

Data Appendix to: Financial Exchange Rates and International Currency Exposures

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Abstract

This appendix provides a more detailed description of the data set. The conceptual framework, methods for creating indices and other analysis are all described in the paper itself.

Data Appendix

1 Estimating Currency Positions: Methods

As noted in section 3, we follow a two-step procedure in estimating currency positions. First, we determine the currency composition of assets and liabilities within individual asset classes. Second, we weight the asset classes by their shares in the country's portfolio in order to construct the aggregate index. This appendix provides a detailed description of how we construct the estimated currency positions.

1.1 Foreign Assets

The asset side of a country's international balance sheet is divided into five classes: portfolio equity, direct investment, portfolio debt, other debt (generally bank-related), and reserves. Each requires its own sources and unique methodology and these methods are described below.

1.1.1 Portfolio Equity

The CPIS data set provides the geographical location of equity asset holdings by country for 68 reporter countries across 220 host countries. In order to provide estimates for country pairs that are missing from the data set, we employ a gravity-based model of bilateral equity holdings to construct estimated positions in these cases.¹

Our approach relies on two key assumptions. First, we assume that equity issued by a country is denominated in the currency of that country. That is, US stocks are denominated in dollars, Japanese stocks in yen and so on. While there is no automatic relation between equity returns and currency movements, it is reasonable to assume that currency-related equity exposures are correlated with the geographical pattern in portfolio and direct investment equity holdings. In particular, especially for smaller source countries, the domestic-currency spot value of a foreign equity should move one for one with the relevant bilateral exchange rate if the foreign-currency equity value moves orthogonally to the bilateral exchange rate.² (See also the discussion in section 2 regarding the lack of

¹See Lane and Milesi-Ferretti (2008), Portes and Rey (2005) and Martin and Rey (2004) for theoretical and empirical support for such a procedure. We do not rely on trade flows, but instead are essentially creating an asset allocation model where host GDP proxies for investment opportunities, and distance and other gravity variables proxy for information costs.

²This also applies if foreign equity is held in the form of an American or global depository receipt . (In

correlation between returns and exchange rate changes).

Second, following Lane and Milesi-Ferretti (2008), we eliminate holdings listed in offshore financial centers. Countries report very large holdings in these offshore centers (such as Luxembourg) but these holdings really represent claims on assets in other final destinations. By excluding these holdings, we implicitly assume that the holdings in offshore centers eventually wind up in the same pattern as those that go directly to other countries. After eliminating offshore centers, we are left with 50 reporting countries and 180 hosts.³

In order to generate estimated positions for those country pairs that are missing from the CPIS dataset, we employ a modified-form of the specification developed by Lane and Milesi-Ferretti (2008) by running a bilateral equity holding regression of the form

$$\log(1 + EQ_{ijt}) = \phi_j + \theta_t + \beta Z_{ijt} + \gamma X_{it} + \varepsilon_{ijt} \quad (1)$$

where ϕ_j represent host country fixed effects, θ_t year fixed effects and Z_{ijt} is a vector of bilateral variables - distance, longitude gap (to proxy for time zone differences), common language dummies, colonial relationship dummies, and measures of relative GDP such as a dummy for both countries being industrial, the gap in GDP per capita and the gap in GDP.

We do not include source country fixed effects, since our goal is to estimate missing source country data, but we can include a number of source country characteristics in X_{it} such as latitude, landlocked status, population, capital controls, and GDP per capita.⁴ Such time invariant (or nearly time invariant) data cannot be included for the host country as the host country fixed effect already controls for all host characteristics.⁵ This regression has considerable explanatory power (R^2 values in the region of 0.79), high enough to generate sensible predicted values, and the coefficients on the independent variables take expected

measuring the international investment position, the domestic versus foreign status of an asset depends on the residence of the issuer, not on the location of the transaction.) Consider a US investor holding stock in a Chilean firm through an ADR listed in New York. Since these stocks are listed primarily in Chile, the dollar price in New York automatically moves with the peso-dollar exchange rate and the peso value of the stock in Chile.

³We follow Lane and Milesi-Ferretti (2008) and primarily use the IMF Background Paper, “Offshore Financial Centers” (2000), as our guide to labelling countries as offshore centers.

⁴Geography and other gravity model controls come from the CEPII geography database. GDP data is from the World Bank WDI database.

⁵While Lane and Milesi-Ferretti (2008) show that the level of trade is a predictor for equity positions, once a sufficient number of gravity controls are included, we find that despite trade receiving a significant coefficient, the R^2 on the overall regression does not move much when including trade. Since there are many missing observations for the trade data, we do not include it.

signs and magnitudes.⁶

We then use these predicted values for the missing observations, along with the actual data, to generate currency composition of equity holdings. For non-reporter countries, we are using synthetic data for their weights. As it turns out, these do not play as dramatic role as one might fear in our overall index creation, since countries that are not CPIS reporters typically hold fairly small equity portfolios. In fact, the External Wealth of Nations data compiled by Lane and Milesi-Ferretti (2007a) show that half of the non-reporters have no equity assets and non-reporters only have an average of 2 to 3 percent of their foreign assets in equity. For this reason, in an overall index, our derived currency composition of their equity assets plays a small role.

1.1.2 Direct Investment

We use the UNCTAD database on stocks of bilateral direct investment assets and liabilities. These data give us both outward and inward stocks of direct investment for 73 reporting countries vis-a-vis up to 196 partner countries. Since we have both inward and outward data, we can infer the bilateral direct investment assets of many non-reporting countries from the bilateral direct investment liabilities of the reporters. Since most major destinations are reporters, this process gives us a reasonable gauge of the currency distribution of the non-reporter countries.

The data are available over 1970-2004, although there are many missing observations. The direct investment stocks are valued at book value or historical cost. While it may be preferable to measure direct investment stocks at market value, this limitation has only limited relevance in establishing the weights for an FDI exchange rate index, since the geographical composition of the stock is the key factor. Since we have both inward and outward data, we can use this to establish bilateral patterns for a large number of countries.⁷

We follow our process for portfolio equity and assume that all direct investment is effectively denominated in the currency of the host country. This is plausible to the extent that direct investment assets have a location-specific component (e.g. structures or installed equipment) and/or profits are largely generated in the host country. However, it is more problematic in the case of export-platform FDI: while domestic costs still matter for

⁶Details of these results are available from the authors upon request.

⁷For a small number of countries we rely on flow data to create a general pattern because the stock data is too incomplete. Also, for a handful of countries where FDI is not significant (less than 1 percent of total assets and less than 40 million dollars) and the data appear incomplete, we drop FDI from total assets and rescale remaining assets.

profitability and the value of the FDI position, it also depends on revenues generated in final customer markets. In addition, the FDI data include both equity and intra-company loans, with the latter plausibly more likely to be denominated in the currency of the source country. While we bear these caveats in mind, we proceed with the assumption that the value of direct investment positions are denominated in the currency of the host country.

1.1.3 Portfolio Debt

In some cases, as is detailed by Lane and Milesi-Ferretti (2007c), countries report the currency composition of their foreign portfolio debt asset portfolios. This information is reported for the United States in the Report on the US Portfolio Holdings of Foreign Securities published by the US Treasury, while the Bank of Japan has released the currency composition of Japanese portfolio debt assets at the end of 2005 in its Portfolio Investment Position Report.

However, for most countries, we do not have direct information on the currency composition of foreign portfolio debt assets. Accordingly, we adopt a multi-step inference procedure. As in the case of portfolio equity, the CPIS dataset provides information on the geographical patterns in bilateral portfolio bond holdings. We again employ a gravity model to fill out the geographical information for missing country pairs (where we have the same number of countries and use the same data as in the equity regressions). For these regressions, the R^2 is approximately 0.77 and again the signs on the coefficients on the independent variables are sensible.

However, since many countries issue foreign-currency debt, estimating the currency composition of foreign debt assets requires additional steps. We begin with the international securities dataset maintained by the BIS.⁸ This dataset contains information on the currency denomination of international bonds for 113 issuing countries.⁹ For some countries (such as the United States), international bonds are issued mainly in domestic currency. For other countries, international bonds are typically denominated in foreign currency, with the relative importance of the major international financial currencies (dollar, euro, yen, Swiss franc, Sterling) varying across countries and over time.

⁸The construction of this dataset is described in BIS (2003).

⁹Where the BIS data set lacks data on the currency of issue for a country, we rely on the World Bank's GFD database of the currency composition of external debt. This is an imperfect measure because it includes non portfolio long term debt (such as bank loans), but the countries which are missing BIS data make up a small fraction of internationally held debt assets. Our dataset focuses on international bond issues - while foreign investors have become active in the domestic bonds markets of developing countries in very recent years, the international bond issues are more important for the vast bulk of our sample period.

In order to estimate the currency composition of portfolio debt assets, a naïve approach would be to simply assume that if a country holds an amount issued by country A, then the currency composition of those holdings reflects the aggregate currency composition of the international debt issued by country A. However, this would be misleading, since investors from countries whose currencies are popular choices for foreign-currency bond issues are apt to disproportionately hold their own currencies when purchasing international debt securities issued by other countries (a tendency seen in the data used below from the US Treasury, Bank of Japan, and ECB).

In order to allow for this currency bias, we follow Lane and Milesi-Ferretti (2007c) in exploiting the data provided by the United States Treasury, the European Central Bank and the Bank of Japan regarding the currency composition of the foreign assets of these regions. The United States reports the currency denomination of its portfolio debt assets in each destination country (US Treasury 2004). From the Bank of Japan data, it is clear that Japanese investors purchase (virtually) all of the yen-denominated debt issued by other countries, while the European Central Bank data suggests that investors from the euro area hold 66 percent of the euro-denominated debt issued by other countries (European Central Bank 2005).¹⁰ Accordingly, we adjust the currency weights derived from the BIS data to take into account the portfolio choices by the investors from the major currency blocs and employ these adjusted weights in working out the currency composition of the foreign holdings of investors from other countries.¹¹

In particular, our re-weighting procedure is as follows. For each issuing country, the US Treasury reports the currency composition of portfolio debt holdings in each country, so we are able to directly subtract the exact US holdings from BIS issuance data to generate new “rest of the world” totals for the currency composition of the international bonds issued by each country that are not held by US investors. Since the information from the Bank of Japan shows that Japanese investors hold nearly all the yen debt that is issued outside Japan, yen shares for issuing countries other than Japan are set to zero for investors from outside Japan.¹² Finally, the ECB reports that euro area investors hold 66 percent of

¹⁰Bank of Japan data show the currency composition and amount of Japanese foreign long-term debt assets. When compared with the BIS currency denomination issuance data set, we see that effectively all yen-denominated debt issued outside Japan is held by Japanese investors.

¹¹That is, if US, European, and Japanese investors all hold debt in Brazil and Brazil issues debt in local currency, dollars, euro, and yen, then the US investor most likely holds dollar debt, the Japanese investor most likely holds more yen debt and the European investor most likely holds more euro debt.

¹²This is not to say that no country holds yen debt except Japan. Simply, most countries hold yen-denominated securities issued by Japanese entities. When another country issues yen debt, it is typically

euro-denominated debt that is issued by non-EMU countries. In this way, the level of euro-denominated debt issued by a non-EMU country that is held by investors outside the euro area is set equal to 34 percent of the total euro denominated debt issued by the country. Accordingly, these adjusted levels are the basis for calculating the currency composition of the foreign portfolio debt held by investors from the rest of the world. Then, we can combine the geographical holdings for a country with the ‘residual’ currency composition of all of the countries where a country holds debt to generate the currency composition of its foreign portfolio debt.¹³

For individual members of the euro area, our procedure is as follows. First, we sum across the euro area members to get the total holdings of the euro area in each host country. Consistent with the approach described earlier, we assume that the total holdings of the euro area in country A is distributed between euro-denominated debt (equal to 66 percent of the total euro-denominated debt issued by country A) and debt denominated in other currencies. With respect to the latter, the currency denomination is allocated along the lines of the rest of world data described above (using the non-euro proportions, after removing US holdings and yen-issued debt outside Japan). At that point, we have the currency denomination of debt assets held by individual euro area countries across each host destination. This does not generate the same currency weights for each euro area member, since each country has a different geographical pattern in its portfolio.

1.1.4 Other Debt

From the BIS, we obtained the breakdown between ‘domestic currency’ and ‘foreign currency’ components for the bilateral foreign assets and liabilities of the banks residents in twenty reporter countries vis-à-vis a large number of counterpart countries over 1977-2005

bought by Japanese investors.

¹³That is, for all other investors, we assume a uniform currency distribution in relation to the international bonds issued by a given host country. In this way, differences in currency exposures among investor countries are driven by dispersion in the geographical distribution of their foreign portfolio debt assets: country A that mostly invests in countries that predominantly issue dollar-denominated bonds faces different country risks compared to country B that mostly targets countries that issue euro-denominated debt.

(on a locational basis).¹⁴¹⁵¹⁶¹⁷The reporters are the dominant banking centers and, despite the small number, capture the bulk of world bank holdings. When looking at the reporters' assets, 72 to 90 percent of them are in other reporter countries. Furthermore, Turkey, the one reporter most representative of the other non reporters has 90 percent of its assets and 91 percent of its liabilities in other reporter countries. Thus, when we use the liabilities of the reporters to infer the assets of the non-reporters, we expect to have good coverage.

We begin with the reporter country asset positions. In calculating the currency composition of non-portfolio debt assets, the 'domestic currency' data are useful, since this tells us the levels of dollar-denominated foreign assets owned by the US banking system, yen-denominated foreign assets for Japanese banks and so on.

Regarding the 'foreign currency' component, a candidate strategy is to allocate this across the major currencies, in line with the aggregate currency shares in foreign currency assets and liabilities that are reported by the BIS. (Of course, our estimates would be more accurate, if it were possible to directly obtain the detailed currency breakdown of the 'foreign currency' component for individual countries.) Furthermore, for those host countries that are also reporting countries (where most of the assets lie), we also know the 'domestic currency' versus 'foreign currency' split in terms of the foreign liabilities of its banking system. If we assume that this proportion is representative for the claims of foreign banks in that country, then we only need to use the 'world' averages for the non-host currency component of the foreign-currency element of the foreign bank claims held by other reporting countries in that destination. Again, because reporters are the dominant banking locations, we are only using world averages for a relatively small portion of assets.

We can make inferences about the currency composition of the foreign assets of the banking systems of non-reporting countries by using the data on currency composition of the foreign liabilities of the banking systems of the reporting countries. These data reveal the geographical pattern of the foreign claims of non-reporting countries vis-à-vis the reporters and the split between the 'domestic currency' and the 'foreign currency' components for each reporter. Because the reporters are dominant currencies, much of

¹⁴Although the foreign assets and liabilities of the banking sector include portfolio items, the currency composition of the aggregate should be a good proxy for the predominant non-portfolio debt component. See also BIS (2003, 2006).

¹⁵Clearly, our study would be enhanced if we could obtain these data for a larger number of reporting countries.

¹⁶The use of the locational data follows balance of payments accounting principles.

¹⁷Following Lane and Milesi-Ferretti (2007c), some national central banks report the currency composition of the foreign assets and liabilities of the "monetary and financial institutions" sector.

their banking liabilities (and hence non-reporters assets) are in their own currency and directly known (for example, 89 percent of the US liabilities are in US dollars). In turn, we can allocate the ‘foreign currency’ component according to the global distribution reported by the BIS. Again, although we only have data for twenty reporters, these include all the major banking centers so that this approach should yield plausible estimates of the currency composition of the foreign non-portfolio debt assets of the non-reporting countries.

1.1.5 Reserves

The IMF tracks the currency composition of reserves for its member countries, in its COFER (Currency Composition of Official Foreign Exchange Reserves) database.¹⁸ However, for confidentiality reasons, the only reported COFER data are for major aggregates (world, industrial country group, developing country group). However, the country-level data have been used on a few occasions in research by IMF-affiliated economists to analyze the determinants of cross-country and time series variation in the currency composition of reserves. We exploit the results from these papers to model currency composition.

The major starting point is Eichengreen and Mathieson (2000). In this paper, the authors run separate regressions by currency to predict the share of reserves held in that currency. The independent variables are trade shares with major currency countries, share of debt denominated in these currencies, and exchange rate regime relations with these countries.¹⁹ An important aspect of this work is that it is not simply the trade share with the currency in question included in each regression, but trade and debt shares with the other major currencies are included as well. That way, we can see that having a very large share of trade with Germany can reduce the share of dollars in reserve holdings, even controlling for the share of trade with the US. The R^2 for these regressions ranges from 0.59 for the US dollar share down to 0.35 for the yen share.

We take the coefficients from these regressions and use them to predict the share for each of the major currencies (the dollar, the DM (euro after 1999), the Swiss Franc, the Yen, and the Pound). Once we have predicted values for each currency, we impose an adding up constraint and re-normalize the results, so that each country has totals that add up to 100 percent.

¹⁸The dataset is described at <https://www.imf.org/external/np/sta/cofer/eng/index.htm>.

¹⁹We use trade data from the IMF DOTS database and exchange rate regime data from Shambaugh (2004). We use debt denomination data from the World Bank GFD database, augmenting with BIS issuance data where necessary. We use the World Bank data as a starting point to be consistent with Eichengreen and Mathieson.

To ensure that the results match information about world totals and can adjust over time with world trends, we make one more adjustment. The constants reported in the Eichengreen-Mathieson regressions are time invariant. We assume that these constants could have been allowed to vary over time and alter them such that world totals for our predicted reserves holdings match the world averages reported in the COFER database. That is, we multiply the predicted currency shares by each countries' total reserves holdings and sum across the world. This gives us the world shares. We subsequently adjust the constants such that the predicted shares change until the predicted world averages match the actual world averages. This lets us take into account world trends in reserves holdings over time.²⁰

We merge this generated data with actual data on reserves for 2000-2004 for twenty countries from Truman and Wong (2006) and Wong (2007). For any country for which we have actual data, we use actual data for those years. Before 2000, we use data from central banks where available (US, Canada, UK) and blend our model generated data with 2000 actual data where in 1999 we weigh the actual data .9 and the model data .1, for 1998 it is .8, .2, etc. In practice our estimates were close to the 2000-4 actual data, so a variety of blending techniques yielded nearly identical results and our model generated estimates for 2000-4 were quite similar to the actual numbers for most of the twenty countries in question.

We can further confirm that our predictions are sensible by drawing on two additional sources of information. First, some countries occasionally report their reserves shares in announcements or media interviews. Relying on news reports of these currency shares, we compare predicted with actual (or at least reported, since there is no verification) reserves shares. Our results seem to perform quite well on this measure. Countries like Sweden that report roughly equal dollar and euro reserves show 40 percent dollar and 50 percent euro reserves in our calculations. China, who is reported to hold roughly 70 percent dollar, 20 percent euro and 10 percent other currencies, is found to hold 70-75 percent dollar, approximately 15 percent euro, and 10-15 percent other in our calculations (over various

²⁰To make the adjustment, we increase (decrease) the constants used to make the predicted values for each currency by the amount that currency is under (over) predicted when compared to world averages. Then the new predicted values are calculated and the predicted world averages recalculated and again compared to the actual world averages. The iterations are continued until there is a near perfect match between predicted and actual world holdings by currency. The constants that would generate predictions that match the world average are not in fact uniquely determined, but this process brings us to a set of constants as close as possible to the time invariant ones reported in the empirical work, and small differences in the constants make virtually no difference to the final results.

recent years). In general, non-EMU European countries tend to hold 40-50 percent each in dollars and euro in our work; Latin American countries tend to hold mostly dollars, Asian countries hold largely dollars with some yen and euro as well, and all these figures seem to mesh reasonably well with the scattered media reports on the subject.

Second, Ewe-Hhee Lim (2006) studies the changing international role of the euro and dollar and gives some regional information on the currency composition of reserves. Again, due to confidentiality, the results are deliberately reported in a way to make it difficult to back out actual currency composition, but we can use these results as a broad check. Lim breaks countries into two groups that we can try to replicate: a dollar-oriented group of Asia, the Western Hemisphere, and other dollar pegs; as well as a Euro-oriented bloc of countries neighboring the euro area plus much of Africa. We aggregate our synthetic country level reserve shares into the same groups. Because the exact members of each group are not reported, we cannot precisely compare our results, and thus we cannot expect to exactly match his output, but these results provide a useful benchmark. Looking at the most recent data for 2004, world average shares were 67 percent US dollar and 25 percent euro. Lim shows the dollar bloc holding 76 percent dollar and 19 percent euro while we find 71 percent dollar and 21 percent euro. The euro bloc holds 33 percent dollar and 57 percent euro in his grouping while we find 46 percent dollar and 50 percent euro. We see that our work moves countries towards their actual data from the starting point of the world averages in both cases. As with the media reports, we do not have perfect matches, but we have a reasonable agreement between our data and our available cross-checks.

1.2 Foreign Liabilities

The liability side of the international balance sheet is divided into four groups: portfolio equity, direct investment, portfolio debt, and other debt. In many cases, the source information for portfolio and other debt are combined, so we do not try to disaggregate them.

1.2.1 Portfolio Equity

Consistent with our treatment on the assets side, portfolio equity liabilities are assumed to be denominated in the currency of the host country. Thus, there is no foreign-currency exposure from equity liabilities. The size of these liabilities is important in creating total liability weights, since the larger is the relative share of portfolio equity or FDI liabilities, the greater the local currency share in liabilities. Thus we only need the size of the liabilities, not

geography or currency denomination. We return to the way different asset class categories are combined below.

1.2.2 Direct Investment

Direct investment liabilities are assumed to be denominated in the currency of the host country.²¹

1.2.3 Portfolio and Other Debt

All debt liabilities are processed in tandem due to data restrictions. We have data from the BIS banking statistics database on banking liabilities for 20 countries (and the implied liabilities to the 20 reporters based on reporters' assets for the remaining countries). In addition, we know the currency composition of portfolio debt liabilities, based on issuance data from the BIS international securities database for 113 reporting countries.

However, neither database includes information on the currency composition of debt owed to official creditors (bilateral or multilateral official debt), which is a prominent source of debt for many developing countries. The World Bank's *Global Development Finance* database shows that debt to official creditors ranges from 35 percent to 53 percent of total developing country debt over the time period 1990-2004. The World Bank does report the currency composition of aggregate external debt which merges bank, bond and official debt data. Due to the importance of the official debt composition, we use this World Bank source for all countries where it is available (it is not available for any industrial country and is missing for a small number of developing countries).²²

For the remaining countries, we create bond-based weights using the currency composition from BIS issuance data and weights for other debt from the BIS banking data. These two weights are merged together to create total debt currency composition weights. The bond based weights are simply a reflection of the currency shares of debt issued by the country. The banking shares follow a similar procedure as other debt assets. For the twenty reporting countries, we know location of all bank liabilities and can use the breakdown of domestic versus foreign currency to determine the extent to which liabilities are in the home currency. Then for locations that are also reporters, we can derive from that

²¹As noted earlier, we plan to refine this choice in a future iteration. The stock of direct investment liabilities includes both equity and debt components. The debt component may at least in part be denominated in the currency of the parent entity or in other major international currencies.

²²For the handful of developing countries that show domestic currency international issuance in the BIS database, we adjust the World Bank currency shares to include the domestic currency issuances.

country's assets how much is in that country's currency (it is reported as domestic currency in the reporter's assets). For the remainder, we allocate based on world totals. For the few countries that are neither reporters nor have data in the World Bank database, we rely on the assets of the reporters to determine location and currency of their liabilities. Again, the reporters are involved in one side or the other of the bulk of banking transactions and we thus have fairly good coverage. See the discussion of other debt assets for details.

2 Uses

The text describes the various uses of the data. We generate Asset, Liability, and net financial weights by combining asset class weights from the External Wealth of Nations data set with these by asset class currency weights.

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