A risk allocation approach to optimal exchange rate policy*

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Abstract

We derive the optimal exchange rate policy for a small open economy subject to terms-of-trade shocks. Firm owners and workers are risk averse but workers more so. Wages are given or partially indexed in the short run, and capital markets are imperfect. The government sets the exchange rate to allocate risk between workers and owners. With less risk-averse firms, and greater difference in risk aversion between workers and firms, the optimal exchange rate should vary little with pure terms-of-trade shocks but more with general shocks to prices. Optimal exchange rate variation is greater with indexed wages, but is smaller when firms behave monopolistically and when wage taxes (profit taxes) change procyclically (countercyclically) with export prices (import prices). The model gives policy rules for determining optimal variations of the exchange rate, and indicates when it is, and is not, optimal to join a currency union with trading partners, implying zero exchange rate variation.

1. Introduction

The choice between fixed and flexible exchange rates, and the "optimal" degree of exchange rate flexibility, has long been fundamental issues in international economics, at least since the seminal contributions of Mundell (1960, 1961) and McKinnon (1963). After the breakdown of the Bretton Woods fixed-rate system in the early 1970s the developed world has adopted a number of approaches to the managing of exchange rates. Many of these have involved pre-determined currency bands within which each country's exchange rate was allowed to fluctuate relative to particular target currencies, or similar "implicit" (and in practice often narrower) bands. More recently we have witnessed two separate new developments. The first of these is the European currency union whereby most European Union member states have adopted the Euro as a common currency, from the start of 1999. The main purpose of the union can perhaps be viewed as the promotion of economic integration among the member nations, thereby reducing transaction costs and promoting specialization and competition within the union. The exchange rate policy of the Euro area versus the outside world is however less well defined and can most reasonably be described as flexible and demand-oriented. More recently other groups of countries, in Latin America, Africa and the Middle East, are in the process of adopting common currencies.[1] The second development is the adoption of inflation targets as monetary policy in several OECD countries outside of the Euro area, such as Canada, Great Britain, Denmark, Sweden, Norway, New Zealand and Australia. In these countries the main role of exchange rate policy is the managing of long-run inflation, to be kept in a typical range around 2 %.

The purpose of this paper is to study a single government's choice of exchange rate policy focusing on roles of the exchange rate quite different from those just described and from the

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[1] See Alesina, Barro and Tenreyro (2002) for overviews and discussions of recent development in this area.

theoretical approaches in the related literature. We consider a stylized small open economy where the entire output is exported, all consumption goods are imported, nominal prices abroad are taken as exogenous by all domestic agents, and where competition creates complete pass-through of foreign to domestic prices. We assume that the nominal wage has a high degree of rigidity (in section 2) or is partly indexed to the consumer price level (in section 3) for the period in question, while domestic prices are always fully flexible. The government is assumed to announce, and commit to, its exchange rate policy (the nominal exchange rate in each of the possible states that may occur in the "next period"), prior to the revelation of the next-period state. At the time the government announces the exchange rate policy, the "next-period" wage is determined in the private sector. Export and import prices are subject to stochastic i.i.d. shocks, firms are assumed to determine employment unilaterally in each state, and there is always some unemployment in the economy, resulting from short-run wage rigidities, in line with standard approaches in "new Keynesian" macroeconomics.

We assume that individuals in the economy can be separated into one of two distinct groups. The first, workers, consume out of wages, while the second, firm owners, consume out of profits. Within each group, all individuals are assumed to have constant and identical degrees of relative risk aversion, but risk aversion may differ between workers and owners. In our model, the "public" thus cannot be identified by a "representative individual", household, or producer as assumed e.g. by Obstfeld and Rogoff (1996, 1998). The risk preferences of individuals in each group are then shown to matter for the government's constrained efficient exchange rate policy, as the exchange rate rule has important consequences for the short-run variations in wages and owner incomes. We will generally assume that workers are more risk averse than firm owners are, following e.g. the traditional implicit labor contracts literature (Azariadis and Stiglitz (1983); Parsons (1986)), e.g. because they have greater immediate consumption needs relative to income,

and relatively fewer effective means of diversifying risks than firms. This should be true even in the presence of capital markets.

Our main result is that when risk markets are incomplete, the final optimal exchange rate policy serves as a device for sharing macroeconomic risk between the two groups considered. This result is similar to the ones of the "implicit contract" theory where wages are determined out of the direct control of authorities. We find a simple closed-form analytical solution to this problem, one that generalizes the familiar Arrow-Borch condition for optimal risk allocation between two parties (see Borch (1962)). In some important special cases, in particular when only workers are risk averse and only export prices are variable, the optimal rule is to keep the exchange rate invariable over time. That means that the government should commit to a monetary union with relevant trade partners. This main result holds both in the basic case, studied in section 2, and under three extensions of the basic model, in section 3, to indexation, taxation and imperfect competition. The details of the optimal policy rule are somewhat reacher with each of these extensions, as explained there as well as in the concluding section 4.

In the literature several attempts have been made to derive "optimal" exchange rate rules. Most of this work compares the efficiency of keeping the exchange rate fixed versus letting it be (fully or partly) flexible. Hamada and Sakurai (1978), Flood (1979), Flood and Marion (1982), Aizenman and Frenkel (1985), Glick and Wihlborg (1990), Hodrick (1989), Weber (1981), Artis and Currie (1981) and Fukuda and Hamada (1987), all extend Mundell's framework to include roles for expectations. Artis and Currie (1981) and Fukuda and Hamada (1987) find that both output and prices are stabilized under fixed rates with "velocity shocks", and destabilized with "demand shocks", and that the choice between regimes rests on which of these types of shocks is more important. Most of these papers are based on ad-hoc criteria, usually involving output-inflation tradeoffs, and not on optimization from "first principles". A different strand of the

literature, represented by Lucas (1982), Helpman and Razin (1982), Magill and Quinzi (1996) and Neumeyer (1998), focuses on the roles for exchange rates in allocating risk in general equilibrium models with incomplete markets. In particular, Neumeyer finds that a monetary union is under certain assumptions preferable to a system of flexible exchange rates, provided that the gains thereby achieved, due to elimination of excess volatility of nominal variables, exceed the cost of changing the asset structure. A large recent literature (e.g. Frankel and Rose (1997, 1998), Devereux and Engel (2000), and Corsetti and Pesenti (2001, 2002)) studies the optimum currency area issue from welfare-maximizing standpoints. The comparison is however also here between a currency union and a flexible exchange rate system and generally under assumptions different from ours; in particular, risk allocation is unimportant. Other contributions studying welfare properties of alternative exchange rate systems are Aizenman (1994), Buiter (2000), Chinn and Miller (1998), Sutherland (1995) and Cooper and Kempf (2004). In particular, Buiter (2000), and Cooper and Kempf (2004) argue against a monetary union when there are asymmetric shocks and only monetary policy is used for stabilization. Cooper and Kempf (2004) however stress that when also fiscal policy can be used, it is very hard to argue against a currency union on efficiency grounds. Sutherland (1995) considers efficiency properties of commitment to a band policy, versus either a fixed or fully flexible rate, using a Poole (1970) type of analysis where the variance of certain target variables is minimized. Many of the above papers assume full flexibility of prices and wages and thus do not directly follow the Mundell tradition. Price stickiness has been considered by Flood and Rose (1995), Obstfeld and Rogoff (1995, 1998), Devereux and Engel (1998, 1999), Rankin (1998) and Hau (1999); the latter paper also (as we do) assumes wage rigidity. In none of this work risk allocation plays any role for the government's optimal choice of exchange rate regime.[2]

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[2]The most closely related work in this respect is perhaps that of Huizinga (1997), on the political economy of exchange rate determination in a developing country, where the exchange rate can be overvalued in the political

Our approach is unorthodox in several respects, *first* by focusing on the optimal exchange rate policy as a risk allocation device; *secondly* by deriving a target rule for the exchange rate, where the government's optimal exchange rate policy is affected by certain underlying fundamentals; and *thirdly*, by focusing completely on real variables.

We have made a few simplifications that limit the scope of our analysis, in particular, we do not study the case in which individuals can smooth their consumption by borrowing and lending in capital markets, and are instead assumed to always consume their current income, as is standard in the new open economy literature (Obstfeld and Rogoff (1996)). We do not either take into account possible government concerns about inflation. Nevertheless we believe that our approach may serve to emphasize and clarify the role of exchange rate policy in such a particular setting. In section 4 below we discuss some of our main assumptions further, and conclude that most results are likely to hold, under a wide range of alternative cases.

2. The basic model

Consider an economy where output is homogeneous and exported in its entirety, and a single consumption good is imported. The economy has a large and given number of identical firms operating in perfectly competitive markets. There is a given labor force L. The country is small and does not affect world market prices of export or import goods. [3]

The economy is stationary across periods.[4] We assume that the economy in any period

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equilibrium when the medial voter gains from low import prices; and Frenkel and Razin (1989), who stress the equivalence between exchange rate policy and tax policy when there may be "dual" exchange rates. The mechanisms by which distributional factors come into play, and the principles for determining the exchange rate, are here however quite different from ours.

[3] Not very much would change if firms were monopolistic competitors in world markets. Generally, optimal prices set by firms would still fluctuate procyclically, in the same way as under exogenous prices here, and be positively related to output, although not necessarily in exactly the same way as here.

[4] Stationarity here follows from the time-independence of all states.

experiences one out of two possible states, 1 or 2; which can easily be generalized to an arbitrary number of states. In state i the world market prices of exports and imports are p_i and q_i, respectively, i = 1,2. Viewed ex ante the probabilities of state 1 and 2 occurring are β and 1-β, respectively.[5] In each state the government sets the exchange rate z_i, where an increase in z_i implies a weakening of the home currency. Export goods are then sold abroad at a price of $p_i z_i$, and import goods are bought by the home country at a price of $q_i z_i$, both in terms of the home currency. The only role of government is to set the exchange rate. In the next section we will study the role of taxes or public expenditures. The current account is assumed to be balanced at all times.

In this model we will assume the following sequence of events. In <u>period 1</u>, prior to the revelation of p_i and q_i, the government announces nominal exchange rate z_i, i = 1,2, for each of the two states that may occur. In period 1 a nominal, and state-invariant, wage w is also agreed between private-sector agents.[6] None of the results below depend on the exact level of w, only on some unemployment actually resulting in equilibrium, and the labor market thus does not clear given this wage, in neither of the states. The government's exchange rate regime announcement is assumed to be fully credible. In particular, the government is not allowed to set the nominal exchange rate <u>after</u> observing the nominal wage set by the private sector. In <u>period 2</u>, the corresponding state (i.e. whether i equals 1 or 2) is revealed and the exchange rate z_i is

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[5] One difference between our approach and one where the stochastic variables (or their logs) follow time-independent Brownian motion or Markov processes is that we will here have a "drift toward the mean" in the variables, while the alternative processes yield no systematic future movement of the state variable. We argue that our assumption is relevant in many situations, in particular when "long-run averages" are known with reasonable certainty; and when the short-run development of prices can be characterized by "business cycles" (with e.g. Brownian motion processes, the notion of "business cycles" is meaningless in the sense that one will have no idea of when the current state is "good" or "bad"). An extension of the current analysis to other stochastic processes must await future research.

[6] The wage may perhaps most naturally be viewed as set through wage bargaining.. The important thing here is however not the exact mechanism for setting the wage, but rather the property that wages are predetermined before the period-specific shock is realized so as to maintain a given average macro employment level.

immediately determined in accordance to the government's commitment in period 1. Firms, taking the wage, all prices and the exchange rate as given, then determine output competitively.

Note that this two-period basic model solution can be viewed as repeating over time, in identical fashion. Indeed, such repetition may be viewed as necessary for the government to establish credibility of its chosen rule, by observation of repeated adherence to this rule.

Firms have Cobb-Douglas production functions L^{γ} where $\gamma \in (0,1)$ is the elasticity of output with respect to labor (L) and also the factor share of labor under perfect competition. Firms' nominal profits in the home currency are given by:

$$\pi_i = p_i z_i L_i^{\gamma} - w L_i \qquad i=1,2 \tag{1}$$

Firms maximize π_i with respect to employment L_i in any given period, yielding the first-order conditions:

$$p_i z_i \gamma L_i^{-(1-\gamma)} = w \qquad i=1,2 \tag{2}$$

This leads to the labor demand equations:

$$L_i = \gamma^{\frac{1}{1-\gamma}} (p_i z_i)^{\frac{1}{1-\gamma}} w^{-\frac{1}{1-\gamma}} \qquad i=1,2 \tag{3}$$

yielding the following expression for firms' nominal profits:

$$\pi_i = (1-\gamma)\gamma^{\frac{\gamma}{1-\gamma}} (p_i z_i)^{\frac{1}{1-\gamma}} w^{-\frac{\gamma}{1-\gamma}} \qquad i=1,2 \tag{4}$$

Assume a given number of perfectly competitive firms in the economy, normalized to one. Firm owners' utility of current profits is assumed to be as follows:

$$U_i = \left(\frac{\pi_i}{q_i z_i}\right)^{\alpha} = (1-\gamma)^{\alpha} \gamma^{\frac{\alpha\gamma}{1-\gamma}} w^{-\frac{\alpha\gamma}{1-\gamma}} p_i^{\frac{\alpha}{1-\gamma}} q_i^{-\alpha} z_i^{\frac{\alpha\gamma}{1-\gamma}} \qquad i=1,2 \tag{5}$$

Note that since $q_i z_i$ is the nominal price of the import good in terms of the home currency, the

argument of the function (5) is the consumption value of profits. $1-\alpha$ is the (constant) coefficient of relative risk aversion. We assume that $\alpha \in (0,1]$, i.e., firm owners are generally risk averse but may as a special case ($\alpha=1$) be risk neutral.

Individual workers are similarly risk averse with (constant) coefficient of relative risk aversion equal to $1-\rho \in (0,1)$, and have following utility function preferences over the current real consumption value of wages:

$$v_i = \left(\frac{w}{q_i z_i} \right)^{\rho} \qquad i=1,2 \qquad (6)$$

From the point of view of the government, the sum of the labor force members' utilities is given by:

$$V_i = L_i^{\delta} \left(\frac{w}{q_i z_i} \right)^{\rho} = \gamma^{\frac{\delta}{1-\gamma}} w^{-\left(\frac{\delta}{1-\gamma}-\rho\right)} p_i^{\frac{\delta}{1-\gamma}} q_i^{-\rho} z_i^{\left(\frac{\delta}{1-\gamma}-\rho\right)} \qquad i=1,2 \qquad (7)$$

Here L_i workers are employed, while $L-L_i$ unemployed; the latter have no current income in the model and thus by assumption zero utility. We will assume that $\delta \leq 1$. When $\delta=1$, the government preference function which represents all workers is said to be <u>utilitarian,</u> since V_i then is the sum of the utilities of employed workers (since as noted unemployed workers are assumed to have no income and thus zero utility). Holding the real wage of employed workers constant, $\delta<1$ would represent "decreasing returns" in the eyes of government, when employment increases. $\delta \in (\rho,1)$ may imply that workers' individual utilities are still aggregated as before, but that a given reduction in unemployment is viewed as more gainful when employment at the outset is lower.

The government is assumed to be able and willing to commit to exchange rates z_i in each of the possible future states, before the state is known. Here, the absolute levels of the exchange rates are unimportant for the solution of the model; only the <u>relative</u> exchange rates between the states matter. This follows because the wage is set simultaneously with or immediately following

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the government's commitment to future exchange rates, so as to achieve a given expected level of employment. In the formal analysis, we then only need to study the government's determination of relative exchange rates.

From (3), (5) and (7), the utilities of both workers and firms as groups are increasing in z as long as there is some unemployment. If the government follows a discretionary policy, it would then have an ex post incentive to set the exchange rate z_i at a sufficiently high level for employment to be maximized. This would however violate not only the condition that the average real wage is given, but also the expectations of labor market participants. The other agents in the economy will anticipate this, and it may lead to non-optimal decisions (or a breakdown of the model). Full commitment to a given exchange rate policy is thus required.

In this light, the government can be viewed as maximizing the ex ante expected utility of the representative owner (EU), taking the expected utility of workers as a group (EV), and the expected real wage, as given.[7] The Lagrangian for this problem can be written as:

$$H = E U - \lambda E V = \beta U_1 + (1 - \beta) U_2 - \lambda [\beta V_1 + (1 - \beta) V_2]. \tag{8}$$

H is maximized with respect to z_1 and z_2.[8] Taking logs, the two resulting equations can be expressed in the following way:

$$(\delta - \alpha) log\ p_i + [\delta - \alpha + (\alpha - \rho)(1 - \gamma)] log\ z_i + (\alpha - \rho)(1 - \gamma) log\ q_i = K, \quad i=1,2 \tag{9}$$

K is a constant and the same for both equations. Combining the two equations contained in (9) yields the following expression:

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[7]Note the asymmetry following from the government (or its monetary authority) maximizing expected long-run utility taken as given that each firm maximizes short-run profits in each state. Thus the government is assumed not to have instruments that directly correct the inefficiencies that result from short-run behavior of firms, nor from workers decisions regarding wage setting.

[8]Note that the problem may equivalently be formulated as one where the utility of workers is maximized given firm owners' utility; or where the government maximizes an asymmetric Nash product of EU and EV respectively.

$$log\left(\frac{z_1}{z_2}\right) = \frac{\delta - \alpha}{\delta - \alpha + (\alpha - \rho)(1-\gamma)} log\left(\frac{p_2}{p_1}\right) + \frac{(\alpha - \rho)(1-\gamma)}{\delta - \alpha + (\alpha - \rho)(1-\gamma)} log\left(\frac{q_2}{q_1}\right) \qquad (10)$$

(10) sums up, in a remarkably simple and intuitive way, the factors behind optimal exchange rate policy in this type of economy. It can be interpreted as an optimal risk allocation problem, between owners on the one hand, and workers on the other, when output is affected by short-run fluctuations in the exchange rate and export and import prices. It can be viewed as a generalized version of Borch's (1962) condition for optimal risk sharing between two parties signing a mutual and binding insurance contract. (10) can readily be generalized to an arbitrary number (or a continuum) of states, and is then a condition for comparing any two of these states.[9]

Interpreting (10) implies analyzing how the optimal exchange rate variation is determined and depends on the agents' degree of risk aversion and on the nature of the shocks affecting import and export prices. We will consider three main cases I-III.

Case I. A shock that increases p_i and q_i proportionally

Since the coefficients before $log(p_2/p_1)$ and $log(q_2/q_1)$ sum to one, the relative exchange rate, $log(z_1/z_2)$, should in this case be adjusted equivalently, leaving import prices ($q_i z_i$) and export prices ($p_i z_i$) in terms of domestic currency, as well as output (and so employment), invariant to such shocks. This implies no real effects on the economy. "Real" and relative prices also remain unchanged even though all prices change simultaneously as a result of the "nominal" shock. A full opposite exchange rate adjustment should here exactly counteract such a shock.

Case II. A shock that affects only relative export prices

Here, only p_2/p_1 changes. A shock of this type can be interpreted either as a pure terms-of-trade

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[9]The extension to more states is easily seen from (8), where we may simply introduce more states with individual probabilities attached to them (or a continuum of states with an associated probability measure).

change, or as a shift in domestic productivity, i.e. a "real" shock. Recall our assumption that $\rho \leq \delta \leq 1$. We may here in turn identify four interesting subcases, A-D. Subcases A-C arise when workers are equally or more risk averse than the firms with respect to total income (i.e. $\alpha \geq \rho$).

A: The exchange rate should adjust so as to leave export prices, $p_i z_i$, (in terms of domestic currency) constant across states

This is optimal only if workers and firms are equally risk averse with respect to income or there are constant returns in the production function. That is, either $\alpha = \rho$, or $\gamma \to 1$, respectively. (The coefficient before $\log(p_2/p_1)$ will then equal one.) Thus, when the two parties are equally risk averse or there are constant returns to scale (CRS) (though risk averse agents), it is optimal to keep output (and employment) constant across states, and let all uncertainty (all possible price fluctuations) be translated through a full variation of the import (and consumer) prices in the home currency, $q_i z_i$.

B: The exchange rate should be kept fixed across states

This is optimal only if the firm risk aversion coefficient equals the coefficient by which the government aggregates individual workers in the utility function, and workers are more risk averse than firms are. This holds when $\alpha = \delta > \rho$ (coefficient before $\log(p_2/p_1)$ will now equal zero) which implies that the government's welfare function aggregating up workers' utilities now exhibits more risk aversion with respect to wages than with respect to employment. The optimal solution for the exchange rate yields constant real wages across states. Producers then face the full variation in world market export prices, and adjust output accordingly and workers as a group will then absorb more risk through variations in employment. We will argue that this case is important as it provides a theoretical support for a monetary union. Note that it covers the

important special case $\alpha=\delta=1$, where owners are risk neutral ($\alpha=1$) and workers risk averse ($\rho<1$), and all workers have the same weight in the government utility function representing them ($\delta=1$).

As long as $\rho<\alpha<\delta$ (the coefficient before log (p_2/p_1) is strictly between zero and one) we will have a solution intermediate between cases A and B. The optimal government policy will be to adjust the exchange rate so as to partly dampen the effects that a shock may have on output, consumer prices, and real wage across states. Recall that in comparison to the solution where $p_i z_i$ is a constant, wages and consumer prices will vary much less. This will be definitely efficient when workers are more risk averse with respect to income variations than firms are ($\rho<\alpha$), and more so the greater the difference in risk aversion, and the less risk averse firms are.

C: $\rho\leq\delta<\alpha$

Now the coefficient before log (p_2/p_1) in (10) is negative. The exchange rate should then be appreciated when the terms of trade are weakened. Now efficient risk allocation implies opposite movements in employment and real consumer prices, and more volatile employment than under fixed exchange rates (which as noted would occur under case B). This is accomplished by further stimulating exports when there is an improvement in terms of trade. Intuitively, firms are now "nearly risk neutral". Profits can then be allowed to vary relatively more between states. Workers will however have their (individual and aggregate) utility affected in two different ways: With a reduction in the export prices, it is optimal to increase the individual worker real income.[10] With an increase in export prices, it will instead be optimal to increase employment.

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[10] Recall that the workers only consume foreign produced goods.

D: ρ>α

Here firms are more risk averse than workers. Then the coefficient before log (p_2/p_1) is greater than one. It is now particularly important to protect firms against risk, and firms' output (and employment) should fluctuate in the opposite direction to domestic import prices. This is accomplished by making the counteracting change in z_i greater than the change in p_i, i.e. $\log(z_1/z_2) > \log(p_2/p_1)$. This <u>reduces</u> employment in the "good" state, while import (and domestic) prices in terms of the domestic currency are made to fluctuate by more than the exogenous fluctuation in export prices, also in terms of the domestic currency.

We will argue that cases C and D are less relevant than cases A and B. For one thing, the model and its solutions are most easy to interpret and justify when δ=1 and all workers count equally in the government's utility function. Then case C becomes irrelevant. Moreover, a main point of departure is that workers are more risk averse than firm owners, eliminating case D. In the following we will accordingly concentrate on cases A and B.

Case III. A shock that affects only relative import prices

Since the coefficient in (10) before $\log(q_2/q_1)$ is one minus the coefficient before $\log(p_2/p_1)$, the discussion concerning this coefficient is essentially the same as that concerning the latter coefficient, only with opposite sign. This coefficient is closer to one, the closer α is to δ, but the same coefficient closer to zero the more similar the agents' risk preferences are (α=ρ) and the more responsive labor demand is to prices (γ→1).

In summarizing the results, the following conditions speak in favor of relatively small or none exchange rate fluctuations:

- When there is a shock to export prices and firms' relative risk aversion coefficient 1-α is close to 1-δ. A special case is one in which all workers count equally in the government

utility function ($\delta=1$), this implies firm risk neutrality.

- When there is a shock to export prices and workers are highly risk averse with respect to income and more than firms.

- When there is a shock to import prices and the two parties are equally risk averse with respect to income.

- With a shock either to export or import prices, and when there are strongly decreasing returns to scale of the macro production function in labour (and correspondingly, the factor share of labour in GNP is relatively low).

Note here finally that the case of identical risk preferences is analytically identical to the standard case studied in most of the literature cited above, where a representative individual is considered. With fluctuations only in export prices, the exchange rate should then be adjusted perfectly to these prices, or kept fixed (enter a monetary union) when the import prices are the ones that fluctuate.

Let us summarise the most relevant results obtained from cases I – III in Table 1.

Table 1

	CASE I	CASE II				CASE III
Change	$\Delta\log(p_2/p_1) =$ $\Delta\log(q_2/q_1)=$ ϕ	$\Delta\log(p_2/p_1) = \phi$; $\Delta\log(q_2/q_1) = 0$				$\Delta\log(p_2/p_1) = 0$ $\Delta\log(q_2/q_1) = \phi$
		$\alpha=\rho$ and $\gamma\to 1$ (but $\alpha\geq\rho$)	$\alpha=\delta(=1)>\rho$	$\alpha<\rho$		$\alpha=\rho;\gamma\to 1$
Effects on exchange rate and other variables	$\Delta\log(z_1/z_2)=\phi$	$p_1z_1=p_2z_2$ q_iz_i vary a lot, $\forall i$ $\Delta\log(z_1/z_2)=\phi$	w/q_iz_i stable $\Delta\log(z_1/z_2)=0$ L_i, p_iz_i vary a lot, $\forall i$	$\log(p_2/p_1)>$ $\log(z_1/z_2)$ $z_ip_i<z_iq_i$		$\Delta\log(z_1/z_2) = 0$ [But $\Delta\log(z_1/z_2)$ $= \phi$ if $\alpha=\delta$]

3. Extensions of the basic model

3.1 Wage indexation

We have so far assumed that the wage is nominally fixed in any given period. Alternatively, assume that the wages are determined such that there is still unemployment in each period, but the wage is adjusted (imperfectly) ex post to unexpected changes in workers' cost of living. This can be represented by a <u>wage indexation scheme</u> of the following form:

$$w = w_0(q_i z_i)^{\theta} \qquad \text{i=1,2} \tag{11}$$

Here w_0 is a base wage (similar to w in section 2 above), and θ a parameter indicating the degree of indexation.[11] When $\theta=0$ there is no indexation and we are back to the model already analyzed above. When $\theta=1$, by contrast, there is full indexation and workers' <u>real</u> wages are kept

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[11]Note however that when $\theta>0$, the <u>level</u> of w_0 will generally not correspond to the level of w in section 2 above, assuming that workers' wage demands are set so as to maintain a given (average) utility level of employed workers. This feature will however in no way affect any of the basic results from the model.

invariable across states. $\theta \in (0,1)$ represents intermediate cases where values closer to unity imply relatively greater degrees of indexation.

The labor demand equations equivalent to (3) can now be written as follows:

$$L_i = \gamma^{\frac{1}{1-\gamma}} w_0^{-\frac{1}{1-\gamma}} p_i^{\frac{1}{1-\gamma}} q_i^{-\frac{\theta}{1-\gamma}} z_i^{\frac{1-\theta}{1-\gamma}} \qquad \text{i=1,2} \qquad (12)$$

Correspondingly, the expression for firms' utility of current profits, replacing (5), is:

$$U_i = \left(\frac{\pi_i}{q_i z_i}\right)^\alpha = (1-\gamma)^\alpha \gamma^{\frac{\alpha\gamma}{1-\gamma}} w_0^{-\frac{\alpha\gamma}{1-\gamma}} p_i^{\frac{\alpha}{1-\gamma}} q_i^{-\frac{\alpha}{1-\gamma}[1-\gamma(1-\theta)]} z_i^{\frac{\alpha\gamma(1-\theta)}{1-\gamma}} \qquad \text{i=1,2} \qquad (13)$$

The government's aggregate of workers' utilities, replacing (7), is likewise given by:

$$V_i = L_i^\delta \left(\frac{w}{q_i z_i}\right)^\rho = \gamma^{\frac{\delta}{1-\gamma}} w_0^{-\left(\frac{\delta}{1-\gamma}-\rho\right)} p_i^{\frac{\delta}{1-\gamma}} q_i^{-\rho(1-\theta)-\frac{\theta\delta}{1-\gamma}} z_i^{\left(\frac{\delta}{1-\gamma}-\rho\right)} \qquad \text{i=1,2} \qquad (14)$$

We may now also derive a new expression for optimal government exchange rate determination, equivalent to (10), as follows:

$$log\left(\frac{z_1}{z_2}\right) = \frac{\delta-\alpha}{(1-\theta)[\delta-\alpha+(\alpha-\rho)(1-\gamma)]} log\left(\frac{p_2}{p_1}\right) + \frac{(\alpha-\rho)(1-\gamma)(1-\theta)-(\delta-\alpha)\theta}{(1-\theta)[\delta-\alpha+(\alpha-\rho)(1-\gamma)]} log\left(\frac{q_2}{q_1}\right)$$

$$(15)$$

The main interesting change implied by wage indexation comes via the term $1-\theta$ in the denominator of the expression (15), before $log\,(p_2/p_1)$ and $log\,(q_2/q_1)$. This term implies that the optimal variation in the exchange rate under the case of an <u>indexed</u> wage, is greater than the equivalent variation under a <u>fixed</u> wage. In other words<u>, the greater the degree of indexation, the greater is the optimal variation in the exchange rate, when only export prices change</u>. The intuitive explanation of this result can be found from inspection of the expressions (13) and (14), for the utilities of firms and workers respectively as viewed by the government. In both

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expressions, the exponent to z_i enters with a factor $1-\theta$, implying that variations in z are now less efficient as a means of affecting the respective utilities. With given risk aversion parameters, a greater variation in z is then required in order to achieve a given allocation of risk between the two groups across states, in response to a given variation in export or import prices. It is consequently necessary for the government to vary the exchange rate by more in order to leave workers and firm owners equally well off.[12] With greater wage indexation, the exchange rate becomes a less powerful mechanism for achieving an efficient allocation of risk between workers and owners. Greater changes in the exchange rate between states are then required to achieve a given (optimal) intertemporal risk allocation.

In the special cases where the solution in section 2 above was to keep the exchange rate fixed, nothing is changed by indexation (case B above). Moreover, when export and import prices change proportionally (a "monetary" shock) the exchange rate should still, as in section 2, be changed in this same proportion, again leaving all real variables constant.

Note also that if the government faces a choice between a fixed-exchange-rate scheme and a variable one, this choice is in our model not affected by the degree of indexation. The reason is that the optimal risk and output allocation are independent of the degree of indexation. Indexation only affects the variability of nominal prices and wages, and not the variability of real prices for consumers and producers. Thus the utilities from solutions with fixed and optimally variable exchange rates, as viewed by the government, are the same whether this latter exchange rate varies little and the wage is totally rigid, or whether the exchange rate varies substantially under wage indexation.

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[12]Another related intuitive explanation is that when there are changes in export prices only, the model in section 2 above yields an optimal tradeoff between productive allocation (variations in labor input) and risk allocation. As long as risk aversion coefficients and labor demand are unaltered, this optimal tradeoff is not changed by the introduction of indexation, requiring a greater adjustment in z when wages are indexed.

3.2 Taxation

In practice the government has other mechanisms than exchange rate variations available, for affecting the riskiness of wage and profit income. As pointed out by a number of authors, such as Varian (1980), Agell (1992), and Bertola and Koeniger (2004), the tax system may play such a role. We will here extend our basic model above, that is without indexation, to a case where profit and wage incomes are subject to taxation, and the possibility that tax rates may differ between states. We here study optimal exchange rate variation for <u>given</u> tax rates: the government is thus not assumed to maximize its objective function with respect to the latter.[13] Assume that after-tax profit income for owners is given by (modifying (5)):

$$U_i = \left(\frac{\tau_i \pi_i}{q_i z_i} \right)^\alpha \qquad i=1,2 \qquad (16)$$

where $1-\tau_i$ is a state-specific tax parameter for each of the states $i = 1,2$, used by the government to affect the general profit level in each of the two period types. Similarly, assume that after-tax real wages are given by (modifying (6)):

$$v_i = \left(\frac{\eta_i w}{q_i z_i} \right)^\rho \qquad i=1,2 , \qquad (17)$$

where $1-\eta_i$ are tax parameters affecting real net wage income. Increases in τ_i and η_i then imply that the respective state-contingent profit or wage tax is lowered. We can here assume that the government adjusts the levels of taxes in such a way that net expected tax revenue is exactly zero (which implies that some of the tax rates will be negative). We now find a new formula for optimal exchange rate determination, similar to (10):

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[13] We thus do not address the issue of how tax revenue is spent, or how large it is. Since only relative tax rates matter for the solution to the model, we may here assume that the absolute rates are adjusted such that expected overall tax revenue is kept at a constant level, possibly at zero.

$$log\left(\frac{z_1}{z_2}\right) = \frac{\delta - \alpha}{\delta - \alpha + (\alpha - \rho)(1-\gamma)}log\left(\frac{p_2}{p_1}\right) + \frac{(\alpha - \rho)(1-\gamma)}{\delta - \alpha + (\alpha - \rho)(1-\gamma)}log\left(\frac{q_2}{q_1}\right)$$
$$- \frac{\alpha(1-\gamma)}{\delta - \alpha + (\alpha - \rho)(1-\gamma)}log\left(\frac{\tau_2}{\tau_1}\right) + \frac{\rho(1-\gamma)}{\delta - \alpha + (\alpha - \rho)(1-\gamma)}log\left(\frac{\eta_2}{\eta_1}\right)$$

(18)

The way, in which the rule for setting relative exchange rates is changed, is now affected by the state-dependent variation in average tax rates $1-\tau_i$ and $1-\eta_i$. It may here be reasonable to assume that the government uses the tax system to smooth real wage income but not profits across states. We will in turn consider both cases. Notice that profits and wage income for each employed worker change across states for given exchange rates when import prices q change; while when export price changes, only profits will be exposed to additional variation. Consider then the case where $q_2 > q_1$ such that real wage and profit incomes are lower in state 2. The government would naturally counteract the effect of a higher q_2 on the workers' income by decreasing their taxes in the second state. This implies setting $\eta_2/\eta_1 > 1$, making the log (η_2/η_1) positive.[14] We see that in general this is likely to increase the optimal variation in the exchange rate (i.e. the exchange rate in state 2 is going to be much lower than in state 1), and more so the larger η_2 becomes in comparison to η_1. Thus, a larger appreciation of the exchange rate will occur as a result of *a tax relief and of the risk sharing mechanism*. These two will just more than compensate the loss in real income due to an increase in import prices. Note however that if the exchange rate in state 2 is allowed to appreciate a great deal (at least relatively to the exchange rate that will prevail in state1), it will create a large swing in export incomes and so in profits to the capitalists. Profits can be smoothed by a combination of exchange rate changes and tax changes such as $\tau_2/\tau_1 > 1$. In fact, the exchange rate will vary less if the government implements procyclical profit taxes. Intuitively, from (18) we can see that for fixed taxes to the workers and export prices, if the

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[14] Note that $\tau\pi$ and ηw are the capitalists' and workers' incomes after tax, respectively. Thus, a lower τ or η

log(q_2/q_1) increases and log(τ_2/τ_1) does so less than proportionately[15], there will be a lower increase in log (z_1/z_2) than would otherwise occur if no tax relief was implemented for exporters.

Note that in the interesting and special case where log(q_2/q_1) = log(τ_2/τ_1) = log(η_2/η_1) (i.e., the retained shares of incomes after tax for both owners and workers are changed in proportion to import prices), the exchange rate should be kept constant.

Introducing new government instruments through taxes opens up a new and very interesting perspective in the model, namely the issue of what variations in tax rates are optimal for a given exchange rate target. Consider in particular a fixed exchange rate, which is the obvious "target" under a monetary union. We see that equation (18) can easily be fulfilled for z_1/z_2 constant, and p_2/p_1 and/or q_2/q_1 changing, by adjusting the relative tax rates appropriately. We have just analysed this above, for the case of variation in import prices alone. The same analysis can be done when export prices vary, as when log (p_2/p_1) increases and the coefficient before log (p_2/p_1) is positive. Complementary policy rules, such as either a countercyclical variation in the profit tax rate, or a procyclical variation in the wage tax rate, can thus affect the optimal exchange rate fluctuations in different ways. Achieving a stable, and at the same time optimal, exchange rate may here be implemented through either a procyclically variable wage tax, which should be higher in the state with high export prices, or a countercyclical profit tax, which is reduced when import prices are high.

3.3 Imperfect competition

In the analysis above all prices are assumed to be given in the world market. Ceteris paribus, perfect competition will allow international price changes to pass on perfectly to domestic

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implies lower taxes collected by the government.

[15] Notice that if the log(τ_2/τ_1) increases in the same proportion as the log(q_2/q_1), it can result in an appreciation of the exchange rate in the state 2. Reasonably, if producers are going to get equally (or more than) compensated with lower taxes when import prices go up, they will have to face an appreciation of the exchange rate in state 2.

consumer and producer markets. In many practical cases the assumption of perfect competition will be violated for several reasons. This is likely to be the case when domestic exporters sell in consumer brand markets with differentiated products, as analyzed e.g. in the seminal paper by Dixit and Stiglitz (1977), and when a country specializes (almost) fully on the production of one or a few goods, producers may behave monopolistically instead of competitively.[16]

We will in this section extend our basic model to encompass the case of monopolistic producers in the export sector. Assume then that instead of (1), firms' profits are given by

$$\pi_i = p_i L_i^{-\sigma\gamma} z_i L_i^{\gamma} - w L_i, \quad i=1,2, \tag{1a}$$

where p_i now may be interpreted as a fixed parameter in the (world) demand function for export goods, and σ is the (absolute value of the) elasticity of the export price with respect to production in the export sector, which is the inverse of the elasticity of world market demand for the home good with respect to export prices, where $0<\sigma<1$. Except for (1a), the model is the same as that in section 2. We can then simply replace γ in that version of the model, by $\gamma(1-\sigma)$ in the current version, and everything else remains the same. Notice that $\gamma(1-\sigma)$ will always be positive. The formula for optimal exchange rate variation becomes

$$log\left(\frac{z1}{z2}\right) = \frac{\delta-\alpha}{\delta-\alpha+(\alpha-\rho)(1-\gamma(1-\sigma))}log\left(\frac{p_2}{p_1}\right) + \frac{(\alpha-\rho)(1-\gamma(1-\sigma))}{\delta-\alpha+(\alpha-\rho)(1-\gamma(1-\sigma))}log\left(\frac{q_2}{q_1}\right)$$

$$\tag{10a}$$

This is a simple extension of the formula (10) in section 2. Considering the standard case where both coefficients before $log(p_2/p_1)$ and $log(q_2/q_1)$ are positive, the effect of imperfect competition

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[16]In fact monopolistic competition does not depend on producers being large, but only on them being specialized given that products are differentiated (which is not the case in our model). It is however generally clear those larger producers will have more power to determine their own prices. See Helpman and Krugman (1991) for discussion of such issues.

is seen to be a relative increase in the weight of $\log(q_2/q_1)$, and a relative decrease in that of $\log(p_2/p_1)$. Thus in particular, when only export demand fluctuates, the exchange rate response to such fluctuations ought to be even smaller, than in our basic model of section 2. Moreover, when there is a shock affecting p_2 causing upward shift in the demand function for exports (i.e. $p_2 L_2^{-\gamma\sigma}$ shifs up), greater monopoly power (measured by σ) implies lower variation in the exchange rate (i.e. z_2 will not change a lot with respect to z_1). Intuitively, the output response to such demand fluctuations is now smaller, and this is the reason why there will be less of a need to adjust the exchange rate (i.e. revaluing in the good state will be that large). In this sense, the monopolistic case strengthens our basic case for a relatively invariable exchange rate. Finally, one could add that under monopoly conditions, wage and profit taxes can be additionally implemented to ameliorate the effect of monopoly power on the low degree of pass-through.

4. Conclusions and discussion

We have derived an optimal rule for the exchange rate when future states are uncertain and the nominal wage is either fully rigid in the short run, or partly indexed to the nominal exchange rate. The main role of the exchange rate in our model is to allocate risk optimally between two groups in the economy, workers and owners. We find that when nominal export and import prices change proportionately in response to the occurrence of a shock, the government should adjust the relative exchange rate to leave all domestic variables constant. With stochastic sectoral ("real") shocks where import prices are likely to vary (perhaps considerably) less than export prices, if wages are fixed in the short run (as in section 2) and both workers and owners are risk averse but workers more so, the exchange rate should be allowed to appreciate in response to a positive shock to export prices alone. Such appreciation should be only partial in the sense that home and world market export prices should move in the same direction.

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The exchange rate should adjust fully (and leave home export prices constant) only when workers and firm owners have equal degrees of relative risk aversion. In another important practical case, with risk neutral owners and risk averse workers (and utilitarian government preferences representing workers), the exchange rate should be kept constant.

Section 3 studies three different extensions to the basic model. First, when wages are partially indexed to the nominal consumer price level ex post, as studied in subsection 3.1, the exchange rate should generally vary more, while neither real variables nor the choice between a fixed-versus variable-rate regime is affected by wage indexation. Secondly, in subsection 3.2 we study the effects of state-variable wage and profit taxes. We here show that such taxes modify the optimal exchange rate rule, in particular by making the exchange rate less sensitive to export prices (import prices) changes when wage taxes (profit taxes) move procyclically (countercyclically). We here also note that a fixed exchange rate can now be implemented as the optimal rate, by varying tax rates appropriately, thus strengthening the case for a monetary union under cases where individual countries have the possibility of independent tax policies. The third extension, in subsection 3.3, deals with imperfect competition for exporters. The main effect of imperfect competition for optimal exchange rate policy is to further reduce the variability of exchange rate fluctuations when export demand fluctuates, as output fluctuations in this case are typically dampened relative to the competitive case.

We have above argued that "real" shocks to the economy on the average imply less variation in import prices than in export prices. This assumption has at least two justifications. First, efficient production in a small open economy is likely to imply that exports are concentrated to a relatively small range of goods, while imports are likely to be much more diversified.[17] Independent fluctuations in relative prices among foreign goods might then largely cancel out for

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[17] Such an argument could clearly justify multiple-equilibrium outcomes of a sort similar to those analyzed by Frankel and Rose (1998) and Corsetti and Pesenti (2002). The idea here is that integration into a monetary union

the composite of imports, but not for the composite of exports. The other justification is that fluctuations in p_i can be interpreted (wholly or partly) as domestic productivity shocks. Such shocks would lead to greater fluctuations in p_i, but in q_i only when consumer goods in question are produced domestically.

The more traditional "representative individual" case arises in our model when owners and workers have the same risk preferences. In the no-indexation case, given fluctuations in export prices alone, the exchange rate should then adjust fully to these in the short run, and optimal responses are the same to price shocks as to "real" shocks. Moreover, the more consumer prices covary with export prices, the less should the exchange rate adjust. In our case by contrast, distinguishing between risk neutral owners and risk averse workers, results are very different. We thus demonstrate that the rather plausible issue, of differential risk preferences between workers and firm owners, may matter greatly for the optimal exchange rate rule.

It should be stressed that our derived solution provides an <u>optimal commitment rule</u> that the government prefers to announce, and be able to follow even after the respective state has been revealed. When this optimal rule implies "very small" or zero fluctuations in the exchange rate, the model can be argued to give a theoretical justification for a monetary union between the countries to which the model applies. Alternatively, an exchange rate band could be viewed as a mechanism for committing to small but nonzero exchange rate fluctuations.[18]

As noted, our analysis is based several assumptions which may need further discussion. The following discussion should also serve as a scope for future research.

i) Individuals in the economy are divided into two well-defined groups, workers and owners. This assumption drives many of our interesting results. Most modern approaches to

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could promote intra-industry specialization, which in turn leads to greater fluctuations in p_2/p_1.

[18]In the multi-state case, a currency band can only directly determine the maximum variation in the exchange rate and not the optimal relative rate associated with each state. It may still then perhaps be viewed as an acceptable approximation to the optimal solution.

international macroeconomics (as represented e.g. by Obstfeld and Rogoff (1996)) take the representative agent approach whereby this issue is by definition excluded. Our justification is the empirical observation that workers (at least in most European countries) largely hold their wealth in their own human capital and to some degree in residential capital, while owners and managers to a much greater extent hold their wealth in production and financial capital. In most European countries, workers own a relatively small fraction of corporate stock.[19] Fluctuations in household wealth can then overwhelmingly be represented by fluctuations in real wages (and by fluctuations in the value of home equity, which is typically correlated with average wages), while for owners and managers much more of wealth depends on business values. Most of workers' wealth is also largely undiversifiable (e.g. financial equities such as stocks and bonds cannot be issued on the basis of human capital), while owners/manager wealth can much more easily be diversified. This should imply that workers are more risk averse than owners. On the other hand, more diversified wealth across groups of individuals should imply more equal risk preferences. This will in case have consequences for the optimal exchange rates, in accordance with comments made above.

ii) No market for foreign exchange. Such a market would make it more difficult for the government to manage the exchange rate as prescribed by the solution to our model, since speculation tends either to drive the equilibrium exchange rate to its expectation over all possible ex post states, or it implies that compensating interest rate differentials between countries are required. This is likely to be a more serious problem the greater are the "optimal" exchange rate fluctuations between states. This however reinforces the criteria for committing to a monetary

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[19]True, in some countries such as Norway the authorities have tried to stimulate more widespread stock ownership through tax reductions for limited quotas of annual mutual-fund investments. Still the overall fraction of stock owned in this way is relatively small, and labor unions remain overall sceptical toward such ownership. In addition pension funds, which in principle represent future benefits of workers, are large stockholders in many countries. The latter should represent no principal problem in our model since pension fund returns do not affect the short-run consumption possibilities of workers, given that workers cannot borrow with future pension

union.

iii) There is no market for savings and other financial instruments for smoothing real income. This is clearly unrealistic, and an unattractive assumption to many economists. Arguably, however, not all risk can be eliminated through these types of markets, in particular not for workers. Workers' incomes, and consumption possibilities, stem from their sale of human capital services, which are generally not fully insurable. A large body of empirical evidence supports this view, much of it from the U.S. where financial markets of this sort are most developed and available in practice to ordinary workers. Mankiw (2000) and Seidman (2001) review this literature, and find that consumption is highly correlated with current income, much more than one should expect if households actually used efficient financial markets for consumption smoothing.[20] These results can follow from either imperfect capital markets, or simply an inability of households to actually smooth consumption, or both. In any case, there may clearly be room for active income-smoothing policies by the government, and a fixed exchange rate may serve exactly such a role here. Firm owners should also clearly have greater possibilities for smoothing consumption relative to current earnings, both because they likely face fewer frictions in the relevant financial markets and because owners are likely to have more savings available for immediate consumption.

iv) All output is exported while all consumption is imported. This assumption involves two different aspects. First, all goods are assumed to be tradables. A more traditional approach in the recent literature is to assume a tradable and nontradable sector (as in Obstfeld and Rogoff (1995, 1998), Devereux and Engel (1998, 1999) and Hau (2000), in the context of two-country models).

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payments as collateral.

[20] Among important studies showing this are Campbell and Mankiw (1989), Shapiro and Slemrod (1995), Parker (1999) and Souleles (1999). In fact, Campbell and Mankiw (1989) estimate that approximately half of all wage income in the U.S. goes to households that consume according to current income, and half to households that consume according to permanent income (as would result with effectively functioning financial markets).

Generally, a nontradable sector should tend to smooth consumption when the variation in p is interpreted as a terms-of-trade shock, but not necessarily when it is interpreted as a productivity shock that also comprises the nontradable sector itself. Secondly, it implies that the country itself produces no export goods that are also imported. A straightforward alternative is here to assume that the country's export goods constitute a certain fraction of its import goods. This can in the model be represented by a positive correlation between import and export prices, such that import prices change in the same direction but by less than export prices. A likely effect is then a greater optimal variation in the exchange rate than that found above (in particular when the optimal rule above implies small exchange rate variations).

v) The exchange rate is pre-set by a monetary authority to optimise a long-run intertemporal utility function withoug facing credibility problems. In the optimization sense, the model is "normative" rather than positive, in attempting to say what the government ought to do, not necessarily what the government actually does. Absent a currency union credibility problems will always be present, in part because a country's government is likely to change from time to time. It could be relevant to take such credibility issues more directly into consideration the model, when discussing the desirability of whether or not join a currency union. While this must be a topic for further work, such additional arguments appear to favor a currency union, relative to the analysis presented above. Another issue for future work is whether a monetary authority, through its exchange rate policy or possibly in coordination with other government policies, may be able to affect real wages and thereby average employment more directly.

Finally, one may consider the relationship between the results from the current model with a more traditional discussion of possible reasons for wanting an independent monetary policy, based on the idea of asymmetric shocks. Asymmetric supply shocks can here be interpreted as

idiosyncratic shocks to export prices, while asymmetric demand shocks can in our model rather be identified with shocks to import prices.[21] Given these interpretations, the exchange rate should here be kept "roughly" constant in view of supply shocks, but possibly vary more when shocks are demand-related. This conclusion is somewhat at odds with "conventional wisdom" as expressed e.g. in the traditional "optimum currency area" literature referred to above, and is more in line with recent arguments, e.g. Buiter (1997, 2000).[22] Our analysis thus supports, and gives a new dimension to, such a distinction.

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[21] The idea here is that a demand shock can be assumed to take the form of an exogenous increase in the need for imports, which could have the same real effects on the economy as an increase in import prices.

[22] As discussed in the recent paper by Cooper and Kempf (2004), this conclusion can in principle be overturned when fiscal policy can be used actively and systematically to counteract country-specific shocks. This is a further interesting topic for future research, within the context of the present model.

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