# ECONOMIC EFFECTS OF CURRENCY UNIONS

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*We develop a new instrumental-variable (IV) approach to estimate the effects of different exchange rate regimes on bilateral outcomes. The basic idea is that the characteristics of the exchange rate between two countries are partially related to the independent decisions of these countries to peg—explicitly or de facto—to a third currency, notably that of a main anchor. This component of the exchange rate regime can be used as an IV in regressions of bilateral outcomes. We apply the methodology to study the economic effects of currency unions. The likelihood that two countries independently adopt the currency of the same anchor country is used as an instrument for whether they share a common currency. We find that sharing a common currency enhances trade, increases price comovements, and decreases the comovement of real gross domestic product shocks.* (*JEL* C3, F3, F4)

## I. INTRODUCTION

A vast empirical literature in international finance investigates the effects of exchange rate regimes on different economic outcomes. For example, several studies have analyzed the effect of exchange rate variability on bilateral trade, foreign direct investment, and relative prices. Other studies have focused on the differential effects of pegged-versus-fixed exchange rates (including stricter forms of fixed exchange rate regimes, such us currency boards or currency unions). The underlying assumption in most studies is that exchange rate regimes are randomly assigned and, hence, exogenous to the outcome variable under study. Standard endogeneity problems, however, can hide the true effect of exchange rate regimes in simple ordinary least square (OLS) estimates. For example, the choice of exchange rate regimes might reflect omitted characteristics that can also influence the economic outcome. Similarly, the adoption of a certain regime might come with other (unmeasured) policies that also affect the outcome.

The first contribution of this paper is to develop an instrumental-variable (IV) approach to address the endogeneity problem present in the estimation of the effects of exchange rate regimes on economic variables, such as bilateral capital flows, trade volumes, and comovement of business cycles. As an illustration, consider two countries that exhibit a low extent of exchange rate variability between them. There are several reasons for this low variability. Some reasons might be related to the deliberate decision of facilitating trade between the two countries, leading to a bias in OLS estimates of the effect of exchange rate variability on the volume of bilateral trade.[1] Another reason, however, might be related to the independent decisions of these two countries to keep a close parity with a third country's currency. In this case, the level of exchange rate variability between the two countries will be exogenous to their bilateral trade. The methodology proposed in this study exploits this triangular relationship with third countries to identify the economic effect of different exchange rate regimes or features of exchange rate regimes (e.g., variability) on bilateral outcomes. In particular, following this example, the methodology isolates the motive for low (or high) variability

*We are grateful to Alberto Alesina, Francesco Caselli, Doireann Fitzgerald, Kenneth Rogoff, Andy Rose, and Jeffrey Wurgler. This research has been supported, in part, by a grant from the National Science Foundation.

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1. Typically, two countries that want to foster trade between themselves will also be more likely to undertake other steps, such as reduction of bilateral tariff and non-tariff barriers. To the extent that these steps cannot be measured in the data, an OLS estimation will attribute all the credit to the low variability.



Economic Inquiry
(ISSN 0095-2583)
Vol. 45, No. 1, January 2007, 1–23

doi:10.1111/j.1465-7295.2006.00001.x
Online Early publication November 27, 2006

that relates to the objective of pegging to a third currency and uses this motivation as an IV for the extent of variability.

While the methodology developed in this paper can be applied to the analysis of different exchange rate arrangements, we illustrate it here with one specific application: the effect of currency unions on bilateral trade and on the extent of comovement of output shocks and price shocks.

Assessing the economic effects of currency unions is imperative, given the recent developments in international monetary arrangements. Twelve Western European countries have recently instituted the euro as their common currency. Sweden, Denmark, and Britain have opted out, but they might join in the near future. Several Eastern European countries are debating the unilateral adoption of the euro as legal tender. Ecuador fully dollarized its economy; El Salvador and Guatemala legalized the use of the U.S. dollar, and other governments in South and Central America are giving serious consideration to dollarization. Six West African states are considering the adoption of a common currency, and 11 members of the Southern African Development Community are debating whether to adopt the U.S. dollar or to create an independent currency union possibly anchored to the South African rand.[2] Finally, six oil-producing countries have expressed their intention to form a currency union by 2010.[3]

A number of recent papers estimate the effect of currency unions on bilateral trade. Most notably, Rose (2000) and Frankel and Rose (2002) report that bilateral trade between two countries that use the same currency is, controlling for other effects, over 200% larger than bilateral trade between countries that use different currencies. The underlying assumption in these studies is that currency unions are randomly assigned. As suggested before, unmeasured characteristics might create spurious links between currency-union status and bilateral trade. For example, compatibility in legal systems, greater cultural links, better infrastructure for bilateral transportation, and tied bilateral transfers may increase the propensity to share a common currency as well as encourage trade between two countries. Similarly, countries willing to share a common currency may also take additional (unmeasured) policies to foster integration and facilitate trade. These omitted characteristics could lead to a positive bias in simple OLS estimates. Other omitted variables may cause a downward bias in OLS estimates. As an example, higher levels of monopoly distortion in a country's economy mean higher markups, which tend to deter trade. At the same time, high levels of monopoly distortion may lead to higher inflation rates under discretion and therefore increase the need to join a currency union as a commitment device to reduce inflation.[4] In this paper we revisit previous estimates of the currency-union effect on trade using the new instrument to address the endogeneity problem.

Trade is not the only interesting variable affected by currency union. Monetary unions might also alter the extent of synchronization of shocks and the patterns of comovement among participants. This consideration is relevant for determining the suitability of the adoption of a foreign currency or participation into currency unions: countries evaluating the decision to join or not should take into account the effect that different currency arrangements have on the patterns of comovement. By adopting a foreign currency or forming a currency union, countries lose the independence to tailor monetary policy to local needs. If currency unions lead to higher synchronization of shocks, this change will generate greater consensus over the direction of monetary policy and reduce the cost of giving up monetary-policy independence. The opposite will be true if currency unions induce less synchronization. Hence, this paper also investigates the effects of currency unions on the patterns of comovement of prices and real gross domestic product (GDP) shocks.

In order to construct the IV, we first estimate the probability that a given country adopts the currency of a main anchor country.

2. The group of West African countries includes Ghana, Nigeria, Liberia, Sierra Leone, Gambia, and Guinea. Initial participants in the Southern African currency union will be South Africa, Botswana, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Swaziland, Tanzania, and Zimbabwe. Zambia is expected also to confirm its membership. Angola, the Democratic Republic of Congo, and Seychelles, also members of the Southern African Development Community, will not join the monetary union.

3. This group includes Saudi Arabia, United Arab Emirates, Bahrain, Oman, Qatar, and Kuwait.

4. Barro and Tenreyro (2006).

The estimation of the relationship "client-anchor," in the terminology used by Alesina and Barro (2002), is interesting in its own right, as it elucidates part of the reason why countries adopt a foreign currency or join currency unions. The IV is then obtained by computing the joint probability that two countries, independently, adopt the same currency. The underlying assumption in the analysis is that there exist factors driving the decision to adopt a third country's currency that are independent of the bilateral links between two potential clients. In other words, the basic idea is to isolate the motive that relates to third countries' currencies and use this motivation as an IV for whether two countries do or do not share a common currency.

The main results of this study are the following. First, regarding the motivation to adopt a foreign anchor's currency, the probability of adoption increases when (1) the client speaks the same language as the anchor, (2) the client is geographically closer to the anchor, (3) the client was a former or current colony of the anchor, (4) the client is poorer in terms of GDP per capita, (5) the client is smaller in terms of population size, and (6) the anchor is richer in terms of per capita GDP.

Second, the IV estimates of the impact of currency unions on bilateral trade indicate a significant positive effect, supporting previous findings by Rose (2000) and coauthors. In other words, endogeneity bias is not responsible for the large effects previously documented.

Third, while OLS estimates indicate that currency unions do not affect the extent of comovement of output shocks, the IV estimates suggest that currency unions may decrease the comovement of output shocks. This finding is consistent with the view that currency unions enhance sectoral specialization, and shocks tend to affect sectors asymmetrically. The bias in OLS is the result of reverse causality: countries with higher comovement are more likely to form currency unions. Finally, the comovement of price shocks increases with currency unions, which supports the observation that a large part of the fluctuations in real exchange rates is due to fluctuations in nominal exchange rates.

The paper is organized as follows. Section II discusses the endogeneity problem in previous empirical analyses of currency unions. It then discusses how the IV approach can be applied to study the economic effects of different exchange rate arrangements. Section III studies the motivation to link the currency to a main anchor. Section IV revisits the currency-union effect on trade. Section V estimates the effects of currency unions on the extent of comovement of prices and outputs. Section VI summarizes and concludes.

## II. ENDOGENEITY BIAS AND A NEW IV APPROACH

### A. Endogeneity

The empirical work on the effects of currency unions (or indeed, other exchange rate arrangements) on trade has been framed within the standard "gravity equation" model. The model states that bilateral trade between a pair of countries increases with the sizes of the countries and decreases with their distance, broadly construed to include all factors that create "trade resistance." The gravity equation is then augmented with a dummy variable indicating whether or not the countries share the same currency. In his seminal paper in the area, Rose (2000) reports that bilateral trade between countries that use the same currency is over 200% larger than bilateral trade between countries with different currencies. Subsequent papers, including Frankel and Rose (2002), Rose and van Wincoop (2001), and Glick and Rose (2002), have expanded the analysis and generally confirmed the large enhancement effect of currency unions on trade. Alesina, Barro, and Tenreyro (2002) summarize and discuss these findings.

The implicit assumption in the various empirical studies is that currency unions (or, more generally, exchange rate arrangements) are randomly formed among countries.[5] Standard endogeneity problems, however, can confound the estimates. For example, countries that would naturally trade more might share characteristics that tend to make them more prone to form a currency union. In addition, countries that decide to join a currency union might also be more likely to foster integration through other means, for example, by encouraging the harmonization of standards to enhance competition and trade and by reducing regulatory barriers. These unmeasured characteristics—to the extent that they affect or are correlated with the propensity

5. For an exception, see Persson (2001).

to share a common currency and the volume of bilateral trade—will bias OLS estimates of the currency-union effect. The use of country-pair fixed effects employed in some studies may not eliminate the bias because a shift at some point in time in trade volumes may be related to a change in the propensity to use a common currency.

### *B. A New Approach*

Two countries may be motivated to share a common currency for several reasons. In order to eliminate the endogeneity bias discussed in the previous section, one needs to isolate the part of the motivation that is exogenous to the bilateral link between the two countries. As an example, consider two countries that use a common currency, say Senegal and Togo, both of which belong to the Financial Community of Africa (CFA) franc zone. Part of the reason why they share a common currency is that both countries want to keep the French franc (now the euro) as a nominal anchor.[6] However, other considerations not related to France but to the objective of promoting political and economic integration between Senegal and Togo may have influenced the decision to share a common currency. These other considerations are likely to bias OLS estimates of the effects of currency unions on trade. Hence, separating out the relation with the anchor provides an instrument to estimate the effect of sharing a common currency on bilateral trade.

Alesina and Barro (2002) provide a formal model for the anchor-client relationship in the context of the currency-union decision. The model shows that countries with lack of internal discipline for monetary policy (as revealed by a history of high and variable inflation) stand to gain more from giving up their currencies, provided that the anchor country is able to commit to sound monetary policy. This commitment is best protected when the anchor is large and the client small (otherwise, the anchor may find it advantageous to relinquish its commitment). In addition, the model shows that, under reasonable assumptions, client countries benefit more from adopting the currency of an anchor with which they would naturally trade more, that is, an anchor with which trading costs—other than the ones associated with the use of different currencies—are small. The model also predicts that small countries benefit more from giving up their currency, and the benefit increases with the size of the anchor. These features of the relation between clients and anchors are used to guide the instrumentation.

To construct the instrument, we use a probit analysis for all country pairings from 1960 to 1997 with six potential anchors that fit the theoretical characterization of Alesina and Barro (2002). Two important characteristics here are country size (GDP) and a record of low and stable inflation. The group of potential anchors that we use consists of Australia, France, Germany, Japan, the United Kingdom, and the United States. The probit regressions include various measures of distance between clients and anchors (to proxy for trading costs) and the sizes of potential clients and anchors.

Suppose that a potential client country, $i$, is evaluating the adoption of the currency of one of the six anchors, denoted by $k$ ($k = 1, 2, \ldots, 6$). The probit regression determines the estimated probability $p(i, k, t)$ that client $i$ adopts the currency of anchor $k$ at time $t$. If the clients adopt an anchor currency independently, the joint probability that countries $i$ and $j$ use the currency of a common anchor $k$ at time $t$ is given by:

$$J^k(i,j,t) = p(i,k,t) \times p(j,k,t).$$

The probability $J^k(i, j, t)$ will be high if both countries are "close enough" to the potential anchor $k$. The joint probability that at time $t$, countries $i$ and $j$ use the same foreign currency, among the six candidates considered in this analysis,[7] is given by the sum of the joint probabilities over the support of potential anchors:[8]

6. The CFA franc has been tied, except for one devaluation, to the French franc, and the French Treasury has guaranteed the convertibility of CFA francs into French francs.

7. This approach neglects the possibility that country $i$ chooses the infeasible outcome of linking simultaneously with more than one of the anchors $k$. We could modify the analysis to rule out these outcomes. However, the results would not be affected because the probability of choosing two anchors simultaneously is negligible, given that each individual probability is itself small.

8. As will become clear in the empirical section, in the IV regressions, we exclude all pairs of countries, $(i, j)$, that include one of the anchors.

$$J(i,j,t) = \sum_{k=1}^{6} J^k(i,j,t) = \sum_{k=1}^{6} p(i,k,t) \times p(j,k,t).$$

The variable $J(i, j, t)$ can be used as an instrument for the currency-union dummy in the regressions for bilateral trade and comovements. The underlying assumption for the validity of the instrument is that the bilateral trade between countries $i$ and $j$ depends on gravity variables for countries $i$ and $j$ but not on gravity variables involving third countries, notably the potential anchors. Gravity variables involving third countries affect the likelihood that the clients $i$ and $j$ share a common currency and thereby influence bilateral trade and comovements between $i$ and $j$ through that channel. The assumption requires that these variables not influence the bilateral trade or the extent of comovement between $i$ and $j$ through other channels.

We should stress that the results are not sensitive to the use of alternative specifications for the probability function, such as logit or multinomial logit models. This last one, in particular, imposes the constraint that the sum of the probabilities to anchor to one of the potential anchors be less or equal to one (the probability of not anchoring is one minus this sum); this restriction, however, is not binding in this context, as the estimated probability of anchoring tends to be very small.

As mentioned in Section I, the endogeneity problem is pervasive in the literature studying the economic effects of exchange rate arrangements. Although this study focuses on the economic effects of currency unions, the methodology can also be applied to the study of different exchange rate arrangements. For example, consider the problem of estimating the effect of nominal exchange rate variability on bilateral trade (or any other bilateral outcome for which exchange rates cannot be considered exogenous). One could, in principle, isolate the part of the exchange rate variability that relates to the independent decision to peg (explicitly or de facto) to a low-inflation currency to overcome the lack of discipline in monetary policy.[9] In this context, one could instrument the extent of variability between two countries using the likelihood that two countries independently target the exchange rate of a common nominal anchor.

## III. DETERMINANTS OF CURRENCY UNIONS: THE ANCHOR-CLIENT RELATIONSHIP

Table 1 has summary statistics for the data. Panel A is for all country pairs, and Panel B is for pairs that include at least one of the six candidate anchors: Australia, France, Germany, Japan, United Kingdom, and United States. We use the Panel B sample for the probit regressions in Table 2.

The data come from Glick and Rose (2002), except for real GDP per capita and population, which come from the World Bank's *World Development Indicators*. The equations are for annual data, include year effects, and allow for clustering over time for country pairs. The dependent variable is based on countries sharing a common currency.[10] The independent variables include the measures of distance that are typically used in the gravity equation literature. We also use measures of size for the anchor and the client.

The second column in Table 2, Panel A, shows the estimated coefficients and their corresponding (clustered) standard errors. We use this probit estimation, which includes all our explanatory variables, as the benchmark–called, for convenience, P1. The third column shows the corresponding estimates of a probit model, called P2, that excludes year effects. As the table shows, there is little change in the estimated coefficients when year effects are excluded. The fourth column shows the probit estimates of a model, called P3, with year effects that exclude the statistically insignificant dummy variables for islands and

9. The form of the peg—and, hence, the dividing line for whether a country is a fixer or a floater—can vary. Crawling pegs, fixed exchange rates with bands of different widths, currency boards, and currency unions are illustrations of the range of options.

10. We depart from the definition of currency unions in Glick and Rose (2002) by treating the CFA countries as in a currency union with France. The main reason to do so is because France has guaranteed free convertibility of the CFA franc into French francs (and now into euros), and the CFA franc has been tied to the French franc, except for one devaluation in 1994. The French franc and currently the euro can and do circulate in the CFA zone. Likewise, we treat the countries in the Eastern Caribbean Currency Union as in a monetary union with the United Kingdom before 1976 and with the United States after that. In both periods, they maintained a strict peg with the British pound and the American dollar, respectively.

**TABLE 1**
Summary Statistics

| Variable | Mean | Standard Deviation |
|---|---|---|
| Panel A. All country pairs | | |
| Log of trade | 9.949 | 3.543 |
| Currency union | 0.022 | 0.147 |
| Log of distance | 8.199 | 0.826 |
| Contiguity dummy | 0.026 | 0.158 |
| Common language dummy | 0.215 | 0.411 |
| Ex-colony/colonizer dummy | 0.021 | 0.143 |
| Common colonizer dummy | 0.094 | 0.291 |
| Current colony (or territory) dummy | 0.002 | 0.041 |
| Regional trade agreement dummy | 0.016 | 0.124 |
| Max(log of per capita GDP in pair) | 8.880 | 1.253 |
| Min(log of per capita GDP in pair) | 6.958 | 1.277 |
| Max(log of population in pair) | 16.974 | 1.495 |
| Min(log of population in pair) | 14.727 | 1.643 |
| Max(log of area in pair) | 13.204 | 1.731 |
| Min(log of area in pair) | 10.533 | 2.339 |
| One landlocked country in pair dummy | 0.206 | 0.405 |
| Two landlocked countries in pair dummy | 0.014 | 0.116 |
| One island in pair dummy | 0.290 | 0.454 |
| Two islands in pair dummy | 0.038 | 0.191 |
| Year | 83.203 | 10.189 |
| Comovement of output shocks | −0.061 | 0.023 |
| Comovement of price shocks | −0.156 | 0.090 |
| Panel B. Subsample of anchor-client pairs | | |
| Currency union | 0.034 | 0.180 |
| Log of distance | 8.371 | 0.775 |
| Contiguity dummy | 0.022 | 0.146 |
| Common language dummy | 0.209 | 0.407 |
| Ex-colony/colonizer dummy | 0.090 | 0.286 |
| Common colonizer dummy | 0.000 | 0.000 |
| Current colony (or territory) dummy | 0.041 | 0.104 |
| Regional trade agreement | 0.028 | 0.166 |
| Max(log of per capita GDP in pair) | 9.915 | 0.349 |
| Min(log of per capita GDP in pair) | 7.488 | 1.479 |
| Max(log of population in pair) | 18.116 | 0.854 |
| Min(log of population in pair) | 15.155 | 1.850 |
| Max(log of area in pair) | 14.142 | 1.522 |
| Min(log of area in pair) | 11.192 | 2.261 |
| One landlocked country in pair dummy | 0.173 | 0.378 |
| Two landlocked countries in pair dummy | 0.000 | 0.000 |
| One island in pair dummy | 0.402 | 0.490 |
| Two islands in pair dummy | 0.066 | 0.249 |
| Year | 80.772 | 10.825 |

*Notes:* In Panel A, the number of observations ($N$) is $N$ = 185,580 except for comovement of output shocks ($N$ = 7,610) and price shocks ($N$ = 7,218). In Panel B, $N$ = 29,988.

landlocked status. The last column shows another probit model, called P4, without year effects and the dummy variables for islands and landlocked status.

Panel B of Table 2 shows the corresponding marginal effects evaluated at the mean values of all variables. Since in this sample only 3.4% of the pairs share a common currency, evaluating the effects at the mean is almost equivalent to evaluating at the mean of the subsample of pairs that do not share a common currency. In other words, the typical country in this sample is far from considering the adoption of a foreign currency. Given that the marginal effects are highly nonlinear, we also computed the marginal effects at the mean of the subsample of pairs sharing a common currency. These values are in Panel C of Table 2. The relevant effects for the marginal country, that is, a country that is close to indifferent about adopting the currency of a potential anchor, would lie somewhere in between.

Table 2 shows that the probability that a country uses the currency of one of the main anchors increases when (1) the client speaks the same language as the anchor, (2) the client is geographically closer to the anchor, (3) the client was a former or current colony of the anchor, (4) the client is poorer in terms of GDP per capita, (5) the client is smaller in terms of population size, and (6) the anchor is richer—among the six anchors considered—in terms of per capita GDP. Notice that the existence of regional trade agreements tends to decrease the propensity to form currency unions.[11] Other geographical characteristics, such as access to the ocean or being an island, do not seem relevant for adopting a foreign currency, once the other control variables are included.

Models P1–P4 are used later to construct the instrument. A question one might ask is to what extent the bilateral variables between each client and the third anchors convey new information beyond the bilateral variables between two potential clients. More concretely, consider whether the joint probability of adopting an anchor's currency, $J(i, j, t)$, adds information, given that the regressions control separately for the bilateral characteristics of the two clients, $i$ and $j$. The key point is that the bilateral relations are not transitive. As a first example, the geographical distance from client $i$ to anchor $k$ and that from client $j$ to anchor $k$ do not pin down the distance between $i$ and $j$. This distance depends on the location of the countries. Similarly, because the language variable recognizes that countries can speak more than one main language, the relation is again nontransitive. For example, if anchor $k$ speaks only French and country $i$ speaks English and French, $k$ and $i$ speak the same language. If another country, $j$, speaks only English, it does not speak the same language as $k$. Nevertheless, $i$ and $j$ speak the same language.

As explained later, we investigate robustness of our estimates by using alternative specifications of the instrument. The specifications differ depending on the control variables that are kept fixed in the computation of $J(i, j, t)$. In particular, we allow the instrument to vary only with "distance" measures, for which the nontransitivity is evident.

## IV. TRADE

Table 3 shows the regressions of bilateral trade on the currency-union dummy and the various gravity characteristics. The regressions use annual data from 1960 to 1997 for all pairs of countries for which data are available. The dependent variable is the logarithm of bilateral trade. The variables included as controls are standard in the gravity equation literature; they comprise various measures of distance and size.[12] The systems include year effects and allow the error terms to be correlated over time for a given country pair. The second column differs in that it includes country fixed effects, which are aimed at controlling for remoteness and other country-specific factors

11. One interpretation of the negative relation can be the following. Well-functioning economies are less likely to use import tariffs and seigniorage as sources of fiscal revenue. Hence, these economies will be more likely to sign free-trade agreements. At the same time, a smaller need for seigniorage revenues reduces the need for commitment (because the inflationary bias stemming from the incentives to monetize budget deficits is smaller). A lower inflationary bias decreases the value of currency unions as commitment devices to temper inflation. This may explain why, in the data, countries that do not need currency unions as an external commitment are also more likely to sign regional trade agreements. Including the European Monetary Union might change this historical pattern, as countries in the European Monetary Union have previously signed free-trade agreements and, most likely, the search for commitment was not the main motivation for the union.

12. Information on bilateral trade, distance, contiguity, access to water, language, colonial relationships, regional trade agreements, and currency unions come, as before, from Glick and Rose (2002). Data on real per capita GDP and population come from the World Bank's *World Development Indicators.* As already explained, the currency union dummy is modified to reflect the link of the CFA franc to the French franc and the link of the Eastern Caribbean dollar to the British pound before 1976 and the American dollar thereafter.

**TABLE 2**
Propensity to Adopt the Currency of Main Anchors

| | Dependent Variable: Currency-Union Dummy | | | |
|---|---|---|---|---|
| | **P1** | **P2** | **P3** | **P4** |
| Panel A. Probit estimates | | | | |
| Log of distance | −1.15193** (0.20217) | −1.21869** (0.20101) | −1.14505** (0.18751) | −1.23296** (0.19439) |
| Contiguity dummy | −1.74841* (0.69799) | −1.70551* (0.68294) | −1.99707** (0.65648) | −1.89314** (0.63279) |
| Common language dummy | 1.13577** (0.30587) | 1.09189** (0.29262) | 1.09401** (0.29541) | 1.08718** (0.29137) |
| Ex-colony/colonizer dummy | 2.21711** (0.26173) | 1.91282** (0.21965) | 2.02862** (0.24524) | 1.77849** (0.20872) |
| Current colony (or territory) dummy | 0.52011 (0.38357) | 0.68842 (0.37978) | 0.43407 (0.37894) | 0.61972 (0.37858) |
| Regional trade agreement | −0.65006* (0.32972) | −1.05111** (0.29073) | −0.61510 (0.40982) | −1.00622** (0.33950) |
| Max(log of per capita GDP in pair) | 1.90668** (0.45607) | 0.45396 (0.28881) | 1.70968** (0.45179) | 0.40294 (0.28305) |
| Min(log of per capita GDP in pair) | −0.33087** (0.08846) | −0.29874** (0.08469) | −0.30952** (0.08395) | −0.28952** (0.08375) |
| Max(log of population in pair) | 0.11085 (0.14700) | 0.18145 (0.14582) | 0.03976 (0.15107) | 0.11182 (0.14061) |
| Min(log of population in pair) | −0.38498** (0.08602) | −0.39318** (0.08556) | −0.38101** (0.08002) | −0.38586** (0.07996) |
| Max(log of area in pair) | 0.35460** (0.06692) | 0.32184** (0.06071) | 0.32907** (0.06624) | 0.30755** (0.05960) |
| Min(log of area in pair) | 0.02116 (0.07028) | 0.06655 (0.07157) | 0.02749 (0.06029) | 0.07060 (0.06242) |
| One landlocked country in pair dummy | −0.49934 (0.33822) | −0.37049 (0.32908) | | |
| One island in pair dummy | −0.26217 (0.31692) | −0.26750 (0.31370) | | |
| Two islands in pair dummy | 0.40178 (0.37475) | 0.32912 (0.38531) | | |
| Year effects | Yes | No | Yes | No |
| Observations | 29,988 | 29,988 | 29,988 | 29,988 |
| Panel B. Marginal effects evaluated at means | | | | |
| Log of distance | −0.00093 | −0.00138 | −0.00165 | −0.00203 |
| Contiguity dummy | −0.00025 | −0.00035 | −0.00047 | −0.00053 |
| Common language dummy | 0.00426 | 0.00509 | 0.00626 | 0.00686 |
| Ex-colony/colonizer dummy | 0.06610 | 0.04595 | 0.06572 | 0.04473 |
| Current colony (or territory) dummy | 0.00111 | 0.00274 | 0.00134 | 0.00301 |
| Free-trade agreement dummy | −0.00021 | −0.00034 | −0.00039 | −0.00050 |

| | | | | |
|---|---|---|---|---|
| Max(log of per capita GDP in pair) | 0.00154 | 0.00051 | 0.00247 | 0.00066 |
| Min(log of per capita GDP in pair) | −0.00027 | −0.00034 | −0.00045 | −0.00048 |
| Max(log of population in pair) | 0.00009 | 0.00021 | 0.00006 | 0.00018 |
| Min(log of population in pair) | −0.00031 | −0.00045 | −0.00055 | −0.00063 |
| Max(log of area in pair) | 0.00029 | 0.00036 | 0.00048 | 0.00051 |
| Min(log of area in pair) | 0.00002 | 0.00008 | 0.00004 | 0.00012 |
| One landlocked country in pair dummy | −0.00025 | −0.00029 | | |
| One island in pair dummy | −0.00020 | −0.00029 | | |
| Two islands in pair dummy | 0.00063 | 0.00063 | | |
| Panel C. Marginal effects evaluated at means of currency-union pairs | | | | |
| Log of distance | −0.43658 | −0.44585 | −0.42999 | −0.44757 |
| Contiguity dummy | −0.36607 | −0.33218 | −0.36772 | −0.33408 |
| Common language dummy | 0.34219 | 0.31197 | 0.32743 | 0.30693 |
| Ex-colony/colonizer dummy | 0.62178 | 0.53830 | 0.58009 | 0.50672 |
| Current colony (or territory) dummy | 0.20382 | 0.26654 | 0.16916 | 0.23903 |
| Free-trade agreement dummy | 0.08641 | 0.05509 | 0.10632 | 0.06104 |
| Max(log of per capita GDP in pair) | 0.72262 | 0.16608 | 0.64202 | 0.14627 |
| Min(log of per capita GDP in pair) | −0.12540 | −0.10929 | −0.11623 | −0.10510 |
| Max(log of population in pair) | 0.04201 | 0.06638 | 0.01493 | 0.04059 |
| Min(log of population in pair) | −0.14590 | −0.14384 | −0.14308 | −0.14007 |
| Max(log of area in pair) | 0.13439 | 0.11774 | 0.12357 | 0.11164 |
| Min(log of area in pair) | 0.00802 | 0.02435 | 0.01032 | 0.02563 |
| One landlocked country in pair dummy | −0.17537 | −0.12714 | | |
| One island in pair dummy | −0.09712 | −0.09508 | | |
| Two islands in pair dummy | 0.15754 | 0.12594 | | |

*Notes:* The sample consists of country pairs that include the six candidate anchors: Australia, France, Germany, Japan, the United Kingdom, and the United States. The equations are for annual data and allow for clustering over time for country pairs. Constant included. Clustered standard errors are shown in parentheses. The definition of currency union treats the CFA franc countries as linked to France and treats the Eastern Caribbean Currency Area (ECCA) countries as linked to the United States since 1976 and to the United Kingdom before 1976. The mean of the currency-union dummy for this sample is 0.034. For dummy variables, the effect refers to a shift from zero to one. Panel B shows marginal effects evaluated at mean values. Panel C shows marginal effects evaluated at mean values corresponding to the subsample of currency-union pairs.

*Significant at 5%; **significant at 1%.

**TABLE 3**
Currency Union and Trade. OLS Estimates. All Country Pairs

| | OLS | |
|---|---|---|
| | Dependent Variable: log(trade) | |
| | Without Fixed Effects | With Fixed Effects |
| Currency union | 0.671** (0.112) | 0.959** (0.114) |
| Log of distance | −1.147** (0.023) | −1.325** (0.024) |
| Contiguity dummy | 0.568** (0.131) | 0.366** (0.133) |
| Common language dummy | 0.447** (0.046) | 0.305** (0.047) |
| Ex-colony/colonizer dummy | 1.174** (0.132) | 1.287** (0.129) |
| Current colony (or territory) dummy | 1.317** (0.195) | 1.374** (0.309) |
| Common colonizer dummy | 0.850** (0.075) | 0.690** (0.070) |
| Regional trade agreement | 0.450** (0.157) | 0.147 (0.177) |
| Max(log of per capita GDP in pair) | 1.072** (0.016) | 1.189** (0.039) |
| Min(log of per capita GDP in pair) | 0.908** (0.014) | 1.155** (0.036) |
| Max(log of population in pair) | 0.955** (0.016) | −0.111 (0.068) |
| Min(log of population in pair) | 0.978** (0.014) | −0.030 (0.065) |
| Max(log of area in pair) | −0.064** (0.013) | |
| Min(log of area in pair) | −0.047** (0.011) | |
| One landlocked country in pair dummy | −0.596** (0.040) | |
| Two landlocked countries in pair dummy | −0.699** (0.116) | |
| One island in pair dummy | −0.011 (0.044) | |
| Two islands in pair dummy | 0.682** (0.108) | |
| Country fixed effects | No | Yes |
| Country fixed effects Wald test, *p* value | | .000 |
| Year fixed effects | Yes | Yes |
| Year fixed effects Wald test, *p* value | .000 | .000 |
| Observations | 185,580 | 185,580 |
| $R^2$ | .66 | .71 |

*Notes:* The equations use annual data from 1960 to 1997, include year effects, and allow for clustering of the error terms over time for country pairs. Country effects refer to each member of the pair not to a country pair.
*Significant at 5%; **significant at 1%.

that inhibit trade, as in Rose and van Wincoop (2001).[13]

Most of the gravity variables have the expected signs: geographical proximity, common border, access to land, common language, common colonial history, and size; all increase the volume of trade between two countries. When country fixed effects are included, however, free-trade agreements and population size do not significantly affect trade.

In the OLS system in Table 3, the estimated coefficient on the currency-union dummy is .67 without country fixed effects and .96 with country fixed effects. These results are consistent with Rose (2000), despite the different definition of currency union used in this study.[14]

One problem with standard estimation of the gravity equations is that the logarithmic specification leads to the exclusion of observations with zero values for trade. While this omission should not, in principle, bias the coefficient on the currency-union dummy in any particular direction, it suggests that the standard specification used in the literature is not entirely appropriate. To address this potential source of bias, we estimated the gravity equation with a censored maximum likelihood procedure, which allows for a

13. Time-invariant country-specific variables are excluded when the country fixed effects are included.

14. The estimated effect of the currency-union dummy is larger when using Rose's stricter definition of a union. The estimated coefficients are then 0.99 without fixed effects and 1.14 with fixed effects.

**TABLE 4**
Currency Union and Trade. Censored Maximum Likelihood Estimate. All Country Pairs

| | Censored Maximum Likelihood Estimates | |
|---|---|---|
| | Dependent Variable: log(trade) | |
| | Without Fixed Effects | With Fixed Effects |
| Currency union | 0.644** (0.031) | 0.895** (0.031) |
| Log of distance | −1.093** (0.006) | −1.240** (0.006) |
| Contiguity dummy | 0.571** (0.029) | 0.353** (0.027) |
| Common language dummy | 0.434** (0.012) | 0.300** (0.012) |
| Ex-colony/colonizer dummy | 1.224** (0.031) | 1.282** (0.031) |
| Current colony (or territory) dummy | 1.283** (0.106) | 1.279** (0.097) |
| Common colonizer dummy | 0.809** (0.017) | 0.618** (0.018) |
| Regional trade agreement | 0.497** (0.036) | 0.165** (0.034) |
| Max(log of per capita GDP in pair) | 1.020** (0.004) | 1.051** (0.015) |
| Min(log of per capita GDP in pair) | 0.883** (0.004) | 1.092** (0.014) |
| Max(log of population in pair) | 0.919** (0.004) | −0.028 (0.027) |
| Min(log of population in pair) | 0.950** (0.004) | 0.118** (0.027) |
| Max(log of area in pair) | −0.060** (0.003) | |
| Min(log of area in pair) | −0.043** (0.003) | |
| One landlocked country in pair dummy | −0.577** (0.011) | |
| Two landlocked countries in pair dummy | −0.700** (0.037) | |
| One island in pair dummy | −0.018 (0.011) | |
| Two islands in pair dummy | 0.645** (0.024) | |
| Country fixed effects | No | Yes |
| Observations | 348,123 | 348,213 |

*Notes:* The equations use annual data from 1960 to 1997 and include year effects. The censored maximum likelihood procedure consists of two stages, one determining the fixed cost equation and the second determining the trade equation (reported).

*Significant at 5%; **significant at 1%.

second equation that indicates whether trade is positive or not.[15] The estimated coefficients using this procedure, shown in Table 4, are close to those obtained with the logarithmic specification using OLS. While not conclusive, these findings suggest that the coefficient on the currency-union dummy is affected little by the exclusion of the zero-valued observations.[16] For the rest of the paper, we use the logarithmic specification of the gravity equation and include country fixed effects.

Table 5 displays the OLS estimates obtained by excluding pairs with anchor countries from the estimation. These results will be helpful as a benchmark to compare the IV estimates, which exclude anchor countries from the estimation. With the exclusion of pairs that include anchor countries, the coefficient on the currency-union dummy falls from 0.959 (last column of Table 3) to 0.865.

Table 6 shows the basic IV results. The first-stage equation in Panel A relates the presence of a currency union to the bilateral variables included in the last column of Table 3 and to our key IV, which we call the *indirect probability of currency union.* This variable is constructed as the joint probability of countries $i$ and $j$ sharing the same currency by adopting the currency of one of the six candidate anchors. This probability comes from results of the form of Table 2. Note that, if $i$ or $j$ are themselves one of the anchors, the indirect probability would include the same bilateral variables that also enter separately as explanatory variables. Therefore, the sample for

15. This procedure was followed by Hallak (2006). The second equation is a proxy for fixed costs and depends on the various measures of distance and size.

16. We also estimated the gravity equation in its nonlinear formulation using Generalized Method of Moments, finding no substantial differences in the estimated coefficient of the currency-union dummy. These results are available on request from the authors.

**TABLE 5**
Currency Union and Trade. OLS Estimation. Country Pairs Excluding Anchor Countries

| | OLS |
|---|---|
| | **Dependent Variable: log(trade)** |
| Currency union | 0.865** (0.137) |
| Log of distance | −1.350** (0.026) |
| Contiguity dummy | 0.565** (0.132) |
| Common language dummy | 0.272** (0.051) |
| Ex-colony/colonizer dummy | 1.021** (0.261) |
| Current colony (or territory) dummy | 2.170** (0.327) |
| Common colonizer dummy | 0.712** (0.072) |
| Regional trade agreement | 0.648** (0.206) |
| Max(log of per capita GDP in pair) | 1.153** (0.043) |
| Min(log of per capita GDP in pair) | 1.172** (0.039) |
| Max(log of population in pair) | −0.015 (0.075) |
| Min(log of population in pair) | 0.099 (0.072) |
| Country fixed effects | Yes |
| Country fixed effects Wald test, $p$ value | .000 |
| Year fixed effects | Yes |
| Year fixed effects Wald test, $p$ value | .000 |
| Observations | 158,237 |
| $R^2$ | .65 |

*Notes:* The equations use annual data from 1960 to 1997, include year effects, and allow for clustering of the error terms over time for country pairs. The sample excludes pairs of countries that include at least one anchor.
*Significant at 5%; **significant at 1%.

Table 6 includes only pairs ($i$, $j$) that exclude any of the six candidate anchor countries.

The most important result in Table 6 is the statistically significant coefficient on the indirect probability of currency union. The $t$-statistic for this coefficient passes the Staiger-Stock test for not having a weak instrument.

Panel B of Table 6 shows the second-stage regression. The estimated effect of currency unions on bilateral trade is even larger than that indicated by OLS: the coefficient on the dummy variable is 1.9.[17] Hence, the results indicate that endogeneity is not the reason for the large effects found by Rose (2000) and coauthors. If anything, OLS results underestimate the impact of currency union on bilateral trade. Barro and Tenreyro (2006) offer a possible explanation for the negative bias. Economies with higher degrees of monopoly distortion and therefore higher markups feature lower trade (compared with the value predicted by the standard gravity equation). At the same time, these economies are more likely to join currency unions to eliminate the inflationary bias stemming from the high distortion.

Table 7 shows a set of robustness checks using alternative specifications of the instrument. Panel A shows the first-stage equations and Panel B shows the corresponding second stage. The first instrumental specification, shown in column IV1, is obtained from probit model P1, evaluating year effects and the landlocked and island dummies at their mean values in the probit prediction. The idea of this instrument is to keep fixed the variables that enter directly in the gravity equation (or that are captured by the country fixed effects). The second instrument, shown under IV2, is similar to IV1, with population and income controls also evaluated at their mean values. This specification ensures that population and income are not driving the exogenous variation in the instrument. IV3 uses the probit model P2, which excludes year effects from the estimation. IV4 is similar to IV3, with the landlocked and island dummies evaluated at their mean values in the probit prediction. IV5 is similar to IV4, with income and population variables also evaluated at their mean

17. The corresponding estimate with Rose's definition of currency union is 3.3.

**TABLE 6**
Currency Union and Trade. IV Estimation. Country Pairs Excluding Anchor Countries

| | IV |
|---|---|
| Panel A. First-stage estimates | |
| | Dependent variable: currency union |
| Indirect probability of currency union | 1.224** (0.101) |
| Log of distance | −0.010** (0.002) |
| Contiguity dummy | 0.007 (0.015) |
| Common language dummy | 0.016** (0.004) |
| Ex-colony/colonizer dummy | −0.006 (0.008) |
| Current colony (or territory) dummy | 0.165 (0.168) |
| Common colonizer dummy | 0.037** (0.007) |
| Regional trade agreement | −0.016 (0.018) |
| Max(log of per capita GDP in pair) | 0.002 (0.003) |
| Min(log of per capita GDP in pair) | 0.006 (0.003) |
| Max(log of population in pair) | −0.006 (0.005) |
| Min(log of population in pair) | 0.005 (0.006) |
| Country fixed effects | Yes |
| Country fixed effect Wald test, $p$ value | .000 |
| Year fixed effects | Yes |
| Year fixed effects Wald test, $p$ value | .000 |
| Observations | 158,237 |
| $R^2$ | .42 |
| Panel B. Second-stage estimates | |
| | Dependent variable: log(trade) |
| Currency union | 1.899** (0.351) |
| Log of distance | −1.336** (0.026) |
| Contiguity dummy | 0.554** (0.131) |
| Common language dummy | 0.237** (0.052) |
| Ex-colony/colonizer dummy | 1.039** (0.257) |
| Current colony (or territory) dummy | 2.005** (0.344) |
| Common colonizer dummy | 0.577** (0.084) |
| Regional trade agreement | 0.648** (0.211) |
| Max(log of per capita GDP in pair) | 1.150** (0.043) |
| Min(log of per capita GDP in pair) | 1.161** (0.040) |
| Max(log of population in pair) | 0.014 (0.076) |
| Min(log of population in pair) | 0.111 (0.072) |
| Country fixed effects | Yes |
| Country fixed effects Wald test, $p$ value | .000 |
| Year fixed effects | Yes |
| Year fixed effects Wald test, $p$ value | .000 |
| Observations | 158,237 |
| $R^2$ | .65 |
| Wu-Hausman test of exogeneity, $p$ value | .000 |

*Notes:* The equations use annual data from 1960 to 1997, include year effects, and allow for clustering of the error terms over time for country pairs. The definition of currency union treats the CFA franc countries as linked to France and the ECCA countries as linked to the United Kingdom before 1976 and to the United States after 1976. The IV is built from the probit prediction (model P1 in Table 4). See formula for the derivation of the instrument in the text.

*Significant at 5%; **significant at 1%.

values. IV6 is built from the prediction of the probit model P3, which excludes landlocked and island dummies (but includes year effects). IV7 is similar to IV6, with year effects, population, and income evaluated at their mean values. IV8 is built from the prediction of the probit P4, which excludes year effects and the landlocked and island dummies.

**TABLE 7**

Currency Union and Trade. Robustness of IV Estimation to Alternative Instruments. Country Pairs Excluding Anchor Countries

| | IV1 | IV2 | IV3 | IV4 | IV5 | IV6 | IV7 | IV8 | IV9 |
|---|---|---|---|---|---|---|---|---|---|
| Panel A. First-stage estimates | | | | | | | | | |
| Probability of currency union | 0.879** (0.063) | 0.628** (0.076) | 1.232** (0.117) | 1.416** (0.123) | 0.670** (0.092) | 1.362** (0.106) | 0.654** (0.083) | 1.387** (0.124) | 0.656** (0.093) |
| Log of distance | −0.012** (0.002) | −0.014** (0.002) | −0.011** (0.002) | −0.012** (0.002) | −0.014** (0.002) | −0.010** (0.002) | −0.014** (0.002) | −0.011** (0.002) | −0.013** (0.002) |
| Contiguity dummy | 0.008 (0.016) | 0.007 (0.017) | 0.011 (0.016) | 0.008 (0.015) | 0.007 (0.017) | 0.002 (0.014) | 0.007 (0.017) | 0.008 (0.015) | 0.008 (0.017) |
| Common language dummy | 0.017** (0.004) | 0.009* (0.005) | 0.016** (0.004) | 0.014** (0.004) | 0.015** (0.004) | 0.015** (0.004) | 0.011* (0.005) | 0.015** (0.004) | 0.016** (0.004) |
| Ex-colony/colonizer dummy | −0.007 (0.008) | −0.004 (0.009) | −0.006 (0.008) | −0.005 (0.008) | −0.007 (0.009) | −0.005 (0.008) | −0.005 (0.009) | −0.005 (0.008) | −0.008 (0.009) |
| Current colony (or territory) dummy | 0.159 (0.167) | 0.170 (0.167) | 0.164 (0.168) | 0.162 (0.168) | 0.169 (0.167) | 0.163 (0.168) | 0.170 (0.167) | 0.162 (0.168) | 0.169 (0.167) |
| Common colonizer dummy | 0.055** (0.007) | 0.073** (0.007) | 0.045** (0.008) | 0.039** (0.008) | 0.085** (0.008) | 0.034** (0.007) | 0.074** (0.007) | 0.039** (0.008) | 0.087** (0.008) |
| Regional trade agreement | −0.064** (0.018) | 0.016 (0.020) | −0.045* (0.019) | −0.071** (0.018) | 0.016 (0.020) | −0.030 (0.018) | 0.016 (0.020) | −0.065** (0.018) | 0.016 (0.020) |
| Max(log of per capita GDP in pair) | 0.013** (0.003) | 0.004 (0.003) | 0.008* (0.003) | 0.008** (0.003) | 0.004 (0.003) | 0.002 (0.003) | 0.004 (0.003) | 0.008* (0.003) | 0.004 (0.003) |
| Min(log of per capita GDP in pair) | 0.018** (0.003) | 0.010** (0.003) | 0.012** (0.003) | 0.013** (0.003) | 0.010** (0.003) | 0.004 (0.003) | 0.010** (0.003) | 0.012** (0.003) | 0.010** (0.003) |
| Max(log of population in pair) | −0.036** (0.006) | −0.028** (0.006) | −0.021** (0.005) | −0.021** (0.005) | −0.031** (0.006) | −0.007 (0.005) | −0.029** (0.006) | −0.020** (0.005) | −0.033** (0.006) |
| Min(log of population in pair) | −0.028** (0.007) | −0.010 (0.006) | −0.012 (0.006) | −0.015* (0.006) | −0.014* (0.006) | 0.002 (0.006) | −0.011 (0.006) | −0.013* (0.006) | −0.015* (0.006) |
| Country fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Country fixed effects Wald test, *p* value | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| Year fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year fixed effects Wald test, *p* value | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| Observations | 158,237 | 158,237 | 158,237 | 158,237 | 158,237 | 158,237 | 158,237 | 158,237 | 158,237 |
| $R^2$ | .40 | .35 | .40 | .41 | .35 | .43 | .35 | .41 | .34 |
| Panel B. Second-stage estimates | | | | | | | | | |
| Currency union | 1.019* (0.414) | 1.932** (0.559) | 1.999** (0.421) | 1.794** (0.386) | 1.559* (0.611) | 1.795** (0.328) | 1.742** (0.578) | 1.853** (0.389) | 1.265* (0.639) |
| Log of distance | −1.348** (0.026) | −1.335** (0.026) | −1.335** (0.026) | −1.337** (0.026) | −1.341** (0.026) | −1.337** (0.026) | −1.338** (0.026) | −1.337** (0.026) | −1.345** (0.026) |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Contiguity dummy | 0.564** (0.132) | 0.553** (0.131) | 0.553** (0.131) | 0.555** (0.131) | 0.558** (0.131) | 0.555** (0.131) | 0.556** (0.131) | 0.554** (0.131) | 0.561** (0.131) |
| Common language dummy | 0.267** (0.053) | 0.236** (0.055) | 0.233** (0.053) | 0.240** (0.053) | 0.248** (0.056) | 0.240** (0.052) | 0.242** (0.055) | 0.238** (0.053) | 0.258** (0.056) |
| Ex-colony/colonizer dummy | 1.024** (0.260) | 1.040** (0.258) | 1.041** (0.257) | 1.037** (0.257) | 1.033** (0.259) | 1.037** (0.258) | 1.036** (0.258) | 1.038** (0.257) | 1.028** (0.260) |
| Current colony (or territory) dummy | 2.145** (0.325) | 1.999** (0.354) | 1.989** (0.350) | 2.021** (0.337) | 2.059** (0.341) | 2.021** (0.337) | 2.030** (0.345) | 2.012** (0.340) | 2.106** (0.338) |
| Common colonizer dummy | 0.692** (0.087) | 0.573** (0.103) | 0.564** (0.088) | 0.591** (0.086) | 0.621** (0.109) | 0.591** (0.083) | 0.598** (0.105) | 0.583** (0.086) | 0.660** (0.112) |
| Regional trade agreement | 0.648** (0.207) | 0.648** (0.211) | 0.648** (0.211) | 0.648** (0.210) | 0.648** (0.209) | 0.648** (0.210) | 0.648** (0.210) | 0.648** (0.211) | 0.648** (0.208) |
| Max(log of per capita GDP in pair) | 1.153** (0.043) | 1.150** (0.043) | 1.150** (0.043) | 1.150** (0.043) | 1.151** (0.043) | 1.150** (0.043) | 1.151** (0.043) | 1.150** (0.043) | 1.152** (0.043) |
| Min(log of per capita GDP in pair) | 1.170** (0.040) | 1.160** (0.040) | 1.160** (0.040) | 1.162** (0.040) | 1.164** (0.040) | 1.162** (0.040) | 1.162** (0.040) | 1.161** (0.040) | 1.168** (0.040) |
| Max(log of population in pair) | −0.010 (0.076) | 0.015 (0.077) | 0.017 (0.076) | 0.011 (0.076) | 0.004 (0.077) | 0.011 (0.076) | 0.009 (0.077) | 0.013 (0.076) | −0.004 (0.078) |
| Min(log of population in pair) | 0.101 (0.072) | 0.111 (0.072) | 0.112 (0.072) | 0.110 (0.072) | 0.107 (0.072) | 0.110 (0.072) | 0.109 (0.072) | 0.110 (0.072) | 0.104 (0.072) |
| Country fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Country fixed effects Wald test, *p* value | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| Year fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year fixed effects Wald test, *p* value | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| Observations | 158,237 | 158,237 | 158,237 | 158,237 | 158,237 | 158,237 | 158,237 | 158,237 | 158,237 |
| $R^2$ | .65 | .65 | .65 | .65 | .65 | .65 | .65 | .65 | .65 |
| Wu-Hausman test of exogeneity, *p* value | .0678 | .0495 | .0030 | .0082 | .2476 | .0013 | .1195 | .0053 | .5228 |

*Notes:* The equations use annual data from 1960 to 1997, include year effects, and allow for clustering of the error terms over time for country pairs. IV1 is built from the prediction of the probit regression (P1 in Table 4), evaluating year effects and the landlocked and island dummies at their mean values. See the formula for the derivation of the instrument in the text. IV2 is similar to IV1, with the population and income controls also evaluated at their mean values in the probit prediction. IV3 is built from the prediction of a probit regression that excludes year effects (P2 in Table 4). IV4 is similar to IV3, with the landlocked and island dummies evaluated at their mean values in the probit prediction. IV5 is similar to IV4, with population and income variables also evaluated at their mean values. IV6 is built from the prediction of a probit regression that excludes the landlocked and island dummies (P3 in Table 4). IV7 is similar to IV6, with year effects, population, and income variables evaluated at their mean values in the probit prediction. IV8 is built from the prediction of a probit regression that excludes year effects and the landlocked and island dummies (P4 in Table 4). IV9 is similar to IV8, with population and income variables evaluated at their mean values in the probit prediction.

*Significant at 5%; **significant at 1%.

Finally, IV9 is similar to IV8, with population and income evaluated at their mean values.

In all cases, the indirect probability of currency union exhibits high *t*-statistics in the first-stage regression, as shown in Panel A of Table 7. Also, the *p* values from a Durbin-Wu-Hausman test, reported at the bottom of the table, in almost all cases, are below 10%, indicating that endogeneity of the currency-union variable biases OLS estimates and the IV technique is required. The second-stage estimates are displayed in Panel B of Table 7. The estimated currency-union effect on trades varies between 1.02 and 2.00, depending on the specification, confirming the results obtained in our benchmark IV estimation.

The estimated trade effects are extremely large and one should exercise caution before generalizing the results. In this sample, most of the countries in currency unions are small and poor clients for which the enhancement effect on trade can be substantial, especially in a proportional sense. Therefore, as Rose (2000) warns, the results cannot be directly extrapolated to more developed countries.

## V. SYNCHRONIZATION OF SHOCKS

Currency unions might also alter the extent of synchronization of shocks. These effects are important for their own sake. Moreover, since the extent of synchronization influences the suitability of currency adoption, a country deciding whether or not to join a union should consider the effect of the union on the patterns of comovement.[18] For example, a positive response of comovements to currency unions will lead to a higher level of consensus over the direction of monetary policy and will thereby reduce the cost of relinquishing an independent currency. A negative response of comovements will have the opposite effect, generating a larger loss associated with the lack of monetary-policy independence.

In this section, we investigate the effect of currency unions on the extent of comovements of real per capita GDP and prices. As suggested before, the response of comovements to currency unions can be theoretically positive or negative. On the one hand, sharing a common currency eliminates the fluctuations in relative prices driven by nominal exchange rate variation and, hence, can lead to higher price comovement. In addition, the common monetary shocks will induce higher comovement in consumption behavior and production decisions. On the other hand, by lowering transaction costs and eliminating exchange rate uncertainty, currency unions might lead to greater specialization. Specialization can take place within a given sector (e.g., different countries producing different models of cars) or between sectors (e.g., one country produces cars and the other produces agricultural goods). To the extent that shocks are sector specific and common to all countries, the second type of specialization will lead to less comovement of shocks.[19]

The standard omitted-variable problem can also arise in the estimation of the effect of currency unions on the extent of comovement of shocks. As already mentioned, currency unions are generally accompanied by parallel efforts to promote integration. For example, two countries adopting a common currency will tend also to lower tariff and nontariff barriers, which are poorly measured in the data. These lower regulatory barriers might increase the comovement of shocks between two countries and, hence, simple OLS estimates will attribute too much credit to the use of a common currency.

To compute bilateral comovement of price and output, we follow Alesina, Barro, and Tenreyro (2002). Relative prices are measured using the real exchange rate calculated from GDP deflators. The measure used is the purchasing power parity (PPP) for GDP divided by the U.S. dollar exchange rate.[20] This measure indicates the price level in country *i* relative to that in the United States, $P_{i,t}/P_{\mathrm{US},t}$. The relative price between countries *i* and *j* is then computed by dividing the value for country *i* by that for country *j*.

18. See also Frankel and Rose (1998) for a discussion of the endogeneity of the optimum currency area criteria. They remark that the criteria for optimality of currency unions should be considered ex post.

19. Krugman (1993) formulated this argument in the context of the discussion of the potential unsustainability of the European Monetary Union.

20. Measures how many units of U.S. output can be purchased with one unit of country *i*'s output, that is, it measures the relative price of country *i*'s output with respect to that of the United States. By definition, this price is always one when *i* is the United States.

For every pair of countries, $(i, j)$, we use the annual time series $\{\ln \frac{P_{i,t}}{P_{j,t}}\}_{t=1960}^{t=1997}$ to compute the second-order autoregression:

$$\ln \frac{P_{it}}{P_{jt}} = b_0 + b_1 \cdot \ln \frac{P_{i,t-1}}{P_{j,t-1}} + b_2 \cdot \ln \frac{P_{i,t-2}}{P_{j,t-2}} + \varepsilon_{tij}.$$

The estimated residual, $\hat{\varepsilon}_{tij}$, measures the part of the relative price that could not be predicted from the two prior values of relative prices. The extent of comovement is then measured as the negative of the root-mean-squared error:

$$CP_{ij} \equiv -\sqrt{\frac{1}{T-3}\sum_{t=1}^{T} \hat{\varepsilon}_{tij}^2}.$$

Similarly, the extent of comovement of output comes from the estimated residuals from the second-order autoregression on annual data for relative per capita GDP:

$$\ln \frac{Y_{it}}{Y_{jt}} = c_0 + c_1 \cdot \ln \frac{Y_{i,t-1}}{Y_{j,t-1}} + c_2 \cdot \ln \frac{Y_{i,t-2}}{Y_{j,t-2}} + u_{tij}.$$

The estimated residuals, $\hat{u}_{tij}$, measure the unpredictable movements in relative per capita output. The measure of the extent of comovement is analogous to the one used for prices:

$$VY_{ij} \equiv -\sqrt{\frac{1}{T-3}\sum_{t=1}^{T} \hat{u}_{tij}}.$$

This measure of comovement is more relevant from the perspective of monetary policy than a correlation of output movements. Consider two countries $i$ and $j$ whose output movements are highly correlated but where the countries exhibit substantially different variabilities of output. Suppose that country $i$ is the one with the lower variability. In this case, the correlation of output movements will be high, but the monetary policy response desired by country $i$ will be insufficient for country $j$. In other words, a high correlation is not sufficient to ensure that the desired monetary policies are similar. Our measure of comovement captures more adequately the criterion for suitability.

Data on PPPs for the GDPs come from the Penn World Tables and are complemented with the World Bank's *World Development Indicators* when the first source is missing.

**TABLE 8**
Currency Union and Price Comovement. OLS Estimation

| | Dependent Variable: Comovement of Price Shocks | |
|---|---|---|
| | **All Country Pairs** | **Country Pairs Excluding Anchor Countries** |
| Currency union | 0.0453** (0.0027) | 0.0471** (0.0031) |
| Log of distance | −0.0027** (0.0007) | −0.0024** (0.0007) |
| Contiguity dummy | 0.0042 (0.0023) | 0.003 (0.0025) |
| Common language dummy | 0.0021* (0.0009) | 0.0019* (0.0009) |
| Ex-colony/colonizer dummy | −0.0074** (0.0021) | −0.0112** (0.0031) |
| Current colony (or territory) dummy | 0.0190 (0.0113) | −0.010 (0.0206) |
| Common colonizer dummy | 0.0034* (0.0013) | 0.0037** (0.0014) |
| Regional trade agreement | 0.0185** (0.0045) | 0.0135* (0.0060) |
| Max(log of per capita GDP in pair) | 0.0015** (0.0005) | 0.0079** (0.0008) |
| Min(log of per capita GDP in pair) | 0.0097** (0.0005) | 0.0164** (0.0009) |
| Max(log of population in pair) | 0.0014* (0.0006) | 0.0094** (0.0007) |
| Min(log of population in pair) | 0.0016* (0.0006) | 0.0103** (0.0007) |
| Country fixed effects | Yes | Yes |
| Country fixed effects Wald test, $p$ value | .0000 | .0000 |
| Observations | 7,218 | 6,513 |
| $R^2$ | .93 | .93 |

*Notes:* The independent variables are the means of the variables from 1960 to 1997, except for GDP and population, which are for 1985.

*Significant at 5%; **significant at 1%.

**TABLE 9**
Currency Union and Price Comovement. IV Estimation. Country Pairs Excluding Anchor Countries. Second-Stage Estimates

| | **Dependent Variable: CP** |
|---|---|
| Currency union | 0.0683** (0.0059) |
| Log of distance | −0.0019** (0.0007) |
| Contiguity dummy | 0.0018 (0.0025) |
| Common language dummy | 0.0012 (0.0010) |
| Ex-colony/colonizer dummy | −0.0109** (0.0032) |
| Current colony (or territory) dummy | −0.0187 (0.0257) |
| Common colonizer dummy | 0.0001 (0.0018) |
| Regional trade agreement | 0.0134* (0.0059) |
| Max(log of per capita GDP in pair) | 0.0080** (0.0008) |
| Min(log of per capita GDP in pair) | 0.0165** (0.0009) |
| Max(log of population in pair) | 0.0094** (0.0007) |
| Min(log of population in pair) | 0.0104** (0.0007) |
| Country fixed effects | Yes |
| Country fixed effects Wald test, *p* value | .0000 |
| Observations | 6,513 |
| $R^2$ | .93 |
| Wu-Hausman test of exogeneity, *p* value | .0000 |

*Notes:* The independent variables are the means of the variables from 1960 to 1997, except for GDP and population, which are for 1985. The IV is built from the probit prediction (model P1 in Table 4). See the formula for the derivation of the instrument in the text.

*Significant at 5%; **significant at 1%.

Data on real per capita GDP come from the *World Development Indicators.*

Table 8 shows the effect of currency unions on the comovements of prices. The first column displays the regressions for all country pairs, whereas the second excludes anchors from the sample. This, again, is done to ensure comparability with our IV estimation. We include all the controls typically incorporated in gravity regressions, that is, various measures of distance and size. The logic for including the same controls is that the forces that determine trade will also affect the extent of price-arbitrage between countries. There are, however, some differences in the way that these forces can influence outcomes. For example, countries that are close in terms of the gravity variables may be motivated to specialize in different products. In this case, nearby countries will be subject to different sectoral shocks and will likely exhibit lower comovements of prices. In any event, it seems prudent to control for the gravity variables.

In the comovement equations, the sample consists of one observation (estimated for the period 1960–1997) on each country pair, for pairs that have at least 20 observations. The regressors, as well as the IVs, are the averages over the period.[21] The table reports the estimates generated by OLS, including country fixed effects.

The regressions show that price comovement rises with regional trade agreements and falls with geographical distance. Sharing a border does not affect the comovement, once distance is taken into account. Speaking the same language and sharing the same colonizer have positive but small effects on comovement. In contrast, countries exhibit relatively lower price comovement with their ex-colonizers.

The currency-union estimates are virtually identical in both samples: they indicate a currency-union effect on price comovement of 0.046 in the whole sample and 0.047 in the sample that excludes pairs with anchor countries. These estimates are quite large: the

21. For GDP per capita and population, we use the value in 1985, because the averages are missing for some countries. Using different years for GDP or population does not alter the main results.

mean of the comovement variable (the negative of the root-mean-squared error of the auto-regressive process described before) is $-0.16$.

Table 9 shows the IV estimation. The first-stage equation (not shown) indicates that the coefficient on our IV, the indirect probability of currency union, again has a high *t*-statistic. The second-stage regression, shown in the table, indicates that the presence of a currency union significantly raises the extent of price comovement. The estimated coefficient is 0.068, which is larger than that found with OLS.

The *p* value from a Durbin-Wu-Hausman test is reported at the bottom of Table 9. The null hypothesis that an OLS estimator of the model would yield consistent estimates is rejected. In other words, endogeneity of the currency-union variable has detrimental effects on OLS estimates, and the IV technique is required. As mentioned before, the positive effect of currency unions on the comovement of price shocks is most likely associated with the decrease in nominal exchange rate volatility stemming from the use of a common currency.

Table 10 presents a set of robustness tests using alternative specifications of the IV. The first-stage regressions (not shown) indicate that again, in all cases, the indirect probability of currency union has a significantly positive coefficient. In the second-stage regressions, shown in the table, the estimated currency-union coefficient varies between 0.0649 and 0.0782 and is always statistically significant. Moreover, *p* values from a Durbin-Wu-Hausman test are always below .05, suggesting that the IV estimator should be preferred.

The comovement of output shocks is studied in Table 11. Speaking the same language, sharing a border, and sharing the same colonizer increase the comovement of output, but the ex-colony/colonizer variable does not affect the extent of comovement. Size, measured by GDP per capita, tends to increase the comovement. However, a rise in the population of the larger country has ambiguous effects on comovement. In the OLS estimation, the effect of currency union on output comovement is positive but statistically insignificant.

Table 12 has the IVs results for output comovement. The first-stage regressions (not shown) again indicate that the coefficient on the indirect probability of currency union is significantly positive. In the benchmark IV estimation shown in the table, the currency-union effect on output comovement is negative, although insignificant at standard critical levels. The Durbin-Wu-Hausman test yields a *p* value of .22, which implies that the dominance of the IV estimator is weaker than that in the case of price comovement. Alternative specifications of the instrument in Table 13 confirm the negative effect, although in all cases statistical significance is low.

A negative effect of currency union on the extent of comovement of outputs could reflect a positive effect of currency unions on sectoral specialization, which can then lead to a decrease in the extent of comovement, as Krugman (1993) suggested. The effect—in absolute values—is not as substantial as the one found for price comovement: the estimated coefficient varies between $-0.0011$ and $-0.0042$, whereas the mean of this variable (the negative of the root-mean-squared error described above) is $-0.06$. This effect, however, might be different for developed countries forming a currency union if developed countries tend to specialize in the same industries. In this case, countries will tend to be exposed to similar sectoral shocks and integration will lead to higher comovement.[22]

## VI. CONCLUSION

This paper proposes a new instrumental variable to study the effects of different exchange rate arrangements on economic outcomes. We apply the methodology to investigate the impact of currency unions on bilateral trade and the extent of comovements of prices and outputs. The instrument relies on the idea that one reason why two countries share a common currency is the attractiveness of a third country's currency as an anchor. The validity of the instrument requires that the motivation to adopt an external anchor's currency is exogenous to the bilateral link between two potential client countries. The results show that the probability that a client

22. See Frankel and Rose (1998) for a study of the relationship between trade and business cycles for Organization for Economic Cooperation and Development countries.

**TABLE 10**
Currency Union and Price Comovement. Robustness of IV Estimation to Alternative Instruments. Country Pairs Excluding Anchor Countries. Second-Stage Estimates

| | IV1 | IV2 | IV3 | IV4 | IV5 | IV6 | IV7 | IV8 | IV9 |
|---|---|---|---|---|---|---|---|---|---|
| Currency union | 0.0717** (0.0064) | 0.0622** (0.0093) | 0.0649** (0.0069) | 0.0678** (0.0070) | 0.0750** (0.0109) | 0.0711** (0.0060) | 0.0638** (0.0094) | 0.0665** (0.0069) | 0.0782** (0.0111) |
| Log of distance | −0.0018** (0.0007) | −0.0021** (0.0007) | −0.0020** (0.0007) | −0.0019** (0.0007) | −0.0017* (0.0007) | −0.0018** (0.0007) | −0.0020** (0.0007) | −0.0019** (0.0007) | −0.0017* (0.0007) |
| Contiguity dummy | 0.0017 (0.0025) | 0.0021 (0.0025) | 0.0020 (0.0025) | 0.0018 (0.0025) | 0.0015 (0.0025) | 0.0017 (0.0025) | 0.0020 (0.0025) | 0.0019 (0.0025) | 0.0014 (0.0026) |
| Common language dummy | 0.0011 (0.0010) | 0.0014 (0.0010) | 0.0013 (0.0010) | 0.0012 (0.0010) | 0.0010 (0.0010) | 0.0011 (0.0010) | 0.0014 (0.0010) | 0.0013 (0.0010) | 0.0009 (0.0010) |
| Ex-colony/colonizer dummy | −0.0109** (0.0032) | −0.0110** (0.0032) | −0.0110** (0.0032) | −0.0110** (0.0032) | −0.0109** (0.0033) | −0.0109** (0.0032) | −0.0110** (0.0032) | −0.0110** (0.0032) | −0.0108** (0.0033) |
| Current colony (or territory) dummy | −0.0201 (0.0266) | −0.0161 (0.0244) | −0.0172 (0.0249) | −0.0185 (0.0256) | −0.0215 (0.0277) | −0.0198 (0.0264) | −0.0168 (0.0247) | −0.0179 (0.0253) | −0.0228 (0.0285) |
| Common colonizer dummy | −0.0005 (0.0017) | 0.0011 (0.0021) | 0.0007 (0.0018) | 0.0002 (0.0018) | −0.0010 (0.0024) | −0.0004 (0.0017) | 0.0008 (0.0021) | 0.0004 (0.0018) | −0.0016 (0.0024) |
| Regional trade agreement | 0.0133* (0.0059) | 0.0134* (0.0059) | 0.0134* (0.0059) | 0.0134* (0.0059) | 0.0133* (0.0059) | 0.0133* (0.0059) | 0.0134* (0.0059) | 0.0134* (0.0059) | 0.0133* (0.0059) |
| Max(log of per capita GDP in pair) | 0.0080** (0.0008) | 0.0080** (0.0008) | 0.0080** (0.0008) | 0.0080** (0.0008) | 0.0081** (0.0008) | 0.0080** (0.0008) | 0.0080** (0.0008) | 0.0080** (0.0008) | 0.0081** (0.0008) |
| Min(log of per capita GDP in pair) | 0.0165** (0.0009) | 0.0164** (0.0009) | 0.0164** (0.0009) | 0.0164** (0.0009) | 0.0165** (0.0009) | 0.0165** (0.0009) | 0.0164** (0.0009) | 0.0164** (0.0009) | 0.0165** (0.0009) |
| Max(log of population in pair) | 0.0094** (0.0007) | 0.0094** (0.0007) | 0.0094** (0.0007) | 0.0094** (0.0007) | 0.0094** (0.0007) | 0.0094** (0.0007) | 0.0094** (0.0007) | 0.0094** (0.0007) | 0.0094** (0.0007) |
| Min(log of population in pair) | 0.0104** (0.0007) | 0.0104** (0.0007) | 0.0104** (0.0007) | 0.0104** (0.0007) | 0.0104** (0.0007) | 0.0104** (0.0007) | 0.0104** (0.0007) | 0.0104** (0.0007) | 0.0104** (0.0007) |
| Country fixed effect | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Country fixed effects Wald test, *p* value | .0000 | .0000 | .0000 | .0000 | .0000 | .0000 | .0000 | .0000 | .0000 |
| Observations | 6,513 | 6,513 | 6,513 | 6,513 | 6,513 | 6,513 | 6,513 | 6,513 | 6,513 |
| $R^2$ | .93 | .93 | .93 | .93 | .93 | .93 | .93 | .93 | .93 |
| Wu-Hausman test of exogeneity, *p* value | .0000 | .0866 | .0032 | .0004 | .0063 | .0000 | .0592 | .0007 | .0024 |

*Notes:* The independent variables are the means of the variables from 1960 to 1997, except for GDP and population which are for 1985. IV1 is built from the prediction of the probit regression (P1 in Table 4), evaluating year effects and the landlocked and island dummies at their mean values. See the formula for the derivation of the instrument in the text. IV2 is similar to IV1, with the population and income controls also evaluated at their mean values in the probit prediction. IV3 is built from the prediction of a probit regression that excludes year effects (P2 in Table 4). IV4 is similar to IV3, with the landlocked and island dummies evaluated at their mean values in the probit prediction. IV5 is similar to IV4, with population and income variables also evaluated at their mean values. IV6 is built from the prediction of a probit regression that excludes the landlocked and island dummies (P3 in Table 4). IV7 is similar to IV6, with year effects, population, and income variables evaluated at their mean values in the probit prediction. IV8 is built from the prediction of a probit regression that excludes year effects and the landlocked and island dummies (P4 in Table 4). IV9 is similar to IV8, with population and income variables evaluated at their mean values in the probit prediction.

*Significant at 5%; **significant at 1%.

**TABLE 11**
Currency Union and Output Comovement. OLS Estimation

| | Dependent Variable: Comovement of Output Shocks | |
|---|---|---|
| | **All Country Pairs** | **Country Pairs Excluding Anchor Countries** |
| Currency union | 0.0001 (0.0011) | 0.0008 (0.0012) |
| Log of distance | −0.0003 (0.0002) | −0.0003 (0.0002) |
| Contiguity dummy | 0.0040** (0.0009) | 0.0036** (0.0009) |
| Common language dummy | 0.0007* (0.0003) | 0.0007* (0.0004) |
| Ex-colony/colonizer dummy | −0.0007 (0.0007) | −0.0001 (0.0011) |
| Current colony (or territory) dummy | −0.0024 (0.0023) | −0.0087 (0.0097) |
| Common colonizer dummy | 0.0021** (0.0005) | 0.0020** (0.0005) |
| Regional trade agreement | 0.0012 (0.0013) | −0.0008 (0.0016) |
| Max(log of per capita GDP in pair) | 0.0071** (0.0002) | 0.0021** (0.0003) |
| Min(log of per capita GDP in pair) | 0.0083** (0.0002) | 0.0031** (0.0003) |
| Max(log of population in pair) | 0.0117** (0.0002) | −0.0009** (0.0002) |
| Min(log of population in pair) | 0.0128** (0.0002) | 0.0001 (0.0002) |
| Country fixed effects | Yes | Yes |
| Country fixed effects Wald test, *p* value | .0000 | .0000 |
| Observations | 7,610 | 6,887 |
| $R^2$ | .91 | .91 |

*Notes:* The independent variables are the means of the variables from 1960 to 1997, except for GDP and population, which are for 1985.
*Significant at 5%; **significant at 1%.

**TABLE 12**
Currency Union and Output Comovement. IV Estimation. Country Pairs Excluding Anchor Countries. Second-Stage Estimates

| | **Dependent Variable: Comovement of Output Shocks** |
|---|---|
| Currency union | −0.0024 (0.0026) |
| Log of distance | −0.0004 (0.0002) |
| Contiguity dummy | 0.0037** (0.0009) |
| Common language dummy | 0.0008* (0.0004) |
| Ex-colony/colonizer dummy | −0.0002 (0.0011) |
| Current colony (or territory) dummy | −0.0066 (0.0095) |
| Common colonizer dummy | 0.0024** (0.0007) |
| Regional trade agreement | −0.0005 (0.0016) |
| Max(log of per capita GDP in pair) | 0.0021** (0.0003) |
| Min(log of per capita GDP in pair) | 0.0031** (0.0003) |
| Max(log of population in pair) | −0.0009** (0.0002) |
| Min(log of population in pair) | 0.0001 (0.0002) |
| Country fixed effects | Yes |
| Country fixed effects Wald test, *p* value | .0000 |
| Observations | 6,887 |
| $R^2$ | .91 |
| Wu-Hausman test of exogeneity, *p* value | .1815 |

*Notes:* The independent variables entered are the means of the variables from 1960 to 1997, except for GDP and population, which are for 1985. The IV is built from the probit prediction (model P1 in Table 4). See the formula for the derivation of the instrument in the text.
*Significant at 5%; **significant at 1%.

# TABLE 13

Currency Union and Output Comovement. Robustness of IV Estimation to Alternative Instruments. Country Pairs Excluding Anchor Countries. Second-Stage Estimates

| | IV1 | IV2 | IV3 | IV4 | IV5 | IV6 | IV7 | IV8 | IV9 |
|---|---|---|---|---|---|---|---|---|---|
| Currency union | −0.0016 (0.0027) | −0.0035 (0.0037) | −0.0046 (0.0032) | −0.0034 (0.0031) | −0.0029 (0.0041) | −0.0013 (0.0025) | −0.0033 (0.0037) | −0.0034 (0.0030) | −0.0025 (0.0042) |
| Log of distance | −0.0004 (0.0002) | −0.0004 (0.0002) | −0.0004* (0.0002) | −0.0004* (0.0002) | −0.0004 (0.0002) | −0.0003 (0.0002) | −0.0004 (0.0002) | −0.0004* (0.0002) | −0.0004 (0.0002) |
| Contiguity dummy | 0.0037** (0.0009) | 0.0038** (0.0009) | 0.0038** (0.0009) | 0.0038** (0.0009) | 0.0038** (0.0009) | 0.0037** (0.0009) | 0.0038** (0.0009) | 0.0038** (0.0009) | 0.0037** (0.0009) |
| Common language dummy | 0.0008* (0.0004) | 0.0009* (0.0004) | 0.0009* (0.0004) | 0.0009* (0.0004) | 0.0009* (0.0004) | 0.0008* (0.0004) | 0.0009* (0.0004) | 0.0009* (0.0004) | 0.0008* (0.0004) |
| Ex-colony/colonizer dummy | −0.0001 (0.0011) | −0.0002 (0.0011) | −0.0002 (0.0011) | −0.0002 (0.0011) | −0.0002 (0.0011) | −0.0001 (0.0011) | −0.0002 (0.0011) | −0.0002 (0.0011) | −0.0002 (0.0011) |
| Current colony (or territory) dummy | −0.0071 (0.0096) | −0.0059 (0.0097) | −0.0052 (0.0096) | −0.0059 (0.0096) | −0.0063 (0.0097) | −0.0073 (0.0096) | −0.0060 (0.0097) | −0.0059 (0.0096) | −0.0066 (0.0098) |
| Common colonizer dummy | 0.0023** (0.0007) | 0.0026** (0.0008) | 0.0028** (0.0007) | 0.0026** (0.0007) | 0.0025** (0.0008) | 0.0023** (0.0007) | 0.0026** (0.0008) | 0.0026** (0.0007) | 0.0025** (0.0008) |
| Regional trade agreement | −0.0005 (0.0016) | −0.0004 (0.0016) | −0.0003 (0.0016) | −0.0004 (0.0016) | −0.0004 (0.0017) | −0.0006 (0.0016) | −0.0004 (0.0017) | −0.0004 (0.0016) | −0.0005 (0.0017) |
| Max(log of per capita GDP in pair) | 0.0021** (0.0003) | 0.0021** (0.0003) | 0.0021** (0.0003) | 0.0021** (0.0003) | 0.0021** (0.0003) | 0.0021** (0.0003) | 0.0021** (0.0003) | 0.0021** (0.0003) | 0.0021** (0.0003) |
| Min(log of per capita GDP in pair) | 0.0031** (0.0003) | 0.0031** (0.0003) | 0.0031** (0.0003) | 0.0031** (0.0003) | 0.0031** (0.0003) | 0.0031** (0.0003) | 0.0031** (0.0003) | 0.0031** (0.0003) | 0.0031** (0.0003) |
| Max(log of population in pair) | −0.0009** (0.0002) | −0.0009** (0.0002) | −0.0009** (0.0002) | −0.0009** (0.0002) | −0.0009** (0.0002) | −0.0009** (0.0002) | −0.0009** (0.0002) | −0.0009** (0.0002) | −0.0009** (0.0002) |
| Min(log of population in pair) | 0.0001 (0.0002) | 0.0001 (0.0002) | 0.0001 (0.0002) | 0.0001 (0.0002) | 0.0001 (0.0002) | 0.0001 (0.0002) | 0.0001 (0.0002) | 0.0001 (0.0002) | 0.0001 (0.0002) |
| Country fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Country fixed effects Wald test, *p* value | .0000 | .0000 | .0000 | .0000 | .0000 | .0000 | .0000 | .0000 | .0000 |
| Observations | 6,887 | 6,887 | 6,887 | 6,887 | 6,887 | 6,887 | 6,887 | 6,887 | 6,887 |
| $R^2$ | .91 | .91 | .91 | .91 | .91 | .91 | .91 | .91 | .91 |
| Wu-Hausman test of exogeneity, *p* value | .3191 | .2230 | .0600 | .1208 | .3540 | .3522 | .2625 | .1142 | .4244 |

*Notes*: The independent variables are the means of the variables from 1960 to 1997, except for GDP and population which are for 1985. IV1 is built from the prediction of the probit regression (P1 in Table 4), evaluating year effects and the landlocked and island dummies at their mean values. See the formula for the derivation of the instrument in the text. IV2 is similar to IV1, with the population and income controls also evaluated at their mean values in the probit prediction. IV3 is built from the prediction of a probit regression that excludes year effects (P2 in Table 4). IV4 is similar to IV3, with landlocked and island dummies evaluated at their mean values in the probit prediction. IV5 is similar to IV4, with population and income variables also evaluated at their mean values. IV6 is built from the prediction of a probit regression that excludes landlocked and island dummies (P3 in Table 4). IV7 is similar to IV6, with year effects, population, and income variables evaluated at their mean values in the probit prediction. IV8 is built from the prediction of a probit regression that excludes year effects and landlocked and island dummies (P4 in Table 4). IV9 is similar to IV8, with population and income variables evaluated at their mean values in the probit prediction.

*Significant at 5%; **significant at 1%.

adopts the currency of a main anchor increases when the client is geographically close, speaks the same language, and shares a colonial relationship with the anchor. It also increases when the client is smaller and poorer and when the anchor is richer. The likelihood that two countries share a common currency is calculated from the probability that each of them, independently, uses the currency of a third country. This likelihood serves as an instrument for the common currency dummy in the estimation of the economic effects of currency unions.

The IV approach is used to revisit the effect of currency unions on trade and to investigate the effect of currency unions on the extent of comovement of prices and outputs. Three main findings follow. First, currency unions significantly increase bilateral trade, a result that supports previous findings by Rose (2000) and coauthors. This finding suggests that the large trade effect found previously for currency unions is not due to endogeneity bias. Second, currency unions significantly increase the extent of price comovement. This response most likely reflects the elimination of nominal exchange rate volatility. Third, the IV results suggest that currency unions might decrease the extent of comovement of output, possibly as a consequence of higher sectoral specialization.

## REFERENCES

Alesina, A., and R. J. Barro. "Currency Unions." *Quarterly Journal of Economics*, 17, May 2002, 409–36.

Alesina, A., R. J. Barro, and S. Tenreyro. "Optimum Currency Unions." National Bureau of Economic Research Macroeconomic Annual, 2002.

Barro, R. J., and S. Tenreyro. "Closed and Open Economy Models of Business Cycles with Marked-Up and Sticky Prices." *Economic Journal*, 116, 2006, 434–56.

Frankel, J., and A. Rose. "The Endogeneity of the Optimum Currency Area Criteria " *Economic Journal*, 108, July 1998, 1009–25.

———. "An Estimate of the Effect of Currency Unions on Trade and Income." *Quarterly Journal of Economics*, 117, 2002, 437–66.

Glick, R., and A. Rose. "Does a Currency Union Affect Trade? The Time Series Evidence." *European Economic Review*, 46, 2002, 1125–51.

Hallak, J. C. "Product Quality and the Direction of Trade." *Journal of International Economics*, 68, 2006, 238–65.

Krugman, P. "Lessons of Massachusetts for EMU, " in *Adjustment and Growth in the European Monetary Union*, edited by F. Torres and F. Giavazzi. Cambridge, United Kingdom: Cambridge University Press, 1993, 241–61.

Persson, T. "Currency Union and Trade, How Large is the Treatment Effect? " *Economic Policy*, 16, 2001, 335–48.

Rose, A. "One Money One Market: Estimating the Effect of Common Currencies on Trade." *Economic Policy*, 15, 2000, 7–46.

Rose, A., and E. van Wincoop. "National Money as a Barrier to International Trade: The Real Case for Currency Union." *American Economic Review*, 91, May 2001, 386–90.