Title

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GLOBAL IMPLICATIONS OF SELF-ORIENTED NATIONAL MONETARY RULES*

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Abstract

It is well known that if international linkages are relatively small, the potential gains to international monetary policy coordination are typically quite limited. But what if goods and financial markets are tightly linked? Is it then problematic if countries unilaterally design their institutions for monetary stabilization? Are the stabilization gains from having separate currencies largely squandered in the absence of effective international monetary coordination? We argue that under plausible assumptions the answer is no. Unless risk aversion is very high, lack of coordination in rule setting is a second-order problem compared to the overall gains from monetary policy stabilization.

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I. Introduction

To what extent might the stabilization gains from having multiple major currencies be squandered through a lack of international cooperation in monetary reform? Over the past ten to fifteen years, individual OECD governments appear to have made enormous progress in mitigating the "commitment" problem in monetary policy. Is it harmful, though, if the major currency areas design their rule-based domestic monetary institutions unilaterally, neglecting international spillover effects? Will such a system produce, say, excessive attention to inflation stabilization and inadequate attention to output stabilization when viewed from a global perspective?

We are not the first to address this question. Persson and Tabellini [1995, 2000] have shown how, in principle, international cooperation in designing *domestic* monetary policy institutions can lead to improved global outcomes, even absent binding international agreements. They themselves, however, cautioned that a deeper understanding of the problem awaited the development of rigorous welfare foundations for open-economy macroeconomics. Fortunately, over the past few years economists have taken large strides in providing such foundations (see the discussion of "new open economy macroeconomics" in Corsetti and Pesenti [2001a], as well as Gali and Monacelli [2000]). In this paper we provide a first application of these new models to the design of monetary policy rules in a strategic international setting.

Our results suggest that the importance of international cooperation in choosing rules is quite sensitive to the nature of distortions in the economy. In fact, we find plausible environments in which there is little or no need for cooperation within a rule-based environment. The adoption of rules, in itself, can overcome problems of both domestic credibility and international spillovers, *even* when countries choose rules on the basis of narrow self interest. The broad intution comes from the theory of the second best. In a rule-based setting, cooperation problems arise mainly when the choice of monetary rule spills over into impacting several distortions—e.g., due to imperfect markets for sharing risk—rather than just the nominal rigidities that raise the standard monetary stabilization issues. Gauging the benefits to cooperation in rule setting then becomes an empirical question.

In a classic paper, Oudiz and Sachs [1984] argued that the benefits to monetary cooperation are not likely to be large across major regions because they are relatively closed.[1] Our results here are quite different, and not only

[1] See also Canzoneri and Edison [1990], who entertain alternative definitions of policy

because we are looking at rule setting rather than ex post responses to a one-time shock. While it is still true that there is no benefit to international monetary cooperation when goods markets are relatively closed, it is also true that the cooperative and Nash equilibria converge as goods markets become perfectly integrated. The potential benefits are greatest in the intermediate cases where both goods and capital markets are imperfectly integrated.

Sections II and III develop a generalization of the new open economy macroeconomics models of Obstfeld and Rogoff [1998, 2000a], extended to incorporate the case of incomplete risk sharing. In sections IV and V, we explore the relationship between the cooperative and non-cooperative rule setting games, and section VI discusses the relationship of our work to the previous literature. Section VII concludes.

II. A Two-Country Sticky-Wage Model

We first adapt the two-country model of Obstfeld and Rogoff [2000a] to encompass incomplete international asset markets, an extension that turns out to affect significantly the scope for international policy coordination. The model itself is not our main focus and its various building blocks are all relatively familiar, so we outline only the essential features.[2]

The world consists of two equally-sized countries, Home and Foreign. Firms produce differentiated goods out of differentiated labor inputs indexed by $[0, 1]$. Home produces differentiated tradable goods on the interval $[0, 1]$, while Foreign's tradables are indexed by $(1, 2]$. In addition, each country produces an array of differentiated nontraded goods indexed by $[0, 1]$.

Let $Y(i)$ denote output of differentiated good i and $L(i, j)$ the demand for labor input j by producer i. Home traded goods production is given by

$$Y_{\mathrm{H}}(i) = \left[\int_0^1 L_{\mathrm{H}}(i, j)^{\frac{\phi-1}{\phi}} \mathrm{d}j \right]^{\frac{\phi}{\phi-1}} . \tag{1}$$

The Home nontraded-goods production function is identical (with L_{N} replacing L_{H}), as are the Foreign production functions. There is only a single contracting period, so we omit time subscripts throughout.

coordination under which gains might be amplified beyond the levels that Oudiz and Sachs reported.

[2]For more details on the underlying model, see Obstfeld and Rogoff [2000a,b].

As usual, firm i's demand for labor of type j is

$$L(i,j) = \left[\frac{W(j)}{W}\right]^{-\phi} Y(i), \tag{2}$$

where $W(j)$ is the nominal wage of worker j and W is the exact production-based index of wages.[3]

A Home individual of type i maximizes the expected value of

$$U^i = \frac{(C^i)^{1-\rho}}{1-\rho} + \chi \log \frac{M^i}{P} - KL^i, \tag{3}$$

where $\rho > 0$ is the (constant) coefficient of relative risk aversion and L^i is total individual labor supply to both sectors. In (3), K is a random shift in the marginal disutility of effort that can be interpreted as a (negative) country-wide Home productivity shock. The Foreign productivity shock, K^*, is distributed symmetrically, though not necessarily independently. Aggregate money supplies, M and M^*, are the other exogenous random variables.

For any person i the overall real consumption index C is Cobb-Douglas with exponent γ on tradables C_{T} and $1-\gamma$ on nontradables C_{N}. The preferences over Home and Foreign traded goods underlying the subindex C_{T} are likewise Cobb-Douglas with equal exponents on C_{H} and C_{F}. Foreign preferences are identical. The consumption subindexes for C_{H}, C_{F}, and C_{N} are constant-elasticity aggregates [analogous to (1)] with identical elasticity θ. Domestic-currency price indexes for C_{H}, C_{F}, and C_{N} are isomorphic to the wage index given in footnote 3, with the consumption substitution elasticity θ in place of ϕ. The domestic-currency price index for overall real consumption C is $P = P_{\text{T}}^{\gamma} P_{\text{N}}^{1-\gamma}$, and the price index for tradable consumption C_{T} is $P_{\text{T}} = P_{\text{H}}^{\frac{1}{2}} P_{\text{F}}^{\frac{1}{2}}$.

Isomorphic to the labor demand eq. (2) are the Home and Foreign consumer demands for individual goods, which depend on relative price with a constant elasticity θ; e.g., Home demand for a typical Home tradable h is $C_{\text{T}}(h) = [P_{\text{T}}(h)/P_{\text{H}}]^{-\theta} C_{\text{H}}$. Given the assumed unit elasticity of substitution between Home and Foreign goods, and between traded and nontraded goods, we have: $C_{\text{H}} = \frac{1}{2}(P_{\text{H}}/P_{\text{T}})^{-1} C_{\text{T}}$ (with a parallel formula for C_{F}) and $C_{\text{T}} = \gamma(P_{\text{T}}/P)^{-1} C$ (with a parallel formula for C_{N}). The first-order condition

[3] The form of the index is $W = \left[\int_0^1 W(j)^{1-\phi} \mathrm{d}j\right]^{\frac{1}{1-\phi}}$.

governing money demand is:

$$\frac{M^i}{P} = \chi \left(C^i\right)^{\rho}. \tag{4}$$

The only internationally traded asset is a real bond indexed to the composite traded good C_{T}. In particular, domestic firms are entirely domestically owned. In the case $\rho = 1$, though, our economy will turn out to mimic one with complete asset markets.

III. Equilibrium Price and Wage Setting and a Closed Form Solution

A. A Closed-Form Solution

We assume that workers set nominal wages a period in advance and, ex post, supply the amount of labor that firms demand at the posted nominal wage. The first-order condition for the optimal preset nominal wage is:

$$W(i) = \left(\frac{\phi}{\phi - 1}\right) \frac{\mathrm{E}\left\{KL^i\right\}}{\mathrm{E}\left\{\frac{L^i}{P}\left(C^i\right)^{-\rho}\right\}}. \tag{5}$$

Absent uncertainty, eq. (5) would simply give the marginal utility of the real wage as a fixed markup over the marginal disutility of labor.

In contrast to wages, prices are flexible and, moreover, monoplistic firms can price discriminate across the Home and Foreign markets. However, with constant and identical elasticities of demand, prices turn out to be the same constant markup over wages in both countries, so that, for example,

$$P_{\mathrm{H}} = \left(\tfrac{\theta}{\theta - 1}\right) W = \mathcal{E} P_{\mathrm{H}}^{*}. \tag{6}$$

Although the law of one price holds, the terms of trade can still vary with the exchange rate:[4]

$$\text{terms of trade} \equiv \frac{\mathcal{E} P_{\mathrm{F}}^{*}}{P_{\mathrm{H}}} = \frac{\mathcal{E} W^{*}}{W}. \tag{7}$$

[4] The price of the Foreign CPI in terms of the Home CPI, the real exchange rate, also can vary. Note that

$$\text{real exchange rate} \equiv \frac{\mathcal{E} P^{*}}{P} = \frac{\mathcal{E} P_{\mathrm{T}}^{*\gamma} P_{\mathrm{N}}^{*(1-\gamma)}}{P_{\mathrm{T}}^{\gamma} P_{\mathrm{N}}^{(1-\gamma)}} = \left(\frac{\mathcal{E} W^{*}}{W}\right)^{1-\gamma}.$$

Because of unit demand elasticities and the constraint that tradable consumption equal tradable output in value, one can easily show that, in all states of nature,

$$C_{\mathrm{T}} = C^*_{\mathrm{T}}.$$

Of course, only the traded goods component of consumption has to be equal across countries; the overall consumption indexes C and C^* need not move together. However, if we measure Home spending *in units of tradables* as

$$Z \equiv C_{\mathrm{T}} + \left(\frac{P_{\mathrm{N}}}{P_{\mathrm{T}}}\right) C_{\mathrm{N}},$$

then, because $P_{\mathrm{N}}/P_{\mathrm{T}} = (1-\gamma)C_{\mathrm{T}}/\gamma C_{\mathrm{N}}$,

$$Z = C_{\mathrm{T}}/\gamma = C^*_{\mathrm{T}}/\gamma = Z^*. \tag{8}$$

Equality of the tradables-denominated spending levels Z and Z^* will be helpful in solving the model.

For the subsequent analysis, it is important to observe that for the log consumption case ($\rho = 1$), utility is separable in tradables and nontradables. Thus, when $C_{\mathrm{T}} = C^*_{\mathrm{T}}$ ex post, we will have perfect international sharing of consumption risks in tradable goods. When $\rho \neq 1$, however, the marginal utility of *tradables* consumption depends on consumption of nontradables. Thus, $C_{\mathrm{T}} = C^*_{\mathrm{T}}$ no longer guarantees internationally equality of the marginal utility of tradables, as efficient risk sharing would require. This will be important for policy coordination, as we explain later.

We can next solve the model by assuming that the exogenous shocks $\{m, m^*, \kappa, \kappa^*\}$ are jointly normally distributed, where lower case letters denote (natural) logs so that, e.g., $m \equiv \log M$. To simplify we assume that the Home and Foreign log productivity shocks have *identical* means and variances, so that $\mathrm{E}\kappa = \mathrm{E}\kappa^*$ and $\sigma^2_\kappa = \sigma^2_{\kappa^*}$. One can conveniently define the "world" and "difference" productivity shocks as:

$$\kappa_w \equiv \frac{\kappa + \kappa^*}{2}, \; \kappa_d \equiv \frac{\kappa - \kappa^*}{2}.$$

Note that because κ and κ^* have identical variances, $\mathrm{Cov}(\kappa_w, \kappa_d) = 0$ and $\sigma^2_\kappa = \sigma^2_{\kappa_w} + \sigma^2_{\kappa_d}$. Decomposing shocks into global and relative components will turn out to be very helpful when we contrast the coordination problems that they raise.

B. The Impact of Uncertainty on the Terms of Trade and Spending

We are now prepared to illustrate what is perhaps the most fundamental difference between our model and the models used in earlier analyses of international policy coordination.

We first express the wage setting equation (5) and its Foreign analog in terms of logs and covariances of logs of the endogenous variables, after simplifying it through use of budget constraints and labor-market equilibrium conditions. The *expected* terms of trade are

$$\begin{aligned} \mathrm{E}\tau &\equiv \mathrm{E}e + w^* - w = f(\overset{(?)}{\sigma_{ze}}, \overset{(-)}{\sigma_{\kappa_w e}}, \overset{(-)}{\sigma_{\kappa_d z}}) \\ &= \frac{-1}{1-(1-\gamma)(1-\rho)} \left\{ [1-(1-\gamma)(1-\rho)^2]\sigma_{ze} \right. \\ &\qquad \left. + \sigma_{\kappa_w e} + 2\sigma_{\kappa_d z} \right\}, \end{aligned} \tag{9}$$

where τ denotes the (log) terms of trade $\mathcal{E}P^*_{\mathrm{F}}/P_{\mathrm{H}}$—making the log real exchange rate $(1-\gamma)\,\tau$. We similarly solve for the expected log of consumption spending measured in tradables,

$$\begin{aligned} \mathrm{E}z &= g(\overset{(?)}{\sigma_z^2}, \overset{(?)}{\sigma_e^2}, \overset{(-)}{\sigma_{\kappa_w z}}, \overset{(-)}{\sigma_{\kappa_d e}}) \\ &= \frac{1}{\rho}\left\{ \omega + \lambda - \frac{1}{2\rho}\sigma_\kappa^2 - \frac{1}{2}[1-(1-\rho)^2]\sigma_z^2 \right. \\ &\qquad \left. - \frac{1}{8}[1-(1-\gamma)^2(1-\rho)^2]\sigma_e^2 - \sigma_{\kappa_w z} - \frac{1}{2}\sigma_{\kappa_d e} \right\}, \end{aligned} \tag{10}$$

where ω and λ are constants that depend on the moments of κ and κ^*.[5] From eq. (8), we see that $\mathrm{E}z = \mathrm{E}z^*$.

In contrast to the ad hoc linear-quadratic formulations used in standard monetary coordination models of the 1980s and 1990s (see Canzoneri and

[5] Specifically,

$$\omega \equiv \left\{ \log\psi - \mathrm{E}\kappa + \frac{(1-\rho)}{2\rho}\sigma_\kappa^2 - \lambda \right\}$$

where

$$\lambda \equiv \frac{(1-\rho)\gamma\left[\frac{\gamma}{2} + \rho - \gamma\rho\right]}{\rho\left[1-(1-\gamma)(1-\rho)\right]^2}\sigma_{\kappa_d}^2.$$

Again, the reader may refer to our working paper, Obstfeld and Rogoff [2000b], for details.

Henderson [1991]), changes in the monetary policy rule affect mean wages and prices here, not only their variances. For example, eq. (9) implies that a higher covariance $\sigma_{\kappa_w e}$ between the world disutility of labor shock κ_w and the exchange rate e (a covariance that can be influenced by monetary rules) discourages planned Home labor effort (relative to Foreign's) because Home's relative marginal utility of real consumption will turn out to be unexpectedly low precisely when the world marginal disutility of effort and home labor supply are unexpectedly high. As a consequence, Home workers will raise their preset wages (compared to Foreign's).

These covariance effects are simply absent in the earlier certainty-equivalent models of monetary policy coordination, which instead rely on an ad hoc inflation cost to create ex post policy tradeoffs. Here, instead, the potential incentive is for countries to manipulate their monetary rules to raise domestic expected welfare at the expense of foreigners. For example, by exploiting the effects of its monetary rule on wages, a country can try to manipulate selfishly the (average values of the) real exchange rate and terms of trade.[6]

In order to express the variances of the endogenous variables in terms of the exogenous shocks, we need to solve the sticky wage model for the *ex post* terms of trade innovation (equal to the ex post nominal exchange rate innovation) and the ex post innovation in spending,

$$\hat{e} = \frac{\hat{m} - \hat{m}^*}{\rho(1-\gamma) + \gamma}, \tag{11}$$

$$\hat{z} = \frac{1}{2\rho}(\hat{m} + \hat{m}^*), \tag{12}$$

where carets over variables denote surprise components, e.g., $\hat{m} \equiv m - \mathrm{E}m$.[7] Once we specify monetary rules for m and m^*, we will be able to present

[6]Some of the effects in eqs. (9) and (10) are of indefinite sign and depend on the size of ρ, the coefficient of risk aversion. (See also Obstfeld and Rogoff [1998, 2000b].) When $\rho = 1$, a ceteris paribus rise in the variance of the log consumption measured in tradables, σ_z^2, will cause workers throughout the world to set higher wages, thereby feeding back into a lower value for $\mathrm{E}z$. This is also the case for $\rho < 1$, but if ρ is sufficiently above 1, the effect may be reversed. The depressing effect of σ_z^2 on $\mathrm{E}z$ is declining in ρ. Indeed, it undergoes a sign change at $\rho = 2$.

[7]To solve for z, take logs of the money Euler eq. (4) and its Foreign counterpart, assuming that $\chi = \chi^*$. Then average the two, applying the definitions of the price indexes, the markup equations for prices, and the equality $C = P_{\mathrm{T}}Z/P$. The exchange rate equation is derived by a similar calculation in differences.

an exact reduced-form solution to the model. Before doing so, however, we show how expected utilities depend on equilibrium covariances.

C. Solving Explicitly for Expected Utility

In studying policy rules, we will look at their welfare implications in the limiting case as $\chi \to 0$ in eq. (3). The justification is that expenditure on money services is small relative to that on other goods. Note, though, that if $\rho = 1$, the solution we present below is exact, for any positive χ. When $\rho = 1$, eq. (4) implies that, in equilibrium, $\chi C = M/P$. Thus we can replace the term $\log C + \chi \log \frac{M}{P}$ by $(1+\chi)\log C$ in evaluating individual utility.[8]

When $\rho = 1$, the utility derived from consumption is simply $\log(C)$ and a Home resident's expected utility (as $\chi \to 0$) takes the form

$$\mathrm{E}U = \mathrm{E}z + \left(\frac{1-\gamma}{2}\right)\mathrm{E}\tau - \psi, \tag{13}$$

where

$$\psi \equiv \frac{(\phi - 1)(\theta - 1)}{\phi\theta}.$$

Foreign expected utility is given by

$$\mathrm{E}U^{*} = \mathrm{E}U - (1-\gamma)\mathrm{E}\tau. \tag{14}$$

Equations (13) and (14) show that while expected consumption measured in tradables, Ez, is a common component of Home and Foreign utility, the real exchange rate (proportional to the terms of trade) is a potential source of conflict. Because expenditure measured in tradables is the same in both countries, a country prefers a real depreciation, which lowers relative prices of nontradables and gives its expenditure a greater real purchasing power.

Notice that the role of Eτ in eqs. (13) and (14) does not stem from optimal tariff considerations, since in this model, an optimal tariff would result in a real *appreciation.* As we discuss in section V, the choice of optimal tariff is separable in our model from the choice of a monetary rule.

[8]By calculating welfare in the limit as $\chi \to 0$, we do not intend literally to imagine that money demand is zero. Indeed, we must continue to assume that there is a positive demand for money in order for the model to make sense. Note, however, that eq. (12) shows that the effect of a log monetary innovation on log global spending is the same regardless how small we make χ. Thus, there is no problem in thinking of our welfare results as becoming an arbitrarily good approximation as $\chi \to 0$.

In the case $\rho \neq 1$, we evaluate expected utility as $\chi \to 0$ by calculating[9]

$$\begin{aligned}
\mathrm{E}U &= \mathrm{E}\left\{\frac{C^{1-\rho}}{1-\rho} - KL\right\} = \left(\frac{1}{1-\rho} - \psi\right)\mathrm{E}\left\{Z^{1-\rho}\left(\frac{\mathcal{E}W^*}{W}\right)^{\frac{(1-\rho)(1-\gamma)}{2}}\right\} \\
&= \left(\frac{1}{1-\rho} - \psi\right) h(\mathrm{E}z, \mathrm{E}\tau, \sigma_z^2, \sigma_e^2, \sigma_{ze}),
\end{aligned}$$

where

$$\begin{aligned}
h(\mathrm{E}z, \mathrm{E}\tau, \sigma_z^2, \sigma_e^2, \sigma_{ze}) &= \exp\left\{(1-\rho)\mathrm{E}z + \frac{(1-\rho)(1-\gamma)}{2}\mathrm{E}\tau + \frac{(1-\rho)^2}{2}\sigma_z^2 \right. \\
&\quad \left. + \frac{(1-\rho)^2(1-\gamma)^2}{8}\sigma_e^2 + \frac{(1-\gamma)(1-\rho)^2}{2}\sigma_{ze}\right\}. \quad (15)
\end{aligned}$$

The expression for Foreign expected utility is of the same form, except that the terms $\mathrm{E}\tau$ and σ_{ze} enter with opposite sign. As in the $\rho = 1$ case, the expected terms of trade, $\mathrm{E}\tau$, provides a potential source of international conflict. An internationally asymmetric welfare distribution might also be induced by the covariance σ_{ze} between world demand and the exchange rate, independently of the effect of σ_{ze} on $\mathrm{E}\tau$ shown in eq. (9).

IV. Policy Coordination: Globally Efficient Precommitment to Monetary Rules

Per our discussion in the introduction, we restrict our attention to comparing policy *rules* such that m and m^* are functions of the productivity shocks κ and κ^*. The commitment to such rules precludes the use of inflation surprises to systematically raise employment and output toward their

[9] The wage eq. (5) as well as the equalities in the preceding footnote, show that

$$\mathrm{E}\{KL\} = \psi\mathrm{E}\left\{C^{1-\rho}\right\}.$$

Thus,

$$\mathrm{E}U = \left(\frac{1}{1-\rho} - \psi\right)\mathrm{E}\left\{C^{1-\rho}\right\}.$$

competitive levels. Similarly, national authorities cannot attempt to manipulate the terms of trade ex post through monetary surprises.[10] Nevertheless, because expected spending and the expected terms of trade do depend on covariance terms that the monetary rules can affect, the ability to precommit does not eliminate all strategic issues.

In general, in sticky wage or price models with additional distortions, it need not be the case that optimal monetary policy aims simply to mimic the flexible-wage equilibrium. The reason is that the multiple distortions (in the present setup, including wage stickiness, monopoly, and the possible failure of international consumption risk sharing) can interact. It turns out, however, that for the particular stylized structure we have assumed, the optimal solution to the global cooperation problem will indeed replicate the flexible-wage solution in a number of important cases, as we shall now demonstrate. It will turn out further that these are precisely the cases where international cooperation in rule setting is not necessary.

If policymakers could cooperate in choosing their domestic monetary policy rules, then with equal weights on national welfares, they would maximize[11]

$$\mathrm{E}V = \tfrac{1}{2}\mathrm{E}U^{*} + \tfrac{1}{2}\mathrm{E}U. \tag{16}$$

To accomplish this, they would maximize over the coefficients in monetary policy feedback rules of the form

$$\begin{aligned} \hat{m} &= -\delta_d \hat{\kappa}_d - \delta_w \hat{\kappa}_w, && (17) \\ \hat{m}^{*} &= \delta_d^{*} \hat{\kappa}_d - \delta_w^{*} \hat{\kappa}_w. && (18) \end{aligned}$$

(Given the loglinear structure of the model, it is plausible to guess that optimal monetary rules will be loglinear too.) Of course, $\mathrm{E}\kappa_w = \mathrm{E}\kappa = \mathrm{E}\kappa^{*}$, so $\mathrm{E}\kappa_d = 0$.

[10] Coresetti and Pesenti [2001*a*] show that for some parameter configurations, the incentive to use unanticipated inflation to raise employment may be exactly offset by optimal tariff considerations. In this special case, results such as ours may be extended to the ex post game.

[11] Unlike earlier cooperation papers, we do not include an ad hoc inflation term in the monetary authorities' objective functions. Though it is a perhaps only a sleight of hand, we could have done so by assuming overlapping contracts, while taking the initial level of wages as given. Then, of course, any change in the monetary rule will have a surprise element to it (due to the preexisting wage contracts), and therefore the level of inflation has a redistributive effect. Our analysis neglects these transitional issues.

A. Expected Utilities under Flexible and Sticky Wages

As a first step in understanding cooperation and conflict in the choice of domestic policy rules, we calculate the flexible- and sticky-wage levels of utility in Home and Foreign.

Under flexible wages monetary policy is irrelevant and the level of expected utility, denoted by a tilde, is

$$\mathrm{E}\tilde{U} = \log(\psi) - \psi - \mathrm{E}\kappa = \mathrm{E}\tilde{U}^* \tag{19}$$

when $\rho = 1$, where we have imposed $\mathrm{E}\kappa = \mathrm{E}\kappa^*$ and $\sigma_\kappa^2 = \sigma_{\kappa^*}^2$. For $\rho \neq 1$,

$$\mathrm{E}\tilde{U} = \mathrm{E}\tilde{U}^* = \left(\frac{1}{1-\rho} - \psi\right) \exp\left[\frac{(1-\rho)\omega}{\rho}\right], \tag{20}$$

where the constant ω is defined in footnote 5.

Expected Home utility under sticky wages can be decomposed in terms of the flex-wage expected utility levels given above and the economic uncertainties caused by wage rigidity. Using eqs. (9) and (10) to substitute for $\mathrm{E}\tau$ and $\mathrm{E}z$ in eqs. (13) and (15), one can calculate that for $\rho \neq 1$

$$\mathrm{E}U = \left(\mathrm{E}\tilde{U}\right) \exp\left[(1-\rho)\Omega(\rho)\right], \tag{21}$$

where $\Omega(\rho)$ is defined (for any $\rho > 0$) as the sum of two terms,

$$\Omega(\rho) = \Omega_w(\rho) + \Omega_d(\rho),$$

such that $\Omega_w(\rho)$ depends on the endogenous covariances $\sigma_e^2, \sigma_{\kappa_w z}$, and $\sigma_{\kappa_d e}$,

$$\begin{aligned} \Omega_w(\rho) &= -\frac{1}{2\rho^2}\left(\sigma_{\kappa_w}^2 + \sigma_{\kappa_d}^2\right) + \frac{\lambda}{\rho} \\ &\quad -\frac{1}{2}\sigma_z^2 - \frac{\frac{1}{8}\left[1-(1-\gamma)^2(1-\rho)\right]\sigma_e^2 + \sigma_{\kappa_w z} + \frac{1}{2}\sigma_{\kappa_d e}}{\rho} \end{aligned} \tag{22}$$

and $\Omega_d(\rho)$ depends on the endogenous covariances $\sigma_{ze}, \sigma_{\kappa_w e}$, and $\sigma_{\kappa_d z}$,

$$\Omega_d(\rho) = -\frac{(1-\gamma)}{2}\left\{\frac{\rho\sigma_{ze} + \sigma_{\kappa_w e} + 2\sigma_{\kappa_d z}}{1-(1-\gamma)(1-\rho)}\right\}. \tag{23}$$

For $\rho = 1$, the expression corresponding to eq. (21) is

$$\mathrm{E}U = \mathrm{E}\tilde{U} + \Omega(1). \tag{24}$$

For Foreign,

$$\mathrm{E}U^* = \left(\mathrm{E}\tilde{U}\right)\exp\left[(1-\rho)\Omega^*(\rho)\right]$$

when $\rho \neq 1$, and when $\rho = 1$, $\mathrm{E}U = \mathrm{E}\tilde{U} + \Omega^*(1)$, where

$$\Omega^*(\rho) = \Omega_w(\rho) - \Omega_d(\rho).$$

Obviously, $\Omega_w(\rho)$ is a symmetric component of world utility that affects Home and Foreign welfare equally. For example, a rise in the variance of world spending (σ_z^2) or in that of the exchange rate (σ_e^2) has symmetrical negative expected utility effects upon Home and Foreign.

The term $\Omega_d(\rho)$ is an asymmetric utility component that affects Home and Foreign in opposite ways. For example, a rise in $\sigma_{\kappa_w e}$ hurts Home because it becomes more likely that demand for Home output will be unexpectedly high when there is an unexpectedly high global aversion to effort. But that same change represents a commensurate benefit to Foreign.[12]

B. Multiple Distortions and the Efficiency of the Flexible-Wage Equilibrium

Is it efficient (from an ex ante standpoint) to have monetary policy rules aim to mimic the flexible-wage equilibrium, as in 1980s style of rational-expectations monetary models? In general, the answer is not trivial, as we have noted, since wage stickiness is not the only distortion here.

First, we note that the monetary policy reaction functions (17) and (18)

$$\delta_d^{flex} = \delta_d^{*flex} = 1, \quad (25)$$
$$\delta_w^{flex} = \delta_w^{*flex} = 1 \quad (26)$$

indeed replicate the flexible-wage equilibrium, so such a policy is always feasible in this model.[13] (In models with more complex price rigidities, however, such replication may not be feasible.)

[12] Observe that whereas $\mathrm{E}\tilde{U} = \mathrm{E}\tilde{U}^*$ when $\mathrm{E}\kappa = \mathrm{E}\kappa^*$ and $\sigma_\kappa^2 = \sigma_{\kappa^*}^2$, $\mathrm{E}U$ still need not equal $\mathrm{E}U^*$ if monetary policies are asymmetric.

[13] Verification is left to the reader. (See also appendix 2.). In terms of the national productivity shocks, the monetary rules would be $\hat{m} = -\hat{\kappa}$, $\hat{m}^* = -\hat{\kappa}^*$. More generally, when labor enters as $\frac{K}{\nu}L^\nu$ in individual utility (3), then $\delta_d^{flex} = \delta_d^{*flex} = \frac{\rho(1-\gamma)+\gamma}{1-(1-\gamma)(1-\rho)}$ and $\delta_w^{flex} = \delta_w^{*flex} = \rho/[\nu - (1-\rho)]$. This generalization, however, would have no important effect on our discussion below.

Next, we establish a sufficient condition under which replicating the flexible-wage allocation is indeed the goal of efficient cooperative policies.[14]

Proposition 1 *If the flexible-wage allocation is constrained Pareto efficient (subject to the constraint that labor supplies are at monopolistic levels), a global monetary policy rule that gives the same real allocation as under flexible wages is efficient.*

Proof: (Sketch). Note that the parameters θ and ϕ governing the monopoly distortion terms in (21) and (24) affect only the identical additive or multiplicative constant $\mathrm{E}\tilde{U}$, but not any of the elements of $\Omega(\rho)$. Thus one can offer subsidies to production and employment that eliminate the monopoly distortions in the goods and labor markets (in both countries) while affecting only $\mathrm{E}\tilde{U}$ but not the relevant gap between $\mathrm{E}U$ and $\mathrm{E}\tilde{U}$. With optimal subsidies in place, the flexible-wage equilibrium is clearly first-best efficient (in terms of expected utilities) under the assumption in the proposition: all distortions have been eliminated. Since the subsidies affect only $\mathrm{E}\tilde{U}$ in (21) and (24), it therefore follows that even in their absence, one cannot Pareto-improve upon replicating the flexible-wage equilibrium ex post. ■

Under the assumptions of Proposition 1, targeting the flexible-wage allocation is also the *optimal* cooperative policy given the assumed 50-50 weights on country utility in the planner objective function (16). The reason is that $\mathrm{E}\tilde{U} = \mathrm{E}\tilde{U}^*$; see eq. (20). Later, however, we will see that Proposition 1 gives a sufficient condition for optimality *regardless* of the weights in (16).

C. Optimal Cooperation

The proposition just proved allows a quick but partial characterization of optimal policies. When all productivity shocks are world shocks (that is, $\hat{\kappa}_d \equiv 0$), or when $\rho = 1$, the sharing of tradable consumption risks is efficient and there are no global distortions to the flexible-wage equilibrium other than the ones caused by monopoly (which enter separably). In these latter cases, therefore, we would expect optimal cooperative policies to target the flex-wage allocation. More generally, however, optimal monetary policy will strike a balance between mitigating the risk sharing and sticky-wage distortions. Specifically, it will exploit the rigidity of wages to improve risk sharing. This is precisely the kind of interaction between distortions that we referred to earlier.

[14]Proposition 1 strengthens and generalizes the log-case ($\rho = 1$) result proved in Obstfeld and Rogoff [2000a].

To understand the tradeoff between distortions in the general case, we now solve explicitly for the optimal policy rules under cooperation. Equations (13), (14), and (16) show that when $\rho = 1$, the objective to be maximized through policy cooperation is simply

$$\mathrm{E}V = \tfrac{1}{2}\mathrm{E}U^{*} + \tfrac{1}{2}\mathrm{E}U = \mathrm{E}z + \text{constant}.$$

When $\rho \neq 1$, expected utility is given for the two countries by eq. (15) and its Foreign analog. Differentiating eq. (16) with respect to any policy-rule parameter δ, and noting that $\mathrm{E}\left\{C^{1-\rho}\right\} = \mathrm{E}\left\{C^{*1-\rho}\right\}$ in a symmetric equilibrium, the planner's first order conditions can be written as

$$\frac{\mathrm{d}\left\{\mathrm{E}z + \frac{(1-\rho)}{2}\sigma_z^2 + \frac{(1-\rho)(1-\gamma)^2}{8}\sigma_e^2\right\}}{\mathrm{d}\delta} = 0. \tag{27}$$

By this logic, we see that for *any* value of ρ, one can derive the optimal cooperative monetary policy rules by assuming that policymakers seek

$$\begin{aligned} \max \mathrm{E}V &= \max\left\{\mathrm{E}z + \frac{(1-\rho)}{2}\sigma_z^2 + \frac{(1-\rho)(1-\gamma)^2}{8}\sigma_e^2\right\} \\ &= \max\left\{\frac{\omega}{\rho} + \Omega_w(\rho)\right\} \end{aligned} \tag{28}$$

over the parameters in their linear monetary policy feedback rules. (Recall again that ω is the constant defined in footnote 5.)

The two countries place opposite weights on the expected real exchange rate and on the covariance σ_{ze} between world spending and the exchange rate. These two factors thus disappear at the global level. This need not imply, of course, that monetary authorities try to fix the nominal exchange rate, unless the Home and Foreign productivity shocks happen to be perfectly correlated.

To solve for the cooperative monetary policy rules that maximize (28), we express the ex post values of z and e as functions of the monetary reaction parameters; this in turn allows us to calculate the covariances in $\Omega_w(\rho)$; recall eq. (22). Appendix 1 expresses the covariances in $\Omega_w(\rho)$ in terms of the δ policy parameters.

The next step is to solve the four first-order conditions given by eq. (27) for the cooperatively optimal parameters $\delta_d^{coop}, \delta_d^{*coop}, \delta_w^{coop}$, and δ_w^{*coop}. By symmetry, $\delta_d^{coop} = \delta_d^{*coop}$ and $\delta_w^{coop} = \delta_w^{*coop}$, where (again, see appendix 1)

$$\delta_d^{coop} = \frac{\rho(1-\gamma)+\gamma}{1-(1-\gamma)^2(1-\rho)}, \tag{29}$$

$$\delta_w^{coop} = 1 \tag{30}$$

Observe that due to the symmetry of the model, purely symmetric shocks can be handled by adjustments in world spending z alone, whereas purely idiosyncratic shocks can be handled by adjustments of the exchange rate e alone. The rule above represents an optimal symmetrical tradeoff between stabilization—a more aggressive procyclical response to the productivity shocks raises world utility—and variability in world spending and the exchange rate, both of which lower world utility, see (22), and are greater the more procyclical are the monetary policy rules.

Comparing the globally optimal rules in eqs. (29) and (30) with the ones that achieve the flexible-wage allocation, eqs. (25) and (26), we see first that when $\rho = 1$, it is always optimal to target the flexible-wage equilibrium (as per Proposition 1). In the special case of symmetric global productivity shocks Proposition 1 still applies even when $\rho \neq 1$, and therefore $\delta_w^{coop} = \delta_w^{flex}$. However, $\delta_d^{coop} = \delta_d^{flex}$ for $\rho \neq 1$ only when $\gamma = 0$ or $\gamma = 1$. In those extreme cases, either all goods are tradable (in which case international consumption risk sharing is perfect) or there are no tradables (in which case there are no consumption risks that countries can share).

When $\rho \neq 1$ but $0 < \gamma < 1$, though, the cooperative equilibrium reflects the general principle of the second-best, according to which it could be desirable to refrain from eliminating the sticky-wage distortion in order to mitigate the risk-sharing distortion. In such cases, according to eqs. (25) and (29), $\delta_d^{coop} < \delta_d^{flex}$ when $\rho < 1$ but $\delta_d^{coop} > \delta_d^{flex}$ when $\rho > 1$. Thus, for $\rho < 1$, exchange-rate fluctuations are dampened relative to a flexible-wage rule, but they are relatively accentuated when $\rho > 1$.

D. Understanding the Tradeoff

What explains the way that optimal policies deviate from targeting the flex-wage allocation? Such situations have received scant analytic attention in the monetary policy literature, so we digress to give the intuition. Continuity is not sacrificed, however, by skipping directly to section V.

To understand the difference between δ_d^{coop} and δ_d^{flex} when risk sharing in tradables is imperfect, note first that by eq. (15), one can write countries' ex post marginal utilities of tradables as

$$
\begin{aligned}
\text{Home marginal utility of tradables} &= Z^{-\rho}\left(\frac{\mathcal{E}W^*}{W}\right)^{\frac{(1-\rho)(1-\gamma)}{2}}, \\
\text{Foreign marginal utility of tradables} &= Z^{-\rho}\left(\frac{\mathcal{E}W^*}{W}\right)^{\frac{-(1-\rho)(1-\gamma)}{2}}.
\end{aligned}
$$

Thus, ex post international marginal utility gaps result exclusively from exchange rate movements (which affect national outputs of nontradables differentially). When there is a positive shock to κ_d, a fall in $\mathcal{E}$ (a Home currency appreciation and a Foreign depreciation) is required to replicate the flexible-wage equilibrium. In the case $\rho < 1$, Home's marginal utility of tradables is consequently below Foreign's at the flexible-wage allocation, as the preceding equations show. In a world of complete asset markets, Home would make a payment of tradables to Foreign in such states of nature. That is impossible here. However, a *reduction* in the extent to which $\mathcal{E}$ falls works very much like a transfer of tradables because, as a result, Home residents work harder, Foreign residents work less, and more Home goods are shipped to Foreign in exchange for fewer Foreign goods.

The logic is symmetric for $\rho > 1$. In that case, were asset markets complete, a positive κ_d would call for a transfer of tradables from Foreign to Home at the flex-wage allocation. Instead, the cooperative equilibrium calls for a sharper fall in $\mathcal{E}$ than does the flex-wage equilibrium. This induces Home residents to produce fewer of their exports and Foreign residents more of theirs than under flexible wages.[15]

V. Noncooperative Choice of Policy Rules

In designing their monetary rules and institutions, countries seldom ask what impact domestic institutional changes will have on welfare abroad. Since, as we have seen, monetary rules can affect the expected real exchange rate, which in turn creates a wedge between home and foreign welfare, the

[15] Notice that when $\rho > 1$, the ex post international gap in the marginal utility of tradables actually is larger at the cooperative equilibrium than at the flex-wage equilibrium. However, the marginal cost of moving further from the flex-wage equilibrium is also higher. Thus, on balance, there is no net expected gain from further increasing the coefficient δ_d^{coop}.

question naturally arises as to whether an environment in which nations cooperate in setting rules is superior. Can the rules needed to achieve the cooperative equilibrium ever be implemented without a binding global monetary compact?

We show in this section that when the optimal cooperative policy rules target the flexible-wage equilibrium ex post, those rules are also Nash equilibrium rules. When the best cooperative rules do not mimic the flexible-wage equilibrium, however, they are not Nash. A corollary of this result is that countries' responses to global, internationally symmetric, shocks do not raise problems of coordination; only asymmetric shocks may be problematic. This is in contrast to earlier literature on international policy cooperation where tradeoffs are caused by ad hoc inflation objectives, and where global shocks play a starring role. We will return to this comparison in section VI.

A. Nash Equilibrium in Policy Rules

Differentiation of eq. (15) for EU shows that in the Nash case, the first-order conditions for Home's problem are the same as those for the problem

$$\max_{\delta_d,\delta_w} \underbrace{\frac{\omega}{\rho} + \Omega_w(\rho)}_{\text{global component}} + \underbrace{\Omega_d(\rho)}_{\text{country-specific component}} . \tag{31}$$

given δ_d^* and δ_w^*. Foreign's effective objective function is simply the global component above *less* the country-specific component.

Starting at the cooperative equilibrium, a small movement of δ_d^{*coop} away from δ_d^{coop}, say, has no first-order impact on the global component of Home expected utility because that term is maximized by a global planner; recall eq. (27). Yet, given the Foreign policy rule, Home might still wish to change its own rule, reaping a net *domestic* gain by shifting the utility-relevant terms Eτ and σ_{ze} in its favor while lowering the global component of welfare by less. In that case, of course, Foreign would lose more than Home gains, and (starting at the cooperative equilibrium) Foreign would face a symmetrical incentive to engage in "beggar-thy-neighbor" rule manipulation. The Nash equilibrium, like the cooperative one, is symmetric, so $\delta_d^{Nash} = \delta_d^{*Nash}$ and $\delta_w^{Nash} = \delta_w^{*Nash}$.

Our next result tells us, however, that there is no individual incentive for countries to defect from the cooperative equilibrium when that equilibrium mimics the flexible-wage equilibrium ex post.

Proposition 2 *In the Nash monetary policy rule setting equilibrium,* $\delta_d^{Nash} = \delta_d^{coop} = \delta_d^{flex}$ *when* $\rho = 1$*, and, for any* $\rho > 0$*,* $\delta_w^{Nash} = \delta_w^{coop} = \delta_w^{flex}$*.*

Proof. See appendix 1, where it is shown by direct calculation that

$$\delta_d^{Nash} = [\rho(1-\gamma)+\gamma]\left\{\frac{2-\gamma}{[1-(1-\gamma)^2(1-\rho)]+\rho(1-\gamma)]}\right\}, \tag{32}$$

$$\delta_w^{Nash} = 1. \tag{33}$$

Setting $\rho = 1$ in eq. (32) and comparing the result with eqs. (29) and (25) for $\rho = 1$ proves the first part of the proposition, while comparison of eq. (33) with eqs. (30) and (26) establishes the second part. ■

Proposition 2 shows that when the flexible-wage equilibrium is constrained-efficient with respect to the monopoly distortions, Home doesn't gain by unilaterally moving its policy rule away from cooperation. Constrained efficiency always holds when $\rho = 1$, and it holds for any $\rho > 0$ when all shocks are global. Thus the cooperative equilibrium—when it mimics the flexible-wage equilibrium—is also the Nash equilibrium of the rule-setting game. But notice that our result actually is stronger than this. In fact, the proposition states that Home never gains from changing its response to global shocks even when idiosyncratic shocks can occur and $\rho \neq 1$. This "separability" property follows from the basic linear-quadratic nature of our model, coupled with the orthogonality of the "world" and "difference" shocks.

Regarding the Nash response to idiosyncratic shocks, we have

Proposition 3 *In the Nash monetary policy rule setting equilibrium,* $\delta_d^{flex} > \delta_d^{Nash} > \delta_d^{coop}$ *when* $\rho < 1$ *and* $\delta_d^{flex} < \delta_d^{Nash} < \delta_d^{coop}$ *when* $\rho > 1$*.*

Proof. Left to the reader. ■

The proof of Proposition 2 in appendix 1 confirms our earlier claim that under the assumptions of Proposition 1, it is optimal for a global planner to target the flexible-wage equilibrium regardless of the country welfare weights in the objective function (16). Thus, we have:

Corollary 4 *If the flexible-wage allocation is constrained Pareto efficient, a global monetary policy that gives the same real allocation as under flexible wages is optimal even for a supranational planner who favors one country over the other.* ■

B. Discussion of Propositions 2 and 3

Proposition 2's conclusion that the Nash and cooperative equilibria of the rule-setting game can coincide contrasts sharply with the earlier policy cooperation literature, much of which dealt with the consequences of noncooperative (ex post) responses to *common* (that is, symmetric) shocks. Here, the response to such common shocks resulting from cooperative choice of rules is always the same as that resulting from noncooperative choice (and the responses to any shocks are the same when $\rho = 1$). Why?

The basic reason for Proposition 2 is that these are cases in which the policy rule is designed to mimic the constrained-efficient flexible-wage equilibrium, thus setting to zero the Home and Foreign sticky-wage distortions measured by[16]

$$\Omega(\rho) = \Omega_w(\rho) + \Omega_d(\rho)$$

and

$$\Omega^*(\rho) = \Omega_w(\rho) - \Omega_d(\rho).$$

But if the sticky-wage distortion has been eliminated, a small increase in the distortion through a change in the policy rule has no first-order welfare effect on Home or Foreign.[17] That is, when the policy parameter δ that solves

$$\frac{\mathrm{d}\Omega_w(\rho)}{\mathrm{d}\delta} = 0$$

leads to the flexible-wage equilibrium ex post, it must also be true that

$$\frac{\mathrm{d}\Omega(\rho)}{\mathrm{d}\delta} = \frac{\mathrm{d}\Omega^*(\rho)}{\mathrm{d}\delta} = \frac{\mathrm{d}\Omega_d(\rho)}{\mathrm{d}\delta} = 0.$$

[16] Of course these terms are not necessarily zero when $\rho \neq 1$ and asymmetric shocks can occur. Indeed, it can be shown (after much algebra) that under the cooperative regime,

$$\Omega(\rho) = \frac{\gamma^2(1-\gamma)^2(1-\rho)^2\sigma^2_{\kappa_d}}{2\rho[1-(1-\gamma)(1-\rho)]^2[1-(1-\gamma)^2(1-\rho)]} > 0.$$

However, δ_w and δ_d enter $\Omega(\rho)$ separably, so we can analyze the problem of choosing δ_w as if asymmetric shocks were absent altogether.

[17] It is critical to this argument that the monopoly distortions have effects that are completely separable from those of the sticky-wage distortion, as we have shown above.

Thus, neither country will be tempted to deviate from any policy rule parameter which, taken individually, is tailored to eliminate the effects of sticky wages on the economy's allocation.[18]

Implicit in the preceding discussion is the presumption that the sticky wage lowers welfare because wage setters would always prefer to have the option of resetting their wages after uncertainty is realized: when there are no asymmetric shocks (or when $\rho = 1$), $\Omega(\rho)$ is maximized at a value of 0.

Equation (32) reports the Nash response to asymmetric shocks, and Proposition 3 places it between the cooperative and flexible-wage response coefficients. When $\rho < 1$, countries respond more aggressively to idiosyncratic shocks than is globally efficient—and as a result, exchange rate variability is excessive relative to the benchmark of optimal cooperation. When $\rho > 1$, however (more likely the relevant case empirically), the Nash equilibrium actually produces more stable exchange rates than does cooperation.

Why? The covariance σ_{ze} is bigger the more activist is Home's monetary policy. As equation (23) shows, this has a negative effect on Home. High σ_{ze} implies that world demand is high precisely when the exchange rate is shifting demand toward Home workers. At relatively high values of ρ, the domestically beneficial reduction in σ_{ze} due to reduced monetary activism dominates the domestic harm due to the concomitant rise in $\sigma_{\kappa_d z}$, implying that, left to its own devices, Home would choose a monetary rule that stabilizes the exchange rate more than under cooperation.

By changing its rule to reduce σ_{ze}, Home inflicts a direct beggar-thy-neighbor loss on Foreign, of course. But at the same time $\Omega_w(\rho)$ (a shared, global component of welfare) declines because $\sigma_{\kappa_d e}$ rises; see eq. (22). This last effect hurts both countries, which have a common interest in seeing the Home currency relatively appreciated (and the Foreign currency, therefore, relatively depreciated) when Home productivity is relatively high (and, therefore, Foreign productivity relatively low).

Our discussion of Proposition 2 is based on the negative impact of sticky wages on *individual* welfare, but we have not yet considered optimal tariff effects, which pertain to *national* welfare. As a general matter, the decisions of individual wage setters need not completely internalize a country's monopoly power over its exports; see Obstfeld and Rogoff [1998, appendix

[18]In the logarithmic case ($\rho = 1$), we infer that a small shift in the policy rule does not induce any change in the nominal wages that workers choose ex ante. When $\rho \neq 1$, however, wages do change.

D.2] and Tille [2000]. Indeed, in the present model, individual domestic producers overestimate the global elasticity of demand for their products, so that either country could raise its own welfare, at the other's expense, by imposing an optimal import tariff. Might not a monetary policy rule be designed likewise to exploit a country's monopoly power in trade, thereby, perhaps, raising $\Omega(\rho)$ above zero even in the absence of a risk-sharing distortion?

The answer is no, essentially for the same reason that the sticky-wage distortion does not interact with the micro-level monopoly distortion. To see this, imagine that Home imposes an optimal import tariff to exploit its national monopoly power in trade. Appendix 2 shows that in the flex-wage equilibrium with an ad valorem tariff of t, Home's utility $\tilde{U}(t)$ has the form

$$\tilde{U}(t) = \Gamma(t)\tilde{U}(0) = \Gamma(t)\tilde{U},$$

implying that the optimal tariff is state-independent. Hence the optimal tariff under uncertainty maximizes

$$\Gamma(t)\mathrm{E}U = \Gamma(t)\left(\mathrm{E}\tilde{U}\right)\exp\left[(1-\rho)\Omega(\rho)\right].$$

But the first-order condition for the nationalistically optimal tariff $[\Gamma'(t) = 0]$ is independent from the conditions for optimal nationalistic monetary policy $[\mathrm{d}\Omega(\rho)/\mathrm{d}\delta = 0]$. Thus, Home's ex ante welfare is maximized when the allocational effects of sticky wages are nullified ex post by monetary policy, irrespective of whether the optimal Home tariff is actually in place. Choosing optimal tariffs and monetary rules are separable problems in this model, though in general, of course, they might not be.

Finally, if one introduces complete nominal asset markets here, it must be possible effectively to index contracts to any possible shift in monetary rules. As we argued in Obstfeld and Rogoff [1995], the hypothesis of rigid nominal prices then becomes harder to maintain.[19]

C. How Can One Plausibly Generate Big Coordination Gains?

One way to assess the quantitative importance of the gain from coordination when $\rho \neq 1$ and $\sigma^2_{\kappa_d} > 0$ is to simulate our model numerically. To that end, we assume that $\sigma^2_{\kappa_d} = \sigma^2_{\kappa_w} = .01$, that $\gamma = 0.6$, and that $\nu = 1$ as in our

[19] For an example of a complete nominal contract model, see Chari, Kehoe, and McGrattan [1998]. With complete international asset markets, the model is no longer loglinear for $\rho \neq 1$. Nonetheless, it is possible to show that very simple monetary rules can replicate the flex-wage allocation.

model. (Chari, Kehoe, and McGrattan [1998] assume $\nu = 1.5$, which would make coordination gains smaller.) For different values of ρ, table I calculates three numbers: (i) the gain from monetary policies that target the flexible-wage equilibrium, compared with policies that hold money supplies constant; (ii) the gain from moving from flex-wage policies to the cooperative equilibrium; and (iii) the ratio of (ii) to (i). The gains (i) and (ii) are expressed as *percentages* of output. Notice that because the Nash equilibrium policy responses lie between the flex-wage and cooperative responses, the ratio (iii) is a strict upper bound on the gains to cooperative versus Nash behavior in rule setting.

Insert Table 1 here

The gain to stabilization falls sharply with ρ because the higher is ρ, the less the necessary adjustment of wages to productivity shocks in the flexible-wage equilibrium (see appendix 2). However, the net gain to cooperation versus simply targeting the flex-wage allocation is uniformly tiny in these calculations. Only at relatively high values of ρ, at which the gain to stabilization is very small, does the gain from coordination climb to over a tenth of the gain from stabilization. It takes implausibly high values of ρ (approaching 100) to raise the coordination gain to above 40 percent of the (by then, miniscule) gain from stabilization. In these simulations, deviations from the flexible-wage equilibrium are small, but that might not be the case in a more general model.

Our results here are consistent with a much broader literature which finds that at the aggregate national level, the potential utility gains from increased international risk sharing are not necessarily large (see Obstfeld and Rogoff [1996]), especially in a setting such as the present one where price effects already provide a significant measure of risk sharing.

An important caveat of our analysis is that our model is structured so that global monetary policy can always replicate the flexible-wage equilibrium exactly, if the authorities so choose. In a model with a greater complexity or variety of nominal rigidities, this may not always be the case.[20] In such cases, our results here do not imply that the cooperative and Nash necessarily coincide, even for global shocks. Whether this can generate large empirical deviations is an empirical question that deserves further research.

[20] See, for example, Devereux and Engel [2000].

VI. Comparisons with Earlier Literature

We have already discussed in the introduction the relationship of our analysis to the work of Oudiz and Sachs [1984]. Their empirical model of coordination between the United States and Europe yields small gains only because trade between the two regions is small. In our model, the benefits to cooperation are also small when the two regions are highly integrated. It is precisely in the intermediate case where both goods and capital markets are imperfectly integrated that the scope for coordination is largest.[21] There are other fundamental differences, not least that Oudiz and Sachs study ex post coordination rather than a rule-setting game, and that they use an old-fashioned Keynesian trade multiplier model. Also, as in all the previous literature, their model is one in which monetary policy cannot systematically raise the expected value of output or employment whereas here it can (via agents' responses to risk). Last (but not least), we show that in our framework, the globally-shared shocks, e.g., oil-price shocks, that inspired the older cooperation literature are a non-issue. Only asymmetric shocks lead to coordination failures.

This contrast between our results and the earlier literature with respect to global shocks is not as stark as it seems. The older models typically assumed that the monetary authorities cared about inflation as well as output stabilization, so that the cooperative response to a global shock would not, in general, call for achieving the flexible wage (price) output level. Thus the standard result that the Nash response should differ from the cooperative one (even in a rule setting game) is perfectly consistent with our propositions 2 and 3. We do not include an ad hoc inflation term in utility, but instead the tradeoffs in the monetary rule game are driven by the covariance structure of the model. Of course, in our analysis, we assumed that liquidity services are a negligible factor in utility. Were that not the case, an additional distortion would be present that might discourage policy from replicating the flexible price equilibrium. Our judgment is that this effect is not empirically important and is heavily dependent on the exact specification of money demand. In any event, we proved that for the case of $\rho = 1$, our results go through exactly even when utility from real balances is fully incorporated.

[21] Corsetti and Pesenti [2001b] have shown that the same kind of result can arise when there is local currency pricing. They find that gains to cooperation are largest in the intermediate case of partial exchange rate passthrough.

Our paper does not actually explore the institutional mechanisms by which a rule-based regime might be implemented. Interesting recent work by Jensen [2000], which builds on earlier results by Persson and Tabellini [1995] and Rogoff [1985], shows that it may indeed be possible to implement institutions at the national level that could mitigate the credibility problems of national monetary authorities both vis-à-vis wage setters and vis-à-vis each other. The question our paper answers is whether, in designing such institutions, countries have any incentives to pay attention to the international spillover effects, even if a mechanism for doing so exists. Persson and Tabellini [1995] do, in fact, informally consider whether the globally optimal cooperative contracting scheme could be the outcome of a game in which countries set contracts unilaterally. They argue that, under some conditions, it could (even if other equilibria are possible also). Persson and Tabellini also note, however, that their contracting scheme may be rather fragile, a point Drazen [2000] emphasizes. It is precisely because of such fragility that we need to better understand the benefits to greater cooperation in rule setting.

Finally, Corsetti and Pesenti [2001a] derive the first-order conditions of a Nash equilibrium at given wages in a new open economy macroeconomic model. However, they present their analysis as suggestive and do not attempt to solve fully for Nash equilibrium, nor is their nonstochastic model suited to exploring rule-setting games.

VII. Conclusions

As the major currency countries adopt institutions more conducive to rule-based monetary policy, one might be concerned at their inward-looking decision-making processes. Modern models of monetary policy transmission suggest a number of channels that might lead countries to choose monetary rules that are optimal from a national perspective but not from a global perspective. While in principle this problem perhaps can be addressed with properly designed domestic monetary institutions, in practice, spillover effects appear to receive only minimal consideration.

We have shown that, surprisingly, this lack of coordination may not always be a big problem, even in a world with significant economic integration. As domestic monetary rules improve, and as international asset markets become more complete, there are plausible circumstances in which the outcome of a Nash monetary rule-setting game begins to approximate the outcome of a cooperative one. In our model, the convergence occurs when globally optimal monetary policy rules seek fully to offset nominal rigidities, and are not forced to also carry the burden of counteracting capital-market imperfections or other extra distortions. This answer falls remarkably neatly out of a welfare-based "new open economy macroeconomics model." Indeed, one simply cannot properly pose the question within the older Mundell-Fleming-Dornbusch style of model that, until now, has served as the workhorse of the cooperation literature.

Our quantitative results suggest that, empirically, the possibility of coordination problems under floating exchange rates is unlikely to contribute much weight to a case for fixed exchange rates. We hardly regard the analysis here as a decisive blow against having a world money, since our framework omits many potentially important elements such as excess volatility, protectionism, and the costs of making and keeping track of payments in multiple currencies. The analysis does cast some doubt, however, on halfway measures to coordinate world monetary policy such as McKinnon's [1984] "world money" targeting, or Williamson's [1985] exchange-rate target zones. Continued improvements of monetary policy institutions at the domestic level, coupled with the further broadening of world capital markets, may render such schemes superfluous or even counterproductive.

Appendix 1: Cooperative and Nash Equilibria

This appendix shows how to calculate the cooperative and Nash equilibria when monetary rules respond to productivity shocks.

Cooperative Equilibrium

The paper's text showed that cooperative policymakers will seek to maximize (28) over policy rules of the form given in eqs. (17) and (18). Equations (10), for Ez, and (28) show that to calculate the cooperative equilibrium, we must express the moments σ_z^2, σ_e^2, $\sigma_{\kappa_w z}$, and $\sigma_{\kappa_d e}$, all of which affect Home and Foreign symmetrically, in terms of the policy parameters of the reaction functions (17) and (18). Expressions (12) and (11) show that rules having the form of (17) and (18) imply

$$\begin{aligned} \hat{z} &= -\frac{1}{2\rho}\left[\left(\delta_d - \delta_d^*\right)\, \hat{\kappa}_d + \left(\delta_w + \delta_w^*\right)\, \hat{\kappa}_w\right], \\ \hat{e} &= -\frac{1}{\rho(1-\gamma)+\gamma}\left[\left(\delta_d + \delta_d^*\right)\, \hat{\kappa}_d + \left(\delta_w - \delta_w^*\right)\, \hat{\kappa}_w\right]. \end{aligned}$$

Thus, we can write:

$$\begin{aligned} \sigma_z^2 &= \frac{\left(\delta_d - \delta_d^*\right)^2}{4\rho^2}\sigma_{\kappa_d}^2 + \frac{\left(\delta_w + \delta_w^*\right)^2}{4\rho^2}\sigma_{\kappa_w}^2, \\ \sigma_e^2 &= \left[\frac{\delta_d + \delta_d^*}{\rho(1-\gamma)+\gamma}\right]^2 \sigma_{\kappa_d}^2 + \left[\frac{\delta_w - \delta_w^*}{\rho(1-\gamma)+\gamma}\right]^2 \sigma_{\kappa_w}^2, \\ \sigma_{\kappa_w z} &= -\frac{\delta_w + \delta_w^*}{2\rho}\sigma_{\kappa_w}^2, \\ \sigma_{\kappa_d e} &= -\frac{\delta_d + \delta_d^*}{\rho(1-\gamma)+\gamma}\sigma_{\kappa_d}^2. \end{aligned}$$

Since the cooperative maximand simplifies to

$$\mathrm{E}V = -\frac{1}{2}\sigma_z^2 - \frac{\left\{\frac{1}{8}\left[1-(1-\gamma)^2(1-\rho)\right]\sigma_e^2 + \sigma_{\kappa_w z} + \frac{1}{2}\sigma_{\kappa_d e}\right\}}{\rho} + \text{ constant}$$

once we write Ez and Eτ in terms of the relevant variances and covariances of endogenous variables, recall eq. (22), the first-order conditions for the reaction function parameter δ_d is

$$\begin{aligned}\frac{\mathrm{d}\mathrm{E}V}{\mathrm{d}\delta_d} &= \frac{\mathrm{d}\Omega_w(\rho)}{\mathrm{d}\delta_d} = 0 \\ &= -\frac{(\delta_d - \delta_d^*)}{4\rho^2}\sigma_{\kappa_d}^2 - \frac{\frac{\left[1-(1-\gamma)^2(1-\rho)\right]}{2[\rho(1-\gamma)+\gamma]}(\delta_d + \delta_d^*)\,\sigma_{\kappa_d}^2 - \sigma_{\kappa_d}^2}{2\left[\rho^2(1-\gamma)+\rho\gamma\right]}.\end{aligned}$$

(We do not write out a verification of second-order conditions, but that detail is easily filled in given the simple structure of the model.) Observe that, thanks to the model's linearity and the orthogonality of the global and relative shocks κ_d and κ_w, the first-order conditions for the optimal Home and Foreign cooperative response elasticities to κ_d do not depend on the response elasticities to κ_w. A further simplification results from noting that, due to the model's symmetry, we must have $\delta_d^* = \delta_d$ at the optimum. Thus, the preceding first-order condition implies that $\delta_d^{coop} = \delta_d^{*coop} = \frac{\rho(1-\gamma)+\gamma}{1-(1-\gamma)^2(1-\rho)}$, which gives us eq. (29). As we have observed, this solution differs from the flexible-wage solution, eq. (25).

To find the cooperative response elasticities δ_w^{coop} and δ_w^{*coop}, we calculate

$$\begin{aligned}\frac{\mathrm{d}\mathrm{E}V}{\mathrm{d}\delta_w} &= \frac{\mathrm{d}\Omega_w(\rho)}{\mathrm{d}\delta_w} = 0 \\ &= -\frac{(\delta_w+\delta_w^*)}{4\rho^2}\sigma_{\kappa_w}^2 - \left(\frac{\left[1-(1-\gamma)^2(1-\rho)\right]}{4\rho[\rho(1-\gamma)+\gamma]^2}\right)(\delta_w - \delta_w^*)\,\sigma_{\kappa_w}^2 - \frac{1}{2\rho^2}\sigma_{\kappa_w}^2.\end{aligned}$$

Again invoking the symmetry of the solution, we find that $\delta_w^{coop} = \delta_w^{*coop} = 1$, which is eq. (30). δ_w^{coop} also matches the flexible-wage response in eq. (26).

Nash Equilibrium

In a Nash equilibrium Home's problem is to find $\max_{\delta_d,\delta_w} \mathrm{E}U$ given δ_d^* and δ_w^*. As eq. (31) shows, Home will wish to alter its cooperative policy rule if it can bring about a first-order increase in the country-specific welfare component $\Omega_d(\rho) = \frac{(1-\gamma)}{2}\mathrm{E}\tau + \frac{(1-\gamma)(1-\rho)}{2}\sigma_{ze}$. Since the benefit to Home from any first-order increase in $\Omega_d(\rho)$ entails an equal loss for Foreign, Foreign (of course) would lose more than Home's gain if Home were to defect from the cooperative equilibrium.

The first-order condition with respect to δ_w takes the form $\frac{\mathrm{dE}U}{\mathrm{d}\delta_w} = \frac{\mathrm{d}\Omega_w(\rho)}{\mathrm{d}\delta_w} + \frac{\mathrm{d}\Omega_d(\rho)}{\mathrm{d}\delta_w} = 0$. The last subsection gives the derivative $\mathrm{d}\Omega_w(\rho)/\mathrm{d}\delta_w$. To calculate

$\mathrm{d}\Omega_d(\rho)/\mathrm{d}\delta_w$, recall from eq. (23) that

$$\Omega_d(\rho) = -\frac{(1-\gamma)}{2}\left\{\frac{\rho\sigma_{ze} + \sigma_{\kappa_w e} + 2\sigma_{\kappa_d z}}{1-(1-\gamma)(1-\rho)}\right\},$$

where the relevant covariances, all of which have opposite effects on Home and Foreign expected utility, are:

$$\sigma_{ze} = \frac{\left(\delta_d^2 - \delta_d^{*2}\right)\sigma_{\kappa_d}^2 + \left(\delta_w^2 - \delta_w^{*2}\right)\sigma_{\kappa_w}^2}{2\rho\left[\rho(1-\gamma)+\gamma\right]},$$

$$\sigma_{\kappa_w e} = -\frac{\delta_w - \delta_w^*}{\rho(1-\gamma)+\gamma}\sigma_{\kappa_w}^2,$$

$$\sigma_{\kappa_d z} = -\frac{(\delta_d - \delta_d^*)}{2\rho}\sigma_{\kappa_d}^2.$$

To find the Nash equilibrium of the rule-setting game, we note first that

$$\frac{\mathrm{d}\Omega_d(\rho)}{\mathrm{d}\delta_w} \propto -\delta_w + 1.$$

Since the value $\delta_w = 1$ sets the preceding derivative to zero while simultaneously satisfying $\mathrm{d}\Omega_w(\rho)/\mathrm{d}\delta_w = 0$ (recall the last subsection), we have (by symmetry) that $\delta_w^{Nash} = \delta_w^{*Nash} = 1$. Of course, these Nash responses to the symmetric world shock also are cooperative responses and act to mimic the flexible-wage equilibrium ex post.

On the other hand, the cooperative response coefficient $\delta_d^{coop} = \frac{\rho(1-\gamma)+\gamma}{1-(1-\gamma)^2(1-\rho)}$ does *not* set to zero the derivative

$$\frac{\mathrm{d}\Omega_d(\rho)}{\mathrm{d}\delta_d} = -\frac{(1-\gamma)}{2\rho}\left\{\frac{\frac{\delta_d}{[(1-\gamma)+\gamma/\rho]} - 1}{1-(1-\gamma)(1-\rho)}\right\}\sigma_{\kappa_d}^2.$$

To find the Nash value δ_d^{Nash}, we therefore must solve

$$\begin{aligned}
\frac{\mathrm{dE}U}{\mathrm{d}\delta_d} &= \frac{\mathrm{d}\Omega_w(\rho)}{\mathrm{d}\delta_d} + \frac{\mathrm{d}\Omega_d(\rho)}{\mathrm{d}\delta_d} = 0 \\
&= -\frac{(\delta_d - \delta_d^*)}{4\rho^2}\sigma_{\kappa_d}^2 - \frac{\left(\frac{\left[1-(1-\gamma)^2(1-\rho)\right]}{2[\rho(1-\gamma)+\gamma]}\right)(\delta_d + \delta_d^*)\,\sigma_{\kappa_d}^2 - \sigma_{\kappa_d}^2}{2\left[\rho^2(1-\gamma)+\rho\gamma\right]} \\
&\quad -\frac{(1-\gamma)}{2\rho}\left\{\frac{\frac{\delta_d}{(1-\gamma)+\gamma/\rho} - 1}{1-(1-\gamma)(1-\rho)}\right\}\sigma_{\kappa_d}^2.
\end{aligned}$$

The Nash equilibrium is symmetric with $\delta_d^{Nash} = \delta_d^{*Nash}$, so the preceding equation has the solution given earlier in eq. (32).

Appendix 2: Flexible-Wage Equilibrium and Tariffs

This appendix shows the effect in a flexible-wage version of the model when Home imposes a tariff on imports. The discussion has the dual purpose of illustrating how tariffs interact with other distortions, and of showing how to solve the flexible-wage model in general.

Tariffs and the distribution of world spending

If the ad valorem tariff rate is t and tariff revenues are rebated to the Home public in lump-sum fashion, then the Home consumer's budget constraint is no longer $P_{\mathrm{T}}C_{\mathrm{T}} = P_{\mathrm{H}}Y_{\mathrm{H}}$; it becomes

$$\begin{aligned} P_{\mathrm{T}}C_{\mathrm{T}} &= P_{\mathrm{H}}Y_{\mathrm{H}} + t\mathcal{E}P_{\mathrm{F}}^{*}C_{\mathrm{F}} = P_{\mathrm{H}}Y_{\mathrm{H}} + \frac{t\mathcal{E}P_{\mathrm{F}}^{*}}{2}\left[\frac{\mathcal{E}P_{\mathrm{F}}^{*}(1+t)}{P_{\mathrm{T}}}\right]^{-1}C_{\mathrm{T}} \\ &= P_{\mathrm{H}}Y_{\mathrm{H}} + \tfrac{1}{2}\left(\frac{t}{1+t}\right)P_{\mathrm{T}}C_{\mathrm{T}}, \end{aligned}$$

where $P_{\mathrm{T}} = [\mathcal{E}P_{\mathrm{F}}^{*}(1+t)]^{\frac{1}{2}}\, P_{\mathrm{H}}^{\frac{1}{2}}$ is the domestic-currency price index for tradables inclusive of the tariff's effect on import prices.

In a world equilibrium, nominal global consumer spending on Home exportables equals the receipts of Home producers, so

$$P_{\mathrm{H}}Y_{\mathrm{H}} = \left[1 - \tfrac{1}{2}\left(\frac{t}{1+t}\right)\right]P_{\mathrm{T}}C_{\mathrm{T}} = \tfrac{1}{2}P_{\mathrm{T}}C_{\mathrm{T}} + \tfrac{1}{2}\left(\mathcal{E}P_{\mathrm{F}}^{*}\right)^{\frac{1}{2}}\, P_{\mathrm{H}}^{\frac{1}{2}}C_{\mathrm{T}}^{*}.$$

Solving, we find that $C_{\mathrm{T}} = (1+t)^{\frac{1}{2}}C_{\mathrm{T}}^{*}$, so that instead of eq.(8), we have the following relationship between the overall Home and Foreign expenditure levels, measured in tradables at domestic prices: $Z = (1+t)^{\frac{1}{2}}Z^{*}$.

Solving for world spending and the terms of trade

Using the deterministic version of the Foreign wage first-order condition corresponding to eq. (5), writing out P^{*} in terms of its components, and using the markup condition (6) for product prices, we derive

$$\left(\frac{\mathcal{E}W^{*}}{W}\right)^{(1-\rho)\gamma/2} = \frac{1}{\psi}K^{*}L^{*\rho}. \qquad (34)$$

Doing the same for Home, but taking account of the tariff's effect on Home import prices and the Home consumer's budget constraint, we find

$$\left(\frac{W}{\mathcal{E}W^*}\right)^{(1-\rho)\gamma/2} = \frac{(1+t)^{(1-\rho)\gamma/2}}{\left[1-\frac{\gamma t}{2(1+t)}\right]^{\rho}}\left(\frac{1}{\psi}\right)KL^{\rho}. \tag{35}$$

To complete the model's solution, we furnish the relationships between L and Z and between L^* and $Z = (1+t)^{\frac{1}{2}}Z^*$. From the Foreign budget constraint, $P_{\mathrm{T}}^* Z^* = \left(\frac{\theta}{\theta-1}\right)W^*L^*$, and the definition of P_{T}^*, we conclude that

$$L^* = \left[\frac{W}{\mathcal{E}W^*(1+t)}\right]^{\frac{1}{2}} Z. \tag{36}$$

Since $L = Y_{\mathrm{H}} + Y_{\mathrm{N}}$, the equality of demand for and supply of total Home output leads to

$$L = \left[\left(1-\frac{\gamma}{2}\right)(1+t)^{\frac{1}{2}} + \frac{\gamma}{2}(1+t)^{-\frac{1}{2}}\right]\left(\frac{\mathcal{E}W^*}{W}\right)^{\frac{1}{2}} Z \tag{37}$$

Using eqs. (36) and (37) to eliminate L^* and L, respectively from eqs. (34) and (35), we obtain two independent relationships that can be solved for Z and $\mathcal{E}W^*/W$ (as we shall do explicitly later in the $t=0$ case).

Solving for utility

By combining the Home wage first-order condition and budget constraint, taking account of the tariff rebate, we find that

$$KL = \psi\left[1-\frac{\gamma t}{2(1+t)}\right]C^{1-\rho}.$$

Since flex-wage utility is given by eq. (3), we may therefore write overall utility (as $\chi \to 0$) as proportional to $C^{1-\rho}/(1-\rho)$:

$$U = \left\{\left(\frac{1}{1-\rho}-\psi\right)\left[1-\frac{\gamma t}{2(1+t)}\right]\right\}C^{1-\rho}. \tag{38}$$

Noting that

$$C = \left[\frac{\mathcal{E}W^*(1+t)}{W}\right]^{(1-\gamma)/2} Z,$$

we see from the purely multiplicative role of terms involving t in eqs. (34)-(36) and (38) that we may write flex-wage utility in the presence of a nonzero tariff t, $\tilde{U}(t)$, as $\tilde{U}(t) = \Gamma(t)\tilde{U}(0)$, where $\tilde{U}(0) = \tilde{U}$, in terms of our earlier notation, and $\Gamma(t)$ is a complicated function of the tariff rate.

The flexible-wage zero-tariff solution

With zero tariffs, the symmetry of the equilibrium leads to a quick solution. Equations (34)-(37) imply that in equilibrium,

$$\frac{\mathcal{E}W^*}{W} = \left(\frac{K^*}{K}\right)^{\frac{1}{1-(1-\gamma)(1-\rho)}}, \quad Z = \left[\frac{\psi}{(KK^*)^{\frac{1}{2}}}\right]^{\frac{1}{\rho}}.$$

These equations are easily combined with the equations for the ex post sticky-wage values of z and e, eqs. (12) and (11), to calculate the monetary response elasticities replicating the flexible-wage equilibrium, eqs. (25) and (26).

We may also calculate

$$\tilde{U} = \left(\frac{1}{1-\rho} - \psi\right) C^{1-\rho}$$

where

$$C^{1-\rho} = \left[\frac{\mathcal{E}W^*(1+t)}{W}\right]^{\frac{(1-\gamma)(1-\rho)}{2}} Z^{1-\rho} = \left(\frac{K^*}{K}\right)^{\frac{(1-\gamma)(1-\rho)}{2[1-(1-\gamma)(1-\rho)]}} \left[\frac{\psi}{(KK^*)^{\frac{1}{2}}}\right]^{\frac{1-\rho}{\rho}}.$$

Using the last equations, we find *expected* utility under wage flexibility:

$$\begin{aligned} \mathrm{E}\tilde{U} &= \left(\tfrac{1}{1-\rho} - \psi\right)\psi^{\frac{1-\rho}{\rho}} \bullet \\ &\quad \exp\left\{-\frac{(1-\rho)}{\rho}\mathrm{E}\kappa + \frac{(1-\rho)^2}{2\rho^2}\sigma_\kappa^2 \right.\\ &\qquad \left. - \frac{(1-\rho)^2\gamma\left[\left(1-\frac{\gamma}{2}\right) - (1-\gamma)(1-\rho)\right]}{\rho^2\left[1-(1-\gamma)(1-\rho)\right]^2}\sigma_{\kappa_d}^2\right\} \\ &= \left(\tfrac{1}{1-\rho} - \psi\right)\psi^{\frac{1-\rho}{\rho}} \bullet \exp\left\{-\tfrac{(1-\rho)}{\rho}\mathrm{E}\kappa + \tfrac{(1-\rho)^2}{2\rho^2}\sigma_\kappa^2 - \tfrac{(1-\rho)\lambda}{\rho}\right\}. \end{aligned}$$

This formula corresponds to eq. (20) in the text.

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References

Canzoneri, Matthew, and Hali Edison, "A new interpretation of the coordination problem and its empirical significance," in *Financial sectors in open economies: Empirical analysis and policy issues*, P. Hooper et al., eds., Washington, D.C.: Board of Governors of the Federal Reserve System (1990).

Canzoneri, Matthew, and Dale Henderson, *Monetary policy in interdependent economies*, Cambridge, MA: MIT Press, (1991).

Chari, V.V., Patrick Kehoe, and Ellen McGrattan, "Monetary shocks and real exchange rates in sticky price models of international business cycles," Federal Reserve Bank of Minneapolis Research Department Staff Report No. 223, (1998).

Corsetti, Giancarlo, and Paolo Pesenti, "Welfare and macroeconomic interdependence," *Quarterly Journal of Economics* (2001*a*), forthcoming.

_____, "International dimensions of optimal monetary policy," Working paper 8230, National Bureau of Economic Research (2001*b*).

Devereux, Michael, and Charles Engel, "Monetary policy in the open economy revisited: Price setting rules and exchange rate flexibility," Working paper 2454, Center for Economic Policy Research (May 2000).

Drazen, Allen, *Political economy in macroeconomics*, Princeton: Princeton University Press (2000).

Gali, Jordi, and Tommaso Monacelli, "Optimal monetary policy and exchange rate volatility in a small open economy," mimeo, Boston College (May 2000).

Jensen, Henrik, "Optimal monetary policy cooperation through state-independent contracts with targets," *European Economic Review* 44 (March 2000), 517-539.

McKinnon, Ronald, *An international standard for monetary stabilization*, Washington, D.C.: Institute for International Economics (1984).

Obstfeld, Maurice, and Kenneth Rogoff, "Exchange rate dynamics redux," *Journal of Political Economy* 103 (1995), 624-60

______, *Foundations of international macroeconomics*, Cambridge, MA: MIT Press (1996).

______, "Risk and exchange rates," Working paper 6694, National Bureau of Economic Research, (1998).

______, "New directions for stochastic open economy models," *Journal of International Economics* 50 (2000*a*), 117-153.

______, "Do we really need a new international monetary compact?" Working paper 7864, National Bureau of Economic Research, (2000*b*).

Oudiz, Gilles, and Jeffrey Sachs, "Macroeconomic policy coordination among the industrial countries," *Brookings Papers on Economic Activity* 1 (1984), 1-64.

Persson, Torsten, and Guido Tabellini, "Double-edged incentives: Institutions and policy coordination," in *Handbook of international economics*, vol. 3, Gene Grossman and Kenneth Rogoff, eds., Amsterdam: Elsevier (1995).

______, *Political economics: Explaining economic policy,* Cambridge, MA: MIT Press (2000).

Rogoff, K., "Can international monetary cooperation be counterproductive?" *Journal of International Economics* 18 (1985), 199-217.

Tille, Cedric, "'Beggar-thy-neighbor' or 'beggar-thyself'? The income effect of exchange rate fluctuations," mimeo, Federal Reserve Bank of New York (2000).

Williamson, John, *The exchange rate system*, 2d edition, Washington, D.C.: Institute for International Economics (1985).

Table I: Gains from stabilization and coordination

Measure	$\rho = 0.5$	$\rho = 1$	$\rho = 2$	$\rho = 4$	$\rho = 8$
(i) Stabilization gain	3.11	1.01	0.33	0.11	0.03
(ii) Coordination gain	0.02	0	6.3×10^{-3}	9.0×10^{-3}	5.8×10^{-3}
(iii) Ratio (ii)/(i)	7.9×10^{-3}	0	1.9×10^{-2}	0.08	0.18