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INTERNATIONAL RESEARCH FORUM ON MONETARY POLICY

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BY ALAN SUTHERLAND

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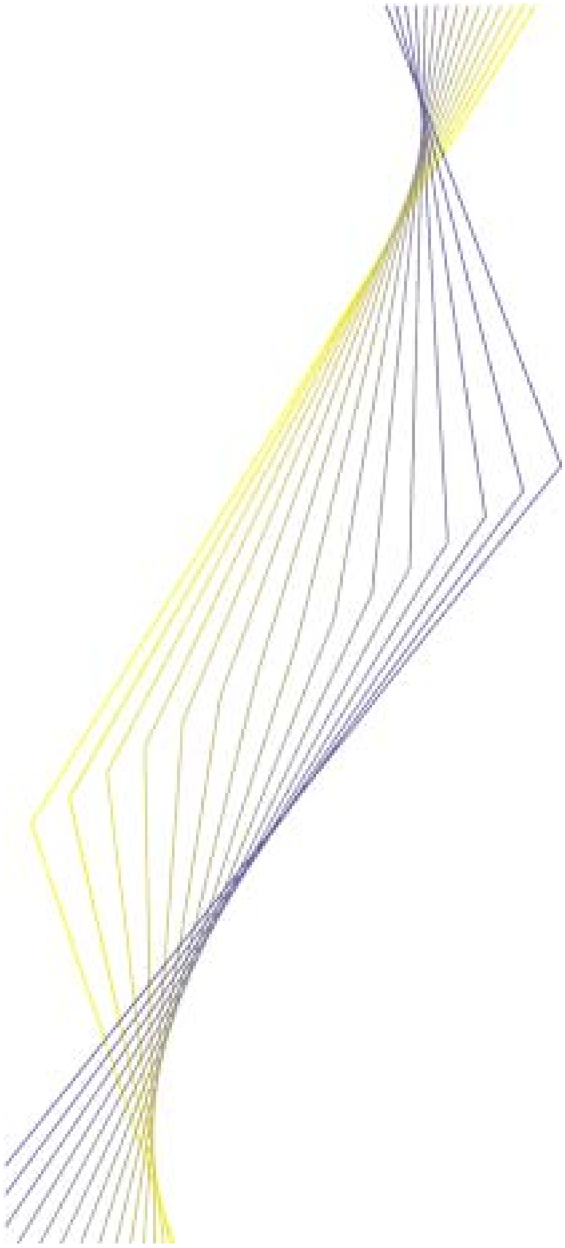

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INTERNATIONAL MONETARY POLICY COORDINATION AND FINANCIAL MARKET INTEGRATION[1]

BY ALAN SUTHERLAND[2]

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1 This research was supported by the ESRC Evolving Macroeconomy Programme grant number L138251046.
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ISSN 1561-0810

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Abstract

The welfare gains from international coordination of monetary policy are analysed in a two-country model with sticky prices. The gains from coordination are compared under two alternative structures for financial markets: financial autarky and risk sharing. The welfare gains from coordination are found to be largest when there is risk sharing and the elasticity of substitution between home and foreign goods is greater than unity. When there is no risk sharing the gains to coordination are almost zero. It is also shown that the welfare gain from risk sharing can be negative when monetary policy is uncoordinated.
Keywords: monetary policy coordination, financial integration, risk sharing.
JEL: E52, E58, F42

Non-technical summary

What are the gains from international coordination of monetary policy? This is a long-standing question in international macroeconomics which was the subject of an extensive literature in the 1980's. More recently attention has returned to the topic following the development of new approaches to analysing the welfare effects of monetary policy in closed and open economies. The 'new open economy macroeconomics literature' emphasises the use of microfounded models and utility-based welfare measures. Obstfeld and Rogoff (2002) analyse the welfare gains from monetary policy coordination in a model of this type. They show that welfare gains do exist but are likely to be very small, both in absolute terms and relative terms (when compared to the welfare costs of business cycle fluctuations).

But the model used by Obstfeld and Rogoff (2002) is special in two respects which are likely to have important implications for the welfare gains from policy coordination. Firstly, the elasticity of substitution between home and foreign goods is restricted to unity. This elasticity determines the extent to which exchange rate changes cause changes in demand for goods from different countries. It is therefore an important determinant of the spillover effect of monetary policy from one country to another. Secondly, Obstfeld and Rogoff assume that international financial markets do not exist. The trade balance is therefore forced into exact balance in all states of the world. Again this removes a potential source of international spillover effects of monetary policy.

The assumption that financial markets do not exist is to some extent less extreme than it may seem at first. When the elasticity of substitution between home and foreign goods is unity the trade balance is always close to balance in any case. The structure of international financial markets is therefore largely irrelevant.

The structure of financial markets does however become much more important when the elasticity of substitution between home and foreign goods differs from unity. In this case large trade imbalances are possible so the structure of financial markets will have an important influence on the behaviour of the exchange rate and the consequential spillover effects of monetary policy. Benigno and Benigno (2001a) analyse a model similar to the Obstfeld and Rogoff (2002) model which allows for a non-unit elasticity of substitution between home and foreign goods and which assumes a financial structure which permits full international consumption risk sharing. They show that the gains from coordination depend on the degree of elasticity of substitution, but in general Benigno and Benigno are not able to solve

explicitly for welfare or quantify the gains from coordination.

A constraint that has hitherto hampered progress on this issue is the fact that it is not possible to obtain an explicit exact solution for welfare when the elasticity of substitution between home and foreign goods differs from unity. This paper adopts an approximation technique to overcome this problem. Second-order accurate solutions for welfare are obtained for the general case where the elasticity of substitution differs from unity. This allows explicit solutions for the coordinated and non-coordinated policy rules to be obtained and explicit expressions for the welfare yielded by coordinated and non-coordinated policy to be derived. It is therefore possible to trace the spillover effects which give rise to gains from policy coordination and it is possible to quantify these gains.

The model is used to investigate the implications of the elasticity of substitution for the gains from policy coordination. The implications of financial market structure are also analysed. The gains from coordination that arise when there is no financial market are compared to the gains that arise when there is international risk sharing.

In the case where there is no financial market it is found that a non-unit elasticity of substitution can indeed give rise to gains from coordination. But, as in the cases analysed by Obstfeld and Rogoff (2002), these gains are quantitatively very small. But in the risk-sharing case it is found that the gains from coordination can be much higher. The existence of financial markets creates additional spillover effects which greatly increase the gains from policy coordination. Quantitatively these gains can be quite large in both absolute and relative terms.

Another way to look at the results presented in this paper is to consider the welfare gains from risk sharing. It is found that when monetary policy is coordinated the welfare level achieved in the risk-sharing case is unambiguously higher than the welfare level in the case where there is no financial market. But when monetary policy is not coordinated the answer is very different. In this case the gains from risk sharing are offset by the additional monetary policy spillover effects generated by the existence of financial markets. These spillover effects can be so strong that, for some parameter combinations, the risk-sharing case yields lower welfare than the case where there are no financial markets.

1 Introduction

What are the gains from international coordination of monetary policy? This is a long-standing question in international macroeconomics which was the subject of an extensive literature in the 1980's (see for instance Canzoneri and Henderson (1991), Currie and Levine (1984), Miller and Salmon (1984), Oudiz and Sachs (1984) and Rogoff (1985)). More recently attention has returned to the topic following the development of new approaches to analysing the welfare effects of monetary policy in closed and open economies. The 'new open economy macroeconomics literature' emphasises the use of microfounded models and utility-based welfare measures.[1] Obstfeld and Rogoff (2002) analyse the welfare gains from monetary policy coordination in a model of this type. They show that welfare gains do exist but are likely to be very small, both in absolute terms and relative terms (when compared to the welfare costs of business cycle fluctuations).

But the model used by Obstfeld and Rogoff (2002) is special in two respects which are likely to have important implications for the welfare gains from policy coordination. Firstly, the elasticity of substitution between home and foreign goods is restricted to unity. This parameter determines the strength of the expenditure switching effect of exchange rate changes and is therefore an important determinant of the spillover effect of monetary policy. Secondly, Obstfeld and Rogoff assume that international financial markets do not exist. The trade balance is therefore forced into exact balance in all states of the world. Again this removes a potential source of international spillover effects of monetary policy.

The assumption of financial autarky is to some extent less extreme than it may seem at first. It is a well-known result that when the elasticity of substitution between home and foreign goods is unity and utility is logarithmic in consumption, the trade balance is always in balance in any case.[2] The structure of international financial markets is therefore irrelevant. It is only in the cases where Obstfeld and Rogoff consider non-logarithmic utility that the structure of financial markets becomes relevant.

The structure of financial markets does however become much more important when the elasticity of substitution between home and foreign goods differs from unity. In this case the trade balance does not automatically balance in all states of the world so the structure of financial markets will have an important influence on

[1] See for instance Corsetti and Pesenti (2001a), Devereux and Engel (1998, 2000) and Obstfeld and Rogoff (1995, 1998, 2002). A recent survey of the literature is provided by Lane (2001).

[2] If all goods are traded then this result holds even when utility is not logarithmic in consumption.

the behaviour of the exchange rate and the consequential spillover effects of monetary policy. Benigno and Benigno (2001a) analyse a model similar to the Obstfeld and Rogoff (2002) model which allows for a non-unit elasticity of substitution between home and foreign goods and which assumes a financial structure which permits full international consumption risk sharing. They show that the gains from coordination depend on the degree of elasticity of substitution, but in general Benigno and Benigno are not able to solve explicitly for welfare or quantify the gains from coordination.

A constraint that has hitherto hampered progress on this issue is the fact that it is not possible to obtain an explicit exact solution for welfare when the elasticity of substitution between home and foreign goods differs from unity. This paper adopts a second-order approximation technique to overcome this problem. Second-order accurate solutions for welfare are obtained for the general case where the elasticity of substitution differs from unity. This allows explicit solutions for the coordinated and non-coordinated policy rules to be obtained and explicit expressions for the welfare yielded by coordinated and non-coordinated policy to be derived. It is therefore possible to trace the spillover effects which give rise to gains from policy coordination and it is possible to quantify these gains.

The model is used to investigate the implications of the elasticity of substitution for the gains from policy coordination. The implications of financial market structure are also analysed. The gains from coordination that arise when there is no financial market are compared to the gains that arise when there is international risk sharing.

In the financial autarky case it is found that a non-unit elasticity of substitution can indeed give rise to gains from coordination. But, as in the cases analysed by Obstfeld and Rogoff (2002), these gains are quantitatively very small. The spillover effects generated by the expenditure switching effect therefore seem to be unimportant when financial markets do not exist. But in the risk-sharing case it is found that the gains from coordination can be much higher. The existence of financial markets creates additional spillover effects which greatly increase the gains from policy coordination. Quantitatively these gains can be quite large in both absolute and relative terms.

Another way to look at the results presented in this paper is to consider the welfare gains from risk sharing. It is found that when monetary policy is coordinated the welfare level achieved in the risk-sharing case is unambiguously higher than the welfare level in the autarky case. But when monetary policy is not coordinated the answer is very different. In this case the gains from risk sharing are offset by the additional monetary policy spillover effects generated by the existence of financial markets. These spillover effects can be so strong that, for some parameter combinations, autarky yields higher welfare than risk sharing.

There have been a number of other contributions to the recent literature which are relevant to the subject of this paper. Corsetti and Pesenti (2001b) analyse the gains from monetary policy coordination when there is incomplete pass-through from exchange rate changes to local currency prices. They show that there are gains to coordination when there is incomplete pass-through even when the elasticity of substitution between home and foreign goods is unity. Clarida, Gali and Gertler (2001) analyse the welfare effects of monetary policy coordination in a model where there are non-optimal 'cost-push' shocks. Again they show that gains from coordination can arise even when the elasticity of substitution between home and foreign goods is unity. Benigno and Benigno (2001b) also consider cost-push shocks but do not consider non-coordinated policy. They show that the optimal coordinated policy can be sustained by each individual monetary authority pursuing a policy of flexible inflation targeting (when 'flexible inflation targeting' is of the form suggested by Svensson (1999)). Benigno (2001) analyses the implications of financial market structure for optimal coordinated policy. He compares an incomplete financial market (where trade is restricted to non-contingent bonds) with full risk sharing. Devereux (2001) also considers the implications of financial market structure. He compares the welfare implications of fixed and flexible exchange rates in the cases of financial autarky and full risk sharing. Tille (1999) analyses the role of the elasticity of substitution between home and foreign goods in the international transmission of shocks. He shows, using a deterministic model, that monetary policy can have a positive or a negative impact on foreign welfare depending on the degree of international substitutability.

This paper proceeds as follows. Section 2 presents the model. Section 3 briefly discusses the measurement of welfare. Section 4 analyses the gains from policy coordination in the special case where utility is logarithmic in consumption. Section 5 considers the more general case where the coefficient of relative risk aversion differs from unity. Section 6 analyses the welfare gains from risk sharing and Section 7 briefly considers the implications of the model for the optimality of price targeting. Section 8 concludes the paper.

2 The Model

2.1 Market Structure

The world exists for a single period[3] and consists of two countries, which will be referred to as the home country and the foreign country. Each country is populated by agents who consume a basket of goods containing all home and foreign produced goods.[4] Each agent is a monopoly producer of a single differentiated product. There is a continuum of agents of unit mass in each country. Home agents are indexed $h \in [0, 1]$ and foreign agents are indexed $f \in [0, 1]$. All agents set prices in advance of the realisation of shocks and are contracted to meet demand at the pre-fixed prices.[5] Prices are set in the currency of the producer.

The detailed structure of the home country is described below. The foreign country has an identical structure. Where appropriate, foreign real variables and foreign currency prices are indicated with an asterisk.

2.2 Preferences

All agents in the home economy have utility functions of the same form. The utility of agent z given by

$$U(z) = E\left[\frac{C(z)^{1-\rho}}{1-\rho} + \chi \log \frac{M(z)}{P} - K y_i(z)\right] \tag{1}$$

[3]The model can easily be recast as a multi-period structure but this adds no significant insights. A true dynamic model, with multi-period nominal contracts and asset stock dynamics would be considerably more complex and would require much more extensive use of numerical methods. Newly developed numerical techniques are available to solve such models and this is likely to be an interesting line of future research (see Kim and Kim (2000), Sims (2000), Schmitt-Grohé and Uribe (2001) and Sutherland (2001)). However, the approach adopted in this paper yields useful insights which would not be available in a more complex model.

[4]In contrast to Obstfeld and Rogoff (2002) all goods in this model are traded goods. The presence of non-traded goods (or equivalently home bias in consumption preferences) is important in generating welfare gains from coordination in the Obstfeld and Rogoff model. The model presented in this paper generates gains to coordination when the elasticity of substitution between home and foreign goods differs from unity. These gains exist even when there are no non-traded goods.

[5]Obstfeld and Rogoff (2002) interpret their model as one where households supply labour to firms. They assume that each household is a monopoly supplier of a particular variety of labour and that wages are sticky (while goods prices are perfectly flexible). This is purely a matter of description. In terms of the analysis of this paper it makes no difference if households are described as supplying labour or supplying goods. In the first case it would be appropriate to regard wages as the sticky nominal variable, while in the second case it would be appropriate to regard prices as the sticky nominal variable.

where $\rho > 0$, C is a consumption index defined across all home and foreign goods, M denotes end-of-period nominal money holdings, P is the consumer price index, $y(z)$ is the output of good z, E is the expectations operator, K is a log-normal stochastic labour-supply shock ($E[\log K] = 0$ and $Var[\log K] = \sigma_K^2$).

The consumption index C for home agents is defined as

$$C = \left[\left(\frac{1}{2}\right)^{\frac{1}{\theta}} C_H^{\frac{\theta-1}{\theta}} + \left(\frac{1}{2}\right)^{\frac{1}{\theta}} C_F^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}} \tag{2}$$

where $\theta \geq 1$. C_H and C_F are indices of home and foreign produced goods defined as follows

$$C_H = \left[\int_0^1 c_H(h)^{\frac{\phi-1}{\phi}} dh \right]^{\frac{\phi}{\phi-1}}, \quad C_F = \left[\int_0^1 c_F(f)^{\frac{\phi-1}{\phi}} df \right]^{\frac{\phi}{\phi-1}} \tag{3}$$

where $\phi > 1$, $c_H(h)$ is consumption of home good h and $c_F(f)$ is consumption of foreign good f. The parameter θ is the elasticity of substitution between home and foreign goods. This is the key parameter which will be the focus of the analysis in later sections. In Obstfeld and Rogoff (2002) this parameter is fixed at unity.

The budget constraint of agent z is given by

$$M(z) = M_0 + (1+\alpha) p_H(z) y(z) - PC(z) - T \tag{4}$$

where M_0 and $M(z)$ are initial and final money holdings, T is lump-sum government transfers, $p_H(z)$ is the price of home good z, α is a production subsidy and P is the aggregate consumer price index.

The government's budget constraint is

$$M - M_0 - \alpha P_H Y + T = 0 \tag{5}$$

where P_H is the aggregate price of home produced goods and Y is the aggregate output of the home economy, defined as follows

$$Y = C_H + C_H^* \tag{6}$$

where C_H^* is aggregate foreign demand for home goods.

2.3 Price Indices

The aggregate consumer price index for home agents is

$$P = \left[\frac{1}{2} P_H^{1-\theta} + \frac{1}{2} P_F^{1-\theta} \right]^{\frac{1}{1-\theta}} \tag{7}$$

where P_H and P_F are the price indices for home and foreign goods respectively defined as

$$P_H = \left[\int_0^1 p_H(h)^{1-\phi} \, dh \right]^{\frac{1}{1-\phi}}, \quad P_F = \left[\int_0^1 p_F(f)^{1-\phi} \, df \right]^{\frac{1}{1-\phi}} \tag{8}$$

The law of one price is assumed to hold. This implies $p_H(j) = p_H^*(j)\, S$ and $p_F(j) = p_F^*(j)\, S$ for all j where an asterisk indicates a price measured in foreign currency and S is the exchange rate (defined as the domestic price of foreign currency). Purchasing power parity holds in terms of aggregate consumer price indices, $P = P^* S$.

2.4 Consumption Choices

Individual home demand for representative home good, h, and foreign good, f, are given by

$$c_H(h) = C_H \left(\frac{p_H(h)}{P_H} \right)^{-\phi}, \quad c_F(f) = C_F \left(\frac{p_F(f)}{P_F} \right)^{-\phi} \tag{9}$$

where

$$C_H = \frac{1}{2} C \left(\frac{P_H}{P} \right)^{-\theta}, \quad C_F = \frac{1}{2} C \left(\frac{P_F}{P} \right)^{-\theta} \tag{10}$$

Foreign demands for home and foreign goods have an identical structure to the home demands. Individual foreign demand for representative home good, h, and foreign good, f, are given by

$$c_H^*(h) = C_H^* \left(\frac{p_H^*(h)}{P_H^*} \right)^{-\phi}, \quad c_F^*(f) = C_F^* \left(\frac{p_F^*(f)}{P_F^*} \right)^{-\phi} \tag{11}$$

where

$$C_H^* = \frac{1}{2} C^* \left(\frac{P_H^*}{P^*} \right)^{-\theta}, \quad C_F^* = \frac{1}{2} C^* \left(\frac{P_F^*}{P^*} \right)^{-\theta} \tag{12}$$

Each country has a population of unit mass so the total demands for goods are equivalent to individual demands.

2.5 Optimal Price Setting

Individual agents are each monopoly producers of a single differentiated good. They therefore set prices as a mark-up over marginal costs. The mark-up is given by $\phi/(\phi - 1)$. For convenience the mark-up is assumed to be offset by a production subsidy, α, which is paid to all producers (financed out of lump-sum taxes). The subsidy is set such that $\phi/\left[(\phi - 1)(1 + \alpha)\right] = 1$. This ensures that the expected level of output is at the socially optimal level (from the point of view of a world social planner).

The first-order condition for price setting is derived in the Appendix and implies the following

$$P_H = \frac{E[KY]}{E[Y/(PC^{\rho})]} \tag{13}$$

where Y is the total output of the home economy.

Notice that prices will contain a form of risk premium which will depend on the variances and covariances of the variables on the right hand side of (13). The risk premium reflects the fact that prices are set before shocks are realised. This risk premium plays a role in the link between shocks, monetary policy and welfare. An increase in the variance of KY for instance will (other things being equal) increase the risk premium and therefore increase the price of home produced goods. This lowers the expected level of output of home goods and therefore reduces the expected level of consumption for both home and foreign consumers. Home and foreign welfare is therefore reduced. Monetary policy can be used to affect the variances and covariances which determine the risk premium and can therefore also affect welfare.[6]

2.6 Home and Foreign Shocks

The foreign economy has a structure identical to the home economy. The foreign economy is subject to labour-supply shocks of the same form as the home economy. For simplicity it is assumed that the variances of the shocks are identical across the two countries, i.e.

$$\sigma_K^2 = \sigma_{K^*}^2 \tag{14}$$

The cross-country coefficient of correlation of shocks is given by υ where $-1 \leq \upsilon \leq 1$.

2.7 Money Demand and Supply

The first order condition for the choice of money holdings is

$$\frac{M}{P} = \chi C^{\rho} \tag{15}$$

It is assumed that the monetary authority in each country chooses a rule for the setting of the money supply. These rules may depend on the realisations of the supply shocks in each country and will take the form

$$M = M_0 K^{\delta_K} K^{*\delta_{K^*}} \text{ and } M^* = M_0^* K^{\delta_K^*} K^{*\delta_{K^*}^*} \tag{16}$$

[6] Note however that the risk premium is not the only link between monetary policy and welfare.

The feedback parameters δ_K, δ_{K^*}, δ_K^* and $\delta_{K^*}^*$ are chosen by policymakers before prices are set and shocks are realised. It is assumed that policymakers are able to pre-commit to their choice of rule.[7]

2.8 Financial Markets and Risk Sharing

When there are no financial markets the current account must balance in all states of the world, i.e.

$$P_H C_H^* = P_F C_F \tag{17}$$

where $P_H C_H^*$ is the value of home sales to the foreign country valued in home currency and $P_F C_F$ is the value of foreign sales to the home country valued in home currency.

In the risk sharing case it is assumed that sufficient contingent financial instruments exist to allow efficient sharing of consumption risks. This implies the following relationship

$$\frac{C^\rho}{C^{*\rho}} = \frac{P}{SP^*} \tag{18}$$

The fact that purchasing power parity also holds means that efficient risk sharing reduces to $C = C^*$.

It is important to specify the point in time at which agents are able to enter into risk-sharing contracts. There are two possible structures. In the first structure contingent claims markets open *after* policymakers have made their choice of monetary policy rules. In the second structure contingent claims markets open *before* policy rules have been chosen. The first structure implies a more limited form of insurance because agents can not insure against the choice of policy rules - they can only insure against the risk implied by a particular pair of rules. The analysis reported in the main text of this paper focuses on the first risk-sharing structure. The alternative structure is briefly analysed in the Appendix.

The distinction between the two risk-sharing structures is important from the point of view of policymakers. In the first structure policymakers are aware that agents are not fully insured against the potential negative impact of the choice of policy rule. Policymakers therefore internalise these costs. In the second case policymakers do not fully internalise the costs of policy rule choice. Not surprisingly

[7] In the case of coordinated policy it is not necessary to assume pre-commitment because the expected level of output is assumed to be at the socially optimal level from the point of view of a world social planner. But in the case of non-coordinated policymaking there is an incentive for individual country policymakers to attempt to reduce output *ex post* in order to improve the terms of trade. In the absence of pre-commitment this creates a deflationary bias in monetary policy. In this case no rational expectations equilibrium exists (as explained in Corsetti and Pesenti (2001b)).

this can greatly increase the cross-country spillover effects of monetary policymaking and can generate very large welfare gains from monetary policy coordination (as is shown in the Appendix). It is, however, questionable that the second risk-sharing structure is plausible. The choice of policy rules is not a stochastic event so it is not (strictly speaking) a source of risk. An insurance scheme which compensates consumers for the policy choices of their governments obviously creates a major moral hazard problem when governments act non-cooperatively.

3 Welfare

One of the main advantages of the model just described is that it provides a very natural and tractable measure of welfare which can be derived from the aggregate utility of agents. Following Obstfeld and Rogoff (1998, 2002) it is assumed that the utility of real balances is small enough to be neglected. It is therefore possible to measure aggregate welfare of home agents using the following

$$\Omega = E\left[\frac{C^{1-\rho}}{1-\rho} - KY\right] \tag{19}$$

It is not possible to derive an exact expression for welfare (except in special cases). The complication arising in this model (which does not arise in other models used in recent literature) is contained in equations (6) and (7). When θ is greater than unity neither of these equations is linear in logs. The model is therefore solved as a second-order approximation around a non-stochastic steady state. This allows a second-order accurate solution for welfare to be derived.

Define the non-stochastic steady state of the model to be the solution which results when $K = K^* = 1$ with $\sigma_K^2 = \sigma_{K^*}^2 = 0$ and for any variable X define $\hat{X} = \log\left(X/\bar{X}\right)$ where $\bar{X}$ is the value of variable X in the non-stochastic steady state.[8] A second-order approximation of the welfare measure is given by

$$\tilde{\Omega} = E\left\{\hat{C} - \hat{Y} + \frac{1}{2}(1-\rho)\hat{C}^2 - \frac{1}{2}\left(\hat{Y} + \hat{K}\right)^2\right\} + O\left(\|\xi\|^3\right) \tag{20}$$

where $\tilde{\Omega}$ is the deviation in the level of welfare from the non-stochastic steady state and the term $O\left(\|\xi\|^3\right)$ contains all terms of third order and higher in deviations from the non-stochastic steady state. Notice that, to evaluate welfare, it is necessary to solve for both the first and second moments of output and consumption. The Appendix describes some of the details of the solution process.

It is now possible analyse the welfare gains from policy coordination.

[8] It is simple to show that the non-stochastic steady state will imply $\bar{Y} = \bar{C} = 1$.

4 The Welfare Gains from Policy Coordination: The Logarithmic Utility Case

It is useful first to consider the case where utility is logarithmic in consumption. In this case the coefficient of relative risk aversion, ρ, is set equal to unity.

4.1 Monetary Policy, the Exchange Rate and Output

Many of the implications of this model can be understood by examining the links between monetary policy in the two countries, the exchange rate and output. It is sufficient for this purpose to consider a log-linearised version of the model. First note that

$$\hat{P}_H = \hat{P}_F^* = 0 + O\left(\|\xi\|^2\right) \tag{21}$$

where $O\left(\|\xi\|^2\right)$ is a residual which contains all terms of order two and above. Equation (21) implies that the deviation of goods prices from their non-stochastic steady state values is zero (to a first-order approximation) so

$$\hat{P} = \frac{1}{2}\hat{S} + O\left(\|\xi\|^2\right), \quad \hat{P}^* = -\frac{1}{2}\hat{S} + O\left(\|\xi\|^2\right) \tag{22}$$

When these expressions are combined with the demands for home and foreign goods it is simple to show that home and foreign aggregate outputs are given by

$$\hat{Y} = \frac{1}{2}\left(\hat{C} + \hat{C}^*\right) + \frac{\theta}{2}\hat{S} + O\left(\|\xi\|^2\right) \tag{23}$$

and

$$\hat{Y}^* = \frac{1}{2}\left(\hat{C} + \hat{C}^*\right) - \frac{\theta}{2}\hat{S} + O\left(\|\xi\|^2\right) \tag{24}$$

Thus aggregate output is determined by aggregate world consumption and the exchange rate. The exchange rate term is the expenditure switching effect. A depreciation of the exchange rate increases demand for home goods and reduces demand for foreign goods. Notice that the strength of the expenditure switching effect is determined by θ (which is the elasticity of substitution between home and foreign goods). These expressions hold regardless of the structure of financial markets.

Now consider the money market equations. When combined with the expressions for aggregate prices the money market equations imply

$$\hat{C} = \hat{M} + \frac{1}{2}\hat{S} + O\left(\|\xi\|^2\right), \quad \hat{C}^* = \hat{M}^* - \frac{1}{2}\hat{S} + O\left(\|\xi\|^2\right) \tag{25}$$

so

$$\hat{C} + \hat{C}^* = \hat{M} + \hat{M}^* + O\left(\|\xi\|^2\right) \tag{26}$$

Thus aggregate world consumption is determined by the sum of home and foreign monetary policy. Again this expression holds regardless of the structure of financial markets.

The structure of financial markets comes into play in the determination of the exchange rate. When there is no financial market the current account has to balance in all states of the world. Using the expressions for aggregate prices and the demands for home and foreign goods, current account balance implies

$$\hat{S} = \frac{1}{\theta - 1}\left(\hat{C} - \hat{C}^*\right) + O\left(\|\xi\|^2\right) \tag{27}$$

Thus, when home consumption exceeds foreign consumption the exchange rate must depreciate in order to maintain current account balance (and vice versa when foreign consumption exceeds home consumption). When this expression is combined with the expressions for aggregate consumption it is found that

$$\hat{S} = \frac{1}{\theta}\left(\hat{M} - \hat{M}^*\right) + O\left(\|\xi\|^2\right) \tag{28}$$

Thus the exchange rate depends on relative money supplies.

When there is risk sharing the risk-sharing condition implies

$$\hat{S} = \hat{C} + \hat{P} - \hat{C}^* - \hat{P}^* \tag{29}$$

When combined with the money market relationships this implies

$$\hat{S} = \hat{M} - \hat{M}^* \tag{30}$$

Thus again the exchange rate depends on relative monetary supplies. But notice that the exchange rate is more sensitive to monetary policy when there is risk sharing (provided $\theta > 1$).

When the exchange rate expressions are combined with the expressions for aggregate consumption and outputs it is found that in the case of financial autarky

$$\hat{Y} = \hat{M} + O\left(\|\xi\|^2\right), \quad \hat{Y}^* = \hat{M}^* + O\left(\|\xi\|^2\right) \tag{31}$$

while in the case of risk sharing

$$\hat{Y} = \frac{1+\theta}{2}\hat{M} + \frac{1-\theta}{2}\hat{M}^* + O\left(\|\xi\|^2\right), \quad \hat{Y}^* = \frac{1+\theta}{2}\hat{M}^* + \frac{1-\theta}{2}\hat{M} + O\left(\|\xi\|^2\right) \tag{32}$$

The important point to note from these expressions is that in the financial autarky case monetary policy has no international spillover effects. A change in home monetary policy only affects home output and a change in foreign monetary policy only affects foreign output. This is because the effects of monetary policy on aggregate world demand are just enough to offset the expenditure switching effect. But in the risk sharing case monetary policy does have international spillover effects. In this case monetary policy has a larger effect on the exchange rate so the expenditure switching effect outweighs the effect of monetary policy on aggregate world consumption. Thus an increase in the home money supply causes an expansion of home output and a contraction of foreign output (and vice versa for an expansion of the foreign money supply).

The expressions for output and the exchange rate just derived will prove useful for understanding the source of the gains from coordination. The returns to monetary coordination are now analysed in the financial autarky and risk-sharing cases.

4.2 Financial Autarky

The Appendix shows that in this case home and foreign welfare can be written as follows

$$\tilde{\Omega} = -\frac{1}{4}E\left[\frac{1}{\theta}(2\theta - 1)\left(\hat{Y} + \hat{K}\right)^2 + \frac{1}{\theta}\left(\hat{Y}^* + \hat{K}^*\right)^2 + \frac{1}{2}(1-\theta)\hat{S}^2\right] \tag{33}$$

and

$$\tilde{\Omega}^* = -\frac{1}{4}E\left[\frac{1}{\theta}(2\theta - 1)\left(\hat{Y}^* + \hat{K}^*\right)^2 + \frac{1}{\theta}\left(\hat{Y} + \hat{K}\right)^2 + \frac{1}{2}(1-\theta)\hat{S}^2\right] \tag{34}$$

while the previous section showed that output levels and the exchange rate are linked to monetary policy by the following simple relationships

$$\hat{Y} = \hat{M}, \quad \hat{Y}^* = \hat{M}^* \tag{35}$$

$$\hat{S} = \frac{1}{\theta}\left(\hat{M} - \hat{M}^*\right) \tag{36}$$

To simplify notation the residual terms $O\left(\|\xi\|^3\right)$ and $O\left(\|\xi\|^2\right)$ have been omitted from these and all subsequent expressions. It should be understood, however, that the welfare expressions are second-order approximations and the output and exchange rate expressions are first-order approximations.

The structure of the welfare functions can easily be understood. Notice that welfare depends negatively on the variances of $\hat{Y} + \hat{K}$ and $\hat{Y}^* + \hat{K}^*$. These terms are effectively the (log deviations of the) disutility of work effort for home and foreign producers. A higher variance of the disutility of work effort tends to raise the risk premium in goods prices. This reduces the expected level of output and consumption. Agents consume both home and foreign goods so welfare in both countries depends on the variance of the disutility of work effort in both countries. But notice that when $\theta > 1$ the variance of home disutility matters more for home welfare than does the variance of foreign disutility (and vice versa for foreign welfare). This is because a rise in the variance of home disutility not only raises the price of home goods for home agents it also results in a switch in world expenditure towards foreign goods and this reduces the income of home agents. The same mechanism means that the variance of foreign disutility has a greater impact on foreign welfare than the variance of home disutility.

Welfare depends positively on the variance of the exchange rate (when $\theta > 1$). This can be understood by considering the definition of the consumer price index. The consumer price index is concave in the price of home and foreign goods. Any volatility in the relative price of home and foreign goods (which would result from exchange rate volatility) will reduce the expected level of aggregate consumer prices. This has a positive effect on utility and welfare. (Another way to understand this effect is to note that, when home and foreign goods are substitutable, agents can reduce the average cost of their consumption basket by switching expenditure towards whichever set of goods are cheapest *ex post*. Relative price volatility is therefore a utility benefit.)

It is assumed that monetary authorities choose money supply rules of the following form

$$\hat{M} = \delta_K \hat{K} + \delta_{K^*} \hat{K}^* \tag{37}$$

and

$$\hat{M}^* = \delta^*_K \hat{K} + \delta^*_{K^*} \hat{K}^* \tag{38}$$

In the case of coordinated policymaking it is assumed that a single world monetary authority chooses the feedback parameters of both rules to maximise world welfare, where world welfare is given by the average of national welfare levels, i.e.

$$\tilde{\Omega}^W = \frac{1}{2}\left(\tilde{\Omega} + \tilde{\Omega}^*\right) \tag{39}$$

In the case of non-coordinated policymaking it is assumed that the feedback parameters of the home monetary rule are chosen by the home monetary authority in an attempt to maximise home welfare and the parameters of the foreign monetary rule are chosen by the foreign monetary authority in an attempt to maximise foreign welfare. Each monetary authority acts as a Nash player and takes as given the parameters of the other country's rule when choosing their own feedback parameters.

The coordinated equilibrium results in the following choices of feedback parameters

$$\delta^C_K = \delta^{*C}_{K^*} = \frac{-1 + \theta - 2\theta^2}{2\left(1 - \theta + \theta^2\right)} \tag{40}$$

$$\delta_{K^*}^C = \delta_K^{*C} = \frac{-1+\theta}{2\left(1-\theta+\theta^2\right)} \tag{41}$$

where the superscript 'C' indicates the coordinated equilibrium. The non-coordinated equilibrium results in

$$\delta_K^N = \delta_{K^*}^{*N} = \frac{1-3\theta+4\theta^2}{-2\left(1-2\theta+2\theta^2\right)} \tag{42}$$

$$\delta_{K^*}^N = \delta_K^{*N} = \frac{-1+\theta}{-2\left(1-2\theta+2\theta^2\right)} \tag{43}$$

where the superscript 'N' indicates the non-coordinated equilibrium. The world welfare level yielded by coordinated policy is

$$\tilde{\Omega}_A^C = \frac{(\theta-1)}{4\left(1-\theta+\theta^2\right)}(1-\upsilon)\sigma_K^2 \tag{44}$$

where again the superscript 'C' indicates the coordinated equilibrium and the subscript 'A' indicates the financial autarky case. The welfare yielded by non-coordinated policy is

$$\tilde{\Omega}_A^N = \frac{\left(-2+7\theta-9\theta^2+4\theta^3\right)}{4\left(1-2\theta+2\theta^2\right)^2}(1-\upsilon)\sigma_K^2 \tag{45}$$

As a point of reference it is useful to consider an inactive policy regime, where feedback parameters are all set to zero. (This is equivalent to a money targeting regime.) The welfare level yielded by this regime is

$$\tilde{\Omega}_A^M = -\frac{1}{2}\sigma_K^2 \tag{46}$$

where the superscript 'M' indicates the case of non-active policy (or money targeting). A number of propositions can now be established. (Proofs follow from a simple comparison of the above expressions and are omitted.)

Proposition 1 *If $\upsilon < 1$ and $\theta > 1$ then $\tilde{\Omega}_A^C > \tilde{\Omega}_A^N$, i.e. there are gains from coordination.*

It is clear from expressions (33) to (36) that there will be gains to coordination provided $\theta > 1$. When $\theta > 1$ each monetary authority cares about the variance of the exchange rate, and monetary policy in each country affects the exchange rate. In addition, when $\theta > 1$, each monetary authority cares more about the volatility of the disutility of work effort in its own country than it does about the volatility of the disutility of work effort in the other country. There is therefore a policy spillover (operating through the exchange rate) and an incentive to bias policy to the benefit of domestic welfare.

The gains from coordination disappear in two circumstances. The first case is when $\theta = 1$. In this case exchange rate volatility does not affect welfare so there is no policy spillover. Each monetary authority therefore maximises the welfare of its population by minimising the variance of the disutility of work effort in its own country. This also maximises world welfare. The second case where there are no gains from coordination is when the shocks in the two countries are perfectly correlated, i.e. when $\upsilon = 1$. This corresponds to a result noted and emphasised by Obstfeld and Rogoff (2002). When shocks are perfectly correlated the use of monetary policy to stabilise the disutility of work effort in one country will automatically also stabilise disutility of work effort in the other country. There is therefore no difference between coordinated and non-coordinated policymaking.

Proposition 2 *If* $\theta > 1$ *then: (a)* $\left|\delta_K^C\right| = \left|\delta_{K^*}^{*C}\right| > \left|\delta_K^N\right| = \left|\delta_{K^*}^{*N}\right|$ *and* $\left|\delta_{K^*}^C\right| = \left|\delta_K^{*C}\right| > \left|\delta_{K^*}^N\right| = \left|\delta_K^{*N}\right|$ *and (b)* $Var\left(\hat{S}^N\right) < Var\left(\hat{S}^C\right)$, $Var\left(\hat{Y}^N\right) < Var\left(\hat{Y}^C\right)$ *and* $Var\left(\hat{Y}^{*N}\right) < Var\left(\hat{Y}^{*C}\right)$ *(where the superscripts 'C' and 'N' indicate values in coordinated and non-coordinated equilibria respectively).*

This proposition shows that non-coordinated policymaking is less active than coordinated policymaking. It also shows that the exchange rate and output levels are less volatile with non-coordinated policymaking. In other words non-coordinated policymaking has a bias towards over-stabilisation. At first sight it may seem strange that optimal coordinated policy should produce more volatility of output and the exchange rate (and by implication the terms of trade). But it should be born in mind that labour supply shocks imply that the socially optimal level of output is changing. The socially optimal monetary policy should allow these changes to occur. Non-coordinated policymaking is preventing full adjustment of real quantities to the underlying socially optimal levels.[9]

Proposition 1 establishes that there are gains to coordination when $\theta > 1$. But in order to determine the size of these gains it is necessary to perform some numerical exercises with different values of θ. Table 1 reports some values for welfare with $\sigma_K^2 = \sigma_{K^*}^2 = 0.01$ and $\upsilon = 0$. A range of values of θ has been suggested in previous literature, for instance Benigno and Benigno (2001a) suggest $\theta = 6$. Table 1 shows welfare calculations for $\theta = 1$ to $\theta = 10$. The first row shows the welfare gain from coordinated policy relative to an inactive policy (i.e. $\tilde{\Omega}_A^C - \tilde{\Omega}_A^M$). The figures in the first row therefore represent the maximum possible gain from following an active policy. The second row shows the welfare gain from non-coordinated policy relative

[9] This result is discussed in more detail in Sutherland (2002).

θ	1	2	4	6	8	10
$\tilde{\Omega}_A^C - \tilde{\Omega}_A^M$	0.500	0.583	0.558	0.540	0.531	0.525
$\tilde{\Omega}_A^N - \tilde{\Omega}_A^M$	0.500	0.580	0.555	0.539	0.530	0.524
$\tilde{\Omega}_A^C - \tilde{\Omega}_A^N$	0.000	0.003	0.002	0.001	0.001	0.001
$\frac{100\times(\tilde{\Omega}_A^C - \tilde{\Omega}_A^N)}{(\tilde{\Omega}_A^C - \tilde{\Omega}_A^M)}$	0.0	0.6	0.4	0.2	0.2	0.1

Table 1: The welfare effects of coordination: Financial autarky

to an inactive policy (i.e. $\tilde{\Omega}_A^N - \tilde{\Omega}_A^M$). The third row shows the absolute gains from coordination (i.e. $\tilde{\Omega}_A^C - \tilde{\Omega}_A^N$). In each case these figures are measured as a percentage of steady state consumption. The fourth row shows the gains from coordination as a percentage of the maximum possible gain from an active policy (i.e. row 3 as a percentage of row 1). It is apparent from Table 1 that the welfare gain from coordination is positive when θ is greater than unity. But the gain is never large, either in absolute or relative terms. This is very similar to the result emphasised by Obstfeld and Rogoff (2002).

4.3 Risk Sharing

The procedure described in the Appendix can be used to show that home and foreign welfare in the risk-sharing case can be written as follows

$$\tilde{\Omega} = -\frac{1}{4}E\left[\frac{1}{\theta}(2\theta-1)\left(\hat{Y}+\hat{K}\right)^2 + \frac{1}{\theta}\left(\hat{Y}^*+\hat{K}^*\right)^2 + \frac{1}{2}\theta(1-\theta)\hat{S}^2\right] \tag{47}$$

and

$$\tilde{\Omega}^* = -\frac{1}{4}E\left[\frac{1}{\theta}(2\theta-1)\left(\hat{Y}^*+\hat{K}^*\right)^2 + \frac{1}{\theta}\left(\hat{Y}+\hat{K}\right)^2 + \frac{1}{2}\theta(1-\theta)\hat{S}^2\right] \tag{48}$$

while it was shown above that output levels and the exchange rate are linked to monetary policy by the following simple relationships

$$\hat{Y} = \frac{1+\theta}{2}\hat{M} + \frac{1-\theta}{2}\hat{M}^*, \quad \hat{Y}^* = \frac{1+\theta}{2}\hat{M}^* + \frac{1-\theta}{2}\hat{M} \tag{49}$$

$$\hat{S} = \hat{M} - \hat{M}^* \tag{50}$$

The form of the welfare function for each country is almost identical to the autarky case. The only difference is a small change to the coefficient on the variance of the exchange rate. The main difference between the this case and the previous case is contained in the determination of output. There is now a spillover effect from monetary policy in one country to the level of output in the other country. It is clear that this creates more scope for gains from coordinated policy. The quantitative implications of this spillover effect are considered below. First consider the expressions for feedback coefficients and welfare levels.

The coordinated equilibrium results in the following choices of feedback parameters

$$\delta_K^C = \delta_{K^*}^{*C} = -1 \tag{51}$$

$$\delta_{K^*}^C = \delta_K^{*C} = 0 \tag{52}$$

while the non-coordinated equilibrium results in

$$\delta_K^N = \delta_{K^*}^{*N} = \frac{1 - 3\theta^2}{-2\theta\,(1 - 2\theta)} \tag{53}$$

$$\delta_{K^*}^N = \delta_K^{*N} = \frac{1 - 2\theta + \theta^2}{2\theta\,(1 - 2\theta)} \tag{54}$$

The world welfare level yielded by coordinated policy is

$$\tilde{\Omega}_R^C = \frac{(\theta - 1)}{4}(1 - \upsilon)\sigma_K^2 \tag{55}$$

where the subscript 'R' indicates the risk sharing case. The welfare yielded by non-coordinated policy is

$$\tilde{\Omega}_R^N = \frac{\left(-1 + 3\theta - \theta^2 - 4\theta^3 + 3\theta^4\right)}{4\theta\,(1 - 2\theta)^2}(1 - \upsilon)\sigma_K^2 \tag{56}$$

Again, as a point of reference it is useful to consider an inactive policy regime. The welfare level yielded by this regime is

$$\tilde{\Omega}_R^M = -\frac{1}{2}\sigma_K^2 \tag{57}$$

A number of propositions can now be established (and again the proofs are omitted).

Proposition 3 *If $\upsilon < 1$ and $\theta > 1$ then $\tilde{\Omega}_R^C > \tilde{\Omega}_R^N$, i.e. there are gains from coordination.*

It is clear from the expressions (47) to (50) that gains from coordination will arise. All the factors that were present in the autarky case are also present in this case. When $\theta > 1$ both monetary authorities care about the volatility of the exchange rate and both monetary authorities can affect the exchange rate using monetary policy. Also welfare in each country is affected more by the volatility of the disutility of work effort within the country than the volatility in the other country. But now there is an extra spillover effect of monetary policy. When $\theta > 1$ a monetary expansion in the home country reduces output in the foreign country because of the expenditure switching effect. Likewise a monetary expansion in the foreign country reduces output in the home country.

Again notice that there are two cases where the gains from coordination disappear. The first is where $\theta = 1$. In this case the spillover effect from monetary policy to foreign output disappears. The second case is where $\upsilon = 1$. Correlated shocks do not create any conflicts between optimal policy in each country. (Note, however, this is not true when the degree of risk aversion is different from unity. This case will be considered in the next section.)

Proposition 4 *If $\theta > 1$ then: (a) $\left|\delta_K^C\right| = \left|\delta_{K^*}^{*C}\right| > \left|\delta_K^N\right| = \left|\delta_{K^*}^{*N}\right|$ and $\left|\delta_{K^*}^N\right| = \left|\delta_K^{*N}\right| > \left|\delta_{K^*}^C\right| = \left|\delta_K^{*C}\right|$ and (b) $Var\left(\hat{S}^N\right) < Var\left(\hat{S}^C\right)$, $Var\left(\hat{Y}^N\right) < Var\left(\hat{Y}^C\right)$ and $Var\left(\hat{Y}^{*N}\right) < Var\left(\hat{Y}^{*C}\right)$.*

In the autarky case it was clear that non-coordinated policy was less active than coordinated policymaking. In this case coordinated policymaking implies a stronger monetary policy reaction to shocks occurring within a country but a smaller reaction to shocks occurring in the other country. In other words non-coordinated policy involves a shifting of the burden of policy adjustment onto the other country. It remains true however that non-coordinated policy implies less volatility in the exchange rate and output levels.

The quantitative implications of risk sharing for the gains from coordination are illustrated in Table 2. The parameter values are the same as those used to construct Table 1 and the structure of the table is identical. It is apparent that the gains from coordination are much larger than in the autarky case in both absolute and relative terms. For instance when $\theta = 6$ the gains from coordination are worth 0.2 percent of steady state consumption which represents 12.3 percent of the gains from optimal stabilisation. These figures obviously can not be described as large, but they are also not trivial.[10]

[10] Notice from (55), (56) and (57) that the size of the welfare effects is proportional to the aggregate variance of the shocks. In a more general model, with more sources of shocks and some persistence in the shock processes, the size of the welfare effects will depend on some aggregate of all shock variances and the degree of persistence of the shocks. This may generate larger welfare effects than reported here.

θ	1	2	4	6	8	10
$\tilde{\Omega}_R^C - \tilde{\Omega}_R^M$	0.500	0.750	1.250	1.750	2.250	2.750
$\tilde{\Omega}_R^N - \tilde{\Omega}_R^M$	0.500	0.736	1.147	1.535	1.916	2.296
$\tilde{\Omega}_R^C - \tilde{\Omega}_R^N$	0.000	0.014	0.103	0.215	0.334	0.454
$\frac{100\times\left(\tilde{\Omega}_R^C - \tilde{\Omega}_R^N\right)}{\left(\tilde{\Omega}_R^C - \tilde{\Omega}_R^M\right)}$	0.0	1.8	8.3	12.3	14.8	16.5

Table 2: The welfare effects of coordination: Risk sharing

5 Risk Aversion and the Welfare Gains from Policy Coordination

The analysis so far has focused on the case where utility is logarithmic in consumption. The coefficient of relative risk aversion, ρ, is therefore unity. This section considers the implications of varying the degree of risk aversion. In what follows much of the explicit derivation is omitted and the discussion concentrates on the parts of the analysis which are modified by the allowing for $\rho \neq 1$.

5.1 Financial Autarky

Using the procedure described in the Appendix it is possible to show that home and foreign welfare can now be written as follows

$$\begin{aligned}\tilde{\Omega} &= -E\left[\frac{\omega\left(\hat{Y}+\hat{K}\right)^2+\left(\hat{Y}^*+\hat{K}^*\right)^2+\left(\hat{Y}-\hat{M}\right)^2-\left(\hat{Y}^*-\hat{M}^*\right)^2}{4\left[1+\rho\left(\theta-1\right)\right]}\right.\\ &\qquad\left.+\frac{1}{8}\left(1-\theta\right)\hat{S}^2-\frac{1}{2}\left(1-\rho\right)\hat{C}^2\right] \qquad (58)\end{aligned}$$

and

$$\begin{aligned}\tilde{\Omega}^* &= -E\left[\frac{\omega\left(\hat{Y}^*+\hat{K}^*\right)^2+\left(\hat{Y}+\hat{K}\right)^2+\left(\hat{Y}^*-\hat{M}^*\right)^2-\left(\hat{Y}-\hat{M}\right)^2}{4\left[1+\rho\left(\theta-1\right)\right]}\right.\\ &\qquad\left.+\frac{1}{8}\left(1-\theta\right)\hat{S}^2-\frac{1}{2}\left(1-\rho\right)\hat{C}^{*2}\right] \qquad (59)\end{aligned}$$

where $\omega = \left[1+2\rho\left(\theta-1\right)\right]$. The output levels and the exchange rate are linked to monetary policy by the following simple relationships

$$\hat{Y} = \frac{\left[1+\rho\left(2\theta-1\right)\right]\hat{M}+\left(1-\rho\right)\hat{M}^*}{2\rho\left[1+\rho\left(\theta-1\right)\right]}, \quad \hat{Y}^* = \frac{\left[1+\rho\left(2\theta-1\right)\right]\hat{M}^*+\left(1-\rho\right)\hat{M}}{2\rho\left[1+\rho\left(\theta-1\right)\right]} \qquad (60)$$

$$\hat{S} = \frac{1}{1+\rho\left(\theta-1\right)}\left(\hat{M}-\hat{M}^*\right) \qquad (61)$$

It is also necessary to consider the relationship between monetary policy and consumption levels. These are as follows

$$\hat{C} = \frac{[1 + 2\rho(\theta - 1)]\,\hat{M} + \hat{M}^*}{2\rho\,[1 + \rho(\theta - 1)]}, \quad \hat{C}^* = \frac{[1 + 2\rho(\theta - 1)]\,\hat{M}^* + \hat{M}}{2\rho\,[1 + \rho(\theta - 1)]} \tag{62}$$

It is apparent from (58) and (59) that the relationship between welfare and output and exchange rate volatility is rather more complicated than in the $\rho = 1$ case. Equations (60) and (61) show that the relationship between output and the exchange rate and monetary policy is also more complicated than in the $\rho = 1$ case. It is now apparent from (60) and (61) that monetary policy can have a spillover effect on output even when there is no risk sharing. Thus, when $\rho > 1$ an expansion of the home money supply will have a contractionary effect on foreign output (and vice versa for an expansion of the foreign money supply). This spillover effect creates a new possibility for welfare gains from policy coordination.

Another important new feature of the above relationships is that welfare now depends on the volatility of consumption. The reason for this is obvious. When utility is logarithmic in consumption agents do not care about the variance of the log-deviation of consumption. But when $\rho > 1$ risk aversion is sufficiently strong to imply that volatility of the log-deviation of consumption has a negative effect on aggregate utility (and vice versa for $\rho < 1$).

Equations (62) show how consumption depends on monetary policy. It is apparent that when $\rho \neq 1$ and $\theta > 1$ consumption in each country depends on monetary policy in each country. Thus, for instance, an increase in the home money supply raises both home and foreign consumption. This is because an increase in the home money supply raises output and income of home agents and this allows home agents to increase consumption of both home and foreign goods. This raises the income of foreign agents who are thus able also to raise consumption. Notice however that the increase in the home money supply has a larger effect on home consumption than it does on foreign consumption.

This link between the money supply in one country and the level of consumption in the other country creates another a new spillover effect of monetary policy. This again creates potential welfare gains from monetary policy coordination.

Table 3 illustrates the quantitative implications of these new spillover effects. In this table $\theta = 2$ and the value of ρ is varied between 1/4 and 8. The baseline parameter values are the same as in previous examples. It is apparent that the size of the welfare gain is increasing as the degree of risk aversion deviates from unity. The size of the welfare gain is now rather larger in relative terms but it remains small in

ρ	1/4	1/2	1	2	4	6	8
$\tilde{\Omega}_A^C - \tilde{\Omega}_A^M$	1.444	0.900	0.583	0.375	0.229	0.167	0.131
$\tilde{\Omega}_A^N - \tilde{\Omega}_A^M$	1.421	0.898	0.580	0.359	0.208	0.147	0.113
$\tilde{\Omega}_A^C - \tilde{\Omega}_A^N$	0.023	0.002	0.003	0.016	0.021	0.020	0.018
$\frac{100\times\left(\tilde{\Omega}_A^C - \tilde{\Omega}_A^N\right)}{\left(\tilde{\Omega}_A^C - \tilde{\Omega}_A^M\right)}$	1.589	0.227	0.571	4.167	9.276	12.00	13.64

Table 3: The welfare effects of coordination: Financial autarky

absolute terms. Thus the new spillover effects working via output and consumption are limited in magnitude when there is no risk sharing.

5.2 Risk sharing

Using the solution procedure described in the Appendix it is possible to show that home and foreign welfare in the risk-sharing case can be written as follows

$$\tilde{\Omega} = -E\left[\frac{\omega\left(\hat{Y}+\hat{K}\right)^2+\left(\hat{Y}^*+\hat{K}^*\right)^2+\left(\hat{Y}-\hat{M}\right)^2-\left(\hat{Y}^*-\hat{M}^*\right)^2}{4\left[1+\rho\left(\theta-1\right)\right]} + \frac{1}{8}\left(1-\theta\right)\theta\hat{S}^2-\frac{1}{2}\left(1-\rho\right)\hat{C}^2\right] \tag{63}$$

and

$$\tilde{\Omega}^* = -E\left[\frac{\omega\left(\hat{Y}^*+\hat{K}^*\right)^2+\left(\hat{Y}+\hat{K}\right)^2+\left(\hat{Y}^*-\hat{M}^*\right)^2-\left(\hat{Y}-\hat{M}\right)^2}{4\left[1+\rho\left(\theta-1\right)\right]} + \frac{1}{8}\left(1-\theta\right)\theta\hat{S}^2-\frac{1}{2}\left(1-\rho\right)\hat{C}^{*2}\right] \tag{64}$$

where again $\omega = \left[1+2\rho\left(\theta-1\right)\right]$. Output levels, the exchange rate and consumption are linked to monetary policy by the following simple relationships

$$\hat{Y} = \frac{1+\rho\theta}{2\rho}\hat{M} + \frac{1-\rho\theta}{2\rho}\hat{M}^*, \quad \hat{Y}^* = \frac{1+\rho\theta}{2\rho}\hat{M}^* + \frac{1-\rho\theta}{2\rho}\hat{M} \tag{65}$$

$$\hat{S} = \hat{M} - \hat{M}^* \tag{66}$$

$$\hat{C} = \frac{\hat{M}+\hat{M}^*}{2\rho}, \quad \hat{C}^* = \frac{\hat{M}+\hat{M}^*}{2\rho} \tag{67}$$

It is again apparent that the main difference between these relationships and their counterparts in the $\rho = 1$ case is the fact that welfare depends on the variance of consumption. This again creates a new spillover effect. But notice now that consumption in each country depends equally on both home and foreign monetary policy. This is an obvious consequence of risk sharing. It is therefore possible that

ρ	1/4	1/2	1	2	4	6	8
$\tilde{\Omega}_R^C - \tilde{\Omega}_R^M$	1.500	1.000	0.750	0.625	0.563	0.542	0.531
$\tilde{\Omega}_R^N - \tilde{\Omega}_R^M$	1.155	0.889	0.736	0.536	0.107	-0.357	-0.835
$\tilde{\Omega}_R^C - \tilde{\Omega}_R^N$	0.345	0.111	0.014	0.089	0.456	0.898	1.366
$\frac{100\times(\tilde{\Omega}_R^C - \tilde{\Omega}_R^N)}{(\tilde{\Omega}_R^C - \tilde{\Omega}_R^M)}$	22.98	11.11	1.852	14.24	81.04	165.8	257.1

Table 4: The welfare effects of coordination: Risk sharing

ρ	1/4	1/2	1	2	4	6	8
$\tilde{\Omega}_R^C - \tilde{\Omega}_R^M$	1.000	0.500	0.250	0.125	0.063	0.042	0.031
$\tilde{\Omega}_R^N - \tilde{\Omega}_R^M$	0.798	0.444	0.250	0.038	-0.393	-0.857	-1.335
$\tilde{\Omega}_R^C - \tilde{\Omega}_R^N$	0.203	0.056	0.000	0.087	0.456	0.898	1.366
$\frac{100\times(\tilde{\Omega}_R^C - \tilde{\Omega}_R^N)}{(\tilde{\Omega}_R^C - \tilde{\Omega}_R^M)}$	20.25	11.11	0.000	69.44	729.0	2156	4371

Table 5: The welfare effects of coordination: Symmetric shocks

the spillover effect operating through consumption levels is potentially more significant than in the autarky case (where home monetary policy had a greater effect on home consumption and foreign monetary policy had a greater effect on foreign consumption).

Table 4 illustrates the quantitative implications for the gains to coordination. It is immediately apparent that the gains from coordination can now be quite large, both in absolute and relative terms, even for quite moderate values of θ and ρ. For instance when $\rho = 4$ the gains from coordination are approaching 0.5 percent of steady state consumption which represents over 80 percent of the gains from optimal stabilisation policy.

5.3 Symmetric Shocks and the Gains from Policy Coordination

In Section 4 is was shown that with $\rho = 1$ there were no welfare gains to policy coordination when the shocks in the two countries are perfectly correlated. This continues to be true in the autarky case when $\rho \neq 1$. But it is not true on the risk-sharing case when $\rho \neq 1$. Table 5 reports the welfare figures for the risk-sharing case when shocks are perfectly correlated (i.e. $\upsilon = 1$).[11] It is apparent that there are substantial gains from coordination. This contrasts with a result emphasised by Obstfeld and Rogoff (2002).

[11] In this example the variances of the individual country shocks are $\sigma_K^2 = \sigma_{K^*}^2 = 0.005$. This ensures that the aggregate world variance is identical to the previous examples where $\upsilon = 0$.

6 The Welfare Gains from Risk Sharing

The analysis so far has concentrated on the welfare gains from policy coordination. But the model also yields estimates of the welfare gains from risk sharing. Table 6 repeats some of numerical welfare results from the previous sections in a way which allows a comparison across financial market structures. Table 6 focuses on the effects of varying θ when $\rho = 1$ (i.e. the case of logarithmic utility). The first row shows the welfare gains from risk sharing when monetary policy is coordinated. The second row shows the same results for the non-coordinated policy regime.

It is clear from expressions (44) and (55) that there is an unambiguous welfare gain to risk sharing when policy is coordinated (provided $\theta > 1$ and $\upsilon < 1$). That there should be such a welfare gain is not *a priori* obvious in a model where there are several market distortions (such as monopoly power and sticky nominal prices). The figures in the first row in Table 6 provide a quantitative measure of the potential welfare gain from risk sharing. These figures are within the range of estimates suggested by previous literature.[12]

The welfare effects of risk sharing are somewhat smaller when monetary policy is not coordinated. A comparison of (45) and (56) shows that risk sharing again provides an unambiguous welfare gain when $\rho = 1$. But figures in the second row of Table 6 show that the welfare gain is smaller than when monetary policy is coordinated. The monetary policy spillover effects created by risk sharing partly offset the welfare gains of risk sharing when monetary policy is uncoordinated.

The welfare gains from risk sharing are, however, very sensitive to the degree of risk aversion. This is illustrated in Table 7. This table again reports values for the welfare gain from risk sharing for the cases of coordinated and non-coordinated monetary policy. In this case θ is set equal to 2 and ρ is varied. It is again clear that the welfare effect of risk sharing is positive when monetary policy is coordinated. But it is also now apparent that the welfare effect can be negative when monetary

[12] For instance Cole and Obstfeld (1991) suggest a welfare gain from risk sharing of the order of 0.2 percent of steady state consumption while van Wincoop (1994) suggests a gain closer to 5 percent of steady state consumption.

θ	1	2	4	6	8	10
$\tilde{\Omega}_R^C - \tilde{\Omega}_A^C$	0.000	0.167	0.692	1.210	1.719	2.225
$\tilde{\Omega}_R^N - \tilde{\Omega}_A^N$	0.000	0.156	0.592	0.996	1.387	1.772

Table 6: The welfare effects of risk sharing: Logarithmic utility

ρ	1/4	1/2	1	2	4	6	8
$\tilde{\Omega}_R^C - \tilde{\Omega}_A^C$	0.056	0.100	0.167	0.250	0.333	0.375	0.400
$\tilde{\Omega}_R^N - \tilde{\Omega}_A^N$	-0.266	-0.009	0.156	0.177	-0.101	-0.503	-0.948

Table 7: The welfare effects of risk sharing: Risk aversion

policy is uncoordinated. Thus the monetary policy spillovers created by risk sharing can be so strong that they outweigh the welfare benefits of risk sharing. The figures in Table 7 suggest that this can occur for quite moderate values of ρ and θ.

7 The Optimality of Price Targeting

One theme in the recent literature on monetary policy has been the welfare implications of price (or inflation) targeting. A number of authors have argued that price or inflation targeting is desirable from a welfare point of view (see for instance, King and Wolman (1999), Goodfriend and King (2001), Woodford (2001)). The final section of this paper briefly discusses the implications of the model for the optimality of price targeting.

The model assumes that all prices are fixed in advance so it is not possible directly to analyse a price targeting policy. But it is possible to gain some indirect insight into the implications for prices by considering the first-order condition for price setting that would be relevant if agents were able to set prices after shocks are realised. The first-order condition for the choice of prices in a flexible-price equilibrium is derived in the Appendix and implies the following

$$\hat{P}_H = \hat{K} + \hat{P} + \rho\hat{C}, \quad \hat{P}_F^* = \hat{K}^* + \hat{P}^* + \rho\hat{C}^* \tag{68}$$

A price targeting policy implies $\hat{P}_H = \hat{P}_F^* = 0$ so, when expressions (68) are combined with the money demand equations the following monetary rules are obtained

$$\hat{M} = -\hat{K}, \quad \hat{M}^* = -\hat{K}^* \tag{69}$$

These rules are relevant for all values of θ and ρ and for all financial market structures. So any equilibrium which implies policy rules of the above form is consistent with price targeting.

It is immediately clear that neither coordinated nor non-coordinated policymaking is consistent with price targeting in the case of financial autarky (as is argued in Benigno (2001) and Obstfeld and Rogoff (2002)). It is however clear that coordinated policy is consistent with price targeting when there is risk sharing. Uncoordinated policymaking is only consistent with price targeting in the risk-sharing case for particular parameter combinations (as shown in Benigno and Benigno (2001a).

8 Conclusion

This paper has analysed the welfare effects of monetary policy coordination in a model where the elasticity of substitution between home and foreign goods can differ from unity. It is shown that welfare gains to policy coordination can arise when the elasticity is greater than unity, but these gains are quantitatively small when there is no international financial market. When, however, there is a sufficiently sophisticated financial market to allow full consumption risk sharing the gains from policy coordination are found to be much larger. This is particularly true when the coefficient of relative risk aversion differs from unity.

The model also yields results concerning the welfare impact of financial market integration (i.e. a move from financial autarky to risk sharing). It is found that the additional monetary policy spillover effects created by financial markets can be so strong that financial market integration can have a negative impact on welfare if monetary policy is not coordinated.

This paper has considered two extreme forms of financial market structure. The gains from coordination are found to differ significantly between the two extremes. But neither extreme is entirely satisfactory as a representation of reality. An obvious next step in this line of research is to investigate the welfare gains to coordination in some intermediate financial market structure. A possible example of an intermediate structure is one where financial trade only takes place in the form of non-contingent bonds. This type of model will inevitably involve asset stock dynamics and will therefore require more extensive use of numerical simulation techniques.[13] An alternative way to model an intermediate degree of risk sharing has recently been proposed by Ligon, Thomas and Worrall (1997, 2000) and Kehoe and Perri (2000). It may also be interesting to consider the gains from monetary policy coordination in this alternative 'endogenous incomplete market' framework.

[13] Techniques which make this form of analysis possible have recently been developed by Kim and Kim (2000), Sims (2000), Schmitt-Grohé and Uribe (2001) and Sutherland (2001).

Appendix

Optimal Price Setting

The price-setting problem facing a fixed-price producer is the following:

$$MaxU(z) = E\left\{\frac{C^{1-\rho}(z)}{1-\rho} + \log\frac{M}{P} - Ky(z)\right\} \tag{70}$$

subject to

$$PC(z) = (1+\alpha)\,p_H\,(z)\,y(z) + M_0 - M - T \tag{71}$$

$$y(z) = c_H(z) + c_H^*(z) = (C_H + C_H^*)\left(\frac{p_H\,(z)}{P_H}\right)^{-\phi} \tag{72}$$

The first order condition with respect to $p_H\,(z)$ is

$$E\left\{(1+\alpha)\,\frac{y(z)}{PC^{\rho}(z)} - \phi\left[(1+\alpha)\,\frac{p_H\,(z)}{PC^{\rho}(z)} - K\right]\frac{y(z)}{p_H\,(z)} = 0\right\} = 0 \tag{73}$$

In equilibrium all agents choose the same price and consumption level so

$$E\left\{(1+\alpha)\,\frac{Y}{PC^{\rho}} - \phi\left[(1+\alpha)\,\frac{P_H}{PC^{\rho}} - K\right]\frac{Y}{P_H} = 0\right\} = 0 \tag{74}$$

where

$$Y = C_H + C_H^* \tag{75}$$

Rearranging yields the expression in the main text.

The price-setting problem facing a flexible-price producer is the following:

$$MaxU(z) = \frac{C^{1-\rho}(z)}{1-\rho} + \log\frac{M}{P} - Ky(z) \tag{76}$$

subject to

$$PC(z) = (1+\alpha)\,p_H\,(z)\,y(z) + M_0 - M - T \tag{77}$$

$$y(z) = c_H(z) + c_H^*(z) = (C_H + C_H^*)\left(\frac{p_H\,(z)}{P_H}\right)^{-\phi} \tag{78}$$

The first order condition with respect to $p_H\,(z)$ is

$$(1+\alpha)\,\frac{y(z)}{PC^{\rho}(z)} - \phi\left[(1+\alpha)\,\frac{p_H\,(z)}{PC^{\rho}(z)} - K\right]\frac{y(z)}{p_H\,(z)} = 0 \tag{79}$$

In equilibrium all agents choose the same price and consumption level so

$$(1+\alpha)\,\frac{Y}{PC^{\rho}} - \phi\left[(1+\alpha)\,\frac{P_H}{PC^{\rho}} - K\right]\frac{Y}{P_H} = 0 \tag{80}$$

where

$$Y = C_H + C_H^* \tag{81}$$

Rearranging yields the expression in the main text.

Model Solution

The solution procedure is described using the autarky case as an illustration. The amendments necessary to derive the risk sharing solution are then described.

In order to derive a solution for the welfare measure it is necessary to derive solutions for both the first and second moments of the model. The first step in the solution process is to replace each equation of the model with a second-order approximation in terms of log-deviations from the non-stochastic steady state. Most of the equations of the model are linear in logs so this process does not involve any approximation for those equations. There are just three pairs of equations where approximations are necessary.

The log-deviation form of the money market equations implies

$$\hat{M} = \hat{P} + \rho\hat{C}, \quad \hat{M}^* = \hat{P}^* + \rho\hat{C}^* \tag{82}$$

For home and foreign demand equations the log-deviation forms are

$$\hat{C}_H = \hat{C} - \theta\left(\hat{P}_H - \hat{P}\right), \quad \hat{C}_F = \hat{C} - \theta\left(\hat{P}_F - \hat{P}\right) \tag{83}$$

and

$$\hat{C}_H^* = \hat{C}^* - \theta\left(\hat{P}_H^* - \hat{P}^*\right), \quad \hat{C}_F^* = \hat{C}^* - \theta\left(\hat{P}_F^* - \hat{P}^*\right) \tag{84}$$

The log-deviation form of current account balance implies

$$\hat{P}_H + \hat{C}_H^* = \hat{P}_F + \hat{C}_F \tag{85}$$

And the log-deviation form of purchasing power parity implies

$$\hat{P} = \hat{P}^* + \hat{S} \tag{86}$$

None of the above equations require any approximation when converting to log-deviation form.

The expressions for total outputs, aggregate prices and price setting do require approximation. The second-order approximation for the total output equations are

$$\hat{Y} = \frac{1}{2}\hat{C}_H + \frac{1}{2}\hat{C}_H^* + \lambda_Y + O\left(\|\xi\|^3\right), \quad \hat{Y}^* = \frac{1}{2}\hat{C}_F + \frac{1}{2}\hat{C}_F^* + \lambda_{Y^*} + O\left(\|\xi\|^3\right) \tag{87}$$

where

$$\lambda_Y = \frac{1}{8}\left(\hat{C}_H - \hat{C}_H^*\right)^2, \quad \lambda_{Y^*} = \frac{1}{8}\left(\hat{C}_F - \hat{C}_F^*\right)^2$$

The second-order approximations for the aggregate price indices are

$$\hat{P} = \frac{1}{2}\hat{P}_H + \frac{1}{2}\hat{P}_F + \lambda_P + O\left(\|\xi\|^3\right), \quad \hat{P}^* = \frac{1}{2}\hat{P}_H^* + \frac{1}{2}\hat{P}_F^* + \lambda_{P^*} + O\left(\|\xi\|^3\right) \tag{88}$$

where

$$\lambda_P = \frac{1}{8}\left(\hat{P}_H - \hat{P}_F\right)^2, \quad \lambda_{P^*} = \frac{1}{8}\left(\hat{P}_H^* - \hat{P}_F^*\right)^2$$

And the second-order approximations for the price setting conditions are

$$\hat{P}_H = E\left[\hat{K} + \hat{P} + \rho\hat{C}\right] + \lambda_{P_H} + O\left(\|\xi\|^3\right) \tag{89}$$

$$\hat{P}_F^* = E\left[\hat{K}^* + \hat{P}^* + \rho\hat{C}^*\right] + \lambda_{P_F^*} + O\left(\|\xi\|^3\right) \tag{90}$$

where

$$\lambda_{P_H} = \frac{1}{2}E\left[\hat{K}^2 + 2\hat{K}\hat{Y} - \hat{P}^2 - \rho^2\hat{C}^2 + \hat{Y}\hat{P} + \rho\hat{Y}\hat{C} - \rho\hat{P}\hat{C}\right]$$

$$\lambda_{P_F^*} = \frac{1}{2}E\left[\hat{K}^{*2} + 2\hat{K}^*\hat{Y}^* - \hat{P}^{*2} - \rho^2\hat{C}^{*2} + \hat{Y}^*\hat{P}^* + \rho\hat{Y}^*\hat{C}^* - \rho\hat{P}^*\hat{C}^*\right]$$

Notice that second-order terms are collected in the six terms λ_Y, λ_{Y^*}, λ_P, λ_{P^*}, λ_{P_H} and $\lambda_{P_F^*}$. Using the above equations it is possible to solve for the first moments of all the variables of the model in terms of these second-order terms. In this way the following expression is obtained for the first-order terms in the home welfare function

$$\begin{aligned} E\left[\hat{C} - \hat{Y}\right] \quad = \quad & \frac{1}{2\left[1 + \rho\left(\theta - 1\right)\right]}E\left\{\lambda_{P_H} - \lambda_{P_F^*} - 2\left[1 + \rho\left(\theta - 1\right)\right]\lambda_Y \right. \\ & \left. + \left(1 - 2\theta\right)\left(1 + \rho\theta\right)\lambda_P - \left(1 - \rho\theta\right)\lambda_{P^*}\right\} + O\left(\|\xi\|^3\right) \end{aligned} \tag{91}$$

Notice now that welfare can be written entirely in terms of second moments. The remaining task is therefore to derive expressions for the second moments of the variables of the model. This task is made easier by noting that second-order accurate solutions for second moments can be derived from first-order accurate solutions for the realisations of variables. First-order accurate solutions for *ex post* realisations can be obtained from equations (82) to (89) by ignoring second-order terms. In the case where $\rho = 1$ the resulting set of equations can be used to derive the following expressions for the λs

$$E\left[\lambda_{P_H}\right] = \frac{1}{2}E\left[\left(\hat{Y} + \hat{K}\right)^2\right] + O\left(\|\xi\|^3\right) \tag{92}$$

$$E\left[\lambda_{P_F^*}\right] = \frac{1}{2}E\left[\left(\hat{Y}^* + \hat{K}^*\right)^2\right] + O\left(\|\xi\|^3\right) \tag{93}$$

$$E\left[\lambda_Y\right] = E\left[\lambda_{Y^*}\right] = \frac{1}{8}\left(1 - \theta\right)^2 E\left[\hat{S}^2\right] + O\left(\|\xi\|^3\right) \tag{94}$$

$$E\left[\lambda_P\right] = E\left[\lambda_{P^*}\right] = \frac{1}{8}\left(1 - \theta\right)E\left[\hat{S}^2\right] + O\left(\|\xi\|^3\right) \tag{95}$$

Home welfare can therefore be written as follows

$$\tilde{\Omega} = -\frac{1}{4}E\left[\frac{1}{\theta}\left(2\theta - 1\right)\left(\hat{Y} + \hat{K}\right)^2 + \frac{1}{\theta}\left(\hat{Y}^* + \hat{K}^*\right)^2 + \frac{1}{2}\left(1 - \theta\right)\hat{S}^2\right] + O\left(\|\xi\|^3\right) \tag{96}$$

which is the expression used in the main text. The expression for foreign welfare follows immediately by symmetry.

The procedure for deriving welfare expressions for the risk-sharing case is identical. The only amendment required is to replace the current account equation with the risk-sharing condition $\hat{C} = \hat{C}^*$. In the case where risk sharing takes place after monetary rules are chosen (i.e. the case considered in the main text) the risk sharing equation is only relevant when deriving solutions for the *ex post* realisations of variables. It therefore only affects the second moments of variables. The current account condition continues to be relevant for the derivation of first-moment terms. But in the case where risk sharing takes place before monetary rules are chosen (i.e. the case considered immediately below in this Appendix) the risk sharing condition is imposed for the derivation of both first and second moment terms.

An Alternative Risk Sharing Structure

This appendix briefly considers the case where risk sharing takes place before monetary policy rules are determined. Only the case where $\rho = 1$ is considered. In this case the solution procedure described above can be used to show that home and foreign welfare can be written as follows

$$\tilde{\Omega} = -\frac{1}{4}E\left[(2-\theta)\left(\hat{Y}+\hat{K}\right)^2 + \theta\left(\hat{Y}^*+\hat{K}^*\right)^2 + 2\theta(1-\theta)\hat{S}^2\right] \tag{97}$$

and

$$\tilde{\Omega}^* = -\frac{1}{4}E\left[(2-\theta)\left(\hat{Y}^*+\hat{K}^*\right)^2 + \theta\left(\hat{Y}+\hat{K}\right)^2 + 2\theta(1-\theta)\hat{S}^2\right] \tag{98}$$

while output levels and the exchange rate are given by (49) and (50) in the main text.

Equations (97) and (98) show that the change in the timing of risk trading has a significant effect on the structure of the welfare function. It is still the case that welfare depends on the volatility of the disutility of work effort in both countries and the volatility of the exchange rate. But now there is a much stronger imbalance between the effects of the volatility of work effort at home and abroad. Consider the home country welfare function. For values of θ greater than 2 home welfare is increasing in the volatility of the disutility of home work effort and decreasing in the volatility of the disutility of foreign work effort. This is as a direct result of the change in timing of risk trading. The home policymaker now knows that home agents are 'insured' against any change in the expected level of their work effort. If the home policymaker chooses a monetary rule which increases the volatility of

θ	1	2	4	6	8	10
$\tilde{\Omega}_R^C - \tilde{\Omega}_R^M$	0.500	0.750	1.250	1.750	2.250	2.750
$\tilde{\Omega}_R^N - \tilde{\Omega}_R^M$	0.500	-	-0.015	0.122	0.166	0.187
$\tilde{\Omega}_R^C - \tilde{\Omega}_R^N$	0.000	-	1.266	1.628	2.084	2.563
$\frac{100\times\left(\tilde{\Omega}_R^C - \tilde{\Omega}_R^N\right)}{\left(\tilde{\Omega}_R^C - \tilde{\Omega}_R^M\right)}$	0.0	-	101.2	93.0	92.6	93.2

Table 8: The welfare effects of coordination: Alternative risk-sharing structure

the disutility of home work effort this will increase home goods prices and reduce home work effort. Home agents will have a lower expected level of income but their consumption level will be tied to the expected level of world output by the risk-sharing arrangement. Home agents therefore benefit from an increase in leisure time while receiving the world average level of consumption. In other words the home policymaker believes that is possible to shift the burden of production onto the foreign economy. This mechanism clearly creates a further spillover effect of monetary policy which potentially increases the gains from monetary policy coordination.

The quantitative implications of the additional spillover effects arising in this case are illustrated in Table 8. The parameter values and construction of the table are identical to the cases discussed in the main text. It is clear that the gains from coordination can now be very large, both in relative and absolute terms. When compared to the case where risk trading takes place after policy rules are chosen non-coordinated policymaking now yields much lower levels of welfare.

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