Exchange Rate Volatility and Intervention:
Implications of the Theory of Optimum Currency Areas

Tamim Bayoumi and Barry Eichengreen[1]
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Abstract

We show that variables pointed to by the theory of optimum currency areas (OCAs) help to explain patterns of exchange rate variability and intervention across countries. But OCA considerations affect exchange market pressures and intervention in different ways. Exchange market pressures mainly reflect asymmetric shocks, while intervention largely reflects the variables that OCA theory suggests cause countries to value stable exchange rates (small size and the extent of trade links). Intervention and exchange market pressure also vary with the structure of the international monetary system.

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I. Introduction

Robert Mundell is rightly regarded as the father of the theory of optimum currency areas.[1] But the theory he spawned, while never lacking in patrimony, was for many years orphaned by the economics profession. Figure 1 shows the number of articles with the phrase "optimum currency areas" in the title for five-year periods since 1961. Evidently, only in recent years with the impetus provided by the debate over European monetary unification has scholarship on this subject taken off.

Along with its time profile, a notable feature of this scholarship is the paucity of empirical work. Until recently, most contributions were theoretical, and to the extent that empirical work on exchange rate behavior and the choice of exchange rate regime acknowledged the predictions of OCA theory, it adopted a skeptical tone. The following conclusion due to Goodhart (1995, p.452) can fairly be regarded as the consensus view.

> "The evidence therefore suggests that the theory of optimum currency areas has relatively little predictive power. Virtually all independent sovereign states have separate currencies, and changes in sovereign states lead rapidly to accompanying adjustments in monetary autonomy. The boundaries of states rarely coincide exactly with optimum currency areas, and changes in boundaries causing changes in currency domains rarely reflect shifts in optimum currency areas."

Here we suggest that this conclusion -- especially the portion represented by the first sentence in the preceding quotation -- is premature. In fact, the theory of optimum currency areas goes a long way toward accounting for the variability of exchange rates between separate national currencies. While Goodhart is right to conclude that the boundaries of political jurisdictions and currency areas almost always coincide, the variability of the

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[1] See Mundell (1961). We abbreviate this as OCA theory in what follows.

exchange rates between the currencies circulating in those areas is largely explicable in terms of OCA theory.

We argue that the variables pointed to by the theory of optimum currency areas help to explain the behavior of the bilateral exchange rates (both nominal and real) on the grounds that the same factors that inform the decision of whether to form a currency union should also influence exchange rate behavior across countries. The evidence turns out to be strongly supportive of this hypothesis. Variables suggested by OCA theory -- notably the importance of asymmetric disturbances to output and the intensity of trade links -- have considerable explanatory power.

The conclusion that OCA variables can account for observed differences across countries in exchange rate variability leaves open the question of how this regularity comes about. It could arise because shocks to the foreign exchange market reflect OCA-related factors. Countries' bilateral rates are stable when the shocks they experience are similar, in other words. Alternatively, pressures could be the same, but governments could intervene more heavily to limit exchange-rate variability vis-a-vis countries with whom OCA considerations loom large. When bilateral trade is relatively important, to cite one factor OCA theory suggests conduces to a preference for a stable bilateral rate, governments will intervene on the foreign exchange market to stabilize it.

The remainder of this paper seeks to differentiate between these explanations of the relationship between OCA variables and exchange rate variability. We construct measures of exchange rate variability and exchange market pressure (the latter designed to capture the magnitude of shocks to the foreign exchange market.) The market pressure index is constructed using information on both exchange rate volatility and intervention. This provides an obvious opportunity to analyze the complementary relationship, namely the determinants of intervention itself.

We find that variables from the theory of optimum currency areas -- principally, proxies for asymmetric shocks -- go some way toward explaining variations across countries in exchange market pressure. Variables suggested by the theory of optimum currency areas also help to explain patterns of foreign exchange market intervention. But while exchange market pressures depend mainly on measures of the cost of an optimum currency area (that is, on variables measuring the extent of asymmetric shocks), intervention depends primarily on the benefits of an optimum currency area (on variables like country size the extent of bilateral trade links).

The overall conclusion is thus that variables pointed to by OCA theory appear to affect the behavior of bilateral exchange rates through both market conditions and intervention. But two sets of considerations pointed to by the OCA literature operate through different channels: asymmetric shocks are the main source of exchange market pressure, while proxies for the deterioration in the transactions value of money due to floating provide the main motivation for intervention.

Our approach has obvious points of contact with previous studies, although it departs from each of them. First there is the literature on the choice of exchange rate regime (starting with Heller 1978).[2] Using data from tables in the International Monetary Fund's Exchange and Trade Restrictions volumes, these studies categorize currencies as fixed or floating and

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[2] For surveys of the subsequent literature, see Savvides (1990, 1993).

estimate limited-dependent-variable regressions to explain into what category countries fall.[3] Here, instead of basing our analysis on the relatively judgmental categorization of exchange rate arrangements utilized in these studies, we analyze the determinants of observed exchange rate variability.[4] In addition, we take seriously the notion that exchange rate variability can in turn affect the country characteristics taken in these studies as determinants of the choice of exchange rate regime, and accordingly estimate our equations by instrumental variables.

We examine choice of exchange rate regime in a framework that allows us to consider systemic as well as country-specific factors. Previous work on this issue has proceeded country by country, ignoring changes in the structure of the international system and the implications of policy in neighboring countries. In the Bretton Woods period when major currencies were pegged, it made little difference from the point of view of an individual country whether to peg to one reserve currency or another since the rates between them varied so little. But once the dollar and DM began to float against one another, pegging to the DM meant floating against the dollar, and vice versa, complicating efforts to stabilize exchange rates. In contrast to previous work, we account for the entire network of bilateral

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[3] Some authors, such as Dreyer (1978) and Melvin (1985), consider more than two categories of exchange arrangements, distinguishing between freely floating currencies and those exhibiting limited flexibility, for example.

[4] Actual exchange rate behavior should convey more information about underlying economic determinants than the putative exchange rate regime. Countries not only have to adopt an exchange rate regime, in other words, they also have to maintain it. The limited-dependent variable on which most previous investigators focus does not make use of all the information available in the variability of the exchange rate.

exchange rate arrangements and not just individual country conditions when modeling the choice of exchange rate regime.[5]

While some previous work has also distinguished exchange market pressure from intervention, we measure intervention in different ways. Glick, Kretzmer and Wihlborg (1995) and Glick and Wihlborg (1996) measure intervention as the percentage change in international reserves as a fraction of the monetary base. Their index can be thought of as measuring by how much the money stock would have risen absent intervention. This is appropriate when the monetary authorities control bank balance sheets through base money (as they do in many countries where banking systems are tightly regulated). In many industrial countries, however, regulation of the domestic financial system is less comprehensive, and excess reserves can seep into the banking system via deposits. This suggests instead normalizing the percentage change in reserves by narrow money, as we do below. Alternatively we measure intervention as the percentage change in narrow money and by the change in the interest differential on the assumption that unsterilized intervention is used for managing exchange rates.

II. Exchange Rate Variability and Exchange Market Pressure

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[5] In addition, our study differs from most of its predecessors in that we employ data for the industrial countries rather than the developing world. Since the developing countries are more heterogeneous, the assumption of a common structure linking country characteristics to exchange rate variability is more problematic. Moreover, the industrial countries have tended to maintain more liberal external regimes and have thus been more dependent on market forces in determining their international economic policies. Finally, the choice of exchange rate regime has gained new urgency in the industrial world in the wake of the crisis in the European Monetary System and the debate over European monetary unification.

The variability of nominal bilateral exchange rates for the 21 industrial countries in our sample is shown in Table 1 for three periods: 1963-72, 1973-82 and 1983-92.[6] Heavily shaded observations denote variability in excess of eight per cent per annum (the sample mean), lightly shaded entries moderate volatility (four to eight per cent).

There are no heavily-shaded entries for the 1960s.[7] But in the 1970s the U.K., the U.S., Japan, Canada, Australia and New Zealand have highly variable exchange rates against virtually every country.[8] The founding members of the Snake (Belgium, France, Germany, Italy, Luxembourg, the Netherlands) display lower-than-average variability vis-a-vis one another.[9] While the non-Europeans continue to display relatively high levels of variability in the 1980s, the core members of the Exchange Rate Mechanism (ERM) of the European

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[6] For convenience, we refer to these periods as the 'sixties, 'seventies, and 'eighties. The exchange rate is measured as the standard deviation of the change in the logarithm of the nominal year-end bilateral rate. Results for real exchange rates, constructed from nominal rates using GDP deflators, are very similar; see Bayoumi and Eichengreen (1996).

[7] Indeed, in most cases volatility is below four percent, reflecting the success with which the Bretton Woods System delivered exchange rate stability. The main exceptions are the U.K., which experienced repeated exchange-market difficulties before being forced to devalue in 1967, and certain countries whose economies were linked to it like Ireland and New Zealand. More surprisingly, Spain also falls into this category. In addition, Finland devalued a month earlier, partly in response to the international financial turbulence caused by uncertainty about sterling.

[8] In comparison, Exchange rates of the Continental European countries are relatively stable against one another. Exceptions are Ireland and Portugal, the first of which behaves "Continentally," the second of which behaves more like the U.K. than a Continental European country.

[9] Denmark and the U.K., with Ireland as part of the U.K. currency area, joined less than a week after the creation of the Snake, while Norway followed within a month.

Monetary System -- Germany, France, Italy, Belgium, Denmark, Ireland and the Netherlands -- display low volatility against one another and also the rest of the world.[10]

Table 1 conveys an impression of movement from a system of pegged exchange rates characterized by uniform behavior, through a transitional period in the 1970s when countries may not yet have arrived at their new preferred arrangement, to a new equilibrium in the 1980s in which the issuers of the major reserve currencies preferred to float but significant parts of Europe preferred to peg against one another.[11]

We can analyze exchange market pressure analogously, constructing a measure of the degree to which countries use changes in reserves to neutralize incipient exchange-rate movements. We measure intervention as:

$$\text{INTERVENTION}_i = [\text{d RES}_i]/\text{NARROW}_i(-1) \qquad (1)$$

where RES is reserves, NARROW is a measure of narrow money, and d is the difference operator. We normalize the change in reserves by narrow money on the assumption that this measures the incipient price level change that this change in reserves will generate. (Below we also replace [d RES]/NARROW (-1) with [d NARROW]/NARROW (-1), on the assumption that only unsterilized intervention is effective for managing exchange rates.)[12]

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[10] Austria and Switzerland, neither of which belonged to the European Community nor participated in the ERM but maintained close economic relations with its core members, display similarly low levels of volatility.

[11] That European core includes Switzerland and Austria, neither of which joined the EC during the sample period, but excludes the U.K. and Spain.

[12] A potential concern is that the data may be dominated by outliers. Kurtosis is large for exchange rate changes in the 1960s and for changes in relative reserves in the 1980s. For the former this plausibly reflects the operation of the Bretton Woods System, under which

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The shadow movement in the exchange rate between countries i and j then becomes:

$$PRESSURE_{ij} = d\ EXRATE_{ij} + INTERVENTION_i - INTERVENTION_j \qquad (2)$$

where EXCH is the exchange rate between countries i and j, measured such that a rise is an appreciation. Our measure of exchange market pressure thus adjusts actual exchange rate changes for the influence of intervention.

Table 2 reports exchange market pressure in a format analogous to Table 1. Again, large values are shaded, heavily for high variability, lightly for intermediate values. For the 1960s the picture resembles that for exchange rate variability. There are very few heavily shaded entries, plausibly reflecting the pervasiveness of capital controls and their success in limiting exchange-market pressure. Whereas the UK, Finland, Ireland and New Zealand show up with lightly-shaded entries in both Tables 1 and 2, in Table 2 this list includes also Germany and Australia, indicating that intervention was successfully used in some cases to prevent exchange market pressure from spilling over into actual exchange rate movements.

Canada, Australia and New Zealand are principal countries with both highly variable exchange market pressure and highly variable exchange rates in the 1970s. The U.S., Japan and Britain appear to have experienced only low or moderate exchange market pressure; by

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[12](...continued)
exchange rates changed at discrete intervals rather than being continually determined by market forces. For intervention there are 19 observations for which normalized reserve flows exceed 25 per cent. These include Australia in 1972 (associated with the breakup of the Bretton Woods System), Britain in 1977 (reflecting the 1976 sterling crisis and the IMF loan), Ireland in 1976-77, 1987 and 1992 (reflecting turbulence in the Snake and the ERM), Norway in 1984-86, and 1989 (most of which can be explained by the exchange market effects of oil and natural gas production), Portugal in 1989 and 1991 (plausibly associated with impending ERM entry), and Finland and New Zealand in 1984, 1986 and 1987 (at a time of instability in commodity markets). Overall, then, these extreme values appear to reflect significant economic events of a sort one would want to include in the analysis.

implication, their variable exchange rates reflect a disinclination to intervene. The U.S.-Canadian rate stands out for its low level of exchange market pressure.[13] A bloc of European countries subject to low levels of exchange market pressure is also evident; while it includes Snake members such as Germany, France, Italy, the Netherlands, and Belgium, it also includes Spain, Sweden and Greece.

In the 1980s, the countries experiencing the most intense pressure are Australia, Finland, Ireland, New Zealand, Norway, and Portugal.[14] In contrast to Table 1, the U.S., Japan and Canada are absent from this list, again suggesting that the variability of their exchange rates reflects not so much exchange market pressure as limited intervention. Within Europe, the lowest levels of exchange market pressure are associated with the bilateral rates linking Germany, France, Belgium, the Netherlands, Austria and (more surprisingly) Italy, Greece, Sweden and Switzerland.

Overall, Tables 1 and 2 differ in two important respects. First, the variance of exchange market pressure rises over time, reflecting capital-market integration.[15] This is in contrast to exchange rate variability, which rises in the ‘seventies and falls in the ‘eighties.[16] Second, the exchange market pressure faced by countries such as the U.S. and Japan is not

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[13] Reflecting, presumably, the integration of the two economies.

[14] In some cases this is due to the effect of a few large observations, as discussed earlier.

[15] As before, this is our shorthand for the periods 1963-72, 1973-82 and 1983-92.

[16] Plausibly reflecting the asymmetric effects of the oil shocks and the growing prevalence of capital controls in the late ‘seventies and early ‘eighties (see Eichengreen 1996). Eliminating the effects of the ERM crisis by removing the data for 1991-92 does not make much difference for this result.

particularly high. High levels of exchange rate variability for these countries reflects their reticence to intervene rather than underlying pressures.

Table 3 reports a measure of intervention equal to one minus stddev(d EXRATE)/stddev(d PRESSURE), where "stddev" denotes the standard deviation.[17] Intuitively, the more shocks to the foreign exchange market are absorbed by intervention, the lower the ratio of exchange rate variability to exchange market pressure. Heavy intervention (defined as an intervention index of over 0.67) are heavily shaded, medium levels of intervention (indexes between 0.33 and 0.66) lightly shaded.

By this measure, intervention was most prevalent in the 1960s, plausibly reflecting the constraints of Bretton Woods.[18] The introduction of generalized floating in the 1970s saw a dramatic fall in intervention, with almost no heavily shaded entries. Except for Finland and within Europe, this pattern persists into the ‘eighties. In Europe commitments to stable exchange rates (either unilateral or through the ERM) produced heavy intervention.

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[17] The "one minus" formulation was used as the raw ratio has the somewhat counter-intuitive property that increased intervention reduces its value. Some earlier authors (Glick, Kretzmer and Wihlborg (1995) and Glick and Wihlborg (1996)) have used the variance of the exchange rate relative to the sum of the variance of the exchange rate and the variance of reserves as their measure of intervention. This assumes no covariance between the exchange rate and reserves. It is preferable in our view to calculate the pressure on the exchange rate as the percentage change in the bilateral exchange rate minus the percentage change in relative international reserves, following Girton and Roper (1977). Reserve accumulations are thus treated as analogous to appreciation of the currency, reserve losses as analogous to depreciation.

[18] The checker-board pattern of the entries show little systematic pattern, however, indicating that the net impact of intervention across bilateral linkages was relatively unpredictable (except in the case of Australia, where intervention appears to have been uniformly heavy across all trading partners).

III. Results

We now ask whether the variables pointed to by the theory of optimum currency areas help to explain these patterns.[19] As determinants of countries' choice of exchange-rate regime, that literature points to asymmetric disturbances, trade linkages, the usefulness of money for domestic transactions, and the extent of labor mobility. While the last of these characteristics is clearly important for adjustment within countries, it has not been particularly important for international adjustment in our sample period. Our empirical work therefore concerns itself exclusively with the first three factors.

We measure asymmetric output disturbances as the standard deviation of the change in the log of relative output.[20] A second proxy for asymmetric shocks is the dissimilarity of the commodity composition of the exports (on the grounds that industry-specific shocks will be more symmetric when two countries have a comparative advantage in the same export industries).[21] To measure the importance trade linkages, we use the average value of exports

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[19] Our earlier work indicates that optimum currency area variables provide a reasonably good explanation for observed patterns of exchange rate volatility, and that this explanatory power has been rising over time, although other non-OCA variables also matter (Bayoumi and Eichengreen, 1996). This section extends these earlier results to consider the relationship between OCA theory, exchange rate pressures and the use of intervention.

[20] In the two countries. Thus, for countries in which business cycles are symmetric and national outputs move together, the value of this measure will be small.

[21] To construct this variable we collected data on the shares of manufactured goods, food and minerals in total merchandise trade for each country. Manufactured goods are defined as the total of basic manufactures, chemicals, machines and transport equipment, miscellaneous manufactured goods, and other goods. Food is the sum of food and live animals, beverages and tobacco, and animal, vegetable oils and fats. Minerals amalgamate data on crude materials excluding fuel with mineral fuels, etc. The dissimilarity of the commodity composition of two countries' exports was then defined as the sum of the absolute values of

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to the partner country, scaled by GDP, for the two countries comprising each pair. We use country size to measure the reduction in the transactions value of the national currency due to floating rates; the costs of a common currency, in terms of macroeconomic policy independence foregone, should be balanced against the benefits, which will be greatest for small economies where there is least scope for utilizing a separate national currency in transactions. That is, small countries should benefit the most from the unit of account, means of payment, and store of value services of a common currency. As a measure of country size we include the arithmetic average of (the log of) real GDP in U.S. dollars of the two countries.[22]

The estimating equation is:

$$SD(y_{ij}) = \alpha + \beta_1\, SD(\Delta y_i - \Delta y_j) + \beta_2\, DISSIM_{ij} + \beta_3\, TRADE_{ij} + \beta_4\, SIZE_{ij} \qquad (1)$$

where $SD(y_{ij})$ is the standard deviation of changes in bilateral exchange rates, of bilateral exchange market pressures, or of our index of intervention (one minus the ratio of the standard deviation of actual exchange rates to exchange market pressures), $SD(\Delta y_i - \Delta y_j)$ is the standard deviation of the difference in the logarithm of real output between i and j, $DISSIM_{ij}$ is the sum of the absolute differences in the shares of agricultural, mineral, and manufacturing

[21](...continued)
the differences in each share (with higher values indicating less similarity in the composition of commodity exports between the two countries).

[22] An alternative, suggested by McKinnon (1963), is to use openness to international trade as a measure of the benefits from stabilizing the exchange rate. However, economic size would appear to be a better measure of the benefits from a stable currency, as a comparison between the benefits of provided by the national currencies of Germany (a large and relatively open economy) and Spain (a smaller and more closed economy) should make clear. To ensure that the exclusion of openness from the regression is not an important factor in the empirical results, we included openness in an extended regression discussed further below.

trade in total merchandize trade, $TRADE_{ij}$ is the mean of the ratio of bilateral exports to domestic GDP for the two countries, and $SIZE_{ij}$ is the mean of the logarithm of the two GDPs measured in U.S. dollars.[23] The independent variables are measured as averages over 1963-72, 1973-82, or 1983-92.

The extent of trade may depend on the variability of the exchange rate as well as influence policies toward it. Similarly, output variability may depend on the exchange rate regime in place. We therefore instrumented these two variables, drawing instruments from the gravity model (which seeks to explain the bilateral trade with whose endogeneity we are concerned): distance between the two countries, contiguity, common language, and the size of the two economies.[24]

The top panel of Table 4 shows the results for exchange rate variability, the middle panel for exchange market pressure, the bottom panel for intervention. The coefficients in the top panel generally enter with their anticipated signs, and 9 of 12 differ from zero at standard confidence levels. Their significance and absolute value increase with time: aside from relative output variability (which, plausibly, has an especially large effect in the turbulent 'seventies),

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[23] A potential technical concern with this specification is that not all of the entries for the dependent variable are independent of each other. However, while it is true that <u>changes</u> in bilateral rates are not independent (the change in the bilateral rate between the dollar and the yen is equal to the change between the dollar and the deutsche mark and between the deutsche mark and the yen), the <u>standard deviations</u> of these rates are independent as the covariances can differ across pairs of countries.

[24] We thank Andy Rose for providing most of these data. In addition, our instrument list included the squares of distance and the size of the two economies. The other two independent variables -- economic size and dissimilarity of trade -- were not considered endogenous, and so were not instrumented. Accordingly, the instrument set included the dissimilarity of exports. (Economic size was not included in the instrument set as it is a linear combination of the instruments measuring the size of the two economies).

they are largest in the 'eighties, when they are all significant. They explain half of cross-section differences in exchange rate variability in the most recent decade, up from 10 per cent in the 'sixties. It would appear that the variables pointed to by the theory of optimum currency areas provide a better explanation for currency variability in the 1980s when countries were free to choose their preferred exchange-rate arrangement, than in the 1960s when they were heavily constrained by the rules of Bretton Woods, or than in the transitional 1970s.

The results in the middle panel also show a consistent pattern. Both proxies for asymmetric shocks are significantly and positively related to the variability of exchange market pressure.[25] Again there is some tendency for the coefficients to grow over time (especially that on output movements), plausibly reflecting the increased tendency for the exchange rate to respond to asymmetric shocks as markets have become more open.

The extent of intervention, analyzed in third panel, appears to depend on our proxies for the benefits of a stable currency: country size and bilateral links (with smaller countries which trade more heavily with one another intervening more). This is the complement of the results for exchange market pressure, where the proxies for asymmetric shocks were consistently more important. Again, the coefficients rise over time (in absolute value), plausibly reflecting the opening of capital markets and hence the need for additional intervention to achieve the desired result.

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[25] The one exception is trade composition in the 1980s, the coefficient on which differs insignificantly from zero. In addition, greater trade intensity appears to have made for greater exchange-market volatility in the 1960s, while small countries experience more exchange market pressure in the 1970s.

In summary, our results suggest that asymmetric shocks increase exchange rate volatility by intensifying exchange market pressure, while small size and trade links reduce volatility by encouraging intervention. The factors to which OCA theory points as costs of a common currency tend to create exchange market pressure, while the factors to which it points as benefits of currency stability prompt intervention.

IV. Sensitivity Analysis

Measuring intervention as the (normalized) change in reserves may not be appropriate if intervention is unsterilized. We explored this possibility by adjusting currency variability for changes in money supply instead of changes in reserves. The results from reestimating the exchange-market pressure equations with this change in specification are in the top panel of Table 5. Our OCA-related variables explain more of the variance in this measure of exchange-market pressure in the ‘eighties than the ‘seventies and the ‘seventies than the ‘sixties. The idea that “OCA costs” explain exchange market pressure while “OCA benefits” explain intervention is less clearly supported: both sets of factors help to explain pressure in the ‘eighties, while neither goes very far toward explaining it in the ‘sixties.

We also measured intervention a third way, as the change in the interest differential, to test for intervention not captured by changes in reported reserves.[26] Our OCA specification works relatively well in the 1960s when intervention is measured using the interest differential,

[26] We generally measured interest rates using the money market rate (and, where that was unavailable, the treasury bill rate) from the IMF’s International Financial Statistics. Normalizing the interest differential in different ways (for example, using different estimates of the interest semi-elasticity of money demand) made little difference for the results; in the end we simply subtracted its level from the measure of exchange-rate variability.

relatively well in the 1980s when intervention is measured using changes in the money supply, and relatively well in the 1970s under both specifications, perhaps reflecting gradual changes over time in the instruments utilized by central banks.

Finally, we considered four variables suggested by the literature on choice of exchange arrangements and one measure of the international regime. To test whether capital controls provide significant insulation from exchange-market pressure, making it easier for countries to stabilize nominal rates, we included an indicator of their presence constructed from tabulations of restrictions on capital-account transactions published in the International Monetary Fund's Exchange and Trade Restrictions volumes.[27] As a measure of financial development we included the ratio of broad money to GDP (constructed as the average of the two countries money/GDP ratios). To capture the idea that more open economies will be more inclined to employ an external anchor, we included the average trade-to-GDP ratio (where trade equals exports plus imports) for the two countries.[28] (This variable was instrumented, since it should be endogenous for the same reasons as bilaterl trade.) As a measure of aymmetric monetary disturbances, we included the average difference in the absolute change in the log of the money supply. Because neither openness or the growth of money supplies was statistically

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[27] Our measure of controls ranges from zero to six, with larger values indicating more comprehensive restrictions.

[28] This is distinct from the tendency for two countries that trade disproportionately with one another to peg their exchange rate as a way of preventing exchange rate volatility from disrupting their commerce, a factor for which we have already controlled by including a measure of bilateral trade.

significant and economically important in any of the three decades; we dropped from the specification reported in Table 5.[29]

Our measure of the international regime is the arithmetic average of the variability of the U.S. dollar exchange rates of each country pair. This is designed to capture the idea that when the dollar was pegged governments were not forced to trade off stability vis-a-vis third currencies against stability vis-a-vis the dollar, which should have increased the attractions of pegging to third countries.[30]

The additional variables (none of which were instrumented) add little to the explanatory power of the regression (as measured by the R^2). The predictions of OCA theory, in other words, provide as satisfactory an explanation for exchange market pressure as the extended model. Including the additional regressors does not much change the estimates of the four OCA variables, although their coefficients become somewhat less well defined. Still, a few of the new results are informative. Capital controls tend to be associated with lower exchange market pressure, consistent with the belief that they had significant insulating power, especially in the 1960s and 1970s.[31] And higher ratios of money to output are negatively

[29]In particular, we find little evidence that more open economies are more inclined to peg, consistent with the findings of Honkapohja and Pikkarainen (1992).

[30]This variable takes on a value of zero when the U.S. is one of the two partner countries.

[31]When we added these same regressors to the equations for the variability of the actual exchange rate and intervention, we found that capital controls were negatively and significantly associated with exchange-rate variability but never significantly associated with itnervention, consistent with this interpretation.

associated with exchange-market pressure, significantly so in the 1960s, as if financial markets in such countries are better able to absorb shocks.[32]

Results from our proxy for the exchange-rate regime suggest that the structure of the international system matters for countries' exchange rate policy. The “system” variable is positive in all three decades but falls in size and significance over time, as if pressure on dollar exchange rates had a greater tendency to spill over into pressure on other bilateral rates in the 1960s and 1970s than in the 1980s (reflecting the declining dominance of the dollar as the anchor for the entire network of bilateral rates in the post-Bretton Woods years).

In the equations for actual exchange rate variability (not reported but available from the authors on request), the dollar rate entered positively and significantly in the 1960s and 1970s, and negatively and significantly in the 1980s. Our interpretation is as follows. Under the Bretton Woods System of pegged-but-adjustable rates, stabilization against the dollar implied stabilization against other currencies; since countries with more stable dollar rates also had more stable rates vis-a-vis other currencies, the coefficient on the "system" variable is positive. Similarly, in the turbulent 1970s, the dollar remained a center for monetary stability. In the 1980s, however, the emergence of Germany as an alternative center of monetary gravity to which other industrial countries, especially in Europe, might peg forced them to choose between stability against the dollar and stability against the mark. Because the U.S. and German currencies fluctuated widely against one another, stabilizing the exchange rate against one anchor currency meant accepting greater variability against the other, with

[32]Consistent with this interpretation, the money/GDP ratio had a significant negative coefficient in the 1960s in the equation for the variability of the actual rate but not the equation for intervention.

stability against the mark being achieved in Europe through extensive intervention despite the continuing underlying role of the dollar. Hence, the coefficient on our "system" variable is negative in this regression. This is evidence, then, that not just country characteristics but also the structure of the international system matters for countries' choice of exchange rate regime.

Overall, then, the results of estimating the extended model point in the same direction as the simple OCA specification. Exchange market pressures largely reflect the magnitude of asymmetric shocks (“OCA costs”), while intervention is driven by the value attached to stable exchange rates (“OCA benefits”). The additional variables do, however, point to some further factors at work. Exchange market pressures also depend upon an economy's financial structure, in particular the level of capital controls and the depth of financial markets. And the results point to the continued importance of the U.S. dollar for the operation of the international system. Exchange market pressure is positively associated with shocks to the dollar exchange rate, although the magnitude of this effect falls over time, presumably reflecting the declining dominance of the United States in the international economy.

V. Conclusions

In this paper we have attempted to link the theory of optimum currency areas to the exchange rates of the industrial countries. Contrary to the presumption informing much of the literature, we find that variables to which the theory points have considerable explanatory power. Countries with more variable exchange rates are subject to larger asymmetric shocks. Those with more stable rates suffer the greatest reduction in the transaction value of the domestic currency when their exchange rates vary, due to their small size and dependence on trade. While asymmetric shocks increase exchange rate variability by magnifying exchange market pressure (by disturbing underlying market conditions, in other words), small size and trade dependence reduce exchange rate variability by prompting intervention. These findings, which we take as the core implications of the theory of optimum areas, are strongly supported by the data.

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Table 4. Results Using Optimum Currency Areas Variables

	1960s	1970s	1980s
		Variability of the Actual Exchange Rate	
Variability of output	1.29 (0.37)**	2.09 (0.62)**	1.61 (0.66)*
Trade ratio (x10^{-2})	0.03 (0.08)	-0.54 (0.11)**	-0.82 (0.10)**
Size of economy (x10^{-2})	0.03 (0.15)	2.26 (0.27)**	2.74 (0.29)**
Dissimilarity of exports (x10^{-2})	0.92 (0.35)**	0.47 (0.78)	1.75 (0.69)*
R^2	0.10	0.32	0.50
		Variability of Exchange Rate Pressure	
Variability of output	2.08 (0.58)**	2.43 (0.82)**	11.02 (1.94)**
Trade ratio (x10^{-2})	0.31 (0.13)*	-0.18 (0.14)	0.06 (0.32)
Size of economy (x10^{-2})	-0.24 (0.24)	0.59 (0.37)+	-0.44 (0.86)
Dissimilarity of exports (x10^{-2})	3.32 (0.54)**	1.93 (1.03)+	-2.33 (2.04)
R^2	0.22	0.15	0.44
		Index of Intervention	
Variability of output	-6.61 (4.53)	-5.51 (4.14)	19.67 (6.55)**
Trade ratio (x10^{-2})	1.36 (0.99)	2.98 (0.72)**	5.57 (1.06)**
Size of economy (x10^{-2})	-4.32 (1.89)*	-13.88 (1.85)**	-17.40 (2.89)**
Dissimilarity of exports (x10^{-2})	1.64 (4.23)	8.93 (5.20)+	8.40 (6.87)
R^2	0.05	0.27	0.30

Notes: Standard errors are reported in parentheses. One and two asterisks indicate that the coefficient is significant at the 5 and 1 percent probability level, respectively, a plus significance at the 10 percent level. Constant terms are not reported. The instruments for variability of output and trade are distance, size of each economy, squares of variables, and dummy variables for a common border and common language. See the text for an explanation of the variables.

Table 5. Results Using Optimum Currency Areas Variables

	1960s		1970s		1980s	
			Money Supply Adjusted Exchange Rate Pressures			
Variability of output	0.21	(0.76)	3.37	(0.83)**	2.66	(1.17)*
Trade ratio (x10^{-2})	-0.14	(0.17)	-0.31	(0.14)*	-0.58	(0.19)**
Size of economy (x10^{-2})	0.63	(0.31)*	1.55	(0.37)**	1.33	(0.52)**
Dissimilarity of exports (x10^{-2})	0.91	(0.71)	-0.39	(1.04)	9.50	(1.23)**
R^2	0.05		0.18		0.41	
			Interest Rate Adjusted Exchange Rate Pressures			
Variability of output	1.75	(0.58)**	2.18	(0.81)**	10.52	(1.95)**
Trade ratio (x10^{-2})	0.28	(0.13)*	-0.16	(0.14)	-0.02	(0.31)
Size of economy (x10^{-2})	-0.13	(0.24)	0.77	(0.33)*	-0.39	(0.86)
Dissimilarity of exports (x10^{-2})	3.65	(0.54)**	2.91	(1.02)**	-1.40	(2.04)
R^2	0.22		0.18		0.42	
			Extended Regressions Using Exchange Rate Pressure			
Variability of output	3.68	(0.71)**	3.96	(1.23)**	13.13	(1.97)**
Trade ratio (x10^{-2})	0.24	(0.13)*	-0.21	(0.17)	0.25	(0.34)
Size of economy (x10^{-2})	-0.25	(0.31)	1.26	(0.66)*	0.67	(1.14)
Dissimilarity of exports (x10^{-2})	2.40	(0.61)**	0.53	(1.33)	-3.07	(2.40)
Capital controls (x10^{-2})	-2.43	(0.45)**	-1.21	(0.36)**	-1.14	(1.08)**
Money Ratio (x10^{-1})	-6.48	(1.89)**	-1.17	(2.56)	0.07	(0.63)
Variability of US rate	0.36	(0.09)**	0.28	(0.12)**	0.26	(0.17)
R^2	0.36		0.15		0.44	

Notes: See Table 4.