Rethinking Optimal Currency Areas

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Abstract

The traditional Mundellian criterion for optimal currency areas, which implicitly assumes commitment to monetary policy, is that countries with similar shocks should form unions. Without such commitment a new criterion emerges: countries with dissimilar temptation shocks, namely those that exacerbate time inconsistency problems, should form unions. Critical to this new criterion is that the institutional framework allows all countries to influence policies in that policy is chosen either cooperatively or by majority rule. When countries have dissimilar temptation shocks, such unions can help overcome the time inconsistency problems that individual countries face. Our model, applied to the European Monetary Union, captures the idea that many Southern European countries gained credibility by joining a union populated mainly by Northern European countries. It also provides a motivation for why the Northern European countries might want to admit countries with historically lower credibility in monetary policy.

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The traditional criterion for forming a union, stemming from the classic analyses of Friedman (1953) and Mundell (1961), is that countries with similar shocks have the least to lose from forming a union. In a union, by definition, monetary policy cannot be tailored to each country's shocks. This observation implies the Mundellian criterion that countries with similar shocks should form a union if the benefits from, say, increased trade, outweigh the costs from the inability to tailor monetary policy to shocks. The implicit assumption in these analyses is that the monetary authority can commit to its policies.

We revisit the classic analyses using the simplest international sticky price model. We assume that both in a union and under flexible exchange rates, the institutional framework for monetary policy allows all countries to influence policies. Specifically, we assume that policy is chosen cooperatively or, equivalently, by majority rule. With commitment, we show that monetary policy should respond only to a subset of shocks, labeled *Mundellian shocks.* The inability to react to the country-specific component of such shocks in a union imposes *Mundellian costs* on member countries.

The focus of our paper is on the desirability of forming a union in environments without commitment to monetary policy. Without such commitment, policymakers have incentives to deviate from the commitment plan to generate surprise inflation. We label shocks that affect these incentives to generate surprise inflation *temptation shocks.* We show that when the union lacks commitment, the inability to respond to the country-specific component of temptation shocks can confer *credibility benefits* on member countries.

This insight leads to a new criterion for optimal currency areas: a group of countries without commitment should form a union if their temptation shocks are sufficiently dissimilar and their Mundellian shocks are sufficiently similar. This criterion sharply differs from the traditional one.

The logic behind our criterion is that without commitment, countries benefit from devices that ensure that they resist temptation shocks. A monetary union in which, by definition,

monetary policy cannot react to country-specific shocks in every country is such a device. In this sense, a monetary union yields benefits by ensuring that policy cannot react to country-specific temptation shocks; it carries the cost, however, that policy cannot react to country-specific Mundellian shocks either.

We illustrate the logic behind our criterion in a simple version of the New Keynesian model used in central banks across the world. This model is essentially Obstfeld and Rogoff's (1995) open economy model with nontraded goods and one-period price stickiness.

The economy consists of a continuum of countries, each of which uses labor to produce traded and nontraded goods. The production of nontraded goods is subject to both *productivity shocks* and *markup shocks*. In this economy, it turns out that productivity shocks are the Mundellian shocks and markup shocks are the temptation shocks. We choose productivity and markup shocks to illustrate our message because they are empirically relevant. Indeed, Smets-Wouters (2007, p. 598) show that markup shocks account for over half of the movements in output in the medium run. Productivity shocks account for most of the rest. More generally, the markup shocks can be taken as a metaphor for shocks that affect the magnitude of the time inconsistency problem.

Here, we follow the New Keynesian literature in interpreting markup shocks as capturing fluctuations in the degree of distortions in the economy. These distortions could come from imperfect competition in product and labor markets or from government policies such as taxes, social insurance programs, and regulation.

The technology is as in Obstfeld and Rogoff (1995). A homogeneous traded good is produced by competitive firms and has flexible prices. Nontraded goods are differentiated, produced by imperfectly competitive firms, and are subject to both markup and productivity shocks. The prices of nontraded goods are sticky for one period. Imperfect competition in the presence of markup shocks implies that the nontraded goods prices carry a time-varying markup over expected marginal cost, thereby inducing time-varying distortions.

These time-varying distortions act like temptation shocks. They do so by giving the monetary authority fluctuating incentives to engineer a surprise inflation so as to diminish the effective markup and increase the production of nontraded goods. Surprise inflation is costly because the purchases of traded goods must be made with previously acquired money. (See Svensson (1985), Nicolini (1998), and Albanesi, Chari, and Christiano (2003) for similar ways of modeling the costs of inflation.) Other ways of making surprise inflation costly should yield similar results.

In terms of the framework for policy, we assume that both under flexible exchange rates and in a union, the institutional framework for setting policy is the same. In both regimes, policy is set in a cooperative fashion to maximize the welfare of the group of countries as a whole. In the Appendix we show that the cooperative policy coincides with the policy that results from majority rule. By keeping the institutional framework the same under the two regimes we ensure that the welfare effects of moving from flexible exchange rates to a union arise solely from the change in monetary regime and not from a change in the extent of cooperation.

With commitment to monetary policy, we derive a modified version of the Mundellian criterion: countries that are similar with respect to productivity shocks lose less by forming a union, and the similarity of markup shocks is irrelevant.

The novel analysis is what happens when countries lack commitment to monetary policy. We model this lack of commitment in a standard way: in each period, the monetary authority sets its policies as a function of the state after the imperfectly competitive producers have set their prices, and it takes as given the evolution of future policy. Under flexible exchange rates, after a high country-specific markup shock is realized, the economy is highly distorted and the monetary authority is strongly tempted to generate surprise inflation. Price setters anticipate that the monetary authority will generate high inflation and, upon seeing a high markup shock, simply increase their prices. In equilibrium, the increase in the temptation

results only in higher inflation. Similar logic implies that inflation is low after a low markup shock. Thus, inflation is variable. In a union, of course, the monetary authority does not respond to country-specific markup shocks so that inflation is less variable.

With productivity shocks, the familiar Mundellian forces present under commitment are still present. Thus, in the context of the simple New Keynesian model, our general criterion specializes to: countries should form a union if they have relatively dissimilar fluctuations in the degree of distortions and relatively similar fluctuations in technology. We show that this criterion in terms of shocks is robust to changes in preferences.

The general message of our analysis is that theory delivers criteria for union formation in terms of shocks. The vast bulk of the empirical literature on optimal currency areas uses a criterion in terms of aggregates. Specifically, countries are good candidates for forming a union if the country-specific components of output and real exchange rates are small. (See Alesina, Barro, and Tenreyro 2003, Bayoumi and Eichengreen 1993, De Grauwe 2018 and the numerous references therein.)

This standard criterion is contradicted by even the simplest New Keynesian model. In our model when the variances of the country-specific components of output and real exchange rates are both high, forming a union may be desirable. To see why, suppose that for a group of countries, temptation shocks account for most of the movements in output and real exchange rates. Without commitment to monetary policy, then, forming a union is desirable for this group. Of course, if Mundellian shocks account for most of these movements, then forming a union is undesirable.

Given this contradiction, we ask does theory imply a robust criterion in terms of aggregates. We show that as we vary the parameters of preferences no robust criterion in terms of aggregates emerges.

A smaller literature uses criteria in terms of shocks and takes the view that countries are good candidates for forming a union if their shocks are similar (see, for example, Bayoumi

and Eichengreen 1994 and Fidrmuc and Korhonen 2003). Since we have shown that countries are good candidates if they have dissimilar temptation shocks, this view is also problematic.

A key part of our analysis is the optimal configuration of unions when countries are asymmetric. This analysis highlights the role of the endogenous response of policy to the composition of the union. We assume that there are two groups of countries labelled *North* and *South*. All countries within a given group have the same stochastic process for shocks. We assume that the South is more distorted than the North in that the markup shocks in the South are both larger on average and more variable than those in the North.

Clearly, with only temptation shocks, if the shocks are not perfectly correlated, countries in the North gain by forming a union among themselves. Any given Southern country also gains from joining the Northern union. The reason is that since the North is less distorted on average, it has greater credibility in policy, and the South enjoys increased credibility by joining the union. An interesting aspect of our analysis is that if the temptation shocks in the North and the South are not too highly correlated, the North gains as well by admitting some Southern countries because of the resulting changes in monetary policy. In particular, when the distortions are imperfectly correlated across regions, the monetary authority's policies become less sensitive to fluctuations in the aggregate distortions in the North.

Consider applying our North-South analysis to the European Monetary Union. Our model captures the idea that many of the Southern European countries gained credibility by joining a union populated mainly by Northern European countries and hence reduced the inflation bias in the Southern countries. Interestingly, it also provides a motivation for why the Northern European countries might want to admit countries with historically lower credibility in monetary policy.

We use our model to ask what configurations of unions are stable in the sense that no individual union desires to admit additional members and that no group of countries can deviate and profitably form their own union. We show that the stable configuration of unions

has a hierarchical form in that every country would like to join any union above its current one in the hierarchy. In this hierarchy, the union at the top of the hierarchy typically has a mix of different types of countries.

Thus far we have considered unions in which policy endogenously responds to the interests of all members. We distinguish our work from an alternative literature, stemming from Friedman (1973), that models unions as either of form of dollarization or as an anchor-client relationship. We argue that both in terms of institutional design and the practical policy record, our model captures key features of the European Monetary Union, in that monetary policy responds to its members' interests, and the anchor-client formulation does not.

In terms of extending our analysis to more general models, note that in our simple model there is a sharp distinction between Mundellian shocks and temptation shocks in that each shock is of one type or the other. In a more general model, each shock may have some Mundellian elements and some credibility elements and the comparison of regimes will depend on the relevant variability of the elements induced by the shocks rather than simply on the shocks themselves. In this sense, the insights developed here should continue to hold in more general models.

In the Appendix we discuss related work by Rogoff (1985), Giavazzi and Pagano (1988), Cooley and Quadrini (2003), Devereux and Engel (2003), Cooper and Kempf (2004), Canzoneri et al. (2006), Fuchs and Lippi (2006), and Aguiar et al. (2015).

1 A Monetary Economy

Our monetary economy builds on the work of Obstfeld and Rogoff (1995), Galí and Monacelli (2005), Kehoe and Pastorino (2014), and Farhi and Werning (2013). The economy consists of a continuum of countries, each of which produces traded and nontraded goods and in which consumers use currency to purchase goods. The traded goods sector in each country is perfectly competitive. The nontraded goods sector consists of imperfectly competitive firms

with sticky prices and fluctuating markups. Both the productivities and the markups of these firms are subject to aggregate and country-specific shocks. Traded goods have flexible prices and are bought with previously acquired cash, whereas nontraded goods have sticky prices and are bought with credit. The assumption that goods must be purchased with previous acquired cash implies that surprise inflation is costly, so that without commitment an equilibrium exists. The assumption that only traded goods are bought with cash is for simplicity.

The assumption that nontraded goods prices are sticky and traded goods prices are flexible captures the key features, outlined by Friedman (1953), that make flexible exchange rates desirable under commitment. Friedman considers an environment in which because of shocks it is desirable to have the relative price of traded and nontraded goods to vary but the prices of nontraded goods are sticky. He argues that since traded goods prices are flexible, a movement in the exchange rate can allow this relative price to move in the same way that it would if nontraded goods prices were flexible.

In each period t, an i.i.d. aggregate shock $z_t = (z_{1t}, z_{2t}) \in Z$ is drawn, and each of a continuum of countries draws a vector of country-specific shocks $v_t = (v_{1t}, v_{2t}) \in V$ that are i.i.d. both over time and across countries. The probability of aggregate shocks is $f(z_{1t}, z_{2t}) = f^1(z_{1t})f^2(z_{2t})$, and the probability of the country-specific shocks is $g(v_{1t}, v_{2t}) = g^1(v_{1t})g^2(v_{2t})$. Here, Z and V are finite sets. We let $s_t = (s_{1t}, s_{2t})$ with $s_{it} = (z_{it}, v_{it})$ and let $h(s_t) = h^1(s_{1t})h^2(s_{2t})$ with $h^i(s_{it}) = f^i(z_{it})g^i(s_{it})$.

These aggregate and country-specific shocks are to the nontraded goods sector. The shock $\theta(s_{1t})$, referred to as a *markup shock,* affects the extent to which the economy is distorted. The shock $A(s_{2t})$, referred to as a *productivity shock,* affects productivity in this sector. We let s^t denote the history of these shocks and $h_t(s^t)$ the corresponding probability. We denote the means of θ and A conditional on the aggregate shocks by $E_v(\theta|z) = \sum_{v_1} g^1(v_1)\theta(z_1, v_1)$ and $E_v(A|z) = \sum_{v_2} g^2(v_2)A(z_2, v_2)$.

The timing of events within a period is that markup shocks are realized, sticky price firms set prices, productivity shocks are realized, the monetary authority chooses its policy, and finally consumers and flexible price firms make their decisions. In the Appendix, we allow a component of markup shocks to be realized after sticky price setters set their prices and a component of productivity shocks to be realized before sticky price setters set their prices and show that both are irrelevant to our comparison of regimes. For markup shocks note that they only affect outcomes by affecting the price-setting incentives of nontraded goods and thereby the incentives of the monetary authority to inflate. If these shocks are realized after prices are set, nontraded goods firms cannot react to them and hence they are clearly irrelevant. For productivity shocks, nontraded goods prices react to those that occur before they are set, prices play their usual allocative role, and there is neither a need for nor an advantage to having the exchange rate react to them.

In all that follows, we will identify a country by its history of country-specific shocks $v^t = (v_0, \ldots, v_t)$. This identification imposes symmetry in that all countries with the same history of country-specific shocks receive the same allocations.

The production function for traded goods in a given country is simply $Y_T(s^t) = L_T(s^t)$, where $Y_T(s^t)$ denotes the output of traded goods and $L_T(s^t)$ the input of labor in the traded goods sector. The problem of traded goods firms is then to choose $L_T(s^t)$ to maximize $P_T(s^t)L_T(s^t) - W(s^t)L_T(s^t)$ where $P_T(s^t)$ is the nominal price of traded goods and $W(s^t)$ is the nominal wage rate. From the zero profit condition, in equilibrium, $P_T(s^t) = W(s^t)$. For notational convenience we replace $W(s^t)$ by $P_T(s^t)$ in what follows.

The production function for nontraded goods is given by $Y_N(s^t) = A(s_{2t})L_N(s^t)$ where $Y_N(s^t)$ denotes the output of nontraded goods and $L_N(s^t)$ denotes the input of labor in the nontraded goods sector. We posit that the prices of nontraded goods $P_N(s^{t-1}, s_{1t})$ are set as

a time-varying markup over a weighted average of the marginal cost of production in that

$$P_N(s^{t-1}, s_{1t}) = \frac{1}{\theta(s_{1t})} \sum_{s_{2t}} \left(\frac{Q(s^t) Y_N(s^t)}{\sum_{\tilde{s}_{2t}} Q(\tilde{s}^t) Y_N(\tilde{s}^t)} \right) \frac{P_T(s^t)}{A(s_t)}, \tag{1}$$

where $1/\theta(s_{1t}) > 1$ is the *markup* in period t and $Q(s^t)$ is the price of a state-contingent claim to local currency units at s^t in units of local currency at s^{t-1}. To emphasize that such a time-varying markup can arise from many models, we provide three alternative microfoundations for it in the Appendix.

Consumer preferences are $\sum_{t=0}^{\infty} \sum_{s^t} \beta^t h_t(s^t) U\left(C_T(s^t), C_N(s^t), L(s^t)\right)$, where $C_T(s^t)$ and $C_N(s^t)$ are the consumption of traded and nontraded goods, and $L(s^t)$ is labor supply. We specialize preferences to $U(C_T, C_N, L) = \alpha \log C_T + (1-\alpha) \log C_N - \psi L$ in most of our analysis and refer to them as *our preferences*. The critical feature of these preferences is their quasi-linearity in labor, which allows us to obtain useful aggregation results along the lines of Lagos and Wright (2005). The budget constraint of the consumer is given by

$$\begin{aligned} & P_T(s^t) C_T(s^t) + P_N(s^{t-1}, s_{1t}) C_N(s^t) + M_H(s^t) + \bar{Q}\left(s^t\right) B(s^t) \\ \leq \; & P_T(s^t) L(s^t) + M_H(s^{t-1}) + B(s^{t-1}) + T(s^t) + \Pi(s^t), \end{aligned} \tag{2}$$

where $T(s^t)$ are nominal transfers, $\Pi(s^t) = P_N(s^{t-1}, s_{1t}) Y_N(s^t) - P_T(s^t) L_N(s^t)$ are the profits from the nontraded goods firms, $\bar{Q}\left(s^t\right)$ is the price of the noncontingent nominal bond in the domestic currency, and $B(s^t)$ are nominal bonds. Here, for simplicity, we abstract from international capital mobility, so the consumers in a given country hold only domestic nominal bonds. With our quasi-linear preferences and shock structure, consumers have no incentive to borrow and lend across countries.

Consumers are also subject to a cash-in-advance constraint that requires them to buy traded goods at t using money brought in from period $t-1$, namely $M_H(s^{t-1})$, so that $P_T(s^t) C_T(s^t) \leq M_H(s^{t-1})$. Under flexible exchange rates, consumers use local currency

to purchase traded goods so that $M_H(s^{t-1})$ is local currency holdings. In a union, consumers use the common currency of the union so that $M_H(s^{t-1})$ is holdings of the common currency. The subscript H denotes an individual household's holdings of money. The nominal stochastic discount factor for the country is easily seen to be $Q(s^{t+1}) = \beta h(s^{t+1}|s^t)U_N(s^{t+1})P_N(s^{t-1}, s_{1t})/(P_N(s^t, s_{1t+1})U_N(s^t))$.

The government budget constraint for each country under flexible exchange rates is $\bar{Q}\left(s^t\right)B\left(s^t\right) = B\left(s^{t-1}\right) + T(s^t) - (M(s^t) - M(s^{t-1}))$, where $M(s^t)$ denotes the money supply in local currency units. In a union, the government budget of a given country is the same except that in the union the seigniorage term is now $\bar{M}(z^t) - \bar{M}(z^{t-1})$ where $\bar{M}(z^t)$ is the *unionwide money supply*. Here we have assumed that the seigniorage revenues are distributed evenly across countries. For initial conditions, we assume that the initial money holdings of consumers in each country $M_{H,-1}$ are equal and these initial money holdings equal the initial money supply in each country M_{-1} and that the initial holdings of bonds B_{-1} are zero in all countries.

With flexible exchange rates, the policy of the monetary authority consists of a specification of nominal interest rates for each country, the quantity of debt, and taxes which satisfies the government budget constraint. In a union, the policy consists of similar objects with the restriction that they satisfy the associated government budget constraint.

An *equilibrium with flexible exchange rates* is a set of allocations, prices, and policy in each of the continuum of countries such that *i*) consumer decisions are optimal, *ii*) firm decisions are optimal, *iii*) the labor market clears in each country, $L_N(s^t) + L_T(s^t) = L(s^t)$, *iv*) goods markets clear, $C_T(s^t) = Y_T(s^t)$, $C_N(s^t) = A(s^t)Y_N(s^t)$, *v*) the monetary authority's budget constraint holds, and *vi*) the money market clears, $M_H(s^t) = M(s^t)$.

Since traded goods are homogenous and freely traded across countries the law of one price holds for traded goods. Under flexible exchange rates the price of traded goods, expressed in units of the local currency, can differ across countries. Since we distinguish countries by their

country-specific shock history v^t, it follows that the local currency price of traded goods in country v^t, $P_T(z^t, v^t)$, need not equal the local currency price in country $\tilde{v}^t$, $P_T(z^t, \tilde{v}^t)$.

An *equilibrium in a monetary union* is defined analogously to an equilibrium with flexible exchange rates with two differences. First, in a monetary union, the local and common currency coincide so that the price of traded goods must satisfy a *price restriction*: it cannot vary with country-specific shocks, in that for any v^t and $\tilde{v}^t$, $P_T(z^t, v^t) = P_T(z^t, \tilde{v}^t)$. Second, there is a unionwide money supply $\bar{M}(z^t)$ and money market clearing requires that the total money held by all the consumers in the union add up to the total money supply in the union, in that $\sum_{v^t} M_H(z^t, v^t) g_t(v^t) = \bar{M}(z^t)$.

Under either regime, fluctuations in markups lead to fluctuations in the degree of distortions. To see this point in the simplest way, suppose that productivity is constant. We can then combine the first order condition of the nontraded goods firm with that of private agents to see that $-U_L/U_N = A\theta(s_t) < A$ so that $1 - \theta$ is the *wedge* between the marginal rate of substitution between labor and nontraded goods and the corresponding marginal rate of transformation. Clearly, the higher is the markup $1/\theta(s_t)$, the greater is the wedge.

2 Optimal Policy

We turn now to analyzing optimal policy under flexible exchange rates and in a monetary union. Throughout we assume that both under flexible exchange rates and in a union, monetary policy is set in a cooperative fashion in that it maximizes an equally weighted sum of welfare of utilities of the member countries and show in the Appendix that doing so is equivalent to majority rule. It is worth noting that for our particular environment there are no externalities, such as terms of trade externalities, so that the cooperative and noncooperative equilibria coincide and thus there are no gains from cooperation.

Consider first optimal policy under commitment. Because any union must satisfy the price restriction, forming a union only restricts the set of outcomes that can be achieved.

Therefore, welfare in a union is always lower than that under flexible exchange rates. This result is general and holds because one feasible choice under flexible exchange rates is to fix the exchange rates forever and thus replicate the union outcomes.

In the Appendix we show that under both regimes optimal policy does not respond to markup shocks, here the temptation shocks and does responds to productivity shocks, here the Mundellian shocks. Intuitively, the monetary authority is forced to live with the distortions from markup shocks and attempts to accomodate productivity shocks.

To develop some intuition for this results consider the flexible exchange rate regime. Note first we can think of the monetary authority as directly choosing all the allocations and prices subject to the equilibrium conditions. To see why policy does not respond to markup shocks, consider an economy in which productivity A is constant. It is easy to show that the cash-in-advance constraint is slack. To maximize welfare the monetary authority would like to achieve an undisorted optimum by setting the marginal rate of substitution between traded and nontraded goods equal to their marginal rate of transformation which, using consumer optimality, implies setting $p_N/p_T = 1/A$. But an equilibrium condition is that monopolists set their prices as a markup $1/\theta$ over marginal costs so that price setting rule for p_N that implies $p_N/p_T = 1/A\theta$. Thus, the monetary authority cannot affect the relative price p_N/p_T and understands that any attempt to do so is frustrated in equilibrium by the reaction of the monopolists. Hence, the monetary authority does not react to markup shocks. In contrast, the monetary authority clearly wants to respond to productivity shocks and, as we show in the Appendix, can do so by setting p_T so that $p_N/p_T = 1/A\theta$ state by state even when both A and θ fluctuate. Policy in the monetary union works similarly, except that, by the nature of the regime, the monetary authority cannot react to country-specific markup shocks.

In the Appendix we prove the following proposition.

Proposition 1. (Welfare Comparisons Under Commitment) The per period expected utility difference between the flexible exchange rate regime and the monetary union is

$(1-\alpha)\, E_z\left[\log E_v\left(1/A\right)|z\right) - E_v\left(\log(1/A)|z\right)\right] > 0.$

Clearly, this utility difference is strictly positive, since the log function is a concave function. Note that if $A(v_2, z_2) = A_v(v_2)A_z(z_2)$ and $A_v(v_2)$ is log normal with mean μ_v and variance σ_v^2 then the utility difference reduces to $(1-\alpha)\sigma_v^2/2$ so that the losses in forming the union are increasing in the volatility of the country-specific productivity shocks. Note that markup shocks play no role in determining the utility difference between the two regimes.

Consider now the same environment except that the monetary authority cannot commit. We model this lack of commitment by having this authority choose policies in the standard Markovian fashion: in each period the monetary authority sets its policies as a function of the state and takes as given the evolution of future policy.

The model features two key frictions. The nontraded goods firms set their prices as a markup over their expected marginal costs and hence distort downward the production of nontraded goods. This distortion gives the monetary authority an incentive to engineer surprise inflation so as to diminish the effective markup and increase the production of nontraded goods. The second friction is that purchases of traded goods must be made with money brought into the period. This feature of the model generates costs for surprise inflation: surprise inflation inefficiently lowers the consumption of traded goods ex post. In equilibrium, the monetary authority balances the benefits of surprise inflation against these costs, and this friction leads to an interior solution for inflation.

It turns out that productivity shocks play the same role here as they do under commitment. Hence, we assume for much of what follows that productivity is constant across countries and time at $A = 1$. Under this assumption, there are only first stage shocks and, hence, for simplicity we write (z_1, v_1) as (z, v).

Flexible Exchange Rates with No Commitment. In a Markov equilibrium, all choices depend on the state confronting agents at the time they make their decisions. We begin by describing the state variables for the nontraded goods and traded goods firms,

the consumers, and the monetary authority. We normalize all nominal variables by the beginning-of-period aggregate stock of money M_{-1} in the given country. With this normalization, the normalized aggregate money stock is 1 in each country. Let b denote the normalized amount of debt in a given country.

Consider a sticky price firm in a given country. The *nontraded firm state* is (b, v, z), and the nontraded goods firm's normalized decision rule is $p_N(b, v, z)$ where $p_N = P_N/M_{-1}$ denotes the normalized nontraded goods price.

At the time the monetary authority chooses its policy, each country is identified by its country-specific state $x_G = (b, v, p_N)$. The *monetary authority's state* is $S_G = (z, \lambda_G)$, where λ_G is a measure over the states x_G in all countries. The monetary authority's policy rule consists of a choice of bond prices, $q(x_G, S_G)$, debt issues, $b'(x_G, S_G)$, and transfers, $T(x_G, S_G)$, for each country. Let $\pi(x_G, S_G) = (q(x_G, S_G), b'(x_G, S_G), T(x_G, S_G), \mu(x_G, S_G))$ denote the policy rule where μ is determined residually from the government budget constraint.

Next, the country-specific component of the *traded goods firm's state* is $x_T = (b, v, p_N, \pi)$, where π is the policy in that country and the corresponding aggregate state is $S_T = (z, \lambda_T)$, where λ_T is a measure over country-specific states of traded goods firms in all countries. The traded goods firm's normalized decision rule is $p_T(x_T, S_T)$, where $p_T = P_T/M_{-1}$ denotes the normalized traded goods price. Finally, the *consumer's state* is (b_H, m_H, x_T, S_T), where b_H and m_H denote the amount of debt and money held by an individual in a country divided by the aggregate stock of money in that country, the country-specific state is x_T, and the aggregate state is S_T.

Here we set up the equilibrium recursively, which is easiest to do so by working backward from the end of a period. The consumer's problem is

$$V(b_H, m_H, x_T, S_T) = \max_{C_T, C_N, L, b'_H, m'_H} U(C_T, C_N, L) + \beta \sum_s h(s') V(b'_H, m'_H, x'_T, S'_T)$$

subject to the cash-in-advance constraint in normalized form $p_T(x_T, S_T) C_T \leq m_H$ and the

budget constraint in normalized form:

$$p_T(x_T, S_T)C_T + p_N C_N + \mu m'_H + \mu q b'_H \leq m_H + b_H + p_T(x_T, S_T)L + T + \Pi(x_T, S_T),$$

where $x'_T = (b', v', p_N(v'), \pi(x'_G, S'_G))$.

The monetary authority's policy consists of a function $\pi(\cdot, S_G)$ which specifies policies for each country x_G which solves

$$\max_{\{\pi(x_G, S_G)\}} \sum V\left(b, 1, v, p_N, \pi(x_G, S_G), S_T\right) d\lambda_G(x_G),$$

subject to the country's government budget constraint, $\mu q b' = b + T - (\mu - 1)$, where S_T is induced by the policy function. This authority internalizes that, in equilibrium, consumers in each country hold all of that country's money and debt, so that $m_H = M_H/M_{-1} = 1$ and $b_H = b$.

The pricing rule for nontraded goods is $p_N(b, v, z) = p_T(x_T, S_T)/\theta(v, z)$,where x_T and S_T are induced by the policy rules of other nontraded setting firms and the monetary authority.

A *Markov equilibrium under flexible exchange rates* consists of a pricing rule for nontraded goods $p_N(b, v, z)$, a profit rule $\Pi(x_T, S_T)$, the monetary authority's policy rule $\pi\left(x_G, S_G\right)$, consumer decision rules and value functions, a price rule for traded goods $p_T(x_T, S_T)$, such that *i*) the sticky price firms and the flexible price firms maximize profits, *ii*) the monetary authority maximizes consumer welfare taking as given the decision rule of the consumers and traded goods firms in the current period and the decision rules of the monetary authority and private agents in all future periods, *iii*) consumers maximize welfare, *iv*) the traded goods market, the nontraded goods market, and the labor market clear, the money market clears in that $m'_H(b, 1, x_T, S_T) = 1$, and $b'_H(b, 1, x_T, S_T) = b'$.

We simplify the monetary authority's problem in several steps. First, debt can be dropped from the state since lump sum taxes are available. Thus future states, future allocations, and

continuation utility are unaffected by the current choices of private agents and the monetary authority so the problem becomes static. Second, since the allocations, traded goods prices, and money growth rates of a given country do not enter into the constraint sets or utility for any other country, we can consider each country in isolation. Finally, we can think of the monetary authority as directly choosing allocations and prices subject to the first order conditions of consumers and market clearing in the goods and labor markets.

With these simplifications, the *static primal Markov problem* is, for each given p_N and θ, choose p_T to solve

$$\max \alpha \log C_T + (1-\alpha) \log C_N - \psi \left[C_T + C_N\right] \tag{3}$$

where $C_T = \min\left\{1/p_T, \alpha/\psi\right\}$ and $C_N = (1-\alpha)p_T/\psi p_N$.

Under the optimal policy an increase in p_N raises the optimal p_T. To see this result, note that when the cash-in-advance constraint is slack the monetary authority increases p_T one-for-one with p_N so as to keep both nontraded and traded goods at their undistorted levels. When the cash-in-advance constraint is binding, the monetary authority increases p_T less than one-for-one with p_N so as to shift some of the burden for adjustment onto traded goods. More formally, the best response of the monetary authority to this problem is $p_T^{flex}(s, p_N) = \max\left\{p_N, F\left(1/p_N\right)\right\}$ for a function F, defined in the Appendix, that is increasing in p_N. Note that this best response does not directly depend on the markup shocks. Given an arbitrary predicted value for the traded goods price, p_T, solving the problem of the sticky price producers gives the price setting rule $p_N(s, p_T) = p_T/\theta(s)$.

In Figure 1, we plot the best response of the monetary authority and the price setting rule for two values of the markup shock. The intersection of these functions is the equilibrium outcome. Notice that this intersection necessarily occurs in the region where the cash-in-advance constraint is binding (above the 45^oline). The reason is that with a positive markup $1/\theta > 1$ so that the price setting rule $p_N = p_T/\theta$ necessarily has a slope greater than one. Intuitively, if the cash-in-advance constraint were not binding, then raising the price of

traded goods p_T has no cost and the solution is to choose p_T so that $p_N = p_T$. This policy ensures that the marginal rate of substitution between traded and nontraded goods equals the marginal rate of transformation between these goods. Such an outcome cannot be an equilibrium because sticky price producers forecasting this policy response will set the price of nontraded goods at a markup so that $p_N = p_T/\theta$ with $1/\theta > 1$. Thus, in equilibrium, raising the price of traded goods must have a positive marginal cost, which happens only if it reduces the consumption of traded goods, which, in turn, requires that the cash-in-advance constraint be binding.

When the markup shock, $1/\theta(s)$, is high, for any given predicted traded goods price, sticky price producers choose a higher price of nontraded goods and the monetary authority reacts accordingly. In sum, in equilibrium, the attempt by the monetary authority to undo the markup distortions is frustrated, and all the monetary authority accomplishes is an increase in the volatility of relative prices, and hence, relative consumptions.

Solving for the Markov equilibrium, we obtain the following lemma.

Lemma 1. The allocations in the Markov equilibrium with flexible exchange rates are given by $L^{flex}(s) = C_T^{flex}(s) + C_N^{flex}(s)$ where

$$C_T^{flex}(s) = \frac{\alpha}{\psi} - \frac{1-\alpha}{\psi}\left(1-\theta(s)\right) \ and C_N^{flex}(s) = \frac{1-\alpha}{\psi}\theta(s.) \tag{4}$$

Monetary Union with No Commitment. To set up the equilibrium in the monetary union recursively, we follow the same procedure as we did with flexible exchange rates. In the Appendix we use the quasi-linearity of preferences to show that the the distribution of money balances is degenerate. This result together with logic similar to that used under flexible exchange rates implies that the monetary authority's problem reduces to a static primal Markov problem: given a distribution of nontraded goods prices $\{p_N(s)\}$ and an

aggregate shock z, the problem is to choose p_T to solve

$$\max \sum_v g(v) \left[\alpha \log C_T(z,v) + (1-\alpha) \log C_N(z,v) - \psi \left(C_T(z,v) + C_N(z,v)\right)\right] \tag{5}$$

where $C_T(z,v) = 1/p_T$ and $C_N(z,v) = (1-\alpha)p_T/\psi p_N(z,v)$ for each v. Let the maximized value of this problem be denoted $U(\{p_N(z,v)\}, z)$. Because policy in the monetary union is chosen to maximize an equally weighted sum of utility of all countries, the weights $g(v)$ in the summation in (5) represent the fraction of all countries with country-specific realization v. Since this fraction also represents the probability that an individual country will experience a country-specific realization v, the maximized value $U(\{p_N(z,v)\}, z)$ is also the expected utility for any individual country.

Solving this problem gives the best response of the monetary authority to any given $\{p_N(s)\}$ and z, which can be written as $p_T = p_T^{Union}(\{p_N(s)\}, z)$. It turns out that this best response only depends on a simple summary statistic of the distribution of nontraded goods prices, namely $E(1/p_N(s)|z)$, the conditional mean of the inverse of these prices. We can then write the best response as $p_T^{Union}(\{p_N(s)\}, z) = F\left(E\left(1/p_N(s)|z\right)\right)$ for the same function F defined under flexible exchange rates. In equilibrium, since nontraded goods prices are set as a markup over marginal cost, the price of traded goods must satisfy the following fixed point equation $\bar{p}_T(z) = F\left(E\left(\theta(s)/\bar{p}_T(z)|z\right)\right)$. Using this value, it is easy to solve for the rest of the allocations from the constraints.

Lemma 2. The allocations in the Markov equilibrium in a monetary union are given by $L^{union}(s) = C_T^{union}(s) + C_N^{union}(s)$ where

$$C_T^{union}(s) = \frac{\alpha}{\psi} - \frac{1-\alpha}{\psi}\left(1 - E_v(\theta|z)\right) and C_N^{union}(s) = \frac{1-\alpha}{\psi}\theta(s). \tag{6}$$

Since the normalized price of traded goods is given by $p_T^{union} = 1/C_T^{union}(s)$, (6) implies that traded goods prices vary with the average of the markup shocks in the union.

The key difference between flexible exchange rates and the monetary union is that under flexible exchange rates the monetary authority reacts to both aggregate and country-specific components of markup shocks, whereas in a union the monetary authority reacts only to aggregate markup shocks and, by design, is unable to react to country-specific markup shocks.

Comparing Welfare. We first show that with only markup shocks, forming a union is beneficial and these benefits are increasing in the variability of country-specific shocks. Comparing the allocations (4) with those in (6), we see that the allocations under flexible exchange rates differ from those in a monetary union only with respect to the consumption of the traded good and the labor needed to produce it. Substituting for the allocations in the objective function gives that the difference in welfare in a union and that under flexible exchange rates is $W\left(E_v\left[\theta|z\right]\right) - E_v\left[W(\theta)|z\right]$ for a given z, where the function $W(\theta) = \alpha \log\left((1-\alpha)(\theta-1)+\alpha\right)$. Since the function $W(\theta)$ is strictly concave in θ, the welfare difference between the regimes is nonnegative, strictly positive whenever there is variability in the country-specific shock v, and increasing in this variability.

Proposition 2. (Union Preferred With Only Markup Shocks) With only markup shocks, the ex ante utility in the Markov equilibrium for a monetary union is strictly higher than the ex ante utility in the Markov equilibrium with flexible exchange rates. Moreover, a mean-preserving spread in the country-specific component of the markup shock θ increases the gains from forming a union.

The idea behind this proposition is that because of concavity of preferences over traded consumption goods, the ex ante welfare associated with the Markov equilibrium in a monetary union is higher than that under flexible exchange rates. Interestingly, as we show in the Appendix, in a union inflation rates are not only less volatile but also lower on average than they are under flexible exchange rates.

The key idea for the difference in welfare is that any attempt to offset the distortions

induced by markup shocks is frustrated in equilibrium by the reaction of sticky price producers. A monetary regime that allows the monetary authorities to respond to markup shocks necessarily lowers welfare by increasing the volatility of relative prices, and hence, relative consumptions. A union is desirable precisely because it prevents the monetary authority from responding to the country-specific components of markup shocks.

We now allow for both shocks and show that if the country-specific volatility of productivity shocks is sufficiently small relative to that of markup shocks, then a monetary union is preferred to flexible exchange rates. When we allow for both markup shocks and productivity shocks, we have two competing forces. Forming a union has *credibility benefits*: doing so effectively commits the country to not react to the country-specific component of its markup shocks. But forming a union also has *Mundellian costs*: doing so also prevents the country from reacting to the country-specific component of its productivity shocks. Our main result is a new optimal currency area criterion.

Proposition 3. (Welfare Comparison Under No Commitment) When the volatility of markup shocks is sufficiently high relative to that of productivity shocks, the credibility benefits are higher than the Mundellian costs and forming a union is preferable to flexible exchange rates. In contrast, when the reverse is true, flexible exchange rates are preferred to a union.

The first part of this result immediately follows from Proposition 2 and continuity of the equilibrium values in the parameters of the model. The proof of the second part essentially mimics the argument with commitment.

It is useful to develop a simple approximation that allows us to determine how large markup shocks must be relative to productivity shocks for a union to be beneficial. The approximation is needed because when productivity shocks are stochastic, the Markov equilibrium does not have a closed-form solution. We take a second order Taylor approximation of the objective function and a first order approximation to the price setting rule. Under

this approximation, the welfare gains of forming a monetary union are given by

$$W^{union} - W^{flex} = \frac{1}{\kappa} var(\log \theta_v) - \left(\frac{1}{1+\kappa}\right) var(\log A_v), \tag{7}$$

where $\kappa = (1-\alpha)\mu_\theta / \left[(2\alpha - 1) - (1-\alpha)\mu_\theta\right]$ and $var(\log \theta_v)$ and $var(\log A_v)$ are the country-specific variances of $\log \theta$ and $\log A$ and μ_θ is the mean value of θ.

Consider now the welfare gains that result from forming a union. The first term in (7) represents the credibility gains of a monetary union: entering a union allows the country to avoid reacting to country-specific markup shocks, which simply add unwanted volatility to the consumption of traded goods. The second term in (7) represents the standard Mundellian losses associated with the inability to respond to productivity shocks. Thus, the optimal currency area criterion has a *monotonicity property in shocks*: holding fixed the variance of the productivity shocks, forming union is relatively more desirable the larger is the variance of the markup shock in that

$$\frac{var(\log A_v)}{var(\log \theta_v)} < \frac{1+\kappa}{\kappa}. \tag{8}$$

We complement this expression with Figure 2, which gives the exact solution for the value of utility in a Markov equilibrium under the two regimes as we vary the relative volatility of the country-specific component of the productivity shock in the nontradable sector. The figure illustrates the monotonicity property in shocks also holds for the exact solution.

Next we ask whether this monotonicity property is robust to the degree of substitutability between traded and nontraded goods. The international macroeconomics literature contains a range of estimates for the elasticity of substitution between these goods. Here we consider a CES specification over traded and nontraded goods of the form

$$\frac{\left[(\alpha C_T)^{\frac{\rho-1}{\rho}} + ((1-\alpha)C_N)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho(1-\sigma)}{\rho-1}}}{1-\sigma} - \psi\ell \tag{9}$$

where ρ is the elasticity of substitution between traded and nontraded goods. Note that our preferences have $\rho = 1$ and $\sigma = 0$. In Figures 3A and 4A we plot the percentage that consumption that must be increased under flexible exchange rates to yield the same welfare as in the monetary union against $stdev(\log A_v)/stdev(\log \theta_v)$ as we vary ρ and α. We see that the optimal currency area criterion has the same monotonicity property in terms of shocks as does our benchmark model.

At a general level, economic theory tells us that whether forming a union is desirable depends on the properties of the shocks. Applying this principle to a simple New Keynesian model yields the general criterion in Proposition 3 and the formula in (8). While the particular formula derived in (8) will change as we alter the structure and shocks in the model, we conjecture that the same monotonicity property will hold for most models: a union is desirable if the Mundellian shocks are similar and the temptation shocks are dissimilar.

Criteria in Terms of Macroeconomic Aggregates. A large empirical literature has taken the view that countries are poor candidates for forming a monetary union if the variances of the country-specific components of output and real exchange rates are large.

Our analysis shows why this view is problematic. To see why, first suppose that under commitment a group of countries have large country-specific movements in real exchange rates and output. Proposition 1 implies that these countries should form a union if these movements are driven mostly by markup shocks and should not if they are driven mostly by productivity shocks.

Next suppose that the countries are contemplating forming a union without commitment and currently are in a flexible exchange rate regime pursuing Markov policies. Here a log-linear approximation of the Markov outcomes yields that, in log-deviation form, the country-specific components of output $y(v)$ and real exchange rates $q(v)$ are

$$y(v) = \frac{1-2\alpha}{1+\kappa}\log A_v(v) + \frac{\alpha+\kappa(1-\alpha)}{\kappa}\log\theta, q(v) = (1-\alpha)\log\theta(v) - \frac{1-\alpha}{1+\kappa}\log A(v)$$

where κ is given in (7). Solving these equations gives the variances of the country-specific shocks in terms of the variances of the endogenous variables. Doing so gives that the optimal currency area criterion has a *monotonicity property in aggregates*: a union is preferable to flexible exchange rates if and only if the variance of output is sufficiently high relative to the variance of real exchange rates in that $var\,(q)\,/var\,(y) < \omega_y/\omega_q$, where the constants ω_y and ω_q are given in the Appendix. Clearly, forming a union can be optimal even if the variance of both output and real exchange rates are high. Thus we have shown that the standard view is incorrect even in the simplest version of the workhorse New Keynesian model.

We now examine the robustness of this monotonicity property in terms of aggregates by considering preferences in the class (9). In Figure 3B we plot the percentage that consumption that must be increased under flexible exchange rates to yield the same welfare as in the monetary union against $stdev(q)/stdev(y)$ for $\rho = .75$ and $\rho = 1.5$. We see that when $\rho = .75$ forming a union is desirable only if the variance of output is relatively *low* whereas when $\rho = 1.5$ forming a union is desirable only if the variance of output is relatively *high*. That is, the criterion in terms of aggregates changes sign as we vary the elasticity of substitution even though for the same comparison the criterion in terms of shocks does not change sign. The reason for this reversal can be seen in Figure 3C where we plot the relative standard deviation in terms of aggregates against the relative standard deviation in terms of shocks. In this figure we see that $stdev(q)/stdev(y)$ is increasing in the $stdev(\log A_v)/stdev(\log \theta_v)$ for $\rho = .75$ and decreasing for $\rho = 1.5$.

Thus, even for this simple variation of our benchmark model the criterion in terms of aggregates is not robust. In Figure 4 we show that as we vary the shares, we have robustness in the shocks criterion but nonrobustness in the aggregates criterion.

These findings lead us to conclude that the robust implication of theory is likely to be the generalized version of Proposition 3 discussed above rather than a specific formula in terms of aggregates.

3 The Stable Configuration of Unions

So far we have assumed that all countries are symmetric and studied their incentives to form a monetary union rather than stay under a regime of flexible exchange rates. Here we analyze an economy with two groups of countries and in the Appendix extend the results to configuration of unions with two or more groups.

We imagine there are two groups of countries, North, N, and South, S, with a measure $\bar{n}^N$ of Northern countries and a measure $\bar{n}^S$ of Southern countries. Here, we focus on an economy with only markup shocks, and we let the markup shocks in the North be $\theta^N(s_t)$ and those in the South be $\theta^S(s_t)$. These shocks are realized at the beginning of the period (and, as before, we drop the subscript 1 denoting the beginning of the period for simplicity). Throughout, we assume that the Southern countries are *more distorted* than the North in that $E\theta^S \leq E\theta^N$ and $var(\theta^S) \geq var(\theta^N)$. Given our definition of the wedge, we see that our condition that Southern countries are more distorted implies that the South has wedges that are both larger on average and more volatile than those in the North.

We turn to asking whether a union of Northern countries should admit Southern countries. The Northern countries understand that if they let in a measure n^S of Southern countries, then the policy followed in the mixed union will be one that maximizes a weighted average of the utility of the Northern and Southern countries, where the weights are proportional to group size in that $\lambda^N = \bar{n}^N / \left(\bar{n}^N + n^S\right)$, $\lambda^S = n^S / \left(\bar{n}^N + n^S\right)$, so that the resulting vector $\lambda = (\lambda^N, \lambda^S)$ satisfies $\lambda^i \in [0,1]$ and $\lambda^N + \lambda^S = 1$. For now, we assume that the Southern countries are originally under flexible exchange rates and will join the union only if they receive higher utility in the union than under a regime with flexible exchange rates.

To determine the size of the union, we begin by solving for the Markov equilibrium and the welfare of the Northern and Southern countries for any given composition of the union. We then ask what composition maximizes the welfare of the Northern countries given that the Southern countries that join the union must be made better off by doing so.

Consider the Markov equilibrium for a particular composition of the union (λ^N, λ^S).

Lemma 3. The allocations in the Markov equilibrium in a monetary union with composition λ are $L^i(s,\lambda) = C_T^i(s,\lambda) + C_N^i(s,\lambda)/A^i$, and

$$C_T^i(s,\lambda) = \frac{\alpha}{\psi} - \frac{1-\alpha}{\psi}\left(1 - \sum_{i=N,S} \lambda^i E_v\left(\theta^i|z\right)\right), C_N^i\left(s,\lambda\right) = \frac{1-\alpha}{\psi} A^i \theta^i\left(s\right). \tag{10}$$

The expected welfare of both Southern and Northern countries for a given composition is $W^i\left(\lambda\right) = \alpha E \log C_T^i(s,\lambda) + (1-\alpha) E \log C_N^i\left(s,\lambda\right) - \psi E L^i(s,\lambda)$. Note that the allocations imply that both groups rank different compositions the same way: if the North prefers composition $\hat{\lambda}$ to λ, then so does the South. The reason is that the North and the South have the same stochastic process for traded goods consumption and have stochastic processes for nontraded goods consumption that are independent of the composition of the union.

We then turn to asking what is the optimal measure of Southern countries that the North finds optimal to admit to the union. This *mixed-union* problem is to choose λ to maximize $W^N(\lambda)$ subject to the feasibility constraint $\lambda^N \geq \bar{n}^N/(\bar{n}^N + \bar{n}^S)$ and the participation constraint of Southern countries $W^S(\lambda) \geq W^S_{flex}$, where W^S_{flex} is defined from the allocations under flexible exchange rates given in Lemma 1. We assume that $\bar{n}^S$ is sufficiently large so that the feasibility constraint does not bind. It is straightforward to prove that if the Southern countries are more distorted then they always prefer joining the union with the North to staying on their own. Hence, we can drop the participation constraints.

Proposition 4. A decrease in the correlation of the distortions in the North and the South increases the optimal measure of Southerners admitted. Likewise, a decrease in the mean distortions in the South increases the optimal measure of Southerners admitted. When distortions are uncorrelated and have equal means, then a decrease in the volatility of distortions in the South increases the optimal measure of Southerners admitted.

Now we ask what configurations of unions will form in this model. We focus on configurations that are *stable* in the sense that there is no deviation by a group of countries to form

their own union that makes all of the members of the deviating group weakly better off and at least one type of them strictly better off.

In developing our analysis, we use the result that all countries rank unions with different compositions in the same way. Our economy has a unique stable configuration of unions: a preferred union, which is a mixed North-South union with the mixture chosen as above, say at $\hat{\lambda}$, and a less preferred union. If the measure of Southern countries is large, the less preferred union consists purely of Southern countries. If the measure of Southern countries is small, the less preferred union consists purely of Northern countries. In either case, since the mixed union maximizes the welfare of both types of countries, neither type has an incentive to defect. We summarize this discussion as follows.

Proposition 5. Under the condition that the South is more distorted and the measure of Southerners is large, a North-South union which solves the mixed union problem and a pure Southern union consisting of the remaining Southern countries is the unique stable configuration of unions. The mixed union has higher welfare for both countries than the pure Southern union.

If the countries of Southern Europe are relatively more distorted than those of Northern Europe, then this proposition provides some perspective on the idea of splitting the current European Monetary Union into two unions: one consisting of Northern countries and one consisting of Southern countries. Our theory suggests that such a split is not desirable unless the distortions in the Southern countries are sufficiently severe.

4 Endogeneity of Policy in a Union

So far we have considered unions in which policy endogenously responds to the interests of all members. An alternative literature considers a very different type of union in which policy responds only to the interests of one of its members. (See the work of Friedman (1973), Alesina and Barro (2002), Alesina, Barro, and Tenreyro (2003), and Clerc, Dellas,

and Loisel (2011).) This type of union can be thought of as one in which small countries, called *clients*, like Ecuador, adopt the currencies of large stable countries, called *anchors*, like the United States.

The key assumption of this work on *anchor-client unions* is that the anchors decide their policy without regard to the interests of the clients. In the Appendix, we analyze anchor-client unions in our model and find a result similar to that in the Mundellian analysis: clients should adopt anchors whose productivity shocks are most similar to their own, and the correlation of markup shocks between anchor and client is irrelevant. In this sense, we have shown that the criteria for forming anchor-client unions are very different from those for forming cooperative or majority-rule unions.

In terms of the European Monetary Union, we argue that it is better described as a union in our sense in which policy is influenced the interests of all the members of the union, rather than as an anchor-client union in which policy responds to the needs of only one country in the union. This argument has an institutional design component and a practical component.

As a matter of institutional design, policy is made by a weighted majority vote, so that, institutionally the union does not resemble an anchor–client relationship. As a practical matter there is a consensus that in the European Monetary Union, policy is best described as responding to the needs of the union as a whole. For example, Mihov (2001, p. 370) argues that "estimation of monetary policy reaction functions finds that the European Central Bank is closer to an aggregate of the central banks in Germany, France, and Italy than to the Bundesbank alone." For similar views, see Alesina, Barro, and Tenreyro (2003)). Indeed, more recent work (see Sturm and Wollmershäuser (2008), for example) estimates the actual policy weights the ECB has implicitly attached to each of the member countries and finds that it is not the large countries such as Germany or France that receive disproportionate policy weights but rather the smaller countries. Finally, Hayo and Hoffman (2006, p. 646) argued that "the ECB's monetary policy is inadequate for the needs of the German economy".

In sum, both the institutional design and the practical policy record make clear the European Monetary Union is not an anchor-client union in which Germany is the anchor and the rest of the member countries are the clients.

5 Conclusion

The key view in the existing literature on currency unions is that countries with similar shocks should form a union. This view is pervasive not only in the literature stemming from the original contributions of Friedman (1953) and Mundell (1961), but also in the followup work on anchor-client unions by Friedman (1973), Alesina and Barro (2002), Alesina, Barro, and Tenreyro (2003), and Clerc, Dellas, and Loisel (2011). Our analysis shows that this traditional view is problematic. Furthermore, the widely-used criterion in the literature in terms of aggregates is inconsistent with the workhorse New Keynesian model.

Our contribution is to show that when countries suffer from time inconsistency problems, forming a cooperative or majority rule union may be more desirable the more dissimilar they are with respect to temptation shocks that exacerbate these time inconsistency problems.

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Figure 1. Equilibrium Determination under Flexible Exchange Rates

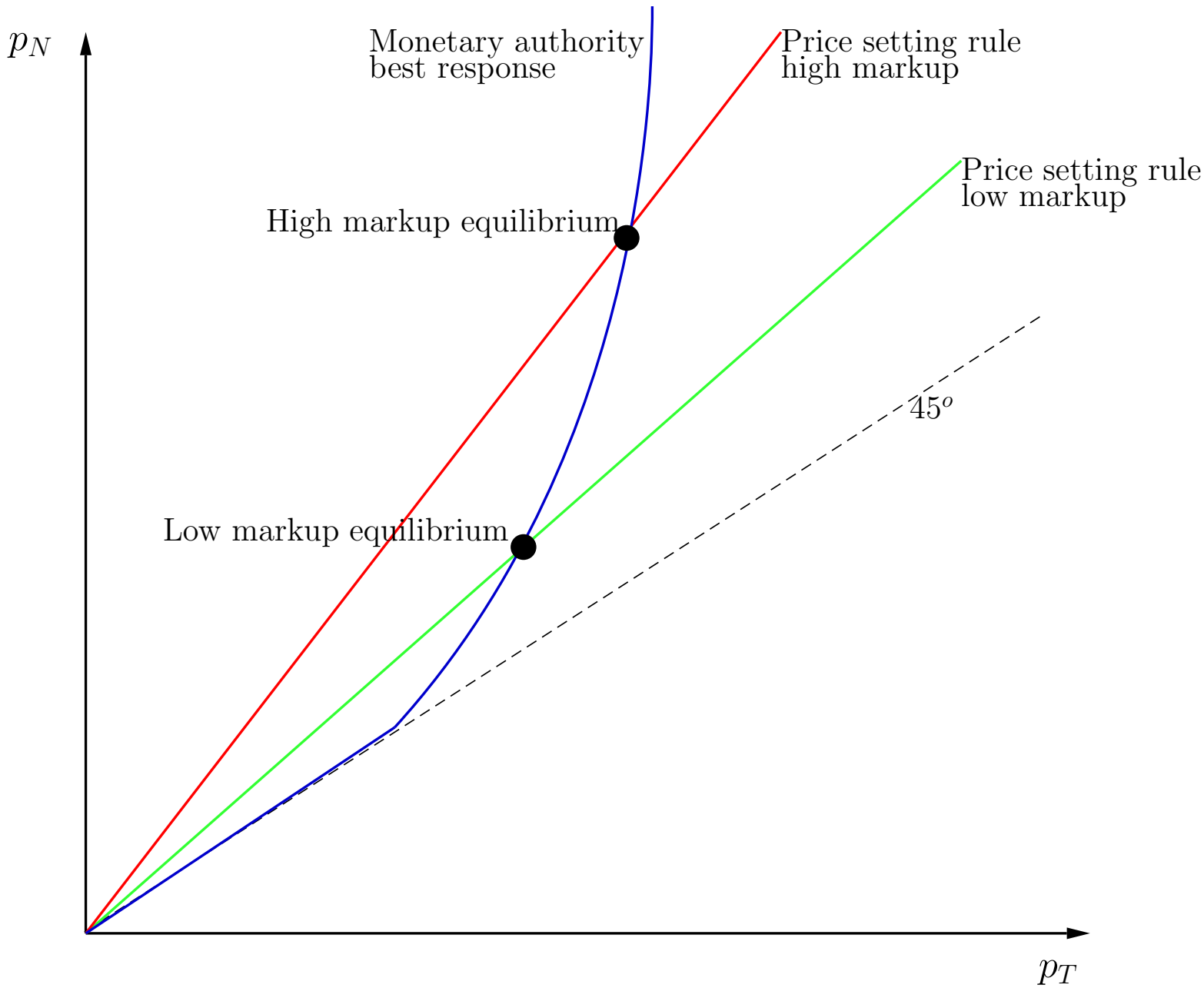

Figure 2. Relative Shock Variability and Welfare

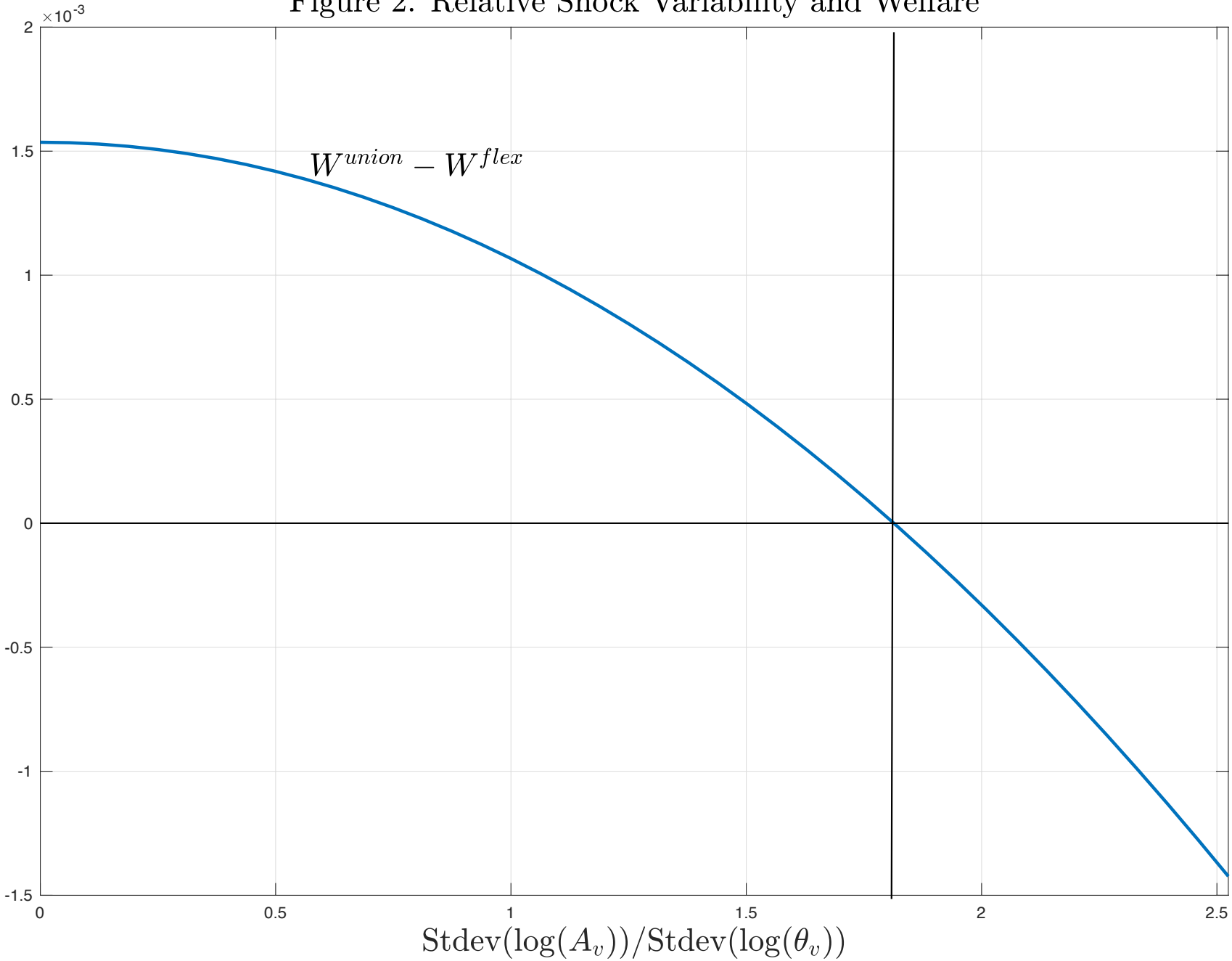

Figure 3A. Robustness of OCA Criterion in Shocks

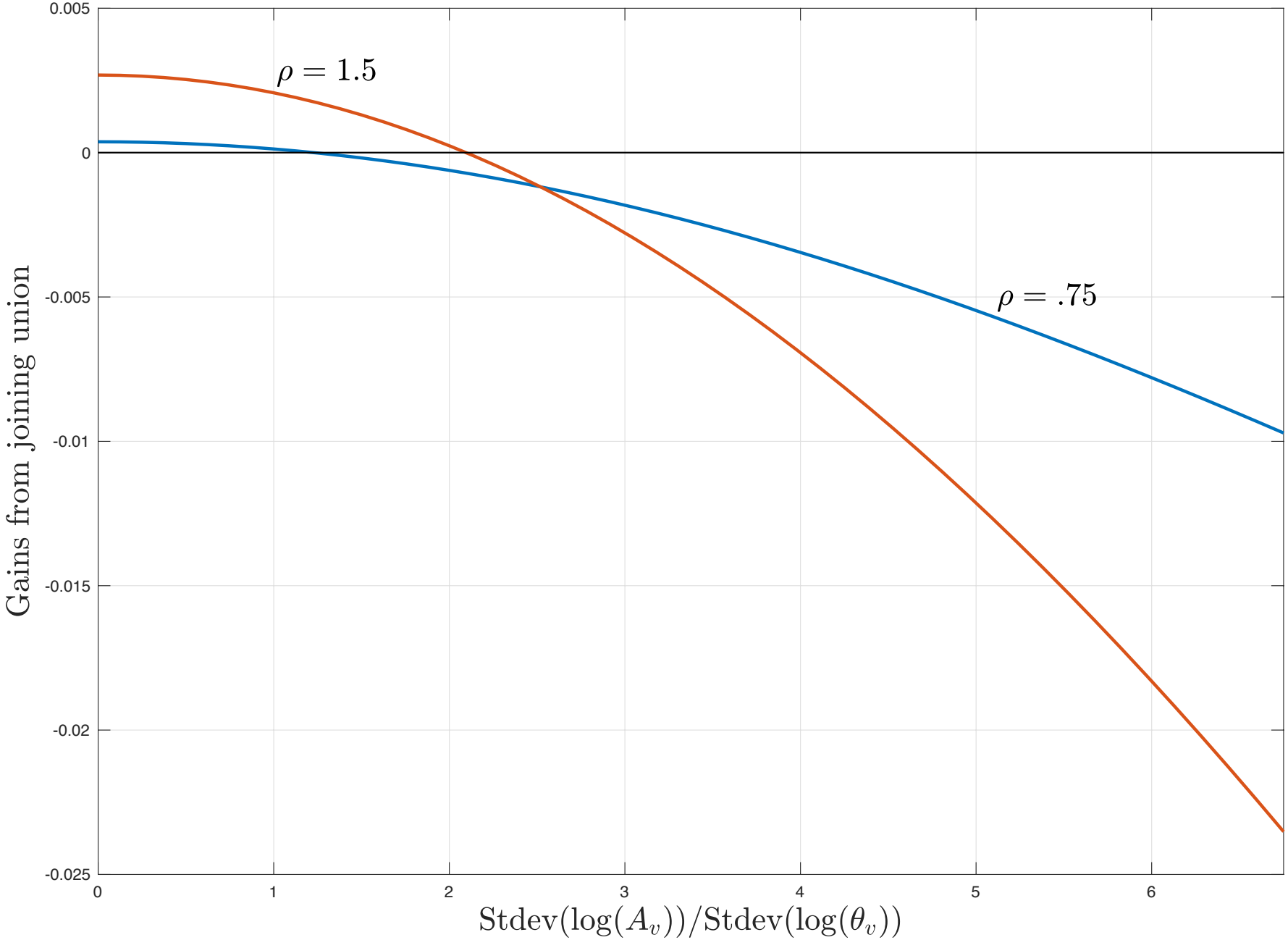

Figure 3B. Nonrobustness of OCA Criterion in Aggregates

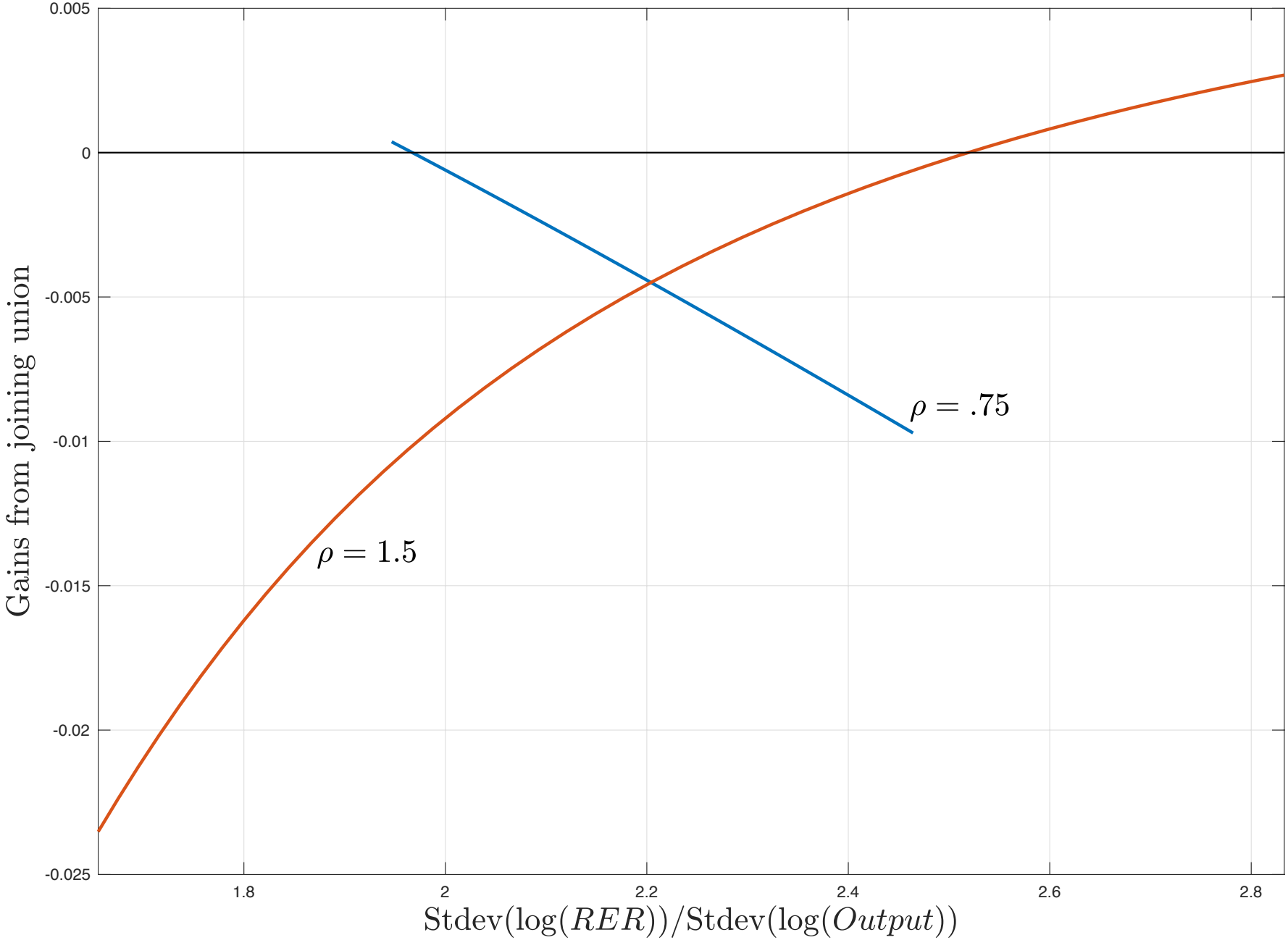

Figure 3C. Relative Variability of Aggregates versus Relative Variability of Shocks

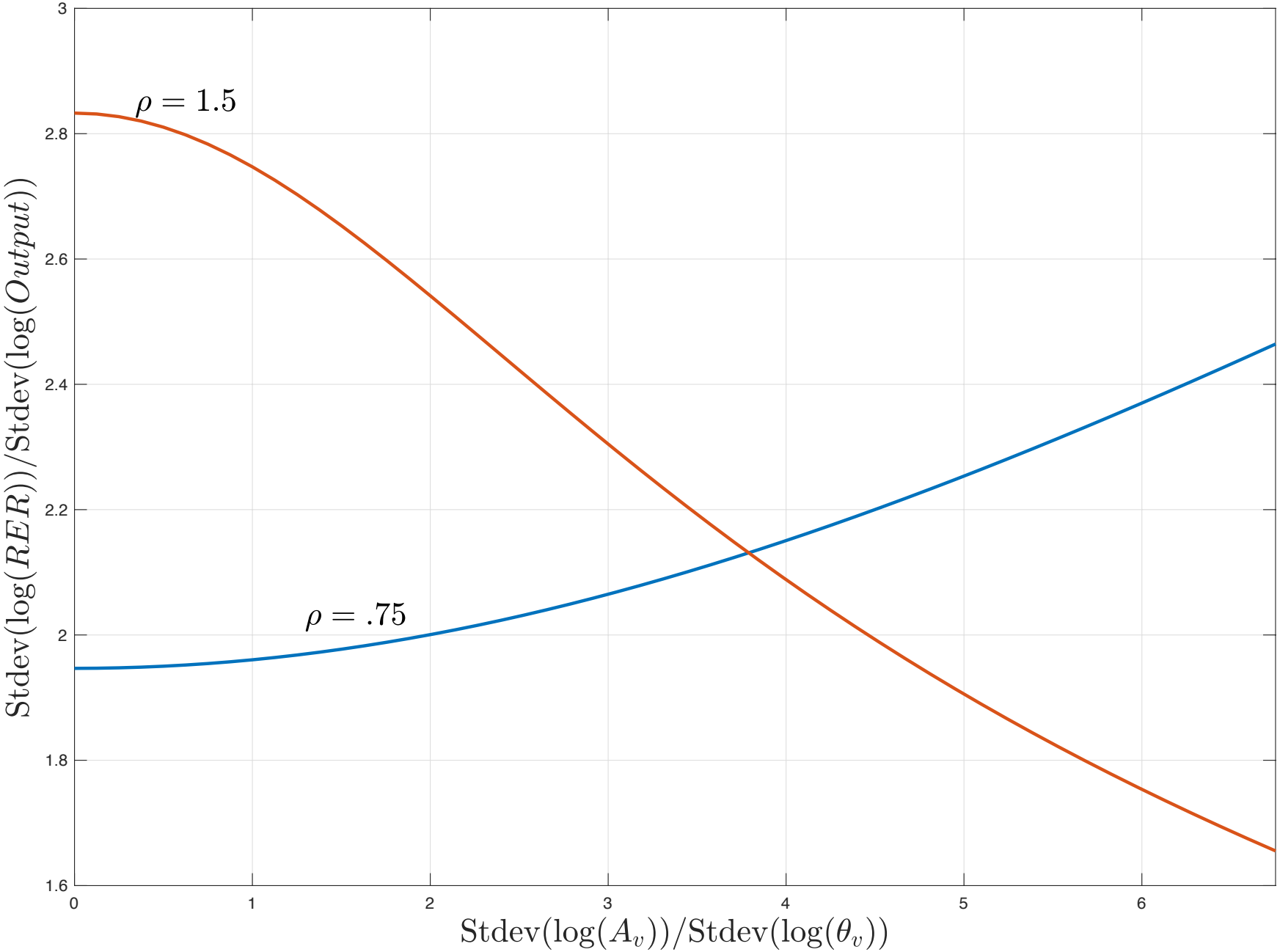

Figure 4A. Robustness of OCA Criterion in Shocka

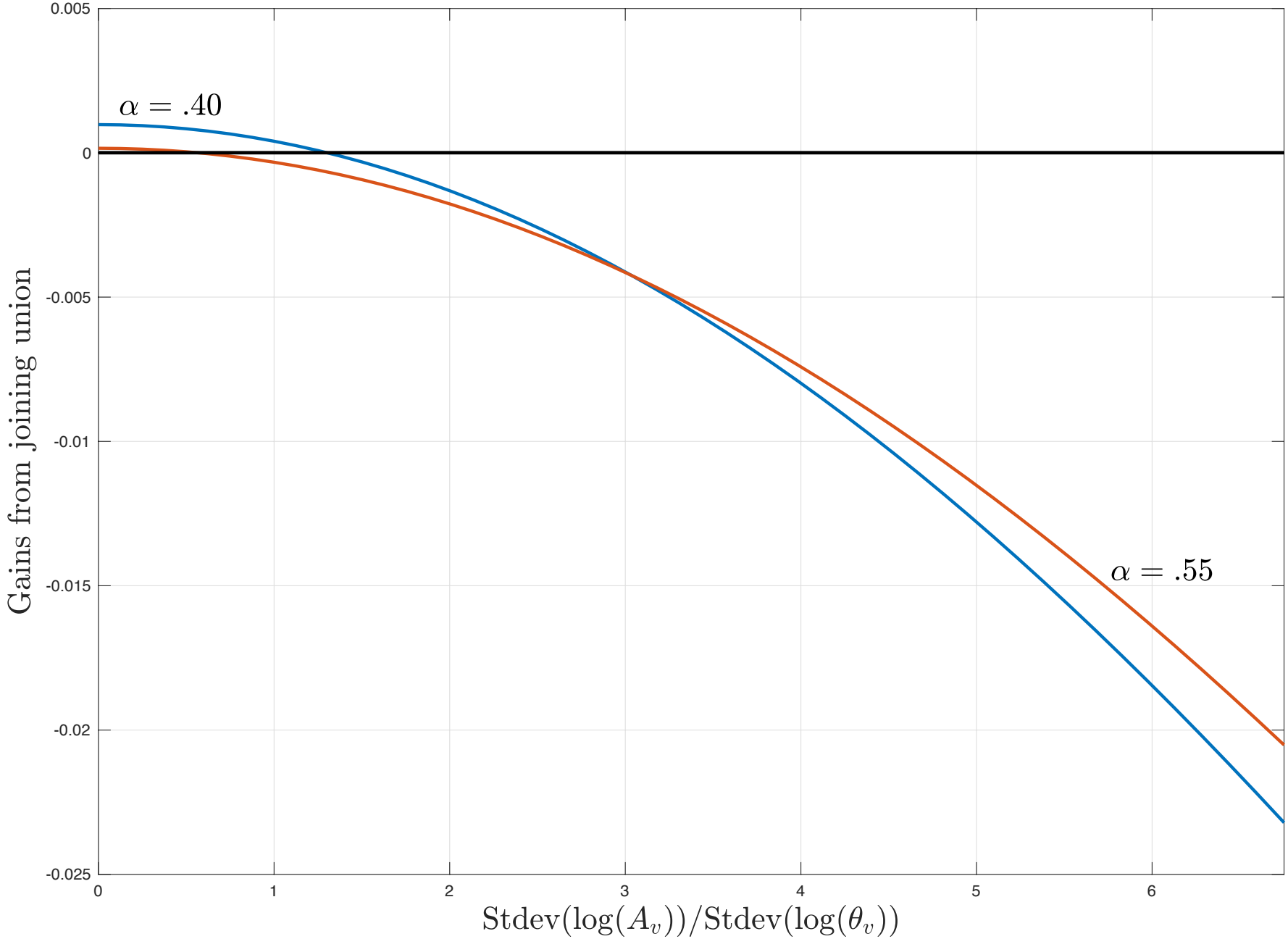

Figure 4B. Nonrobustness of OCA Criterion in Aggregates

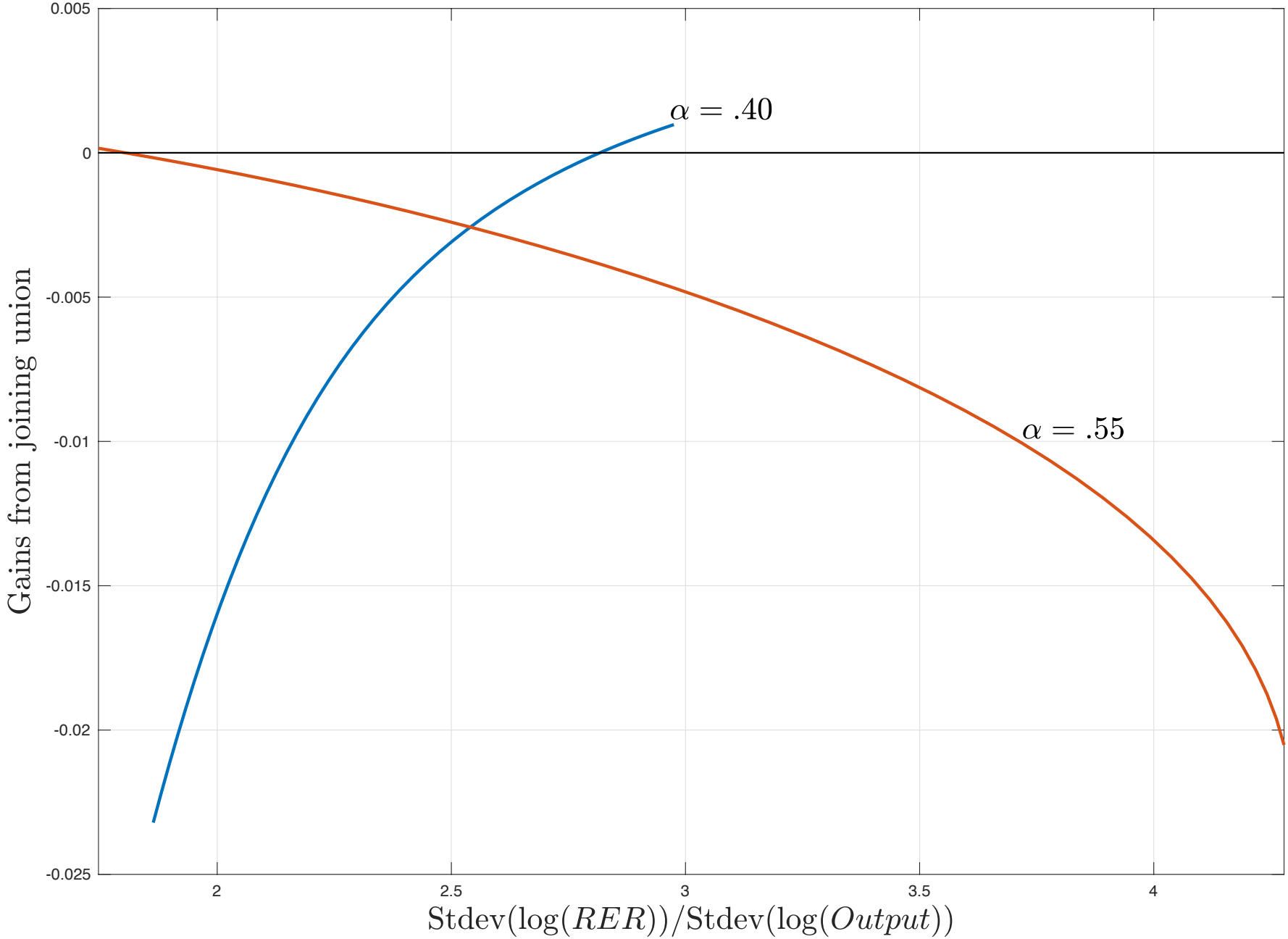

Figure 4C. Relative Variability of Aggregates versus Relative Variability of Shocks