To that end, we normalize all domestic nominal quantities on the output price, P_t. Furthermore, dropping the time subscripts, define the following set of normalized variables: $e \equiv EQ/P$, $w \equiv W/P$, $m^{d'} \equiv M^{d'}/P$, $j \equiv J/P$, $a \equiv A/P$, and $\pi \equiv P/P_{-1}$, the gross rate of inflation. The household's state vector is defined by

$s = (b^d, k^d, m^d, S)$ with S denoting the aggregate state vector, defined in Section 2.3. The dynamic programming problem can then be written as follows, with next period's values denoted by primes, ('):

$$v(b^d, k^d, m^d, S) = \max_{c_D, c_F, l, n, b^{d'}, k^{d'}, m^{d'}} \{U(c_D, c_F, l) + \beta \mathrm{E}[v(b^{d'}, k^{d'}, m^{d'}, S')]\} \tag{5}$$

subject to

$$\begin{aligned} & c_D + ec_F + k^{d'} - (1-\delta)k^d + eb^{d'} + m^{d'} \\ & \leq Rk^d + wn + R_F eb^d + m^d/\pi + \phi j \end{aligned} \tag{6}$$

$$c_D + ec_F \leq m^d/\pi + a \tag{7}$$

$$l + n \leq 1 \tag{8}$$

$b^d, \; k^d, \; m^d$ given

The solution to the dynamic programming problem above yields the following set of Euler-equations:

$$U_l/w = \beta \; \mathrm{E}\Big\{[R' + (1-\delta)]U_l{}'/w'\Big\} \tag{9}$$

$$U_l/w = \beta \; \mathrm{E}\Big\{[R_F{}'(e'/e)]U_l{}'/w'\Big\} \tag{10}$$

$$U_l/w = \beta \ \mathrm{E}\Big\{U_{cD}'/\pi'\Big\} \tag{11}$$

$$U_{cF}/U_{cd} = e \tag{12}$$

The first three equations show the intertemporal margins facing the households. By reducing today's leisure time, and increasing work effort, say, the left hand sides of these equations measure the foregone marginal utility, which is balanced against enhanced consumption/leisure opportunities tomorrow, from investing the additional labour income in capital, (eq. (9)), foreign bonds, (eq.(10)), or money balances, (eq.(11)). The last equation defines the intratemporal margin between the domestic and the foreign consumer good, with the marginal rate of substitution equated to the relative price, the real exchange rate.

2.2 Firms

The non-fisheries sector consists of a perfectly competitive industry that is modelled by a single aggregative firm. That firm uses capital and labour in its production process. The fisheries sector has access to a renewable resource, a homogeneous fishing stock, whose period catch is assumed exogenous and subject to a stochastic process. To keep matters as simple as possible, we further assume that these two sectors can be defined in terms of an aggregator function, whereby total output is dependent on capital, labour, fish catch, and a general shock to productivity:

$$\max_{K,N} \ \{F[K, N, H(\theta_D), \theta_G] - RK - wN\} \tag{13}$$

where F is the production function, which is continouously differentiable concave, and linearly homogeneous in the pair (K, N); K and N are the aggregate per capita amounts of capital and employment respectively; H is the fisheries sector production technology, assumed linear; θ_D is a shock to fish catch; and θ_G is a total factor productivity shock.

The maximization of (13) yields the following standard static first order conditions:

$$F_K = R \tag{14}$$

$$F_N = w \tag{15}$$

where the marginal products of the two factors are equated to their rental rates.

2.3 The monetary authority

Under the regime of a floating exchange rate, the monetary authority has the option of conducting an independent policy rule, which may or may not be state dependent:

$$M_{t+1} = \mu(S)M_t \tag{16}$$

where $S = (b, k, m, \theta_D, \theta_F, \theta_G)$ is the aggregate state vector, and θ_F is a shock to non-fish export demand, whose role is described in more detail below.

Any increment to the money stock is passed on to households as a transfer:

$$M_{t+1} = M_t + J_t$$

Under currency peg, the stock of nominal balances evolves according to the balance of payments (see below).

2.4 The balance of payments

Let V_t denote the balance of payments in nominal terms:

$$V_t = P_t X(\theta_{Ft}, e_t) + E_t H(\theta_{Dt}) - E_t c_{Ft} + R_{Ft} E_t b_t - E_t b_{t+1}, \tag{17}$$

or, in a normalized form:

$$v = X(\theta_F, e) + eH(\theta_D) - ec_F + R_F eb - eb' \tag{18}$$

where X defines a demand function for non-fish exports; [2] $eH(\theta_D)$ is the value of fisheries exports; and ec_F is the spending on the imported consumer good, both in terms of domestic output. In sum, the first three terms define the trade balance, while the last two register the net factor income and capital accounts vis-à-vis the foreign economy.

2.5 Equilibrium

A recursive competitive equilibrium of the model is defined in a standard manner. [3] Included are the following equilibrium conditions:

Output market equilibrium:

$$F[K, N, H(\theta_D), \theta_G] = c_D + K' - (1-\delta)K + X(\theta_F, e) + eH(\theta_D)$$

Labour market equilibrium:

$$L + N = 1$$

Balance of payments equilibrium:

$$v = X(\theta_F, e) + eH(\theta_D) - ec_F + R_F eb - eb' \begin{cases} = 0 & \text{floating} \\ > (<) 0 & \text{monetary union} \end{cases}$$

[2] We note that X can be viewed as an analogue to an inverted form of equation (13); namely $c_F = \Psi(c_D, e)$, with $\Psi_1 > 0$, and $\Psi_1 < 0$. Reciprocally, by defining such a function for the foreign sector we obtain $X(\theta_F, e)$, with X_1, $X_2 > 0$, where θ_F is exogenously given and stochastic. The exact nature of θ_F is left unspecified here. It can be thought of as a foreign consumer response to a productivity shock; alternatively, it can be taken as a taste shock. This shock belongs to the category of terms-of-trade shocks, whose importance for open economies, especially emerging economies in Latin America, has been emphasized by Del Negro and Obiols-Homs (2001), and Mendoza (1995).

[3] In brief, it can be stated by defining: a set of household decision rules; a set of aggregate decision rules; the aggregate laws of motion governing the evolution of the endogenous state variables; the laws of motion of the exogenous state variables; the set of output and factor pricing functions; and the value function that satisfy (5) and the equilibrium conditions in the markets for output, capital, labour, foreign exchange, and money.

Money market equilibrium:

(i) *floating*

$$m' = \mu(S)m^d/\pi, \qquad v = 0$$

(ii) *monetary union*

$$m' = m^d/\pi + v, \qquad \pi = e_{-1}/e$$

Note that in the case of monetary union, where E can be normalized to one without loss of generality, the domestic output price, P, and the real exchange rate, e, become an inverse of one another, i.e. $e = 1/P$.

2.6 The model in full

After imposing the equilibrium and aggregate consistency conditions, the model consists of the following equations:

$$U_l/F_N = \beta\ \mathrm{E}\Big\{[F_K{}' + (1-\delta)]U_l{}'/F_N{}'\Big\} \tag{19}$$

$$U_l/F_N = \beta\ \mathrm{E}\Big\{[R_F{}'(e'/e)]U_l{}'/F_N{}'\Big\} \tag{20}$$

$$U_l/F_N = \beta\ \mathrm{E}\Big\{U_{cD}{}'/\pi'\Big\} \tag{21}$$

$$U_{cF}/U_{cd} = e \tag{22}$$

$$c_D + ec_F = m' \tag{23}$$

$$L + N = 1 \tag{24}$$

$$F[K, N, H(\theta_D), \theta_G] = c_D + K' - (1-\delta)K + X(\theta_F, e) + eH(\theta_D) \tag{25}$$

$$v = X(\theta_F, e) + eH(\theta_D) - ec_F + R_F eb - eb' \begin{cases} = 0 & \text{floating} \\ > (<) 0 & \text{monetary union} \end{cases} \tag{26}$$

$$m' = \begin{cases} \mu(S)m/\pi & \text{floating} \\ m/\pi + v & \text{monetary union} \end{cases} \tag{27}$$

3. Calibration

This section describes the calibration of the model to Icelandic data. There are two important things to notice here. First, some key macroeconomic quantities such as output, consumption and investment are available on a quarterly basis only since 1997. That leaves us with calibration to annual data as the only option. Second, the Icelandic economy has undergone nontrivial secular changes in a number of areas over the last couple of decades. One example is the gradual transition from rather strict capital controls to a complete capital mobility across the national borders. Another example is the increased diversification of exports, with the share of fisheries products in total exports declining from 58 % in 1980 to about 40 % in the year 2000. Lastly, experiencing persistent high inflation in the 1970's and the 1980's, the economy has entered a low to moderate inflation phase in the 1990's. [4] For these reasons, we base the calibration on the most recent state of the economy.

The functional forms used for parameterizing the model are given below.

The period utility function is logarithmic in consumption and linear in leisure, which is consistent with assuming indivisibilities in labour services, as suggested by Hansen (1985)

[4] For example, the consumer price index registered an annual average increase of 33 % during 1971-90, dropping to 3.2 % in 1991-2000.

and Rogerson (1988). It is well known in the real business cycle literature that adopting, e.g. logarithmic preferences over leisure, generally yields too smooth cyclical employment.

$$U(c_D, c_F, l) = \ln c_d + \eta_1 \ln c_F + \eta_2 l, \qquad \eta_1,\ \eta_2 > 0$$

Export demand is given by

$$X(\theta_F, e) = \theta_F e$$

The general production technology is Cobb-Douglas.

$$F(K, N, H(\theta_D), \theta_G] = (\theta_D)^{\xi} \theta_G K^{\alpha} N^{1-\alpha}$$

Fisheries output is linear in fish catch.

$$H(\theta_D) = \zeta \theta_D$$

where ζ is the ratio of fish to nonfish exports.

The stochastic processes are all assumed to be AR(1):

$$\ln {\theta_D}' = \kappa_D \ln \theta_D + \epsilon_D, \qquad \epsilon_D \in N(0, \sigma_D^2)$$

$$\ln {\theta_F}' = \kappa_F \ln \theta_F + \epsilon_F, \qquad \epsilon_F \in N(0, \sigma_F^2)$$

$$\ln {\theta_G}' = \kappa_G \ln \theta_G + \epsilon_G, \qquad \epsilon_G \in N(0, \sigma_G^2)$$

Finally, we assume a simple *ad hoc* monetary rule in the case of a floating exchange rate. According to this rule, money growth partly accommodates the domestic resource shock, implying more price stability than attained under, say, a constant money growth rule:

$$\mu(S_t) = \bar{\mu}(\theta_{Dt})/\theta_{Dt-1})^{0.2},$$

where $\bar{\mu}$ is the mean gross growh rate, which we set to one.

Based on Icelandic annual data from the second half of the 1990's, we obtain average estimates of: an investment to output ratio, I/Y, of 0.20, a capital-output ratio, K/Y, of 2.93, the capital share of output, α, of 0.337, and the fish to nonfish export ratio, ζ, of 0.84. The value of $\xi = 0.15$ is consistent with a share of fisheries of c. 13 % in the aggregator function, F. In line with the foreign bond position in the late 1990's, we calibrate the model around a ratio of foreign debt to output of 50 %.

The values for K/Y and I/Y are consistent with a depreciation rate, δ, of 0.0683. From the steady-state version of the Euler equation for capital investment, (19), this further yields an estimate for the discount factor, $\beta = 0.955$, which is consistent with a foreign bond rate of interest of 4.71 %. The value of $\eta_2 = 3.652$ was obtained from the steady-state form of equation (21), by assuming households to spend 40 % of their nonsleeping hours on employment. [5] Using data on the ratio of imports of goods and services to GDP, we obtain a value for η_1 of 0.78.

The parameter values in stochastic processes for fish catch and foreign export demand are based on estimated AR(1)'s from the sample period 1980-99. The autocorrelation coefficients so obtained are $\kappa_D = 0.689$ and $\kappa_F = 0.626$, and the standard errors are $\sigma_D = 0.057$ and $\sigma_F = 0.027$ respectively. For the general productivity shock we simply use the annualized Kydland-Prescott (1982) value for the autocorrelation coefficient, $\kappa_G = 0.81$, and calibrate the standard error to match the output volatility in the model with the Icelandic data, which yields $\sigma_G = 0.014$.

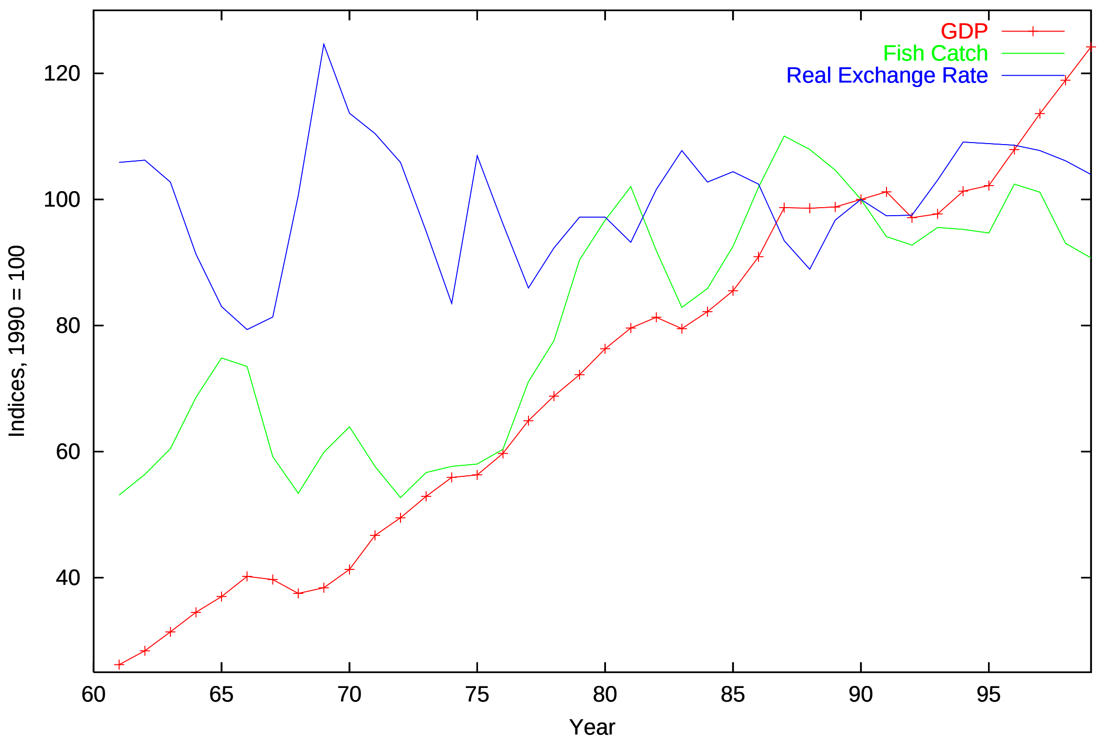
4. The Results

4.1 Icelandic economy data samples

Figure 1 and Table 1 contain some summary statistics on Icelandic macroeconomic prices and quantites, based on a data sample from the period 1961-1999, divided into three subsamples: one ranging from 1961-79, another spanning 1980-99, and finally, one from 1988-99. Of these samples, the last comes probably closest in identifying the contemporary 'Icelandic business cycle' pattern. All data in Table 1 have been detrended with the Hodrick-Prescott filter.

[5] Long working hours in Iceland is a well documented phenomenon. According to surveys undertaken by the Statistical Bureau of Iceland and others, the average working week for those engaged in full-time employment is about 50 hours.

Figure 1: GDP, Fish Catch, and the Real Exchange Rate



According to Table 1, Icelandic macroeconomic aggregates have the following characteristics. First, the volatility of output is larger than seen in a typical industrialized economy, with a standard deviation of 4.21 per cent during 1961-99. In most OECD economies, this statistic is in the 2 - 3 per cent range [See e.g. Gudmundsson and Zoega (2000).] Second, consumption tends to register more volatility than output, which is by no means unique among smaller economies [Gudmundsson and Zoega (2000).] Third, investment is three to four times as volatile as output and highly procyclical, which is in line with observations from a number of countries. Fourth, employment is relatively smooth, but less so in the second half of the period. Fifth, the real exchange rate, e, is countercyclical, a tendency which follows from the dominating role of the domestic resource shocks. A negative shock to fish catch lowers productivity *and* decreases net exports, forcing a devaluation of the domestic currency. Sixth, net exports as a ratio to output, are countercyclical, a tendency generally shared by other economies [See e.g. Clarida (1991), Mendoza (1991), and Gudmundsson and Zoega (2000).] Last, but not least, output and outher quantities show a decreasing volatility over the period, with the standard deviation of output declining from 4.81 % in 1961-79 to 3.2 % in 1988-99. An important factor in this trend is the declining share of fisheries products (highly volatile by nature) in exports. In the 1960's, this share stood at around 65 percent; by 1999 it had dropped to 41 percent.

Table 1

Summary of Second Moments

Icelandic data

	1961 - 99		1961 - 79		1980 - 99		1988 - 99	
Variable	stdev	corr w/y	stdev	corr w/y	stdev	corr w/y	stdev	corr w/y
y	4.21	1.00	4.81	1.00	3.50	1.00	3.20	1.00
c	4.57	0.89	4.85	0.92	4.30	0.92	4.02	0.89
i	12.31	0.80	13.80	0.79	11.17	0.85	13.29	0.90
n	1.97	0.54	1.12	0.41	2.64	0.85	2.05	0.95
w^c	7.71	0.88	8.28	0.89	7.05	0.83	4.60	0.82
e	8.68	-0.75	11.54	-0.82	4.58	-0.68	3.22	-0.51
u/y	3.16	-0.20	3.82	-0.14	2.26	-0.47	2.27	-0.75
eb'/y	4.86	-0.77	4.99	-0.80	4.65	-0.65	3.01	-0.67

Notes: All data are HP-filtered, setting the smoothing parameter to 100. The series on private consumption excludes expenditures on durables; investment includes public works and buildings; w^c denotes the real wage in terms of the coposite consumption good; and u net exports. Data source: National Economic Institute

4.2 Model results: second moments and impulse responses

Table 2 contains second moments on some macroeconomic aggregates, based on two model versions concerning exchange rate regime: [6] one with floating rates, the other with a monetary union. [7] Although neither regime is seen to match the actual exchange rate policy pursued by the Icelandic authorities since 1990 or so, we believe that taking the period 1990-2000 as a whole, it is better described by a floating rate regime than a monetary union. [8] As an illustration, the basket of foreign currency, composed by the Central Bank of Iceland, rose by 15.2 percent during 1993-94 (in response to negative resource and other shocks), and fell by 4 percent during 1997-2000, a period of expanding economic activity and increasing net capital inflows. [9]

Table 2 lists the standard deviations of output, consumption, investment, employment, the real wage, in composite consumer good units, the real exchange rate, the ratio of net exports to output, and net foreign debt over output. The contemporaneous correlations with output are also shown. Comparing the floating exchange rate version with the Icelandic data sample from 1988-99, we observe that the model does rather well in capturing the second moments of output, investment, and employment. Consumption and real wages are too smooth in the model, but it gets both correlations with output about right. Given that the sample period is not characterized by clear floating, an overshooting in real exchange rate volatility should perhaps not come as a surprise. The dominating effects of the domestic resource shock show up clearly in the countercyclical movements of the real exchange rate, e. A positive shock to fish catch, θ_D, affects productivity as well as the balance of payments. To restore equilibrium in the market for foreign exchange, the domestic currency must rise, i.e. e must fall. A general productivity shock affects domestic production in the same manner and enhances household expenditure in general. Unlike the shock to fish catch, it has no direct effect on the current account. Hence, a rise in θ_G forces a depreciation of the domestic currency, that is, a rise in e. A positive shock to non-fish export demand, θ_F, acts positively on the balance of payments, and hence, negatively on e. Under floating rates, the shock to fish catch dominates the other two in the foreign exchange rate market.

[6] The models were solved using the method of parameterized expectations, proposed by Marcet (1988) and DenHaan and Marcet (1990).

[7] In the model, we treat the foreign economy as a homogeneous entity, but it is abundantly clear that the real world is different. While no presumption is made here as to which currency would be the real world counterpart to the foreign money in the model, the present Icelandic trade pattern would suggest the Euro as the most probable candidate.

[8] For a more detailed account of the exchange rate policy in Iceland in the post-War era, see e.g Gudmundsson et.al. (2000).

[9] In effect, it can be argued that a *credible* currency peg, or a monetary union membership, has not been in operation in Iceland since 1914, when the Danish krone, to which the Icelandic krona was pegged, was taken off the gold standard. For example, during the Bretton Woods era, 1944-71, but Iceland was formally aligned with that system, the krona price per US dollar rose by a factor of 13.5.

Table 2

Summary of Second Moments

	Icelandic data		**Model**			
	1988 - 99		Floating		Monetary union	
Variable	stdev	corr w/y	stdev	corr w/y	stdev	corr w/y
y	3.20	1.00	3.27	1.00	3.48	1.00
c	4.02	0.89	3.05	0.82	1.60	0.83
i	13.29	0.90	14.01	0.95	11.36	0.95
n	2.05	0.95	2.29	0.91	2.55	0.94
w^c	4.60	0.82	2.56	0.83	1.35	0.83
e	3.22	-0.51	4.27	-0.51	1.86	-0.03
u/y	2.27	-0.75	0.77	-0.81	0.69	0.36
eb'/y	3.01	-0.67	2.97	-0.73	1.25	-0.81

Notes: All data are HP-filtered, setting the smoothing parameter to 100. w^c denotes the real wage in terms of the coposite consumption good; u net exports.

The model predicts too smooth behaviour of net exports; however, in line with the data these show a strong countercyclical tendency. The net foreign asset position, shown as debt in the table, is closely matched by the model, both in terms of volatility and correlation with output.

The effect of joining a monetary union, a form of a credible currency peg, is to give up the exchange rate as an absorber of external shocks. The function of restoring equilibrium in the markets for goods, labour, money, and foreign exhange, is therefore left to domestic prices. Unsurprisingly, the real exhange rate volatility is much reduced, by over a half, with the standard deviation falling from 4.27 to 1.86 percent. This is also illustrated in Figure 2, which shows the impulse response of e to a one standard deviation resource shock. With much more muted response to disturbances, the fish catch shock no longer dominates the others with regard to the cyclical property of e, which becomes essentially acyclical.

Figure 2: Imp. Res., Domestic Resource Shock

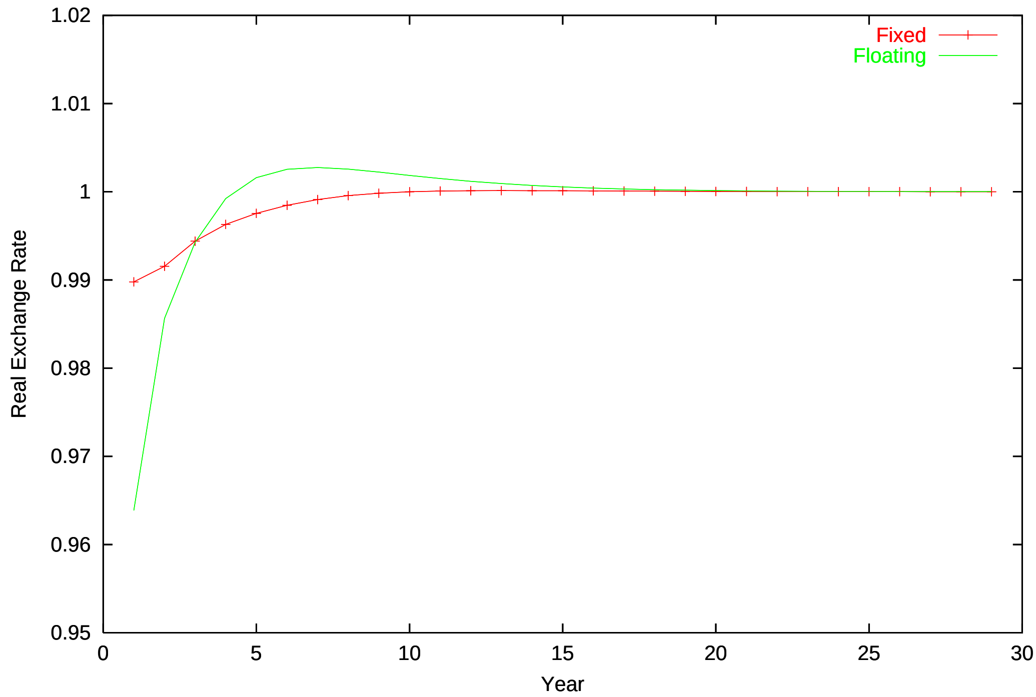


Figure 3: Imp. Res., Domestic Resource Shock

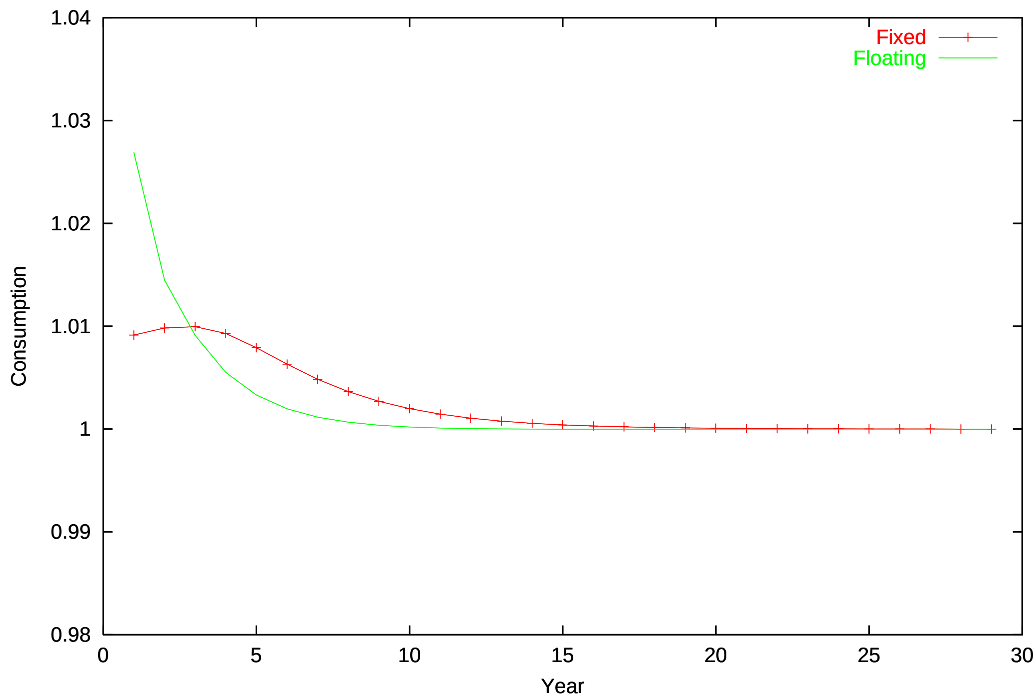


Figure 4: Imp. Res., Domestic Resource Shock

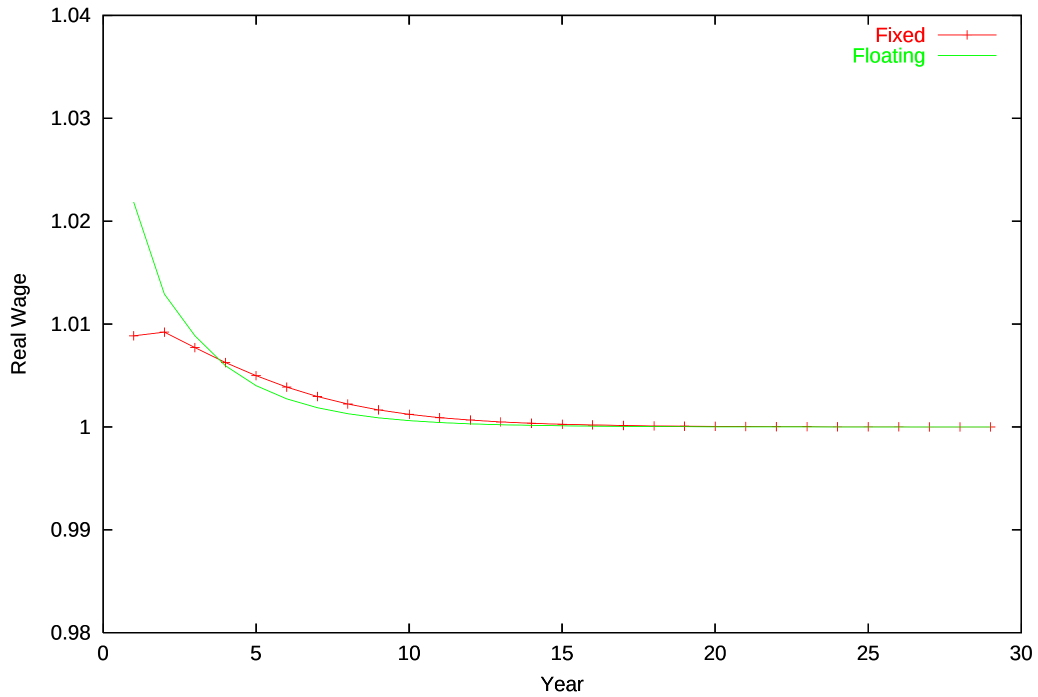


Figure 5: Imp. Res., Domestic Resource Shock

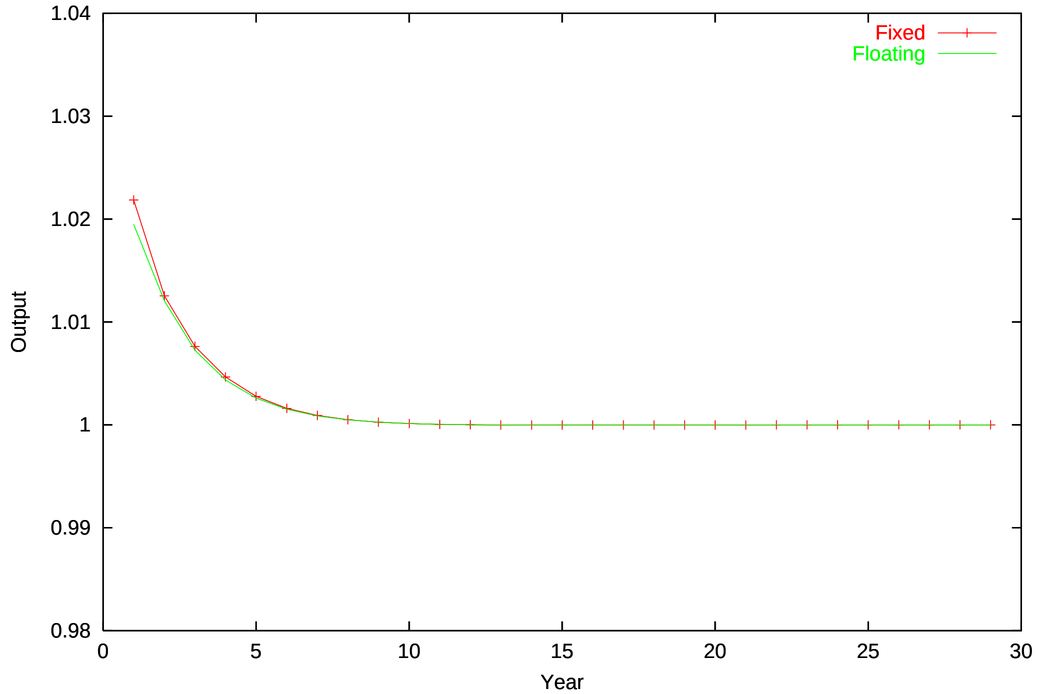


Figure 6: Imp. Res., Domestic Resource Shock

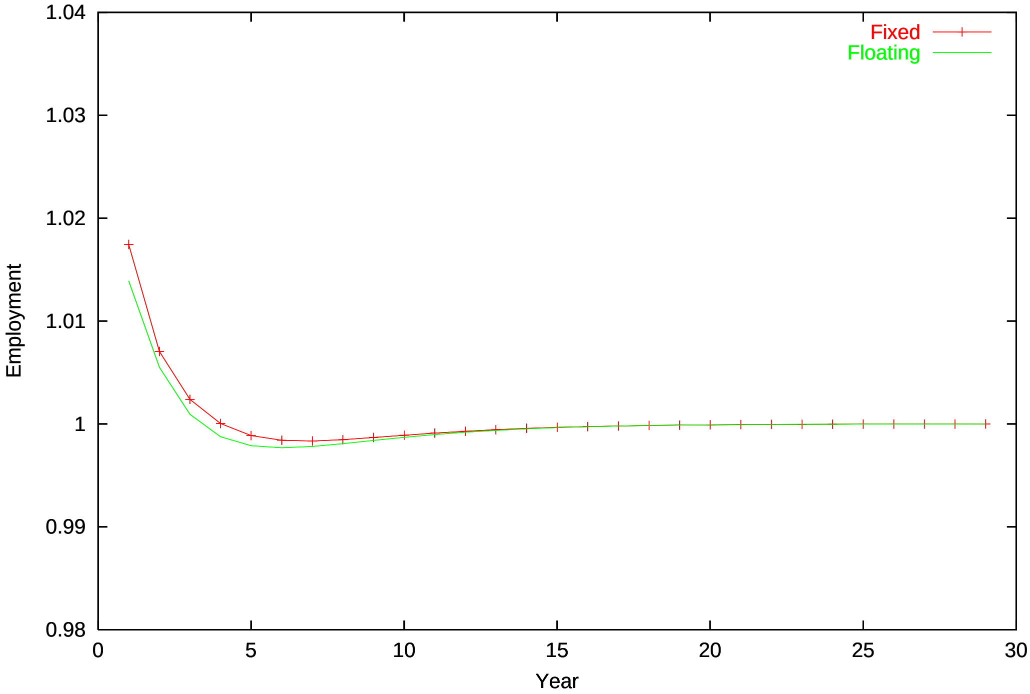
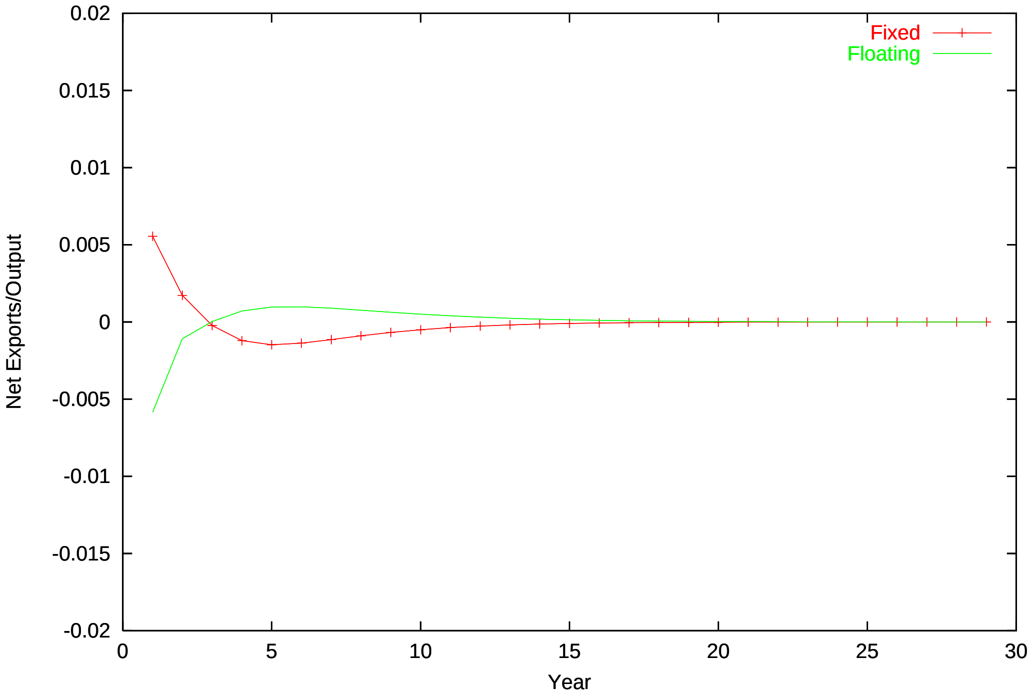
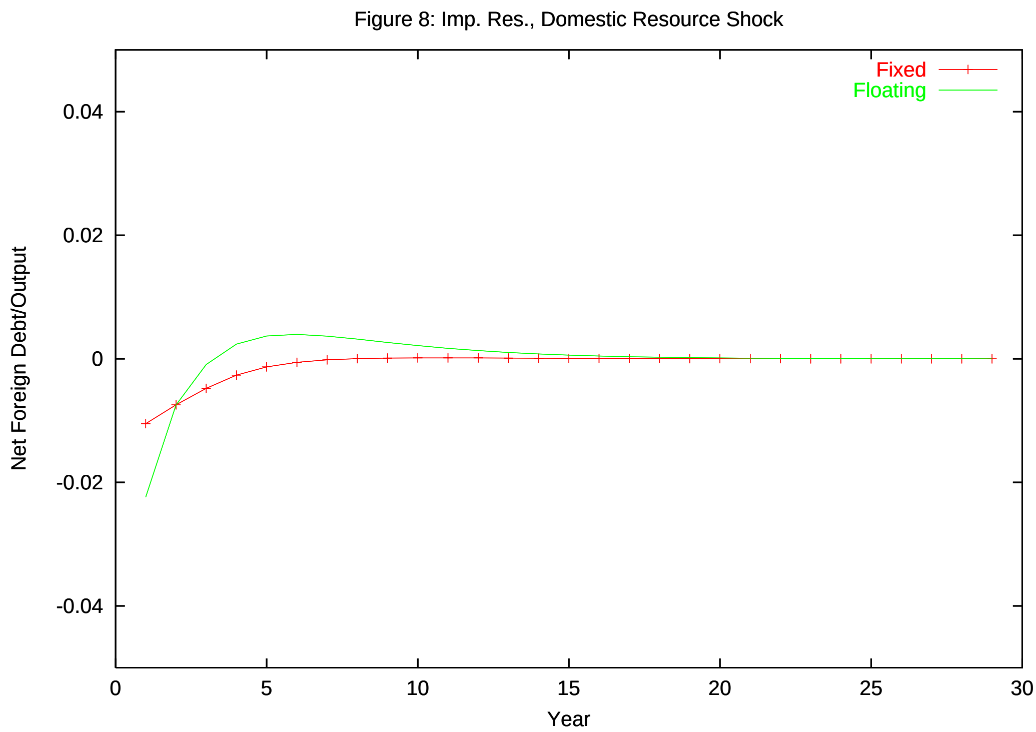


Figure 7: Imp. Res., Domestic Resource Shock





The volatilities of consumption and real wages show large reductions, while output and employment become more volatile. The standard deviation of consumption is down from 3.1 to 1.6 percent, and of real wages down from 2.6 to 1.4 percent. This is largely due to a stabilized import price, which is an important component in the consumer price index. [10] Figures 3 and 4 display the impulse responses of total consumption and the real wage to a domestic resource shock under the two exchange rate regimes. Output and employment are slightly more volatile under monetary union than under floating. The standard deviation of employment is up from 2.3 to 2.6 percent, and of output from 3.3 to 3.5 percent. This clearly indicates the reduced ability of the economy to absorb external shocks, especially when dominated by country specific real shocks, under monetary union. Figures 5 and 6, showing the impulse responses of output and employment to a fish catch shock, reveal the same pattern. This concern has been subject to much public and some scholarly debate in Iceland over the years. [See e.g. Agnarsson et.al. (2000) for a summary on various criteria against which country's (e.g. Iceland's) suitability to join the ECU might be tested.]

[10] Define the consumer price index by $P^c = P^{\frac{1}{1+\eta_1}} E^{\frac{\eta_1}{1+\eta_1}}$. Note that the logarithmic preferences over c_D and c_F allow us to define a composite consumer good whose price is given by P^c. With a strongly countercyclical E, as under floating, P^c becomes countercyclical relative to P. In case of a positive shock to θ_D, say, this has the effect of increasing both consumption and real wages defined in terms of the composite consumption good.

The switch from floating to monetary union also affects net exports, which move from a countercyclical to a procyclical behaviour. Figure 7 shows the impulse reponse function of net exports to a positive shock to θ_D. Under floating, the fall in e is so pronounced that net exports in effect respond negatively. The reason is an inflow of capital, triggered by increased productivity. To maintain balance of payments equilibrium, e must fall sufficiently, implying a temporary deficit on the current account. Under monetary union, with a much more muted decline in e, net exports show a positive response. The foreign debt position is strongly countercyclical in both regimes, but much smoother under monetary union. Again, this owes largely to a stabilized real exchange rate. In either case, an increase in θ_D, say, reduces e, which in turn lowers the stock of foreign debt to output ratio. Under a floating rate, this effect is more pronounced, as shown in Figure 8.

4.3 The issue of wage rigidity.

Ever since Mundell (1961), one of the critera for assessing whether or not an economy can successfully adopt a regime of fixed exhange rates, has been the issue of nominal wage flexibility. With flexible nominal wages, an economy can absorb adverse shocks with falling wages, in order to bring about the required decline in real wages. Under flexible exchange rates, the pressure on the nominal wage rate is less severe since an exchange rate depreciation can provide the required adjustment in the real wage. This is indeed how adverse shocks, whether rooted in fish catch or elsewhere, have been absorbed in Iceland in the post-War era. [11] Evidently, it is in order to examine how the two exchange rate regimes, a flexible rate, and a currency peg, fare with respect to nominal wage stickiness.

Table 3

Probabilty of $\Delta W < 0$, percent

π	1.02	1.04	1.10
Floating	1.7	< 0.1	< 0.1
Monetary union	15.8	1.5	< 0.1

Table 3 reports the unconditional probability of a negative nominal wage change in any given period, as predicted by the two model versions. The table lists cases for different inflation rate averages, ranging from 2 to 10 percent per annum. [12] A clearly defined pattern is evident in the table. First, as expected, the strain on the nominal wage is more

[11] See e.g. Einarsson and Magnusson (1985), and Agnarsson et.al. (2000).

[12] We note that under monetary union, the permanent inflation rate is determined by the foreign economy.

severe under monetary union than under flexible rates. For example, with a 2 percent average inflation, the probability of a negative wage change is 15.8 percent (about one year in six) under monetary union, versus 1.7 percent under floating. [13] Second, declining nominal wages become ever less likely with increased inflation. With the average inflation rate rising to 4 percent, the probability of a nominal wage decline is down to 1.5 percent under monetary union, and to under 0.1 percent with floating. A further increase of average inflation to 10 percent per annum reduces this probabilty to under 0.1 percent in either regime. One should note that even in the 'low' inflation case of 2 %, the required nominal wage rate decline is very modest on most occasions. For example, the probability of encountering a fall in excess of one percent is 2.4 %, versus the 15.8 % attached to *any* decline in nominal wages.

How do these results square with Icelandic data? During the period 1955-99, a nominal wage decline is incident in one year only (1959). This would amount to one year in 50, or about a 2 percent chance. Given that the reduction of nominal wages in 1959 was brought about by a governmental decree, and with little record of how actully paid wages evolved that year, there is a case for downplaying its relevance. Doing so would practically set the probabilty to zero. The average inflation rate, as measured by the private consumption price deflator, in this period was 18.4 percent, compared with a 10 percent rate shown for the highest case in Table 3. With permanent inflation in the double digits, the model predicts the chance of observing a falling nominal wage rate being next to nil. In the present day's environment of 2-3 % inflation, this chance becomes, however, appreciable in the case of a currency peg. Given the historical inflation and exchange rate profiles of the Icelandic economy, it is difficult to predict how labour market statistics were to behave under monetary union membership [the Lucas critique (1976) again, as Buiter (2000) correctly notes.] In sum, it seems reasonable to argue that nothing in the data is patently at variance with the model.

4.4 Welfare comparisons.

The functional forms for household utility employed in Section 3 imply concave preferences over the two consumer goods in the model. Hence, any volatility in consumption entails a welfare cost to the households. To compare the welfare cost of the two alternative exchange rate regimes, we use the measure of *compensating variation* suggested by Lucas (1987). The measure is based on the following question: By how much would the representative household have to be compensated in terms of increased consumption, across all states and periods, in order to leave it indifferent between the regime in question and perfectly smooth paths for c_D and c_F? Since both exchange rate regimes share the same nonstochastic steady state equilibrium, we can confine our comparison to fluctuations around that path.

[13] Since the model abstracts from growth, average inflation and average nominal wage increases are identical. Adding growth to the model would require a downward adjustment in the inflation figures in Table 3.

Let $(\bar{c}_D, \bar{c}_F, \bar{l})$ denote the nonstochastic steady state values of the domestic consumer good, the foreign consumer good, and leisure, respectively, and let $\{c_D, c_F, l\}$ be the stochastic equilibrium path for these variables from the exchange rate regime under consideration. In brief, the welfare cost can be measured as:

$$\mathrm{E}\left[U(\nu c_D, \nu c_F, l)\right] = U(\bar{c}_D, \bar{c}_F, \bar{l})$$

where E is the unconditional expectation operator, and $\nu \geq 1$ is the compensation factor that leaves the household indifferent between the current policy regime, and fluctuation-free consumption and leisure paths. The compensation factor is obtained by the following approximation:

$$\nu - 1 = \frac{1}{2(1+\eta_1)}\left[\mathrm{Var}(c_D) + \eta_1 \mathrm{Var}(c_F)\right]$$

where $\mathrm{Var}(z), \quad z = c_d, c_F$ is the unconditional variance. Note that since utility is *linear* in leisure, it does not appear in this measure. Table 4 presents the cyclical welfare costs associated with the two exchange rate regimes, assuming an identical steady state rate of inflation (zero):

Table 4

Welfare costs of Icelandic business cycles

Regime	Welfare cost
Floating	0.074
Monetary union	0.016

According to Table 4, households would be willing to give up 0.074% of their nonstochastic steady state consumption of the domestic and the imported good to eliminate the business cycle under the regime of floating exchange rates. [14] Under monetary union, they would surrender 0.016% for the same objective. This difference comes from lower volatility of both c_D and c_F under monetary union, owing to much smoother real exchange rate, e. Thus, the latter dominates the former in the order of under one tenth of a percentage point, a small number compared to, say, welfare calculus exercises on the cost of

[14] Alternative monetary rules, such as constant growth rule, yields essentially the same result.

inflation, but a qualititative indication nonetheless. [15] This narrow difference between alternative monetary regimes is paralleled in some other studies. For example, Schmitt-Grohé and Uribe (2001) find several specifications of an independent monetary policy to marginally dominate 'dollarization' in the case of the Mexican business cycle. The main reason for 'dollarization' being more costly is the assumption of nominal rigidities in the sector of nontradeables. The small welfare loss differentials across policy regimes owe to the fact that the welfare cost of business cycles, as measured in the representative agent framework, are quite small, as highlighted by Lucas (1987). [16]

5. Conclusions

This paper sets out a simple two goods small open economy model with a domestic resource shock as the driving force of the economy's business cycle. Two exchange rate regimes, floating and a monetary union membership are compared with respect to business cycle behaviour of selected macroeconomic variables. For simplicity, households engage in investment decisions and rent capital and labour services to the firms. The households have access to an international bond market, which provides a channel for savings (or debt issue) in addition to capital and money holdings. With a floating exchange rate, the monetary authority can pursue an independent monetary policy and, for that matter, insulate the domestic inflation from the inflation rate undergoing in the rest of the world. Under this regime, the exchange rate plays a vital role in absorbing macroeconomic shocks, bringing about required adjustments in realitve prices, without necessiating any major response in domestic prices. Under monetary union membership the home country does not adopt an independent monetary policy, since the money stock passively adjusts to any changes in the balance of payments vis-à-vis the foreign economy. The burden of absorbing shocks falls entirely on domestic prices, so in order to bring about a given decline in real wages, say, either nominal wages must fall or the goods price must rise, or both. In general, we expect relative prices to be more responsive to real shocks under floating, while quantities, such as output and employment, should show more stability.

The model was calibrated to recent data on the Icelandic economy and simulated under the two alternative exchange rate regimes. Qualititavily, these general predictions show up in the simulations. Under floating, which we take to be the closer approximation to

[15] For a literature on the welfare cost of inflation, see e.g. Cooley and Hansen (1989), Gomme (1993), and Einarsson and Marquis (1999).

[16] Using post-War U.S. data on consumption, Lucas (1987) obtained very low estimates for the welfare cost of business cycles. For example, with the degree of relative risk aversion in the 1-5 range, as widely assumed in the RBC literature, the estimated welfare loss ranges from 0.008 to 0.042% of total consumption. Attempts to evaluate the welfare costs of business cycles in a heterogeneous agents framework have come up with mixed results, depending on how the idiosyncratic shocks relate to the aggregate shocks assumed in the model. For example, assuming the expected duration of unemployment to be longer in a 'bad' aggregate state than in a 'good' state, Krussel and Smith (1999) obtain somewhat larger (but still quite small) welfare losses than those implied by the representative agent version of the same model.

Iceland's post-War economic history, output and employment are smoother than under currency peg. The real wage and the real exchange rate are, on the other hand, more volatile under floating. So is total consumption, due to the fairly large share of the imported good. In quantititive terms, the two model versions are not so far apart with respect to output and employment. Consumption and relative prices, i.e. the real wage and the real exchange rate, are about twice as volatile under floating than under monetary union membership. Considering the welfare calculus of business cycles, that regime is marginally Pareto superior to floating rates, due to more stable consumption. The concern that rigid nominal wages might hamper the economy's ability to adjust to real shocks under currency peg appears not to be a major problem according to the simulations. Clearly, imposing nominal wage rigidity would increase the volatility of output and employment under low inflation, but unlikely by a substantial amount. Furthermore, the empirical relevance of such rigidity remains unclear.

Finally, apart from wage and price rigidities, the presence of liquidity effects is another example of a temporary friction [see e.g Christiano and Eichenbaum (1995), and Fuerst (1992)] that might be important in defining the short term dynamics of the model. Such addition would, however, call for a model calibration to data of higher than annual frequency. Perhaps a topic worthy of future research.

References

Agnarsson, S., A. Hall, T.T. Herbertsson, S. Ingólfsson, G. Magnússon, and G. Zoega (2000), "EMU and the Icelandic Labour Market," in M. Gudmundsson, T.T. Herbertsson, and G. Zoega (eds.) *Macroeconomic Policy: Iceland in an Era of Global Integration*, University of Iceland Press: 115-155.

Buiter, W.H. (2000), "Is Iceland an Optimal Currency Area?," in M. Gudmundsson, T.T. Herbertsson, and G. Zoega (eds.), ibid: 33-55.

Cardia, E. (1991), "The Dynamics of a Small Open Economy in Response to Monetary, Fiscal and Productivity Shocks," *Journal of Monetary Economics*, vol.28, no.3.

Christiano, L.J. and M. Eichenbaum (1995), "Liquidity Effects, Monetary Policy, and the Business Cycle," *Journal of Money, Credit and Banking*, vol. 27, no. 4, Part 1 (November): 1113-1158.

Conzaga, G.M., and M.C.T. Terra (1997), "Equilibrium Real Exchange Rate, Volatility and Stabilization," *Journal of Development Economics*, vol. 54, no. 1: 77-100.

Cooley, T. and G.D. Hansen (1989) "The Inflation Tax in a Real Business Cycle Model," *American Economic Review*, vol. 79: 733-48.

Cooley, T.F., and V. Quadranini (2001), "The Costs of Loosing Monetary Independence: The Case of Mexico," *Journal of Money, Credit, and Banking*, vol. 33, no. 2, Part 2, May: 370-97.

Del Negro, M., and F. Obiols-Homs (2001), "Has Monetary Policy Been So Bad That It Is Better to Get Rid of It?" *Journal of Money, Credit, and Banking*, vol. 33, no. 2, Part 2, May.

DenHaan, W.J. and A. Marcet (1990), "Solving the Stochastic Growth Model by Parameterizing Expectations," *Journal of Business and Economics Statistics*," vol. 8, no. 1 (January): 31-34.

Einarsson, T. (1992), "A Real Business Cycle Model on Small Country Assumptions, with Shocks to Productivity and Foreign Tastes," Iceland Economic Papers, no.21.

Einarsson, T. and G. Magnússon (1985), "Hagsveiflur, gengismál og jöfnunarsjóðir," [in Icelandic], in S. Snævarr (ed.) *Klemensarbók*, Almenna Bókafélagið: 89-111.

Einarsson, T. and M.H. Marquis (1999) "Transitional and Steady-state Costs of Disinflation When Growth Is Endogenous," *Economica*, vol.66, November: 489-508.

Fernandez, G., and T.J. Kehoe (2000), "Capital Flows and Real Exchange Rate Fluctuations Following Spain's Entry into the European Community," *Journal of International Economics*, vol. 51, no 1: 49-78.

Fuerst, T.S. (1992), "Liquidity, Loanable Funds, and Real Activity," *Journal of Monetary Economics*, vol. 29, no. 1, (February): 3-24.

Gomme, P. (1993) "Money and Growth Revisited: Measuring the Costs of Inflation in an Endogenous Growth Modelm," *Journal of Monetary Economics*, vol. 23, October: 51-77.

Gudmundsson, M., T. Pétursson, and A. Sighvatsson (2000), "Optimal Exchange Rate Policy: The Case of Iceland," in M. Gudmundsson, T.T. Herbertsson, and G. Zoega (eds.), ibid: 57-113.

Gudmundsson, B. and G. Zoega (2000), "A Study of Iceland's Fiscal Policy, 1960-1998," in Gudmundsson, T.T. Herbertsson, and G. Zoega (eds.), ibid: 195-219.

Hansen, G.D. (1985), "Indivisible Labor and the Business Cycle," *Journal of Monetary Economics*, 16, November: 309-27.

Krussel, P. and A.A. Smith (1999), "On the Welfare Effects of Eliminating Business Cycles," *Review of Economic Dynamics*, vol.2, no.1, January: 245-72.

Lucas, R.E. (1976), "Econometric Policy Evaluation: A Critique," in K. Brunner and A.H. Meltzer (eds.) *Carnegie-Rochester Conference Series on Public Policy*, vol.1: 19-46.

Lucas, R.E. (1987), *Models of Business Cycles*, Yrjo Jahnsson Lectures. London and New York: Blackwell.

Marcet, A. (1988), "Solving Non-linear Models by Parameterizing Expectations," Manuscript, Carnegie-Mellon University, Graduate School of Industrial Administration.

Mendoza, E.G. (1991), "Real Business Cycle in a Small Open Economy," *American Economic Review*, vol. 81, no. 4: 797-818.

Mendoza, E.G. (1995), "The Terms of Trade, the Real Exchange Rate, and Economic Fluctuations," *International Economic Review*, vol. 36, February: 101-37.

Mendoza, E.G. (2001), "The Benefits of Dollarization When Stabilization Policy Lacks Credibility and Financial Markets Are Imperfect," *Journal of Money, Credit, and Banking*, vol. 33, no. 2, Part 2, May: 440-74.

Mundell, R.A. (1961), "A Theory of Optimum Currency Areas," *American Economic Review*, vol. 51: 657-675.

Rogerson, R. (1988), "Indivisible Labor, Lotteries, and Equilibrium," *Journal of Monetary Economics*, vol. 21: 3-16.

Schmitt-Grohé, S., and M. Uribe (2001), "Stabilization Policy and the Costs of Dollarization," *Journal of Money, Credit, and Banking*, vol. 33, no. 2, Part 2, May: 482-509.