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A NEW INDEX OF CURRENCY MISMATCH AND SYSTEMIC RISK

Romain Rancière, Aaron Tornell and Athanasios Vamvakidis

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Romain Rancière, Paris School of Economics, IMF and CEPR
Aaron Tornell, University of California, Los Angeles
Athanasios Vamvakidis, IMF

ABSTRACT

A New Index of Currency Mismatch and

Systemic Risk*

This paper constructs a new measure of currency mismatch in the banking sector that controls for bank lending to unhedged borrowers. This measure explicitly takes into account the indirect exchange rate risk that banks undertake when they lend to borrowers that will not be able to repay in the event of a sharp depreciation. Such systemic risk taking is not captured by indicators that are based only on banks' balance sheet data. The new measure is constructed for 10 emerging European economies and for a broader sample that includes 19 additional emerging economies, for the period 1998-2008. Comparisons with previous currency mismatch measures that do not adjust for unhedged foreign currency borrowing illustrate the advantages of the new approach. In particular, the new measure flagged the indirect currency mismatch vulnerabilities that were building up in a number of emerging economies before the recent global crisis. Measuring currency mismatch more accurately can help country authorities in their efforts to address vulnerabilities at the right time, avoiding hurting growth prospects.

Romain Rancière
Paris School of Economics
48, Boulevard Jourdain
75014 Paris, France
FRANCE

Aaron Tornell
Department of Economics
UCLA
405 Hilgard Avenue
Los Angeles
California CA 90024-1477
USA

Email: ranciere@pse.ens.fr

Email: tornell@econ.ucla.edu

Athanasios Vamvakidis
IMF
700 19th Street
Washington
DC 20431
USA

Email: avamvakidis@imf.org

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I. INTRODUCTION[1]

Currency mismatch—the extent to which an economy's liabilities are denominated in foreign currency while its assets are denominated in domestic currency—is one of the main mechanism by which emerging economies take on systemic risk. Yet existing measures of currency mismatch, based on aggregate data, do not capture the full extent of systemic risk taking. This paper presents a new currency mismatch index in the banking sector that captures indirect systemic risk taking by adjusting for foreign currency lending to unhedged borrowers.

Currency mismatch can expose an emerging economy to systemic risks through balance sheet vulnerabilities. Currency mismatch has been one of the key vulnerabilities leading to crises in emerging economies (i.e., Mexico 1994 and East Asian 1997–98). It also reached unprecedented levels during the economic boom before the recent crisis in emerging Europe.

However, currency mismatch can also be a growth engine, by allowing financially constrained firms (i.e., new and small firms) in emerging economies finance profitable investment projects.[2]

To benefit from financing in foreign currency, but also address excessive vulnerabilities and reduce crisis risks when foreign currency borrowing reaches excessive levels, country authorities should be able to measure currency mismatch properly. Introducing macro-prudential measures or capital controls to limit currency mismatch when it is too low could hurt investment and growth by limiting financing, particularly for small and medium enterprises that tend to suffer from credit constraints. However, allowing excessive levels of currency mismatch could lead to a severe crisis in case of an abrupt devaluation. A good measure of currency mismatch could help authorities strike the right balance in this trade-off.

The literature has estimated currency mismatch based on two main, straightforward measures. The first is based on the net national debt or debt service requirements to the net exports of a country. The second is based on the ratio of foreign currency denominated liabilities to foreign currency denominated assets of the banking sector. These measures have the virtue of being simple and using readily available data. However, they might miss instances in which systemic risk is developing.

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[2]See Ranciere, Tornell and Vamvakidis (2010) for empirical evidence on this dual role of currency mismatch at the macro and micro levels.

- While the first measure captures external aggregate imbalances, it is not designed to capture sectoral imbalances that could generate systemic risk. This is the case when an economy has a low foreign currency debt relative to its net exports, but its debt is concentrated in borrowers with no foreign currency income. The presence of a vibrant export sector does not imply that a government would be able to tax exporters during a crisis in order to bailout debtors with foreign currency exposures.

- The second measure, by looking exclusively at bank balance sheets, often finds the *notional* degree of currency mismatch to be small, as banks with foreign currency liabilities also tend to lend in foreign currency. The latter is the result of prudential requirements or internal risk management practices. However, if debtors cannot effectively hedge their exchange rate risk, banks are indirectly exposed to exchange rate risk through credit risk. Thus, there is a *de-facto* systemic risk, which is not reflected in a notional currency mismatch measure that focuses only on banks' balance sheets.

A currency mismatch measure that appropriately captures the evolution of systemic risk should therefore control for indirect channels by which foreign currency debt can generate insolvencies across different classes of bank's debtors. Such a measure should control for the sources of foreign currency income for different classes of foreign currency borrowers.

The recent experience of the emerging European economies illustrates the deficiencies of the available currency mismatch measures. During the precrisis boom, banks in emerging Europe borrowed in foreign currencies to extend loans denominated in foreign currencies both to the corporate sector and to households. Indeed, the share of foreign currency lending to total lending reached well above 50 percent in most emerging European economies in 2007, which was substantially higher than in other emerging economies (see Figure 1.) A substantial share of this credit was extended to sectors with no foreign currency revenues, and financed consumption and investment in nontradables goods.

This indirect mismatch suggests that the de-facto exchange rate risk taken on by banks was substantial and contributed to aggregate systemic risk. If foreign exchange borrowers cannot hedge their exchange rate risk, then following an abrupt devaluation a large share of foreign currency loans will not be repaid, and the number nonperforming bank loans will increase substantially. This could dramatically affect the capital of the banking system and thus have systemic implications for the economy.

An appropriate measure of currency mismatch needs to account for this source of systemic risk, and address the concern that the true currency mismatch in the banking system might be much larger than that suggested by banks' balance sheet data. However, such a measure is not available, primarily because of lack of readily available data on the composition of

banks' assets and liabilities and the extent to which borrowers in foreign currency are hedged.

This paper constructs such a de-facto currency mismatch measure. It does so by combining information on foreign currency assets and liabilities of banks with BEEPS firm-level data and other data sources from national authorities and the IMF's confidential Vulnerability Exercise for Emerging Economies to adjust for the fraction of foreign currency loans granted to borrowers with no foreign currency income. The latter is subtracted from the asset side of the banks' balance sheets. Therefore, this measure takes explicitly into account the part of the banks' foreign currency assets that is foreign currency loans to unhedged borrowers and are, therefore, indirectly subject to exchange rate risk through credit risk.

The paper constructs such a measure for 10 emerging European economies, for which detailed balance sheet data is available over the period 1998–2008. It then computes a similar de-facto currency mismatch measure for 19 additional emerging economies, for which less detailed data are available. Interestingly, the new de-facto currency mismatch measure is much larger than other currency mismatch measures that do not control for the banks' borrowers' ability to hedge.

The rest of the paper is structured as follows. Section 2 describes the construction of the de-facto currency mismatch measure. Section 3 discusses the new currency mismatch measure for emerging Europe before and after the recent crisis, and compares it with other measures. Section 4 discusses the new currency mismatch for a broader set of emerging economies. And section 5 includes concluding remarks. The appendix contains a description of the empirical methodology for measuring currency mismatch and the data sources.

II. A NEW MEASURE OF CURRENCY MISMATCH

At the macro level, the early literature on currency mismatch primarily focused on economy-wide aggregates, such as the ratio of foreign national debt to net exports.[3] While, such measures capture external aggregate imbalances, they are not designed to capture sectoral imbalances that could generate systemic risk. For instance, while an economy might have a low foreign currency debt relative to its net exports, its debt might be concentrated in borrowers with no foreign currency income. More recent literature has tried to address this concern by looking at sector balance sheet data (e.g., Rosenberg and others (2005)). Recently, Prat (2007) has made such an analysis for the banking sector. She computes the banks' currency mismatch as the share of their foreign currency liabilities not covered by their foreign currency assets. However, this literature does not adjust for foreign currency loans made to unhedged borrowers.

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[3]Goldstein and Turner (2004) and Eichengreen, Hausmann and Panizza (2007) review this literature.

The new, de-facto currency mismatch measure is computed as the ratio of foreign currency denominated net unhedged liabilities to total bank assets, where the former is determined by the share of banks' net foreign currency liabilities that is lent to unhedged borrowers (see the Appendix for details.) The formula of the new currency mismatch measure in the banking sector is the following:

Foreign currency denominated net unhedged liabilities / total bank assets = {[foreign currency foreign liabilities + foreign currency domestic liabilities] - [foreign currency foreign assets + foreign currency domestic assets] + [foreign currency lending to unhedged households + foreign currency lending to unhedged nonfinancial firms]} / [total bank assets]

The components of the numerator in the above formula include:

- Foreign currency foreign liabilities: foreign currency claims of nonresidents towards the domestic banking sector (i.e., loans of foreign banks, including parent foreign banks to their subsidiaries, and foreign currency deposits of nonresidents).

- Foreign currency domestic liabilities: foreign currency claims of residents towards the domestic banking sector (i.e., foreign currency deposits of residents).

- Foreign currency foreign assets: foreign currency claims of the banking sector towards nonresidents (i.e., deposits, or loans in foreign currencies).

- Foreign currency domestic assets: foreign currency claims of the banking sector towards residents (i.e., foreign currency loans).

- Foreign currency lending to unhedged households: the part of the banks' foreign currency domestic assets that is foreign currency lending to unhedged households.

- Foreign currency lending to unhedged nonfinancial firms: the part of the banks' foreign currency domestic assets that is foreign currency lending to unhedged firms.

The adjustment includes foreign currency lending to unhedged households and nonfinancial firms. As such lending is subject to exchange rate risk through balance sheet effects in households and nonfinancial firms, a sharp exchange rate depreciation would turn a large share of such loans to nonperforming loans. Therefore, a currency mismatch of a bank's borrower will lead to a currency mismatch for the bank if the borrower cannot repay the foreign currency loan during a crisis. Therefore, foreign currency loans to unhedged borrowers should be subtracted from the asset side of the banking sector in order to calculate a currency mismatch measure that captures more accurately the extent of systemic risk.

This measure assumes that exporters are able to hedge all exchange rate risk. However, it should be noted that even loans to borrowers with foreign currency income may not be serviced during a crisis if their foreign income declines, for example, due to a drop in exports as foreign demand drops sharply.[4]

The construction of such a measure requires refined data about bank balance sheets that permits tracking the evolution of credit to different sectors, including nonfinancial firms and households, and measuring the extent to which the debtors are hedged for exchange rate risk. Such data is not readily available, which might explain the lack of such de facto currency mismatch measures in the literature.

III.   MEASURING CURRENCY MISMATCH IN EMERGING EUROPE

This section constructs the new measure of currency mismatch for emerging European economies by using data from a large number of sources (see Appendix for details.) Data on foreign currency domestic and foreign asset and liabilities by sector and data on total bank assets are from Haver Analytics and from the internal and confidential IMF Vulnerability Exercise for Emerging Economies. The share of foreign currency lending to corporates with no foreign currency income is from a number of sources, including various EBRD and World Bank firm survey data, country authority data, and various country studies.

The data include the extent to which firms hedge their foreign currency exposure, but not the extent to which households do. One could assume that either households hedge foreign exchange risk to the same extent as firms do, or they do not hedge at all. The currency mismatch measure for emerging Europe is calculated under both alternatives, using data on foreign currency loans to households and to firms separately. However, for the additional 19 emerging economies in the next section the data are available only for foreign currency loans to the whole private sector, without separating households and firms. Thus, for these 19 countries the currency mismatch measure assumes that households' hedging is the same as that in firms.

Figure 2 shows the de-facto currency mismatch in all emerging European economies with available data during 1998–2008, ranked based on the change in currency mismatch during this period. The sample includes 10 countries with available data that account for 86 percent of East Europe's GDP, excluding Russia. The estimates show that currency mismatches increased throughout emerging Europe during the boom years before the recent crisis, particularly in Bulgaria, Latvia, Estonia, and Lithuania. On average, currency mismatches as a share of bank assets increased by 16 percentage points during the last ten years in the region. Before the crisis, the currency mismatch measure reached the highest level in

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[4]Indeed, the IMF's WEO estimates that emerging Europe's exports of goods and services fell by 11 percent in volumes, or 21 percent in nominal U.S. dollars, in 2009.

Romania, Estonia, Croatia, Latvia, and Lithuania. The only economies without currency mismatches before the crisis (a negative measure in 2007) included the Czech Republic and, less so, Ukraine.[5]

To assess the importance of controlling for foreign currency lending to unhedged borrowers, Figure 3 shows an unadjusted notional currency mismatch (foreign currency denominated net liabilities without adjusting for foreign currency lending to unhedged borrowers) next to the de-facto adjusted measure. The comparison shows that while most countries do not exhibit currency mismatch according to the unadjusted measure, they exhibit very large mismatches according to the measure that adjusts for unhedged foreign currency lending. The difference is on average equal to 23 percentage points, and is particularly sharp in Estonia, Latvia, and Bulgaria.

Did unhedged lending go mostly to households or to the corporate sector? Focusing on the years before the recent crisis, Table 1 shows the calculated currency mismatches for 2004 and 2007, without adjusting for unhedged foreign currency borrowing (first column), adjusting only for unhedged borrowing by households (second column), adjusting only for unhedged borrowing by firms (third column), and fully adjusting for unhedged borrowing (fourth column). A comparison of unadjusted and fully adjusted for unhedged foreign currency borrowing currency mismatches in 2004 and in 2007 shows that currency mismatches increased in most countries during this period, in most cases substantially. A comparison of the second and third columns, which compares the extent to which the adjustment for unhedged foreign currency borrowing is due to household vs. firms, shows that most of the unhedged borrowing during the precrisis period was done by firms. However, unhedged foreign currency borrowing by household increased substantially by 2007—which may reflect the mortgage-financed housing boom in some of the countries in the region. A comparison of the fourth and last columns in Table 1 show that assuming that households hedge as much as firms do or they do not hedge at all does not make a big difference. Indeed, the currency mismatch measures under these two assumptions are quite similar (the correlation between the two is close to one).

In many countries, firms took on additional insolvency risk via *direct* foreign currency borrowing from abroad, particularly in response to central bank measures to limit currency mismatch in the domestic banking sector.[6] Although the baseline currency mismatch measure does not include such direct borrowing, the fifth column in Table 3 contains currency mismatch estimates that include direct foreign currency borrowing from abroad.[7] The

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[5] Although Ukraine was overheating before the global financial crisis and eventually had a severe crisis and an IMF program, its external imbalances did not reach levels as high as in most of the rest of emerging Europe.
[6] Direct borrowing from abroad by corporates was often accompanied by a repayment guarantee by the domestic foreign owned bank to the parent bank abroad. Therefore, the exchange rate risk was still assumed by the domestic banking sector, while the loan was repaid to the parent bank.
[7] Based on data in Rosenberg and Tirpak (2009); see Appendix for details.

estimates suggest that such borrowing increased currency mismatch in all countries in the sample before the crisis.

Table 2 compares the new currency mismatch measure with two standard measures in the literature, for the precrisis period. The first is net external debt to exports of goods and services—net debt is defined as total external debt minus foreign assets of the central bank and the banking sector. The second is external debt service to exports of goods and services. These comparisons suggest that the new measure of currency mismatch provides new information. Although the share of net external debt to exports seems to be highly correlated with the new measure, the correlation of the changes is very small. The share of external debt service to exports is even less correlated with the new measure, both in terms of levels and changes.

IV. MEASURING CURRENCY MISMATCH IN EMERGING ECONOMIES

This section expands the country sample to include non-European emerging economies, as well as additional European emerging economies, for which data are available in less detail than in the above sample of the 10 emerging European economies. It is even more challenging to compute the currency mismatch for non European emerging economies because of the lack of detailed data on domestic banks' foreign currency loans to residents and foreign currency deposits of residents. In addition, data on foreign currency loans are not available separately for firms and households. The exceptional magnitude of foreign currency borrowing across sectors before the recent crisis has fostered a data collection effort in Eastern Europe that seems unparalleled in the rest of the emerging world, despite the role of currency mismatch in the financial crises of the 1990s. Nevertheless, this section uses a number of sources and simplifying assumptions to expand the de-facto currency mismatch measure to 19 additional countries (see Appendix for more details).

- Data on foreign currency loans to residents and foreign currency deposits of residents are from the internal and confidential IMF Vulnerability Exercise for Emerging Economies, which is based on data provided by country authorities. Some gaps in the data on foreign currency deposits of residents are complemented by using data in Arteta (2003 and 2005) and Haver Analytics.

- Data on banks' foreign assets and liabilities are from a data set constructed by Prat (2007) for: Argentina, Brazil, China, Indonesia, Mexico, Peru, Philippines, Russia, Thailand, Turkey, and Uruguay. Data from the IMF's International Financial Statistics (IFS) are used for: Bosnia & Herzegovina, Costa Rica, Egypt, Guatemala, Kazakhstan, Serbia, Venezuela, and Vietnam. Unfortunately, the IFS data on bank foreign assets and liabilities do not specify currency denomination. Thus, for these 8 countries it is assumed that all the banks' foreign assets and liabilities are denominated in foreign currency. As discussed below, this assumption does not turn out to make a big difference.

- Data for the share of unhedged foreign currency borrowing comes from various sources. For Latin America, the share is based on firm survey data in Kamil (2004 and 2010). For other regions, data come from various World Bank's Enterprise Surveys, setting the share of unhedged foreign currency borrowing equal to the share of non-exporting firms with foreign currency loans to the total number of firms with foreign currency loans—assuming that foreign currency loans in the tradable sector are fully hedged. As explained above, due to lack of separate data on foreign currency loans to firms and households, the share of unhedged borrowing is assumed to be the same for households and firms.

To assess whether the currency mismatch measure using IFS data on bank foreign assets and liabilities captures currency mismatch in a similar way as the measure based on more detailed data, the currency mismatch generated by them is compared with the baseline currency mismatch measure for the 10 emerging European economies of the previous section. The simple correlation of the changes in the two currency mismatch measures is 0.85, suggesting that using IFS data is a reasonable approximation.

In the extended sample of emerging economies, emerging Europe stands out with the largest currency mismatch before the recent crisis. According to Figure 4, the six economies with the largest currency mismatch in 2008 were all in Europe. They include Romania, Bosnia and Herzegovina, Estonia, Lithuania, Croatia, and Latvia.

Emerging Europe also stands out in terms of changes, as the region with the sharpest increase in currency mismatch before the recent crisis. As Figure 5 shows, the six economies with the largest increase in currency mismatch are in this region: Estonia, Latvia, Bulgaria, Ukraine, Lithuania, and Serbia.[8]

V. CONCLUDING REMARKS

This paper constructs a new measure of currency mismatch for the banking sector that captures indirect systemic risk taking by adjusting for foreign currency lending to unhedged borrowers. The new measure is the ratio of foreign currency denominated net unhedged liabilities to total bank assets. It adjusts the banks' net foreign currency liabilities by subtracting from the asset side foreign currency loans to households and firms without foreign currency income. Therefore, the new currency mismatch measure takes into account that banks can also be exposed to foreign exchange risk indirectly, through credit risk.

The paper finds that this *de-facto* measure of currency mismatch is much larger than other measures of currency mismatch that do not control for indirect mismatches in the banks' balance sheets. Therefore, in assessing systemic risk, policymakers should monitor not only

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[8]This figure uses the IFS data for NFA for the additional 19 emerging economies.

mismatches in banks' balance sheets, but also indirect imbalances via the ability of banks' borrowers to repay foreign currency debts.

The new measure is calculated for 10 emerging European economies and for a broader sample that includes 19 additional emerging economies. The results suggest that currency mismatch increased substantially in emerging Europe before the recent crisis, more so and reaching much higher levels than in emerging economies in other regions. Therefore, such a measure would have clearly flagged vulnerabilities in emerging Europe well before the recent crisis.

Measuring currency mismatch properly can guide country authorities in their efforts to address external vulnerabilities at the right time. The new measure can be used to flag risks of excessive currency mismatch that, in addition to other vulnerability indicators, could call for macro-prudential measures. However, it can also indicate when currency mismatch is at comfortable levels, in which case policy action would not necessarily be recommended, as it could lead to a credit crunch, hurting growth prospects.

Table 1. Currency Mismatches in Emerging Europe in Percent of Bank Sector Assets: Adjusting for Unhedged Borrowing, 2004－07

		2004				
	Unadjusted	Adjusted for unhedged foreign currency borrowing from domestic banks			Including unhedged foreign currency loans from abroad	Assuming totally unhedged households
		By households	By firms	Fully adjusted		
Bulgaria	-28.7	-26.7	-3.9	-1.9	2.0	-1.2
Croatia	28.5	28.6	32.2	32.3	35.8	32.4
Czech Rep.	-30.7	-30.7	-28.8	-28.8	-26.8	-28.7
Estonia	-33.1	-18.4	-13.1	1.5	4.9	11.5
Hungary	-2.1	-0.9	4.9	6.1	8.4	7.1
Latvia	-31.0	-21.6	-19.1	-9.6	-9.0	-8.0
Lithuania	-13.4	-9.7	-0.8	3.0	4.6	6.5
Poland	-7.3	-2.3	-4.3	0.7	2.3	3.2
Romania	12.1	18.0	24.9	30.8	35.0	32.1
Ukraine	-43.2	-38.0	-26.3	-21.1	.	-19.5

		2007				
	Unadjusted	Adjusted for unhedged foreign currency borrowing from domestic banks			Including unhedged foreign currency loans from abroad	Assuming totally unhedged households
		By households	By firms	Fully adjusted		
Bulgaria	-31.9	-27.0	-4.0	0.9	6.9	2.6
Croatia	21.7	21.8	24.6	24.7	31.6	24.7
Czech Rep.	-24.5	-24.4	-22.4	-22.4	-20.0	-22.4
Estonia	-25.9	3.5	4.3	33.7	39.3	53.6
Hungary	-5.8	0.6	1.6	8.0	11.2	13.5
Latvia	-26.3	-5.7	-5.4	15.1	17.4	18.5
Lithuania	-5.1	2.7	6.3	14.1	17.0	21.4
Poland	-9.1	-4.9	-3.8	0.4	2.6	2.5
Romania	10.9	22.8	23.5	35.4	39.5	38.1
Ukraine	-34.2	-20.9	-19.7	-6.3	.	-2.0

Source: authors' calculations (see Appendix).

Note: the numerator is expressed as liabilities minus assets, and therefore, an increase in the above percentages reflects an increase in currency mismatch.

Table 2. Currency Mismatch Measures in Emerging Europe, 2004—07

	Net external debt/exports			External debt service/exports			Foreign currency denominated net unhedged liabilities/total bank		
	2004	2007	Change	2004	2007	Change	2004	2007	Change
Bulgaria	2.8	4.5	1.7	0.3	0.6	0.2	-1.9	0.9	2.8
Croatia	3.5	5.0	1.5	0.4	0.6	0.3	32.3	24.7	-7.6
Czech Rep.	1.2	1.0	-0.2	.	.	.	-28.8	-22.4	6.4
Estonia	4.1	5.0	0.9	0.4	0.6	0.2	1.5	33.7	32.2
Hungary	5.4	4.4	-1.0	0.3	0.2	0.0	6.1	8.0	1.9
Latvia	3.4	10.0	6.6	0.2	0.4	0.1	-9.6	15.1	24.7
Lithuania	3.7	4.0	0.3	0.4	0.8	0.3	3.0	14.1	11.1
Poland	3.2	4.5	1.3	0.4	0.3	-0.1	0.7	0.4	-0.3
Romania	4.7	9.0	4.3	0.1	0.5	0.4	30.8	35.4	4.6
Ukraine	2.0	3.8	1.7	0.3	0.3	0.0	-21.1	-6.3	14.8
Correlation with new measure	0.7	0.7	0.3	-0.2	0.5	0.0	…	…	…
Rank Correlation with new measure	0.8	0.8	0.2	0.0	0.4	0.1	…	…	…

Note. Standard currency mismatch measures in the literature divide net external debt or external debt service with exports or net exports.
As most emerging European economies had negative next exports before the crisis, the denominator in the table is total exports.
An increase in all measures reflects higher currency mismatch.

Figure 1. Bank Loans in Foreign Currency in Percent of TotalBbank Loans,
Emerging Europe, 2007
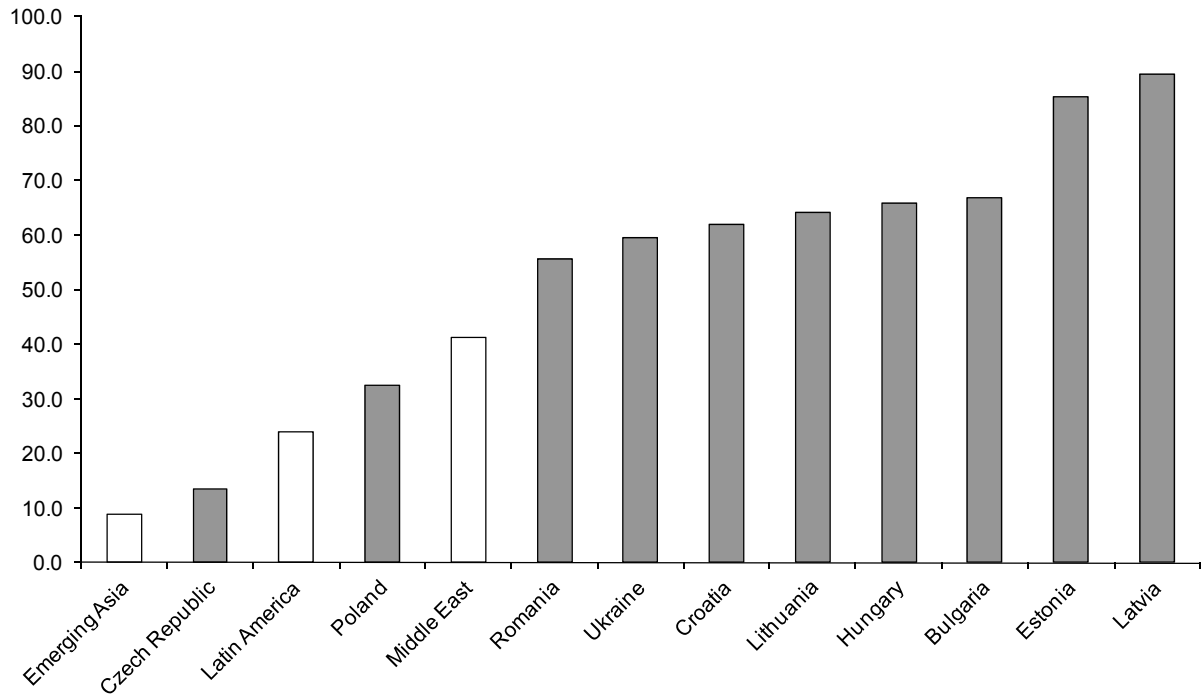
Source: IMF, Database of Vulnerability Exercise for Emerging Economies.

Figure 2. Currency Mismatch in Emerging Europe, 1998-08

Source: Authors' calculations.

Figure 3. Currency Mismatches in Emerging Europe, with and without Adjustment
for Unhedged Lending, 2007

Source: Authors' calculations.

Figure 4. Currency Mismatch in Emerging Economies, 2008

Source: authors' calculations.

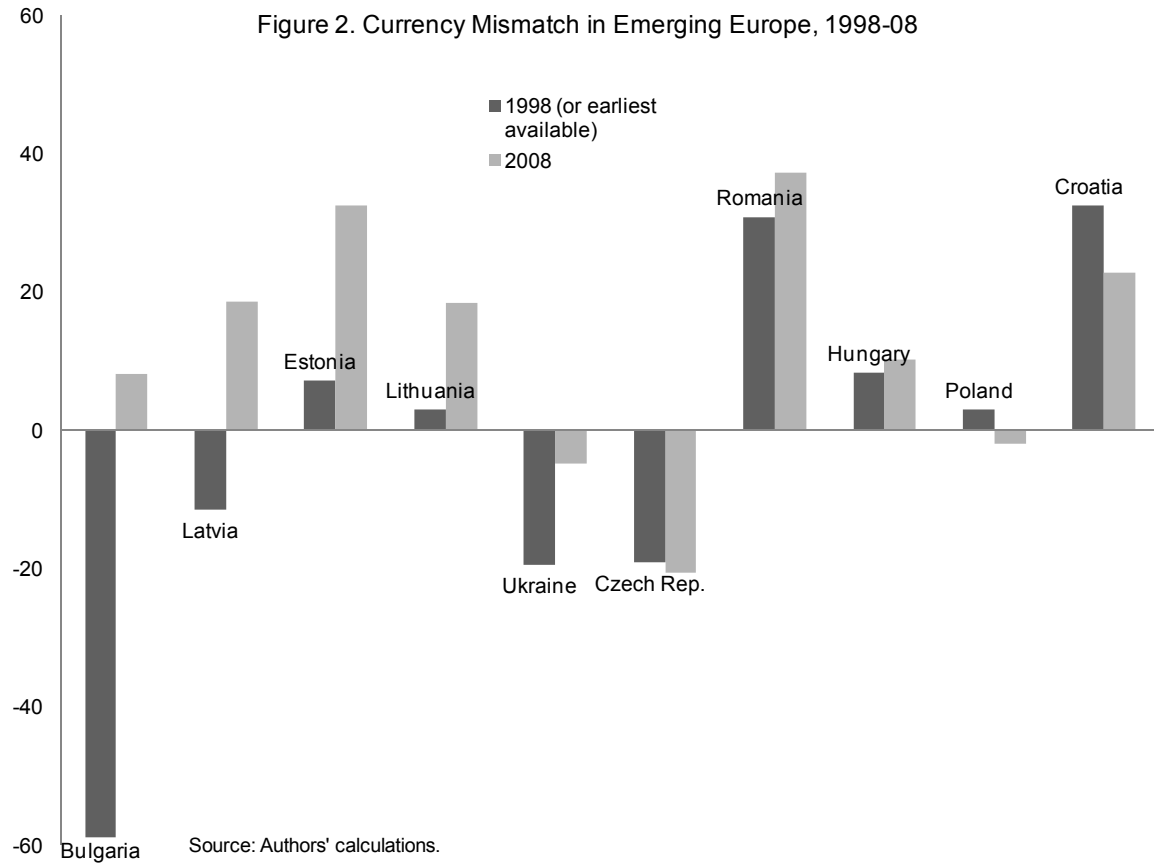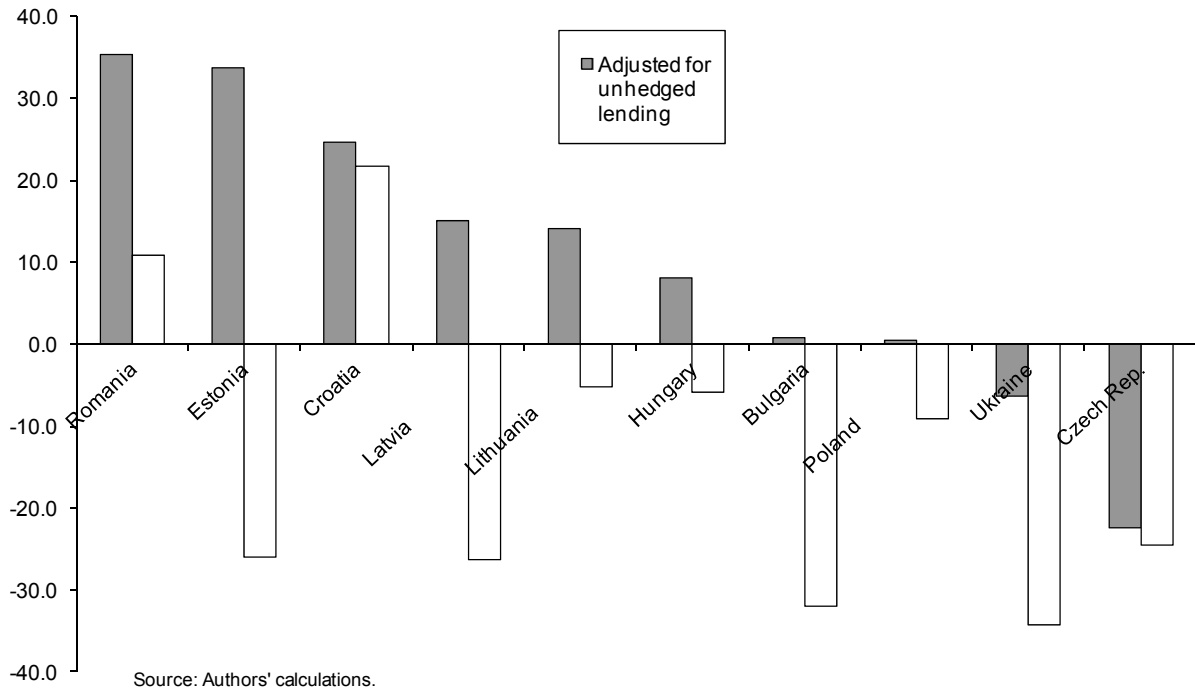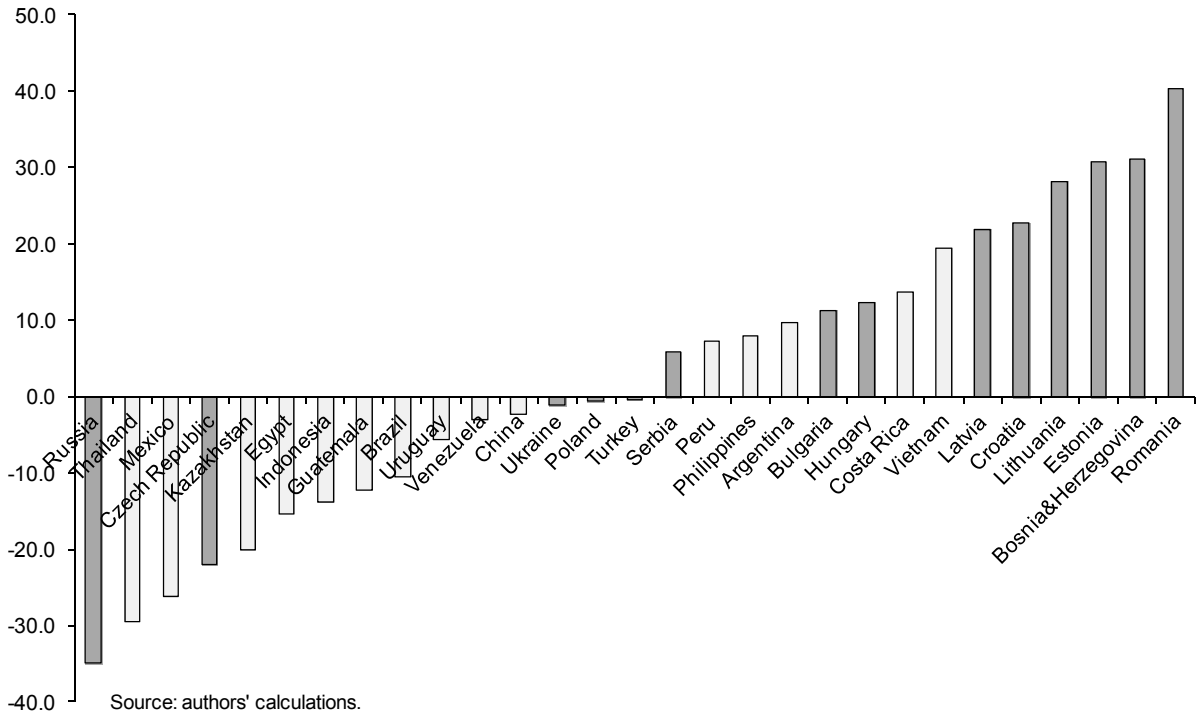Figure 5. Increase in Currency Mismatch in Emerging Cconomies before the Crisis
(2004-07)

Source: authors' calculations.
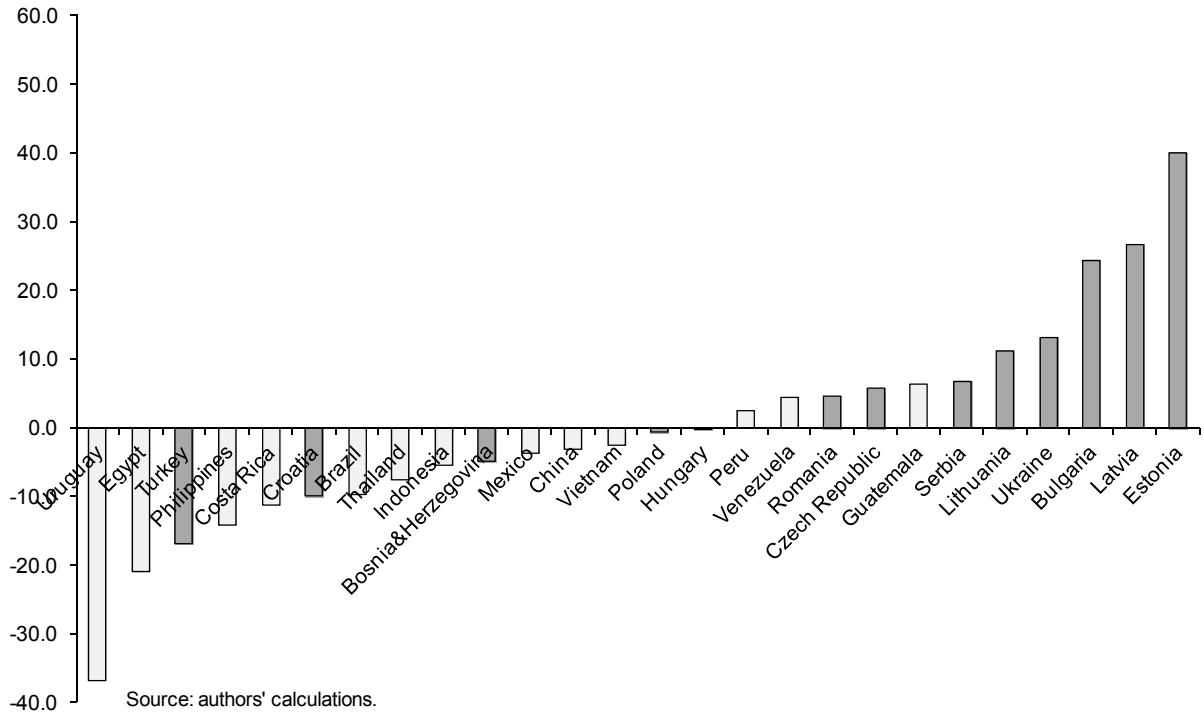
Appendix. Calculation of Currency Mismatch and Data Sources

Definition

The measure of currency mismatch in the paper is the gap between foreign currency assets and liabilities, both with respect to residents and non residents (domestic and foreign net assets in foreign currencies), adjusted for an estimate of foreign currency lending that is not hedged, and divided by total bank assets. The formula of the calculation is the following:

foreign currency denominated net liabilities = {foreign currency foreign liabilities + foreign currency domestic liabilities − foreign currency foreign assets − foreign currency domestic assets + foreign currency lending to unhedged households + foreign currency lending to unhedged nonfinancial firms} / {total bank assets}

In more detail:

- Foreign currency foreign liabilities include all foreign currency claims of nonresidents towards the domestic banking sector, such as loans of foreign banks, including parent foreign banks to their domestic subsidiaries, and foreign currency deposits of nonresidents. Bank loans from abroad reached high levels during the recent boom in emerging Europe. Foreign currency deposits of nonresidents were also substantial in some countries.

- Foreign currency domestic liabilities include all foreign currency claims of residents towards the domestic banking sector, such as foreign currency deposits of residents. The latter have been historically very large in emerging Europe.[9]

- Foreign currency foreign assets include all foreign currency claims of the banking sector towards nonresidents, such as deposits, or loans in foreign currencies.

- Foreign currency domestic assets include all foreign currency claims of the banking sector towards residents, such as foreign currency loans, which grew very rapidly during the recent boom in emerging Europe.

- Foreign currency lending to households is part of the banks' foreign currency domestic assets. However, many households have no foreign currency income, and therefore, are not hedged when they borrow in foreign currency. Therefore, the calculation of the banks' currency mismatch subtracts foreign currency lending to such households from

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[9] According to anecdotal evidence, during east Europe's liberalization in the early 1990s, large amounts of foreign currency that were "held in mattresses," primarily Deutsche Marks, were deposited in banks. They were later converted into euros. Initially, they served as a hedge against inflation, given memories of price instability during liberalization. Even though inflation stabilized at low levels in the current decade, most of these deposits remained, in some cases in anticipation of euro adoption.

the banks' foreign currency assets, because such lending is assumed to be subject to exchange rate risk, directly for the households, and indirectly, through credit risk, for the banks. Private sector foreign currency deposits, including of households, are large in emerging Europe and do provide a hedge. However, it is reasonable to expect that households with large foreign currency deposits don't need to also borrow in foreign currency. As data on the share of households that are not hedged are not available, we have assumed that this share is equal to the share of firms without foreign currency income (where the households are employed). As a robustness test, we also consider the case in which households cannot hedge at all.

- Foreign currency lending to nonfinancial firms is also part of the banks' foreign currency domestic assets. However, some of this lending goes to firms that do not have foreign currency income and are, therefore, not hedged, resulting in credit risk for the banks and, indirectly, exchange rate risk. To adjust for the latter, we subtract foreign currency loans to nonfinancial firms that have no foreign currency income from the banks' foreign currency domestic assets (we assume that financial firms have foreign currency income).

- Finally, we divide by total bank assets, to adjust for the size of the banking sector in each country. We also test the robustness of the results when we divide our measure by GDP.

Data sources

Data on foreign currency domestic and foreign asset and liabilities by sector and data on total bank assets are from Haver Analytics. Data are available for 10 countries: Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, and Ukraine. These economies produce 86 percent of East Europe's GDP, excluding Russia. Based on data availability, we measure currency mismatches for the period 1998–2008, although in most cases we focus on the boom and bust period during 2004–07. Data on direct foreign currency from abroad, which are also discussed in the text and are added in the measure of currency mismatch as a robustness test, are from Rosenberg and Tirpak (2009).

We use a number of sources for the share of foreign currency lending to firms with no foreign currency income. Up to 2003, this share is based on EBRD survey data for 2002 and equals the share of nonexporting companies with foreign currency loans to total companies with foreign currency loans. For the subsequent years, we use EBRD survey data for 2005 for the Czech Republic, Estonia, Hungary, Lithuania, and Poland.[10] For Bulgaria and Romania, the share of unhedged foreign currency lending is given by the share of corporate foreign currency lending to tradable sectors, as estimated in Sorsa,

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[10] The EBRD survey data (BEEPS Firm Level Data) for 2002 refer to the stock of debt. However, the data for 2005 refer to the last loan only. We have assumed that the latter applies to the stock of debt as well, which is an approximation. The results are robust if we do not make this assumption and use other proxies instead, as the appendix discusses.

Bakker, Duenwald, Maechler, and Tiffin (2007). For Croatia, it is based on Central Bank survey data for the share of foreign currencies loans to unhedged clients (this includes both households and corporates; see Hilaire and Ilyina (2007).) And for Latvia, it is estimated based on data provided by the central bank for the share of tradables in corporate foreign currency loans. The results remain robust if we use only EBRD data, or if we use only data from the sources described above for Bulgaria, Romania, Croatia, and Latvia, and assume that the other countries have similar shares of unhedged foreign currency lending (taking the average, or the minimum).

A number of alternative sources were combined to expand the currency mismatch data set to additional emerging economies. Data on foreign currency loans to residents and foreign currency deposits of residents are from the confidential IMF Vulnerability Exercise for Emerging Economies, based on data provided by country authorities. Some gaps in the data on foreign currency deposits of residents are complemented by using data in Haver Analytics and in Arteta (2003 and 2005).

We use various sources for the share of unhedged foreign currency borrowing in the corporate sector. The share of unhedged foreign currency borrowing for Latin America is based on firm survey data in Kamil (2004 and 2010) and is assumed to be equal to the share of nonexporting companies with foreign currency loans to total companies with foreign currency loans. The share for other economies is from the World Bank's Enterprise Survey (https://www.enterprisesurveys.org/Portal/Login.aspx?ReturnUrl=%2fPortal%2felibrary.aspx%3flibid%3d14&libid=14) and is also assumed to be equal to the share of nonexporting companies with foreign currency loans to total companies with foreign currency loans. We have assumed that a company with a share of foreign currency loans in total loans higher than 30 percent could be subject to exchange rate risk. If a company sells more than 70 percent of its products domestically then it is labeled as a nonexporter (the results are robust to alternative thresholds). The estimates using the World Bank data are for various years during the period that we are considering, for most cases during 2002–04, but we use the earliest or the latest observation for the years before, or after respectively.

For bank foreign assets and liabilities in foreign currency, we use data constructed by Prat (2007) for Argentina, Brazil, China, Indonesia, Mexico, Peru, Philippines, Russia, Thailand, Turkey, and Uruguay. And we use IMF IFS data for Bosnia & Herzegovina, Costa Rica, Egypt, Guatemala, Kazakhstan, Serbia, Venezuela, and Vietnam. The latter, however, does not specify the currency denomination of the banks' foreign assets and liabilities. We have therefore assumed that all the banks' foreign assets and liabilities for these countries are denominated in foreign currency. The data for the long-run growth regressions are from the IMF World Economic Outlook database, except of the trade share and the age dependency ratio, which are form the World Bank's World Development Indicators.

Appendix. Table 1. Currency Mismatch Data

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Argentina	25.2	29.2	.	.	.	.	.	.	.	.	.	.
Bosnia&Herzegovina	.	.	.	.	.	18.6	16.5	19.2	17.4	10.2	13.8	.
Brazil	.	.	.	-2.3	-2.6	-0.7	-0.8	-0.7	.	.	.	.
Bulgaria	-58.9	-61.4	-68.5	-58.6	-37.2	-23.4	-1.9	-12.5	-14.7	0.9	8.2	2.4
China	.	.	.	.	6.6	5.2	4.9	4.4	.	.	.	.
Costa Rica	.	.	.	20.4	21.2	14.1	19.5	10.4	7.6	5.0	12.9	.
Croatia	32.4	35.7	33.9	34.6	37.7	34.6	32.3	28.8	26.5	24.7	22.7	23.9
Czech Republic	-14.8	-19.8	-21.7	-24.8	-32.2	-28.0	-28.8	-32.9	-26.9	-22.4	-20.6	-19.9
Egypt	.	.	.	3.7	4.9	5.9	4.2	-4.8	-12.3	-14.8	-16.6	.
Estonia	7.2	6.5	4.7	-7.3	-5.8	-6.4	1.5	13.3	24.3	33.7	32.5	31.2
Guatemala	.	.	.	.	.	-19.4	-19.6	-17.1	-15.7	-13.6	-13.8	.
Hungary	.	.	.	.	.	8.3	6.1	8.2	9.9	8.0	10.2	12.7
Indonesia	11.7	13.0	.	8.9	7.7	7.6	5.6	7.3	.	.	.	.
Kazakhstan	.	.	.	.	.	.	-18.8	-9.9	-12.6	-5.7	-20.1	.
Latvia	.	.	.	.	.	-11.5	-9.6	4.1	16.5	15.1	18.5	13.8
Lithuania	.	.	.	.	.	.	3.0	4.7	10.7	14.1	18.4	10.6
Mexico	-1.6	-0.6	.	-4.0	-3.6	-3.2	-1.4	-0.9	.	.	.	.
Peru	-10.2	-10.5	-11.2	-11.1	-10.3	-0.1	-1.4	-15.9	.	.	.	.
Philippines	15.5	18.0	18.3	17.7	19.2	21.5	23.0	21.9	.	.	.	.
Poland	.	3.0	1.0	2.4	1.9	1.1	0.7	0.6	1.0	0.4	-2.0	-2.4
Romania	.	.	.	.	.	.	.	30.8	32.2	35.4	37.2	34.0
Russia	.	7.5	.	9.2	15.6	.	7.8	7.3	.	.	.	.
Serbia	.	.	.	.	-18.5	-9.4	3.2	5.6	-3.7	-2.8	5.9	.
Thailand	-11.7	-7.4	.	-3.1	-2.6	-1.8	-1.5	-1.1	.	.	.	.
Turkey	0.0	0.0	.	21.5	18.1	14.0	13.7	10.5	.	.	.	.
Ukraine	.	.	.	.	.	-19.4	-21.1	-30.8	-14.5	-6.3	-4.9	7.5
Uruguay	124.6	109.8	.	23.4	20.1	29.8	30.9	32.3	.	.	.	.
Venezuela	-6.1	-7.9	-4.9	-3.0	-7.3	-8.5	-8.3	-5.2	-5.8	-4.1	-3.1	.
Vietnam	12.7	.	.	2.9	11.0	19.2	17.0	13.8	13.2	16.6	18.3	.

Note: The methodology and data sources are discussed in detail in the Appendix. The above currency mismatch measures use IFS data on foreign assets and liabilities for the following countries: Bosnia & Herzegovina, Costa Rica, Egypt, Guatemala, Kazakhstan, Serbia, Venezuela, and Vietnam.

Appendix. Table 2. Currency Mismatch Data (using only IFS data for foreign assets and liabilities)

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Argentina	-29.4	-37.1	.	.	.	.	.	.	-4.3	-5.1	-5.7
Bosnia&Herzegovina	.	.	.	.	.	-18.6	-16.5	-19.2	-17.4	-10.2	-13.8
Brazil	.	.	.	-1.1	-4.3	-0.8	0.9	4.3	6.3	9.0	10.5
Bulgaria	22.4	24.4	35.2	32.8	15.3	2.6	-14.9	0.3	6.4	-8.6	-18.3
China	.	.	.	.	-1.3	-1.7	-0.9	0.6	1.8	1.3	2.6
Costa Rica	.	.	.	-20.4	-21.2	-14.1	-19.5	-10.4	-7.6	-5.0	-12.9
Croatia	.	.	.	-13.7	-19.8	-17.4	-18.6	-20.1	-16.8	-13.2	-17.0
Czech Republic	.	.	.	24.6	34.9	28.0	28.8	32.9	27.1	22.3	20.6
Egypt	.	.	.	-3.7	-4.9	-5.9	-4.2	4.8	12.3	14.8	16.6
Estonia	.	.	.	.	.	.	25.2	10.9	-3.1	-22.1	-19.4
Guatemala	.	.	.	.	.	19.4	19.6	17.1	15.7	13.6	13.8
Hungary	-2.5	-1.8	-3.9	-0.8	-1.7	-5.1	-5.1	-7.1	-6.4	-5.8	-7.7
Indonesia	.	.	.	8.5	9.2	10.6	9.6	9.3	14.6	16.3	15.3
Kazakhstan	.	.	.	.	.	.	18.8	9.9	12.6	5.7	20.1
Latvia	.	.	.	.	.	-13.3	-15.6	-20.9	-20.8	-19.5	-23.6
Lithuania	.	.	.	.	.	.	7.3	-5.9	-5.1	-14.0	-27.1
Mexico	.	.	.	16.0	19.1	18.9	19.0	20.5	19.4	20.8	28.4
Peru	-1.6	5.0	6.9	10.0	12.0	3.3	1.4	16.2	10.2	4.5	5.9
Philippines	-22.1	-20.9	-22.6	-20.9	-19.4	-20.2	-21.4	-18.0	-10.0	-6.7	.
Poland	.	.	.	.	.	.	19.2	21.8	16.8	9.9	4.3
Romania	.	.	.	.	.	.	.	1.4	11.9	6.1	0.5
Russia	.	.	.	15.1	17.4	.	29.4	36.2	40.8	41.5	34.9
Serbia	.	.	.	.	18.5	9.4	-3.2	-5.6	3.7	2.8	-5.9
Thailand	.	.	.	16.6	19.7	20.1	21.1	21.4	24.5	27.7	29.5
Turkey	.	.	.	-23.6	-22.8	-18.5	-15.4	-8.7	-4.3	-1.6	0.4
Ukraine	.	.	.	.	.	10.4	15.0	23.2	3.7	-2.6	-16.0
Uruguay	.	.	.	-17.6	-24.6	-24.0	-20.8	-11.4	0.9	12.6	10.5
Venezuela	6.1	7.9	4.9	3.0	7.3	8.5	8.3	5.2	5.8	4.1	3.1
Vietnam	-12.7	.	.	-2.9	-11.0	-19.2	-17.0	-13.8	-13.2	-16.6	-18.3

Note: The methodology and data sources are discussed in detail in the Appendix. The above currency mismatch measures use IFS data on foreign assets and liabilities.

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