Currency Premia and Global Imbalances[*][†]

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Abstract

We show that a global imbalance risk factor that captures the spread in countries' external imbalances and their propensity to issue external liabilities in foreign currency explains the cross-sectional variation in currency excess returns. The economic intuition is simple: net debtor countries offer a currency risk premium to compensate investors willing to finance negative external imbalances because their currencies depreciate in bad times. This mechanism is consistent with recent exchange rate theory based on capital flows in imperfect financial markets. We also find that the global imbalance factor is priced in the cross sections of other major asset markets.

Keywords: Currency Risk Premium; Global Imbalances; Carry Trade.

JEL Classification: F31; F37; G12; G15.

1 Introduction

Imbalances in trade and capital flows have been the centerpiece of much debate surrounding the causes and consequences of the global financial crisis. Therefore it would seem natural that, given the financial crisis consisted of collapsing asset prices worldwide, global imbalances may help shed light on our fundamental understanding of asset price dynamics. The foreign exchange (FX) market provides a logical starting point for testing this hypothesis as exchange rate fluctuations and currency risk premia are theoretically linked to external imbalances (e.g., Gabaix and Maggiori, hereafter GM, 2014), and recent events in the FX market provide a reminder of the potential importance of such a link. Following the US Federal Reserve's announcement on 22 May 2013 that they would taper the size of their bond-buying programme, emerging market currencies including the Indian rupee, Brazilian real, South African rand and Turkish lira all sold-off sharply. A common characteristic among these four countries is that they are some of the world's largest debtor nations. In fact, the Financial Times on 26 June 2013 attributed the large depreciation of the Indian rupee (which fell by 22 percent against the US dollar between May and August 2013) to investors' concerns over India being "one of the most vulnerable emerging market currencies due to its current account deficit" (Ross, 2013).

In this paper we provide empirical evidence that exposure to countries' external imbalances is key to understanding currency risk premia and thus supports a risk-based interpretation of the carry trade, a popular strategy that involves an investor borrowing in currencies with low interest rates (funding currencies) and simultaneously lending in currencies with high interest rates (investment currencies).[1] Our findings are consistent with the model of GM (2014), who provide a novel theory of exchange rate determination based on capital flows in imperfect financial markets. Specifically, GM (2014) propose a two-country model in which exchange rates are jointly determined by global imbalances and financiers' risk-bearing capacity. In their model, countries run trade imbalances and financiers absorb the resultant currency risk, i.e., financiers are long the debtor country and short the creditor country. Financiers, however,

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[1] The carry trade strategy builds on the violation of uncovered interest rate parity. See Hansen and Hodrick (1980), Bilson (1981), Fama (1984), Engel (1996), Lustig and Verdelhan (2007), Della Corte, Sarno and Tsiakas (2009), Lustig, Roussanov and Verdelhan (2011), Burnside, Eichenbaum, Kleshchelski and Rebelo (2011), Koijen, Moskowitz, Pedersen and Vrugt (2013), Menkhoff, Sarno, Schmeling and Schrimpf (2012a), and Lettau, Maggiori and Weber (2014).

are financially constrained and this affects their ability to take positions. Intuitively, if there is little risk-bearing capacity financiers are unwilling to intermediate currency mismatches regardless of the excess return on offer. In contrast, when financiers have unlimited risk-bearing capacity they are willing to take positions in currencies whenever a positive excess return is available, and hence the currency risk premium is miniscule.

We focus the empirical analysis around two simple testable hypotheses, which are consistent with predictions of the GM (2014) theory. First, currency excess returns, i.e. the returns to a carry trade strategy, are higher when (i) interest rate differentials are larger, (ii) the funding (investment) country is a net foreign creditor (debtor), and (iii) the funding (investment) country has a higher propensity to issue liabilities denominated in domestic (foreign) currency. Condition (i) is standard since on average exchange rate movements do not offset interest rate differentials due to the risk premium. Condition (ii) is novel and captures the link between external imbalances and currency risk premia in the theory of GM (2014). Condition (iii) is not derived explicitly in GM (2014) but it reflects their argument, studied in one of their extensions of the model, that the currency denomination of external debt also matters for currency risk premia. One reason why this is the case is that countries which do not or cannot issue debt in their own currency are more risky.[2] In essence, this testable hypothesis distinguishes between the interest rate and the net foreign asset position as two different, even if related, sources of currency risk premia.

Second, the GM theory also predicts that, when there is a financial disruption (i.e., risk-bearing capacity is very low and global risk aversion is very high), net-debtor countries experience a currency depreciation, unlike net-creditor countries. This testable hypothesis makes clearer an important part of the mechanism that generates currency risk premia in imperfect capital markets: investors demand a risk premium for holding net debtor countries' currencies *because* these currencies perform poorly in bad times, which are times of large shocks to risk-bearing capacity and global risk aversion.

In our empirical analysis, we test and provide evidence in support of the two hypotheses described above. In relation to the first testable hypothesis, we document that a currency

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[2] This mechanism is consistent with the literature on the 'original sin' (e.g. Eichengreen and Hausmann, 2005) and is akin to a valuation channel for the external adjustment of imbalances whereby the exchange rate facilitates the re-equilibration of external imbalances (see e.g. Gourinchas and Rey, 2007; Gourinchas, 2008; Lane and Shambaugh, 2010).

strategy that sorts currencies on net foreign asset positions and a country's propensity to issue external liabilities in domestic currency – termed the 'global imbalance' strategy – generates a large spread in returns. Then, we empirically test whether a risk factor that captures the combination of spread in external imbalances and the propensity to issue external liabilities in domestic currency can explain the cross-section of currency excess returns in a standard asset pricing framework. Our central result in this respect is that our global imbalance risk factor explains over 90 percent of currency excess returns, thus supporting a risk-based view of exchange rate determination that is based on macroeconomic fundamentals and, specifically, on net foreign asset positions. This result holds both for a broad sample of 55 currencies and for a subsample of the 15 most liquid currencies over the period from 1983 to 2014.[3]

The economic intuition of this factor is simple, in line with the GM (2014) model: investors demand a risk premium to hold the currency of net debtor countries, especially if funded principally in foreign currency. High interest rate currencies load positively on the global imbalance factor, and thus deliver low returns in bad times when there is a spike in global risk aversion and the process of international financial adjustment requires their depreciation. Low interest rate currencies are negatively related to the global imbalance factor, and thus provide a hedge by yielding positive returns in bad times. This result suggests that returns to carry trades are compensation for time-varying fundamental risk, and thus carry traders can be viewed as taking on global imbalance risk.

We also document how net foreign asset positions contain information that is (related but) not identical to interest rate differentials in the cross section of countries. Conditioning on information on external imbalances to form currency portfolios provides economic value to a currency investor who uses conventional strategies such as carry, momentum, and value. Notably, in a global minimum volatility portfolio that includes carry, momentum, value and our proposed global imbalance strategy, we find that the latter strategy receives a weight of 46 and 51 percent for the two samples of countries we examine. This supports the validity of GM's (2014) prediction that there is an effect of net foreign asset positions on currency excess

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[3] Despite the existence of theoretical models that link exchange rates to external imbalances, there have hardly been any attempts to relate currency risk premia *cross-sectionally* to currencies' sensitivity to external imbalances. When the FX literature has investigated the empirical link between exchange rates and external imbalances, the analysis was carried out in a time series setting (e.g. Alquist and Chinn, 2008; Della Corte, Sarno and Sestieri, 2012). It thus seems quite natural to employ a cross-sectional perspective on the role of global imbalances to help understand currency risk premia in general, and carry trades in particular.

returns that is distinct from a pure interest rate channel.

In relation to the second testable hypothesis, we provide evidence using a battery of panel regressions that in bad times (defined as times of large global risk aversion shocks, as proxied by the change in the VIX) net-debtor countries experience a currency depreciation, whereas net-creditor countries experience an appreciation. This result is consistent with the risk premium story of GM (2014): investors demand a risk premium for holding net debtor countries' currencies *because* these currencies perform poorly in bad times.

Our paper builds on the growing literature searching for a risk-based explanation to currency premia. Lustig, Roussanov and Verdelhan (2011) and Menkhoff, Sarno, Schmeling and Schrimpf (2012a) have both found a global risk factor in currency excess returns. However, while these global risk factors provide valuable information on the properties of currency returns, the question as to what fundamental economic forces drive the factors and, hence, currency risk premia, remains unanswered, leaving us tantalizingly close to a more complete understanding of currency premia. This paper tackles this issue by shedding some light on the *macroeconomic* forces driving currency premia.[4]

In the empirical analysis we sort currencies into five portfolios according to their forward discounts as pioneered by Lustig and Verdelhan (2007). This is equivalent to using the interest rate differential relative to the US dollar to rank foreign currencies because no-arbitrage requires that forward discounts are equal to interest rate differentials. The first portfolio contains the funding currencies of a carry trade strategy (low-yielding currencies relative to the US dollar) while the last portfolio contains the investment currencies in a carry trade strategy (high-yielding currencies relative to the US dollar). We then show that carry trade returns can be understood as compensation for risk by relating their cross-section to the global imbalance factor. This factor is an easily constructed variable. We first split currencies into two baskets using the ratio of net foreign assets to GDP, and then sort currencies within each basket based on countries' percentage share of external liabilities denominated in domestic currency. The reordered currencies, beginning with creditors whose external liabilities are primarily denominated in domestic currency (the safest currencies) and moving to debtors whose external liabilities are primarily denominated in foreign currency (the riskiest currencies), are

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[4] Other papers studying carry trade returns include Brunnermeier, Nagel and Pedersen (2009), Christiansen, Ranaldo and Söderlind (2011), Colacito and Croce (2013), Farhi and Gabaix (2014), Farhi, Fraiberger, Gabaix, Ranciere and Verdelhan (2014) and Jurek (2014).

grouped into quintiles. These quintiles form our five 'global imbalance' portfolios. The global imbalance factor is simply constructed as the difference between the excess returns on the extreme portfolios. It is equivalent to a high-minus-low strategy that buys the currencies of debtor nations with mainly foreign currency denominated external liabilities and sells the currencies of creditor nations with mainly domestic currency denominated external liabilities. We refer to the global imbalance risk factor as the IMB factor, or simply IMB.

It is important to note that, while the IMB factor contains information that is clearly related to the spread in interest rates across countries, its pricing power is not mechanical in the sense that it cannot be attributed simply to feedback effects from interest rates to net foreign assets. Although feedback effects may exist between interest rates and net foreign assets whereby higher interest rates attract more capital flows, global imbalances capture fundamental information related to currency risk premia that is not embedded in interest rates. This argument is key in GM (2014), who show theoretically that currency premia will be required even if both countries have the same interest rate as long as one is a debtor relative to the other.[5] In fact, recent anecdotal evidence emphasizes the fundamental importance of net foreign assets over and above interest rates in determining currency premia: the US Federal Reserve's announcement in May 2013 that it would scale-back its bond buying programme caused a spike in risk aversion – the VIX index rose from below 14 to over 20 during the subsequent month. In currency markets, following the Federal Reserve announcement, currencies with very similar interest rates behaved very differently, and only the currencies with large external deficit positions experienced sharp depreciations. The economic mechanism in GM (2014) and the empirical evidence in this paper make sense of this behavior, which would be hard to rationalize otherwise.[6]

Further analysis provides refinements and robustness of our main results, including the following: (i) We show that sorting currencies on their beta with the global imbalance factor

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[5] This result is also consistent with the empirical work of Habib and Stracca (2012), who find that net foreign assets are more important for predicting exchange rate returns than interest rate differentials.

[6] Specifically, at the point of the Federal Reserve announcement, Australia, New Zealand, and South Korea – three of the most volatile currencies in the Asia Pacific region – had almost identical interest rates (2.50 percent in New Zealand and Korea, 2.75 percent in Australia). Yet, over the May to September period, the Australian dollar depreciated by 16 percent against the US dollar, the New Zealand dollar depreciated by 10 percent, while the Korean won fell by only 1 percent. The contrasting sizes of depreciation reflect the contrast in deficit positions at the end of the first quarter of 2013, when Australia and New Zealand both had external deficit positions relative to GDP of over 60 percent, while South Korea had a far more modest 6 percent deficit.

yields portfolios with a significant difference in returns. These portfolios are related, but not identical, to the base test assets of currency portfolios sorted on forward discounts. (ii) We test the pricing power of the global imbalance risk factor for currency excess returns sorted by momentum and value, as well as for cross-sections of returns in other markets, including equities, bonds and commodities. These tests are much more powerful given the larger cross-section of test assets, and the results suggest that the IMB factor also prices these portfolios. (iii) We depart from the base scenario of a US-based investor and run calculations using alternative base currencies, taking the viewpoint of a British, Japanese, Euro-based and Swiss investor. The results indicate that the IMB factor is priced in each case. (iv) We test the IMB risk factor on portfolios formed using only the most liquid developed and emerging currencies, showing that there are no qualitative changes in the results. (v) We measure the individual contribution to the currency risk premium of net foreign asset positions and the propensity to issue liabilities in domestic currency, and find that both matter. (vi) We also run cross-sectional asset pricing tests on individual currencies' excess returns, and again record that IMB is priced. Overall, we find that the further analysis corroborates the core finding that global imbalance risk is a key fundamental driver of risk premia in the FX market.

The remainder of the paper is organized as follows. Section 2 describes the theoretical background of our analysis and the hypotheses we take to the data. In Section 3 we describe the data and provide details of how portfolios are constructed. In Section 4 we describe the properties of the global imbalance strategy and its returns, while in Section 5 we report asset pricing tests and further analysis to understand the link between currency excess returns and global imbalances. Section 6 reports evidence on the behavior of exchange rate returns and global imbalances in bad times. In Section 7 we present a number of extensions and robustness exercises, before concluding in Section 8. A separate Internet Appendix provides robustness tests and additional analyses.

2 Theoretical Motivation and Testable Hypotheses

The contribution of this paper is purely empirical, but our empirical analysis has a clear theoretical motivation, which is based primarily on the recent theory of exchange rate determination proposed by GM (2014). This theory makes a substantial leap forward in considering the interaction between capital flows and financial intermediaries' risk-bearing capacity in a model of exchange rate determination with imperfect financial markets. In the most basic, two-period version of the model – termed the 'Gamma' model – each country borrows or lends in its own currency and global financial intermediaries absorb the exchange rate risk arising from imbalanced capital flows. Since financial intermediaries demand compensation for holding currency risk in the form of an expected currency appreciation, exchange rates are jointly determined by global capital flows and by the intermediaries' risk-bearing capacity, which GM (2014) refer to as 'broadly defined risk aversion shocks'.[7]

This theory has clear implications for the returns to a carry trade strategy that buys high-interest rate ("investment") currencies and sells low-interest rate ("funding") currencies. GM (2014, equation (27), Proposition 12) derive the return to the carry trade from the Gamma model as follows:

$$E\left(RX\right) = \Gamma \frac{\frac{i^*}{i} E\left(imp_1\right) - imp_0}{\left(i^* + \Gamma\right) imp_0 + \frac{i^*}{i} E\left(imp_1\right)} \tag{1}$$

where RX denotes currency excess returns, or the return to a carry trade strategy (higher RX means higher carry trade returns). The variable imp_t denotes the dollar value of US imports at time t; with exports normalized to unity in equation (1), the evolution of imports $E\left(imp_1\right) - imp_0$ determines net foreign asset positions in the model. i and i^* are the domestic and foreign riskless interest rates. Γ captures risk-bearing capacity of financiers. When risk-bearing capacity is low (Γ is high in equation (1)), financial intermediaries are unwilling to absorb any imbalances, regardless of the excess return available, and hence no financial flows are necessary as trade inflows and outflows will be equal in each period. As risk-bearing capacity increases (Γ decreases), excess returns fall but do not entirely disappear, except when Γ is extremely low and financial intermediaries are prepared to absorb any currency imbalance so that uncovered interest rate parity holds. GM (2014) show that during periods of financial distress, when risk-bearing capacity declines, debtor countries suffer a currency depreciation whereas creditor countries experience a currency appreciation.

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[7] In the empirical work, we proxy Γ by changes in the VIX, a commonly used measure of global risk aversion. In the first version of their model, GM had Γ exogenous. In the latest draft of GM (2014), the model is solved under the constraint that Γ is directly related to conditional volatility, which nests as a special case the simpler model where Γ is exogenous. In the more general formulation an increase in volatility tightens the constraint both directly and indirectly via feedback effects. In short, GM (2014) refer to Γ as loosely proxying for global risk aversion shocks, and the latest version of their model also allows for the direct effect of conditional volatility.

Equation (1) shows that the returns of a carry trade will be higher when interest rate differentials are larger, and when the funding (investment) currency is issued by a net creditor (debtor) country. Put another way, carry traders require a premium to hold the currency of debtor nations relative to creditor nations.[8]

In the basic version of the Gamma model, by assumption each country borrows or lends in its own currency, but in practice most countries do not (or cannot) issue all their debt in their own currency.[9] Although GM (2014) do not provide a full analytical extension of their model that allows for currency mismatches between assets and liabilities, in Section 2.3 and in Proposition 7 (point 3), GM (2014) consider the impact of the currency denomination of external liabilities, illustrating how this generates a valuation channel to the external adjustment of countries whereby the exchange rate moves in a way that facilitates the re-equilibration of external imbalances.[10] GM highlight how this result is consistent with the valuation channel to external adjustment studied by e.g. Gourinchas and Rey (2007), Gourinchas (2008), and Lane and Shambaugh (2010), and gives a role to the currency denomination of external liabilities in their model. Thus in our empirical analysis we also allow for this effect by considering whether currencies of countries with a higher propensity to issue liabilities in foreign currency offer a higher currency risk premium, given that such countries require much sharper depreciations to correct their external imbalances.[11]

The mechanism described above implies the first testable hypothesis, which is a variant of Proposition 12 in GM (2014) with the additional condition that captures the effect of the currency denomination of liabilities.

Hypothesis 1 *The carry trade return is bigger when (i) the interest rate differential is*

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[8] To clarify these effects analytically in equation (1), first consider the case when $i^*/i > 1$, i.e., the interest rate in the foreign (investment) country is higher than the one in the funding country (the US). GM show that $\frac{\partial E(RX)}{\partial (i^* - i)} > 0$, which means that the carry trade return increases with higher interest rate differentials. Second, set $E\left[imp_1\right] - imp_0 > 0$ (while setting $i^*/i = 1$), i.e., the funding country (the US) is a net foreign creditor. Given that imp is the value of US imports in US dollars, $E\left[imp_1\right] - imp_0 > 0$ implies that the US is expected to become a net importer at $t = 1$ in order to offset its positive external imbalance at $t = 0$, and clearly $\frac{\partial E(RX)}{\partial (E(imp_1) - imp_0)} > 0$. This establishes the result that the expected carry trade return is higher if the country of the funding currency is a net creditor, and viceversa.

[9] See the literature on the 'original sin' (e.g. Eichengreen and Hausmann, 2005, and the references therein).

[10] This is achieved by allowing for some pre-existing level of debt which is not necessarily fully denominated in a country's own currency.

[11] This is because the initial depreciation makes countries with foreign-currency denominated liabilities poorer, not richer, by increasing their debt burden (see e.g. the portfolio balance model in Gourinchas, 2008, Section 3.2.2, and the references therein).

larger, (ii) the funding (investment) country is a net foreign creditor (debtor), and (iii) the funding (investment) country has a higher propensity to issue liabilities denominated in domestic (foreign) currency.

This testable prediction suggests that there are two drivers of FX excess returns, the first driven purely by the carry component (condition (i) above), and the second driven by the evolution of external debt and its currency of denomination (conditions (ii) and (iii)). In our portfolio analysis, we combine the information in conditions (ii) and (iii) to capture both the spread in external imbalances and the propensity to issue external liabilities in foreign currency, although we also examine their separate effects in some of our tests and in the regression analysis.

We test Hypothesis 1 in several ways. Above all, we form portfolios sorted on external imbalances (net foreign assets to GDP ratio) and the share of foreign liabilities in domestic currency to examine whether they provide predictive information for the cross-section of currency excess returns. We show that this portfolio sort generates a sizable and statistically significant spread in returns: a currency strategy that buys the extreme net debtor countries with highest propensity to issue external liabilities in foreign currency and sells the extreme creditor countries with lowest propensity to issue liabilities in foreign currency – which we term the 'global imbalance' strategy – generates Sharpe ratios of 0.59 for a universe of major countries and 0.68 for a broader set of 55 countries. This confirms the essence of Hypothesis 1 that currency excess returns are higher for net-debtor countries with higher propensity to issue liabilities in foreign currency, which are also found to be countries with higher interest rates, i.e. typical investment currencies in the carry trade.

A central mechanism in the model of GM (2014) is that during periods of financial distress, when risk-bearing capacity declines, debtor countries suffer a currency depreciation whereas creditor countries experience a currency appreciation. This is indeed the logic that rationalizes why net debtor countries must offer a currency risk premium, implying the second empirical prediction we take to the data, which is Proposition 2 of GM (2014).

Hypothesis 2 *When there is a financial disruption (Γ increases), countries that are net external debtors experience a currency depreciation, while the opposite is true for net-creditor countries.*

This prediction follows naturally from the previous analysis and our empirical results provide supporting evidence on its validity through the estimation of a battery of panel regressions.

3 Data and Currency Portfolios

This section describes the main data employed in the empirical analysis. We also describe the construction of currency portfolios and the global imbalance risk factor.

Data on Spot and Forward Exchange Rates. We collect daily spot and 1-month forward exchange rates vis-à-vis the US dollar (USD) from Barclays and Reuters via Datastream. The empirical analysis uses monthly data obtained by sampling end-of-month rates from October 1983 to June 2014. Our sample comprises 55 countries: Argentina, Australia, Austria, Belgium, Brazil, Canada, Chile, China, Colombia, Croatia, Czech Republic, Denmark, Egypt, Estonia, Euro Area, Finland, France, Germany, Greece, Hong Kong, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Japan, Kazakhstan, Latvia, Lithuania, Malaysia, Mexico, Morocco, Netherlands, New Zealand, Norway, Philippines, Poland, Portugal, Russia, Singapore, Slovakia, Slovenia, South Africa, South Korea, Spain, Sweden, Switzerland, Thailand, Tunisia, Turkey, Ukraine, United Kingdom, and Venezuela. We call this sample 'all countries'.

A number of currencies in this sample are pegged or subject to capital restrictions. In reality, investors may not easily trade some of these currencies in large amounts even though quotes on forward contracts (deliverable or non-deliverable) are available.[12] Hence, we also consider a subset of 15 countries which we refer to as 'developed countries'. This sample includes: Australia, Belgium, Canada, Denmark, Euro Area, France, Germany, Italy, Japan, Netherlands, New Zealand, Norway, Sweden, Switzerland, and the United Kingdom. After the introduction of the euro in January 1999, we remove the Eurozone countries and replace them with the euro.[13] As in Lustig, Roussanov, and Verdelhan (2011) and many subsequent studies, we remove data when we observe large deviations from the covered interest rate parity

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[12] According to the Triennial Survey of the Bank for International Settlements (2013), the top 10 currencies account for 90 percent of the average daily turnover in FX markets.

[13] The sample of developed countries matches both Lustig, Roussanov, and Verdelhan (2011) and Menkhoff, Sarno, Schmeling and Schrimpf (2012). The full sample of countries, instead, comprises a wider set of countries than previous studies. We also consider a set of 35 countries as in Lustig, Roussanov, and Verdelhan (2011) and 48 countries as in Menkhoff, Sarno, Schmeling and Schrimpf (2012a), as well as a set of countries comprising the most liquid currencies (termed 'developed and emerging' sample). Qualitatively, the results remain the same; see e.g. Tables A.8 and A.9 of the Internet Appendix.

(CIP) condition.[14]

Data on External Assets and Liabilities. Turning to macroeconomic data, we obtain end-of-year series on foreign assets and liabilities, and gross domestic product (GDP) from Lane and Milesi-Ferretti (2004, 2007), kindly updated by Gian Maria Milesi-Ferretti. Foreign (or external) assets are measured as the dollar value of assets a country owns abroad, while foreign (or external) liabilities refer to the dollar value of domestic assets owned by foreigners. The data for all countries included in our study are until the end of 2012. For each country we measure external imbalances – the indebtedness of a country to foreigners – using the net foreign asset position (the difference between foreign assets and foreign liabilities) relative to the size of the economy (GDP), which we denote nfa. We retrieve monthly observations by keeping end-of-period data constant until a new observation becomes available.

We also use end-of-year series on the proportion of external liabilities denominated in domestic currency (denoted ldc) from Benetrix, Lane and Shambaugh (2014), which updates the data from Lane and Shambaugh (2010), kindly provided by Philip Lane. The data is available from 1990 to 2012. We construct monthly observations by keeping end-of-period data constant until a new observation becomes available. Note that we maintain the 1990 proportions back until 1983.[15]

Currency Excess Returns. We define spot and forward exchange rates at time t as S_t and F_t, respectively, and take into account the standard value date conventions in matching the forward rate with the appropriate spot rate (e.g., Bekaert and Hodrick, 1993). Exchange

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[14] On the one hand, one may be concerned that times when CIP deviations occur are likely to be times of distress in the FX market that can be particularly informative about risk premia. On the other hand, some of those times can be characterized by extreme illiquidity and lack of tradability, so that prices are essentially uninformative. Moreover, the GM theory assumes no riskless arbitrage. We filtered the data as follows: for the Developed sample of 15 countries, we do not remove any observations. For the broader sample, we eliminate the following observations: Argentina from September 2008 to April 2009, and from May 2012 to June 2014; Egypt from November 2011 to August 2013; Indonesia from December 1997 to July 1998, and from February 2001 to May 2005; Malaysia from May 1998 to June 2005; Turkey from November 2000 to November 2001; South Africa for August 1985, and from January 2002 to May 2005; Russia from December 2008 to January 2009; Kazakhstan from November 2008 to February 2009. These are episodes where CIP deviations were very large (generally in excess of 25 percent) and likely not tradable. Note that the removal of CIP deviations does not affect any of our results in this paper with two exceptions: Turkey for the period around the 2001 devaluation, and Malaysia for the 1998-2005 period of capital controls.

[15] This assumption makes no qualitative difference to our findings as when we examine the sample period starting in 1990 (dropping the first 7 years of data altogether) our portfolio results are qualitatively identical. This is not surprising since ldc is a highly persistent variable (see Benetrix, Lane and Shambaugh, 2014).

rates are defined as units of US dollars per unit of foreign currency such that an increase in S_t indicates an appreciation of the foreign currency. The excess return on buying a foreign currency in the forward market at time t and then selling it in the spot market at time $t+1$ is computed as

$$RX_{t+1} = \frac{(S_{t+1} - F_t)}{S_t}, \tag{2}$$

which is equivalent to the spot exchange rate return minus the forward premium

$$RX_{t+1} = \frac{S_{t+1} - S_t}{S_t} - \frac{F_t - S_t}{S_t}. \tag{3}$$

According to the CIP condition, the forward premium approximately equals the interest rate differential $(F_t - S_t)/S_t \simeq i_t - i_t^*$, where i_t and i_t^* represent the US and the foreign riskless rates respectively, over the maturity of the forward contract. Since CIP holds closely in the data (e.g., Akram, Rime, and Sarno, 2008), the currency excess return is approximately equal to the exchange rate return (i.e., $(S_{t+1} - S_t)/S_t$) plus the interest rate differential relative to the US (i.e., $i_t^* - i_t$). As a matter of convenience, throughout this paper we refer to $fd_t = (S_t - F_t)/S_t = i_t^* - i_t$ as the forward discount or interest rate differential relative to the US.

We construct currency excess returns adjusted for transaction costs using bid-ask quotes on spot and forward rates. The net excess return for holding foreign currency for a month is computed as $RX_{t+1}^l \simeq (S_{t+1}^b - F_t^a)/S_t^a$, where a indicates the ask price, b the bid price, and l a long position in a foreign currency. The net excess return accounts for the full round-trip transaction cost occurring when the foreign currency is purchased at time t and sold at time $t+1$. If the investor buys foreign currency at time t but decides to maintain the position at time $t+1$, the net excess return is computed as $RX_{t+1}^l \simeq (S_{t+1} - F_t^a)/S_t^a$. Similarly, if the investor closes the position in foreign currency at time $t+1$ already existing at time t, the net excess return is defined as $RX_{t+1}^l \simeq (S_{t+1}^b - F_t)/S_t^b$. The net excess return for holding domestic currency for a month is computed as $RX_{t+1}^s \simeq (F_t^b - S_{t+1}^a)/S_t^b$, where s stands for a short position on a foreign currency. In this case, the investor sells foreign currency at time t in the forward market at the bid price F_t^b and offsets the position in the spot market at time $t+1$ using the ask price S_{t+1}^a. If the foreign currency leaves the strategy at time t and the short position is rolled over at time $t+1$, the net excess return is computed as $RX_{t+1}^s \simeq (F_t^b - S_{t+1})/S_t^b$. Similarly, if the investor closes a short position on the foreign currency at time $t+1$ already existing at time t, the net excess return is computed as $RX^s_{t+1} \simeq (F_t - S^a_{t+1})/S^b_t$. In short, excess returns are adjusted for the full round-trip transaction cost in the first and last month of the sample. The total number of currencies in our portfolios changes over time, and we only include currencies for which we have bid and ask quotes on forward and spot exchange rates in the current and subsequent period.

Carry Trade Portfolios. We construct five carry portfolios, rebalanced monthly, and use them as test assets in our empirical asset pricing analysis. At the end of each period t, we allocate currencies to five portfolios on the basis of their forward discounts (or interest rate differential relative to the US). This exercise implies that currencies with the lowest forward discounts (or lowest interest rate differential relative to the US) are assigned to Portfolio 1, whereas currencies with the highest forward discounts (or highest interest rate differential relative to the US) are assigned to Portfolio 5. We then compute the excess return for each portfolio as an equally weighted average of the currency excess returns within that portfolio. For the purpose of computing portfolio returns net of transaction costs, we assume that investors go short foreign currencies in Portfolio 1 and long foreign currencies in the remaining portfolios. The strategy that is long Portfolio 5 and short Portfolio 1 is referred to as CAR.[16]

Global Imbalance Portfolios. Motivated by the theoretical considerations discussed in Section 2, we construct the global imbalance risk factor as follows: at the end of each period t, we first group currencies into two baskets using the net foreign asset position relative to GDP (nfa), then reorder currencies within each basket using the percentage share of external liabilities denominated in domestic currency (ldc). Hence, we allocate this set of currencies to five portfolios. Portfolio 1 corresponds to creditor countries whose external liabilities are primarily denominated in domestic currency (safest currencies), whereas Portfolio 5 comprises debtor countries whose external liabilities are primarily denominated in foreign currency (riskiest currencies). We refer to these five portfolios as the global imbalance (or IMB) portfolios. We

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[16] Lustig, Roussanov, and Verdelhan (2011) study these currency portfolio returns using the first two principal components. The first principal component is proxied using an equally weighted strategy across all portfolios, which is a strategy that borrows in the US money market and invests in foreign money markets. This zero-cost portfolio is called the dollar risk factor, abbreviated to DOL. The second principal component is proxied with a long position in Portfolio 5 and a short position in Portfolio 1, and is equivalent to a carry trade strategy that borrows in the money markets of low yielding currencies and invests in the money markets of high yielding currencies. This high-minus-low portfolio is called the slope factor.

then compute the excess return for each portfolio as an equally weighted average of individual currency excess returns within the portfolio. For the purpose of computing portfolio returns net of transaction costs, we assume that investors go short foreign currencies in Portfolio 1 and long foreign currencies in the remaining portfolios. We construct the global imbalance risk factor as the difference between Portfolio 5 and Portfolio 1. This is equivalent to a high-minus-low strategy that buys the currencies of debtor countries with mainly foreign currency denominated external liabilities and sells the currencies of creditor nations with mainly domestic currency-denominated external liabilities. We refer to this strategy as the global imbalance strategy, and to the global imbalance risk factor as the IMB factor.

Figure 1 clarifies the outcome of our sequential sorting procedure. Note that the procedure does not guarantee monotonicity in both sorting variables (nfa and ldc) because Portfolio 3 contains both low and high ldc countries. However, the corner portfolios contain the intended set of countries: specifically, P_1 contains the extreme 20% of all currencies with high nfa and high ldc (creditor nations with external liabilities mainly in domestic currency) whereas portfolio P_5 contains the top 20% of all currencies with low nfa and low ldc (debtor nations with external liabilities mainly in foreign currency). The global imbalance factor is constructed as the average return on P_5 minus the average return on P_1. We use 5 portfolios (as we do for carry) rather than 6 as we have a limited number of currencies in the sample of developed countries as well as at the beginning of the sample of all countries, and also because we want to have the same number of portfolios in both samples of countries. In the Internet Appendix we show that our core results are qualitatively identical if we form the IMB factor using 4 portfolios for developed countries and 6 portfolios for all countries; see Figure A.1, Tables A.12 and Table A.13 in the Internet Appendix. We also show that, if we use an independent double sort, the risk prices for both nfa and ldc are statistically significant; see Figure A.1, and Tables A.14 and A.15. Finally, we also show robustness using a simple double sort of interest rate differentials and nfa.

Currency Momentum Portfolios. At the end of each period t, we form five portfolios based on exchange rate returns over the previous 3 months. We assign the 20% of all currencies with the lowest lagged exchange rate returns to Portfolio 1, and the 20% of all currencies with the highest lagged exchange rate returns to Portfolio 5. We then compute the excess return for each portfolio as an equally weighted average of the currency excess returns within that portfolio. A strategy that is long in Portfolio 5 (*winner currencies*) and short in Portfolio 1 (*loser currencies*) is then denoted as MOM.[17]

Value Portfolios. At the end of each period t, we form five portfolios based on the lagged five-year real exchange rate return as in Asness, Moskowitz and Pedersen (2013). We assign the 20% of all currencies with the highest lagged real exchange rate return to Portfolio 1, and the 20% of all currencies with the lowest lagged real exchange rate return to Portfolio 5. We then compute the excess return for each portfolio as an equally weighted average of the currency excess returns within that portfolio. A strategy that is long in Portfolio 5 (*undervalued currencies*) and short in Portfolio 1 (*overvalued currencies*) is then denoted as VAL.

Risk Reversal Portfolios. At the end of each period t, we form five portfolios based on out-of-the-money options.[18] We compute for each currency in each time period the risk reversal, which is the implied volatility of the 25-delta call less the implied volatility of the 25-delta put, and assign the 20% of all currencies with the highest risk reversal to Portfolio 1, and the 20% of all currencies with the lowest risk reversal to Portfolio 5. We then compute the excess return for each portfolio as an equally weighted average of the currency excess returns within that portfolio. A strategy that is long in Portfolio 5 (*high-skewness currencies*) and short in Portfolio 1 (*low-skewness currencies*) is then denoted as RR.

4 The Global Imbalance Strategy

This section describes the properties of the net returns from implementing the global imbalance currency strategy and constructing the IMB factor. We also provide a comparison with the net returns from the traditional carry trade strategy (CAR). Specifically, Table A.1 in the Internet Appendix presents descriptive statistics for the five portfolios sorted on interest

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[17] Consistent with the results in Menkhoff, Sarno, Schmeling, and Schrimpf (2012b), sorting on lagged exchange rate returns or lagged currency excess returns to form momentum portfolios makes no qualitative difference to our results below. The same is true if we sort on returns with other formation periods in the range from 1 to 12 months.

[18] The implied volatility quotes used for this exercise are an updated sample of the data used by Della Corte, Sarno and Tsiakas (2011), to which we refer the reader for a full description of the data.

rate differentials (forward discount), both for the full sample of countries and the subset of developed countries. Recall that CAR is a long-short strategy that is long in Portfolio 5 (the investment currencies) and short in Portfolio 1 (the funding currencies). Excess returns to Portfolio 1 are adjusted for transactions costs occurring in a short position and excess returns to Portfolio 5 are adjusted for transaction costs occurring in a long position. All excess returns are expressed in percentage per annum.

The CAR results show the properties recorded in several papers in the literature on carry trades. Average excess returns display an increasing pattern when moving from Portfolio 1 to Portfolio 5 for both samples, and the average excess return from a long-short strategy that buys Portfolio 5 and sells Portfolio 1 – the CAR portfolio – is 5.44 (4.67) percent per annum after transaction costs for all (developed) countries. The Sharpe ratio (SR) is equal to 0.65 for all countries, and 0.43 for developed countries.[19]

It is instructive to look at the last three rows in Table A.1, reporting the average interest rate differential (fd), net foreign asset position to GDP (nfa), and share of external liabilities in domestic currency (ldc) across portfolios P_1 to P_5. Clearly the spread in interest rate differentials (which by construction increase monotonically from P_1 to P_5) is very large, about 11 and 6 percent for all countries and developed countries, respectively. The last two rows reveal that there is a similar spread in nfa and ldc, which means that investment (funding) currencies tend to be currencies of net debtor (creditor) countries with a relatively higher (lower) propensity to issue external liabilities in foreign currency.

In Table 1 we present the same summary statistics for the five global imbalance portfolios sorted on nfa and ldc, as well as for the global imbalance factor IMB. The average excess return tends to increase from P_1 (0.92 and 0.67 percent per annum) to P_5 (5.32 and 4.65 percent per annum) for both samples, albeit non-monotonically for the sample of all countries. When we compare SRs, we observe that the global imbalance strategy has a higher Sharpe ratio than the carry trade strategy: 0.68 compared to 0.65 for all countries, and 0.59 compared to 0.43 for developed countries. This comparison suggests that the global imbalance strategy

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[19] We also report the maximum drawdown (MDD) and the frequency of currency portfolio switches ($Freq$). The MDD, defined as the maximum cumulative loss from the strategy's peak to the following trough, is large in both samples, reflecting the large-scale unwinding of carry trade positions following the bankruptcy of Lehman Brothers in September 2008. $Freq$ is computed as the ratio between the number of portfolio switches and the total number of currencies at each date. Overall, there is little variation in the composition of these portfolios, which is not surprising given that interest rates are very persistent.

has appealing risk-adjusted returns in its own right, which is perhaps surprising given the information required to update the global imbalance strategy arrives only once a year.[20]

The last three rows in Table 1 report the average fd, nfa, and ldc across portfolios P_1 to P_5. The spread in interest rate differentials is about 7 and 3.5 percent for all countries and developed countries, which is a large spread but far less than the 11 and 6 percent reported for CAR in Table A.1. This suggests that part of the return from the global imbalance strategy is clearly related to CAR (interest rate information), but part of it is driven by a different source of predictability which is in external imbalances but not in interest rate differentials. The last two rows reveal that there is a sizable spread in nfa and ldc, which is monotonic for nfa for both samples of countries examined and is much larger than the corresponding spread for CAR portfolios.

Overall, the currencies of net debtor countries with a relatively higher propensity to issue external liabilities in foreign currency have higher (risk-adjusted) returns than the currencies of net creditor countries with higher propensity to issue liabilities in domestic currency, consistent with GM (2014) and Hypothesis 1 stated in Section 2.

In Figure 2 we present graphical evidence on the relation between carry trade returns and global imbalance risk by grouping carry trade returns into four baskets conditional on the distribution of the IMB factor. The first group comprises the 25 percent of months with the lowest realizations of the IMB factor whereas the last group contains the 25 percent of months with the highest realizations of the IMB factor. We then compute for each group the average carry trade return. Figure 2 shows that average excess returns for the carry trade strategy increase monotonically when moving from low to high global imbalance risk. The carry trade has its best overall performance when global imbalance risk is high and vice versa, suggesting a relation between currency excess returns and global imbalance risk. We now turn to a more rigorous investigation of this similarity using formal asset pricing tests.

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[20] Specifically, we construct monthly excess returns but global imbalance portfolios are in practice rebalanced only at the end of each year when new information on nfa and ldc becomes available. In contrast, carry trade portfolios are rebalanced every month as information on forward discounts is available monthly. The impact of this difference is confirmed by the frequency of currency portfolio switches (Freq), which displays less variation for the global imbalance portfolios than the carry trade portfolios.

5 Does Global Imbalance Risk Price Carry Returns?

This section presents cross-sectional asset pricing tests for the five carry portfolios and the global imbalance risk factor, and empirically documents that carry trade returns can be thought of as compensation for time-varying global imbalance risk.

Methodology. We denote the discrete excess returns on portfolio j in period t as RX_t^j. In the absence of arbitrage opportunities, risk-adjusted excess returns have a price of zero and satisfy the following Euler equation:

$$E_t[M_{t+1} RX_{t+1}^j] = 0 \tag{4}$$

with a Stochastic Discount Factor (SDF), M_{t+1} linear in the pricing factors f_{t+1}, given by

$$M_{t+1} = 1 - b' \left(f_{t+1} - \mu\right) \tag{5}$$

where b is the vector of factor loadings, and μ denotes the factor means. This specification implies a beta pricing model where the expected excess return on portfolio j is equal to the factor risk price λ times the risk quantities β^j. The beta pricing model is defined as

$$E[RX^j] = \lambda' \beta^j \tag{6}$$

where the market price of risk $\lambda = \Sigma_f b$ can be obtained via the factor loadings b. $\Sigma_f = E\left[\left(f_t - \mu\right)\left(f_t - \mu\right)'\right]$ is the variance-covariance matrix of the risk factors, and β^j are the regression coefficients of each portfolio's excess return RX_{t+1}^j on the risk factors f_{t+1}.

The factor loadings b entering equation (4) are estimated via the Generalized Method of Moments (GMM) of Hansen (1982). To implement GMM, we use the pricing errors as a set of moments and a prespecified weighting matrix. Since the objective is to test whether the model can explain the cross-section of expected currency excess returns, we only rely on unconditional moments and do not employ instruments other than a constant and a vector of ones. The first-stage estimation (GMM_1) employs an identity weighting matrix. The weighting matrix tells us how much attention to pay to each moment condition. With an identity matrix, GMM attempts to price all currency portfolios equally well. The second-stage estimation (GMM_2) uses an optimal weighting matrix based on a heteroskedasticity and autocorrelation consistent (HAC) estimate of the long-run covariance matrix of the moment conditions. In this case, since currency portfolio returns have different variances and may be correlated, the optimal weighting matrix will attach more weight to linear combinations of moments about which the data are more informative (Cochrane, 2005). The tables report estimates of b and implied λ, and standard errors based on Newey and West (1987) with optimal lag length selection set according to Andrews (1991).[21] The model's performance is then evaluated using the cross-sectional R^2, the square-root of mean-squared errors $RMSE$, the χ^2 test statistics, and the HJ distance measure of Hansen and Jagannathan (1997). The χ^2 test statistic evaluates the null hypothesis that all cross-sectional pricing errors (i.e., the difference between actual and predicted excess returns) are jointly equal to zero. We report asymptotic p-values for the χ^2 test statistics. The HJ distance quantifies the mean-squared distance between the SDF of a proposed model and the set of admissible SDFs. To test whether the HJ distance is equal to zero, we simulate p-values using a weighted sum of χ^2_1-distributed random variables (see Jagannathan and Wang, 1996; Ren and Shimotsu, 2009).

The estimation of the portfolio betas β^j and factor risk price λ in equation (6) is also undertaken using a two-pass ordinary least squares regression following Fama and MacBeth (FMB, 1973). In the first step, we run time-series regressions of portfolio excess returns against a constant and the risk factors, and estimate the betas β^j. In the second step, we run cross-sectional regressions of portfolio returns on the betas, and estimate the factor risk prices λ as averages of all these slope coefficients. Note that in the second stage of FMB regressions we do not add any constant to capture the common over- or under-pricing in the cross section of returns. Our results, however, remain virtually identical when we replace the DOL factor with a constant in the second stage regression. This is because the DOL factor has no cross-sectional relation with currency returns, and it works as a constant that allows for a common mispricing. We report Newey and West (1987) and Shanken (1992) standard errors with optimal lag length selection set according to Andrews (1991).

Risk Factors and Pricing Kernel. The most recent literature on cross-sectional asset pricing in currency markets has considered a two-factor pricing kernel. The first risk factor

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[21] We estimate μ and Σ_f using the sample average and the sample covariance matrix of the risk factors, respectively (e.g., Lustig, Roussanov, and Verdelhan, 2011). We also implement a first-stage GMM where μ and Σ_f are jointly estimated with the factor loadings b. In doing so, we account for estimation uncertainty associated with the fact that factor means and the factor covariance matrix have to be estimated (Burnside, 2011; Menkhoff, Sarno, Schmeling and Schrimpf, 2012a). The results remain qualitatively the same.

is typically the expected market excess return, approximated by the average excess return on a portfolio strategy that is long in all foreign currencies with equal weights and short in the domestic currency – essentially the DOL factor. For the second risk factor, the literature has employed several return-based factors such as the slope factor of Lustig, Roussanov, and Verdelhan (2011) or the global volatility factor of Menkhoff, Sarno, Schmeling and Schrimpf (2012a). Regardless of its parsimony and the likely omission of other potential factors, this simple empirical model has delivered important insights on the relation between global risk and expected currency returns. Following this literature, we employ a two-factor SDF with DOL as the first factor. For the second risk factor, we use the IMB factor to further assess the validity of the theoretical prediction in Hypothesis 1 that carry trade returns are linked to external imbalances, and that currencies more exposed to global imbalance risk offer a higher risk premium.

Cross-Sectional Regressions. Panel A of Table 2 presents the cross-sectional asset pricing results. The excess returns to portfolios sorted on forward discounts (RX^j_{CAR} for $j = 1, \ldots, 5$) serve as test assets whereas the dollar factor DOL and the global imbalance factor IMB enter as risk factors. Both test assets and risk factors are adjusted for transactions costs. The SDF is defined as

$$M_{t+1} = 1 - b_{DOL}\left(DOL_{t+1} - \mu_{DOL}\right) - b_{IMB}\left(IMB_{t+1} - \mu_{IMB}\right)$$

where μ_{DOL} and $\mu_{_{IMB}}$ denote the factor means. Panel A reports estimates of factor loadings b, the market prices of risk λ, the cross-sectional R^2, the square-root of mean-squared errors $RMSE$, the χ^2 test statistics, and the HJ distance. Newey and West (1987) corrected standard errors with lag length determined according to Andrews (1991) are reported in parentheses, while Shanken corrected standard errors are in brackets. The p-values of the χ^2 test statistics and HJ distance measure are also reported in brackets. The results are reported for all countries (left panel) and developed countries (right panel) using GMM_1, GMM_2, and the FMB approach.

We focus our interest on the sign and the statistical significance of λ_{IMB}, the market price of risk attached to the global imbalance risk factor. We find a positive and significant estimate of λ_{IMB}. The global imbalance risk premium is 7 percent per annum for all countries, and 5 percent per annum for developed countries, and these point estimates are identical for all three estimation methods employed. A positive estimate of the factor price of risk implies higher risk premia for currency portfolios whose returns comove positively with the global imbalance factor, and lower risk premia for currency portfolios exhibiting a negative covariance with the global imbalance factor. The standard errors of the risk prices are approximately equal to 2 percent for all estimation methods. Overall, the risk price is more than two standard deviations from zero, and thus highly statistically significant. We also uncover strong cross-sectional fit with R^2s ranging between 74 and 87 percent for the full sample of countries, and between 88 and 91 percent for the subset of developed countries. Further support in favor of this model comes from the fact that we are unable to reject the null hypotheses that the cross-sectional pricing errors are jointly equal to zero and that the HJ distance is equal to zero.[22]

Time-Series Regressions. In Panel B of Table 2, we report the least squares estimates obtained from running time-series regressions of currency excess returns on a constant and risk factors for each of the five currency portfolios (for $j = 1, \ldots, 5$)

$$RX^j_{CAR,t+1} = \alpha^j + \beta^j_{DOL} DOL_{t+1} + \beta^j_{IMB} IMB_{t+1} + \varepsilon^j_{t+1}.$$

This exercise allows us to clearly identify which of the currency portfolios provide a hedge against global imbalance risk. As expected, the estimate of the betas for the DOL factor are essentially all equal to one as this factor does not capture any of the dispersion in average excess returns across currency portfolios. The estimates of β_{IMB} are positive for currencies with a high forward discount (high interest rate differential relative to the US), and negative for currencies with a low forward discount (low interest rate differential relative to the US). For example, these betas increase monotonically for the sample of all countries from -0.33 for the first portfolio to 0.46 for the last portfolio, and results for developed countries are comparable. Finally, the last column reports the time-series R^2s, which range from 74 to 85 percent for all countries, and from 74 to 86 percent for developed countries.

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[22] Lewellen, Nagel and Shanken (2010) show that a strong factor structure in test asset returns can give rise to misleading results in empirical work. If the risk factor has a small (but non-zero) correlation with the 'true' factor, the cross-sectional R^2 could still be high suggesting an impressive model fit. This is particularly problematic in small cross sections, like in our case. For this reason, we carry out asset pricing tests that involve, in addition to the carry trade strategy, other currency strategies as well as equity, bond and commodity strategies. The results, reported later in the paper, corroborate the findings in this section.

These results suggest that carry trade returns are systematically related to global imbalance risk, and carry trade funding currencies are associated with net creditor nations whereas carry trade investment currencies are linked to net debtor nations. The unconditional time-series correlation between carry trade returns and the global imbalance risk factor is 60 percent, indicating a strong, albeit not perfect, positive correlation. This is consistent with Hypothesis 1 in the sense that there are two sources of risk premia driving carry trade returns – interest rate differentials and the evolution of net foreign assets.[23]

Note that we do not argue that these two channels are unrelated. On the contrary, it is well-documented that there is a cross-sectional correlation between interest rates (typically real interest rates) and net foreign asset positions (e.g. Rose, 2010). In Table 3, we present results from a cross-sectional regression of the nominal interest rate differentials used in our study on net foreign assets and the share of liabilities denominated in domestic currency. These results show clearly that net foreign assets enter the regression with a strongly statistically significant coefficient and with the expected sign: higher nfa is associated with lower interest rates. The R^2 is lower than one might expect, however, suggesting that there are likely to be important omitted variables in the regression. Indeed, when we add inflation differentials and output gap differentials to the regression, net foreign asset positions remain strongly significant, but the R^2 increases dramatically, mainly due to inflation differentials.[24] In short, even though the information in global imbalances is related to interest rate differentials, there is likely to be some independent information in global imbalances. Next, we provide some evidence on the value of this information.

Value added of global imbalance information. Taken together, the results reported till now suggest that the global imbalance strategy has creditable excess returns overall, and these returns are highly but imperfectly correlated with the returns from the carry trade. The lack of a perfect correlation is in line with the GM (2014) theory and Hypothesis 1,

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[23] Table A.2 in the Internet Appendix reports details on the portfolio composition for both carry trade and global imbalance portfolios. Panel A (Panel B) reports the top six currencies for each of the carry (global imbalance) portfolios. Panel C reports the probability that a given currency enters simultaneously in the same carry and global imbalance portfolio. For corner portfolios, this probability ranges from 38 to 45 percent for all countries, and from 41 to 47 percent for developed countries, consistent with the notion that the carry trade and global imbalance strategies are similar, albeit not identical.

[24] Inflation and the output gap are the core variables in macro models of the short-term interest rate, commonly used in the 'Taylor rule' literature. Note that the regressions in Table 3 are run for 53, rather than 55, countries due to difficulties in obtaining reliable data for the full sample for Greece and Venezuela.

which states that interest rate differentials and the evolution of global imbalances are different sources of currency risk premia. This means that a currency investor would likely gain some diversification benefit from adding the global imbalance strategy to a currency portfolio to enhance risk-adjusted returns.

To better understand the value of global imbalance information for a currency investor, we compute the optimal currency portfolio for an investor who uses three common currency strategies – namely carry, momentum, and value – and adds to this menu of strategies the global imbalance strategy. Specifically, consider a portfolio of N assets with covariance matrix Σ. The global minimum volatility portfolio is the portfolio with the lowest return volatility, and represents the solution to the following optimization problem: min $w'\Sigma w$ subject to the constraint that the weights sum to unity $w'\iota = 1$, where w is the $N \times 1$ vector of portfolio weights on the risky assets, ι is a $N \times 1$ vector of ones, and Σ is the $N \times N$ covariance matrix of the asset returns. The weights of the global minimum volatility portfolios are given by $w = \frac{\Sigma^{-1}\iota}{\iota'\Sigma^{-1}\iota}$. We compute the optimal weights for both samples of countries examined, and report the results graphically in Figure 3.

The results show that the optimal weight assigned to the global imbalance strategy is actually the highest across all four strategies, equal to 46 and 51 percent for the two sets of countries. The Sharpe ratio of the minimum volatility portfolio for the developed sample, for instance, is quite impressive, at 0.63. However, this number drops to 0.49 if the investor is not given access to the global imbalance strategy, and only employs the other three currency strategies. Similarly for the sample with all countries, the Sharpe ratio equals 0.75 when the global imbalance strategy is included and drops to 0.67 when it is excluded from the menu of currency strategies.[25] These findings confirm that there is independent information in global imbalances about currency risk premia which is not embedded in interest rate differentials.[26]

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[25] In a further exercise, we also include in the menu of strategies the risk-reversal currency strategy. In this case the sample is reduced considerably as data for risk reversals only start in 1996. Nevertheless, for both samples of countries the weight on the global imbalance strategy is higher than 40 percent and the highest of all 5 strategies considered.

[26] Another way to assess the value added of the information in net foreign assets beyond interest rate differentials is to double sort on nfa and interest rate differentials. Ideally, one would want to sort on nfa, ldc and interest rate differentials, but our cross-section is simply too small to do this. However, for the sample of all countries, an independent double sort on nfa and interest rate differentials delivers a gross mean return of 2.19 (volatility of 5.05) for net foreign assets and 4.33 (volatility of 6.46) for interest rate differentials. The Sharpe ratios are 0.51 and 0.78. The results for the sample of developed countries are qualitatively identical. In short, these results confirm that there is additional information in the ratio of NFA to GDP that is not

Portfolios based on IMB Betas. We provide evidence of the explanatory power of the IMB factor for currency excess returns from a different viewpoint. We form portfolios based on an individual currency's exposure to global imbalance risk, and investigate whether these portfolios have similar return distributions to portfolios sorted on forward discounts. If global imbalance risk is a priced factor, then currencies sorted according to their exposure to global imbalance risk should yield a cross section of portfolios with a significant spread in average currency returns.

We regress individual currency excess returns at time t on a constant and the global imbalance risk factor using a 36-month rolling window that ends in period $t-1$, and denote this slope coefficient as $\beta^i_{IMB,t}$. This exercise provides currency i exposure to IMB only using information available at time t. We then rank currencies according to $\beta^i_{IMB,t}$ and allocate them to five portfolios at time t. Portfolio 1 contains the currencies with the largest negative exposure to the global imbalance factor (lowest betas), while Portfolio 5 contains the most positively exposed currencies (highest betas). Table 4 summarizes the descriptive statistics for these portfolios. We find that buying currencies with a low beta (i.e., insurance against global imbalance risk) yields a significantly lower return than currencies with a high beta (i.e., high exposure to global imbalance risk). The spread between the last portfolio and the first portfolio is in excess of 5 percent per annum for both sets of countries. Average excess returns generally increase, albeit not always monotonically, when moving from the first to the last portfolio. Moreover, we also find a clear monotonic increase in both average *pre*-formation and *post*-formation betas when moving from Portfolio 1 to Portfolio 5: they line up perfectly well with the cross-section of average excess returns in Table 1. Average *pre*-formation betas vary from -0.22 to 1.35 for all countries, and from -0.94 to 0.67 for developed countries. *Post*-formation betas are calculated by regressing realized excess returns of beta-sorted portfolio j on DOL and IMB. These figures range from -0.30 to 0.31 for all countries, and from -0.57 to 0.59 for developed countries. Overall, these results confirm that global imbalance risk is important for understanding the cross-section of currency excess returns, providing further support to Hypothesis 1.

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contained in interest rates.

6 Exchange Rates and Net Foreign Assets in Bad Times

We now turn to testing Hypothesis 2, as stated in Section 2. In essence, the testable prediction from GM (2014) we take to the data is that exchange rates are jointly determined by global imbalances and financiers' risk-bearing capacity so that net external debtors experience a currency depreciation in bad times, which are times of large shocks to risk bearing capacity and risk aversion (Γ is high in the model). In contrast, net external creditors experience a currency appreciation in bad times.

We test this hypothesis in two different ways. First, we estimate a panel regression where we regress monthly exchange rate returns on a set of macro variables, allowing for fixed effects. As right-hand-side variables, we employ the net foreign assets to GDP ratio (nfa) lagged by 12 months, and the interest rate differential lagged by 1 month. In some specifications we also include the share of external liabilities in domestic currency (ldc), and the change in VIX on its own. Importantly, we also allow for an interaction term between nfa as well as the interest rate differential and the change in the VIX index (specification 1-2-3), or the change in VIX times a dummy that is equal to unity when the change in VIX is greater than one standard deviation and is zero otherwise (specifications 4-5-6).[27] The VIX index is commonly used as a proxy for global risk appetite and, in our exercise, we use the change in VIX (in two different formulations) to proxy what GM (2014) term 'global risk aversion shocks' in reference to Γ, i.e. shocks to the willingness of financiers to absorb exchange rate risk.[28]

The key variable of interest in these regressions is the interaction term between nfa and the VIX change. Given our variable definitions, Hypothesis 2 requires a positive coefficient on this variable, which would imply that at times when global risk aversion increases (as proxied

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[27] We also add a constant, and the lagged exchange rate return as a control variable.

[28] Given the reference to shocks, we use the change in VIX rather than the VIX in level. It is well known that the change in VIX has negligible serial correlation, whereas the VIX in level is very persistent (e.g. Ang, Hodrick, Xing and Zhang, 2006). We use the change in VIX contemporaneously in these regressions in order to capture the effect of the shock on exchange rate returns predicted by Hypothesis 2, which states that net debtor countries' currencies depreciate on impact when global risk aversion increases. Presumably the impact of risk aversion shocks on exchange rate returns goes beyond this contemporaneous effect though, and indeed we find that results are similar when using 1 or 2 lags of the change in VIX. Finally, an alternative interpretation of Γ might be that it captures (changes in) the amount of capital available in financial markets to bear risk. In this case one would expect that returns of the carry trade strategy decline as the amount of capital increases, and in fact there is evidence in the literature that this is the case (e.g. Jylha and Suominen, 2011; Barroso and Santa-Clara, 2014). However, our interpretation of Γ is, much like GM (2014), that it reflects shocks to global risk aversion and hence the change in VIX seems a reasonable proxy.

by the VIX change) countries with larger net foreign asset positions to GDP experience a currency appreciation, whereas the currencies of countries with larger net debtor positions depreciate. The results, reported in Table 5, indicate that this is the case as the interaction term is positive and strongly statistically significant in all regression specifications, even when controlling for the interest rate differential, the change in VIX and the other control variables described above. It is instructive to note that the change in VIX also enters significantly and with the expected sign, meaning that increases in global risk aversion are associated with appreciation of the US dollar.[29]

For completeness, we also run similar panel regressions for excess returns rather than exchange rate returns, reported in Table A.5 of the Internet Appendix.[30] The results corroborate the results obtained for exchange rate returns but also provide one more interesting finding, namely that the share of foreign liabilities issued in domestic currency is now statistically significant, whereas it was not in Table 5. This indicates that this variable is likely to be related to currency excess returns (carry trade returns) via interest rate differentials rather than exchange rate returns.

The second test of Hypothesis 2 we carry out involves estimating time-series regressions of the returns from the five global imbalance portfolios on the change in VIX. Remember that the long (short) portfolio comprises the currencies with highest (lowest) net foreign liabilities and a higher (lower) propensity to issue external liabilities in foreign currency. Hence Hypothesis 2 requires that the return on the long portfolio is negatively related to global risk aversion shocks, proxied by the change in VIX; by contrast the return on the short portfolio should be positively related to the change in VIX. The results from estimating these regressions are reported in Table 6 (both for excess returns and just the spot exchange rate component), and show a monotonic decline in the coefficients on the change in VIX, as one would expect. However, the coefficients for Portfolio P_1 (the short portfolio) and P_2 are not statistically different from zero, implying that the currencies of net creditors do not respond to global risk

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[29] Finally, it is also interesting to note that the net foreign asset position to GDP ratio (not interacted with the VIX) is either not statistically different from zero or, in two cases, enters the regression with a negative coefficient, implying that in normal times net debtor currencies experience appreciation. This seems plausible in the GM (2014) framework as in normal times there is strong demand for net debtor currencies by investors interested in capturing the risk premium offered by these currencies.

[30] The main difference is that we do not condition on the interest rate differential in these regressions as the interest rate differential is on the left-hand-side of the regression (in the currency excess return).

aversion shocks. The coefficients for portfolios P_3, P_4 and P_5 are negative and statistically significant, and they are largest for P_5, implying that the currencies in the long portfolio of the global imbalance strategy depreciate the most in bad times. Overall, the currencies issued by the extreme net debtor countries with the highest propensity to issue liabilities in foreign currency depreciate sharply in bad times relative to the currencies issued by the extreme net creditor countries with the lowest propensity to issue liabilities in foreign currency. This result constitutes further supportive evidence for Hypothesis 2.

7 Further Analysis

In this section, we present a battery of additional exercises that further refine and corroborate the results reported earlier.

Asset Pricing Tests on Other Cross-Sections of Returns. In our empirical asset pricing analysis, the pricing power of the global imbalance factor was tested using two cross-sections: the carry trade cross section, and the global imbalance cross section. While this is a very direct way to test the predictions of GM (2014), the cross-sectional regressions are based on a small number of observations (5 data points). Moreover, the two cross-sections are highly related in light of our empirical results, further reducing the number of test assets. Therefore, we test the pricing power of the global imbalance factor on a larger number of test assets.

First, we consider other currency strategies, both separately and jointly. In Table 7, we report estimates of factor loadings and risk prices using first-stage GMM for the carry trade (already reported earlier in Table 2), the global imbalance strategy, currency momentum, currency value, and risk reversal strategies. For all strategies the sample spans from 1983 to 2014, except for the risk reversal strategy, where the sample begins in 1996. In these individual tests we are still using only five data points in the cross-sectional regressions, but it is more likely that at least some of these cross-sections of returns do not have the same factor structure. The results indicate that global imbalance risk prices fairly well four of these cross-sections (with the price of risk being estimated in the range between 0.04 and 0.07, and a high R^2), with the exception being currency momentum – for which the price of risk is not significant, the R^2 is miniscule and the HJ rejects the null of zero pricing errors. This is not surprising given the well-documented difficulty in pricing momentum portfolios (e.g. Menkhoff, Sarno, Schmeling and Schrimpf, 2012b). We then increase test power by pooling these cross-sections of returns to form a cross-section of 20 currency portfolio returns (excluding the risk reversal portfolios) since 1983, and 25 currency portfolio returns since 1996 (including also the risk reversal portfolios). The results, reported in the last two columns of Table 7, indicate that global imbalance risk prices both these cross-sections of currency returns, with a reasonable R^2 (0.53 and 0.65 respectively), and insignificant HJ tests.

Second, in Table 8, we further expand the set of assets by adding to the cross-section of 20- or 25- currency returns also 25 equity portfolio returns (sorted either by size and book-to-market, or by size and momentum), 5 international bond portfolio returns, and 7 commodity portfolio returns.[31] Starting from Panels A and B, which report the results for the cross-sections of currency and equity portfolios, we find that the global imbalance risk factor is priced in this large cross-section of returns, even controlling for Fama-French factors.[32] The IMB risk price estimate is between 0.07 and 0.09 and highly statistically significant, the R^2 is in the range between 0.78 and 0.86, and the HJ test is statistically insignificant. Similarly, Panel C reports the results when we augment the currency cross-sections with 5 international bond portfolio returns, and we control for an international bond factor. In Panel D, we add to the currency cross-sections 7 commodity portfolio returns, and in this case we control for a commodity factor. Both in Panels C and D, the global imbalance risk factor is priced with comparable estimates of the risk price, and we find insignificant HJ tests.

Overall, these results suggest that global imbalance risk is priced broadly across currency strategies, and some of the most common equity, international bonds and commodity strategies.

Asset Pricing with a Constraint on the Price of Risk. The asset pricing exercise reported in Table 2 suggested that the IMB factor prices the cross-section of currency excess returns sorted on interest rate differentials, i.e. carry trades. However, IMB is a tradable

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[31] For the equity cross-section, we collect the 25 global portfolios sorted on size and book-to-market, and size and momentum from Kenneth French's website. We use equally weighted portfolios that do not include the US in order to be consistent with currency portfolios that are dollar-neutral by construction. These portfolios include 22 countries. For the commodity portfolios, we take the seven commodity portfolios from Yang (2013). For international bonds, we sort bonds of different maturities (1-3y, 3-5y, 5-7y, 7-10y, >10y) for 19 countries into five portfolios depending on their redemption yield. We use total return indices denominated in US dollars from Datastream.

[32] We use 3 Fama-French factors in each regression. In Panel A, they are market, SMB and HML, while in Panel B HML is replaced by WML (momentum). Overall, we estimate 5 risk prices in both Panels A and B.

risk factor and thus its price of risk must equal its expected return. This means that the price of global imbalance risk cannot be a free parameter in estimation. To address this issue, we follow the suggestion of Lewellen, Nagel and Shanken (2010) and include the global imbalance factor as one of the test assets, alongside the interest rate differential-sorted portfolios, which effectively means we constrain the price of risk for IMB to be equal to the mean return of the traded global imbalance portfolio. The results, reported in Table A.3 in the Internet Appendix, provide evidence that the performance of the model is slightly improved and that the estimates of the price of risk are statistically identical to the returns from the global imbalance strategy reported in Table 1.[33]

This result is comforting since it implies that our factor price of risk makes sense economically, that the factor prices itself, and is thus arbitrage-free. We add the global imbalance risk factor to the test assets for *all* the asset pricing tests that follow.[34]

Individual Currencies. Ang, Liu and Schwarz (2010) argue that forming portfolios may potentially destroy information by shrinking the dispersion of betas. In Table A.4 we deal with this concern and present cross-sectional asset pricing tests with individual currency excess returns as test assets. Since the set of currencies is now unbalanced, we only report estimates of market prices of risk obtained via FMB regressions. Also, since country-level excess returns, especially for currencies with limited trading activity, may be contaminated by outliers, least square estimates can be severely distorted and fail to deliver unbiased estimates. We deal with this problem by using the least absolute deviation (LAD) estimator which is robust to thick-tailed errors and is not sensitive to atypical data points (Bassett and Koenker,

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[33] Alternatively, if we calibrate the risk price to the mean returns reported in Table 1 and estimate a single-factor model, we obtain results which are virtually identical to the ones in Table A.3.

[34] Recall that data for *ldc* are only available since 1990 and we backfill the data to 1983 by keeping that constant at their 1990 values for all countries. One may be concerned about the impact of this choice, and therefore we check the robustness of this decision. Suppose we start in Jan 1991 (given that *ldc* is available at the end of Dec 1990) and stop the sample in December 2013 (we keep using forward filling up to 1-year ahead). Using the above sample, we construct the global imbalance portfolios and the IMB factor, and also carry out asset pricing tests on the carry portfolios while imposing the restriction on the price of IMB risk. For the developed sample, we find that the IMB factor has a mean return of 3.91 (t-stat = 2.54), and $SR = 0.53$. The one-step GMM estimate of the price of risk is 4 percent (t-stat = 2.53). For the sample of all countries, the mean return is 4.73 (t-stat = 2.84), and $SR = 0.69$, with the point estimate of the price of IMB risk from one-step GMM equal to 5.5 percent (t-stat = 3.31). For both samples of countries, the IMB factor prices well the test assets, and we cannot reject the null of zero pricing errors with large p-values. In short, the results are qualitatively identical when using a sample period that does not require backfilling the *ldc* data prior to 1990.

1978; Koenker and Bassett, 1982). In short, we use the FMB procedure with robust regressions in the first and second step to account for outliers in individual currency excess returns. We report bootstrapped standard errors in parentheses.[35]

In Panel A the test assets are excess returns constructed as long positions in foreign currencies irrespective of the level of interest rates. Note that these individual currency excess returns are not adjusted for transaction costs as ex-ante we ignore whether an investor should buy or sell the foreign currency. We refer to these excess returns as unconditional excess returns. The pricing kernel includes the DOL and IMB as risk factors. The market price of global imbalance risk is positive and statistically significant, and the estimate is very close to the estimates obtained in Table 2 (0.05 and 0.06 for our two samples of countries). The cross-sectional R^2 is reasonably high, 34 percent for all countries and 64 percent for developed countries, but is of course lower than the R^2 for portfolio returns. This is expected as individual excess returns are far more noisy than portfolio returns.

In Panel B we use as test assets excess returns managed on the basis of interest rate differentials: the US investor buys the foreign currency and sells the US dollar when the forward discount is positive (i.e., the foreign currency interest rate is higher than the US interest rate), and vice versa. Results remain largely comparable to the previous panel. In short, these results suggest that the global imbalance risk factor does a reasonably good job at pricing the cross-section of individual currency excess returns.

Alternative base currencies. We depart from the base scenario of a US-based investor and run calculations using alternative base currencies, taking the viewpoint of a British, Japanese, Euro-based and Swiss investor. The results indicate that, in each case, the global imbalance portfolio has similar return characteristics to the ones reported in Table 1 (see Table A.6 in the Internet Appendix), and the global imbalance risk factor prices the cross-section of carry trade returns (Table A.7 in the Internet Appendix).

This is comforting since it makes clear that the US is not playing a key role in driving

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[35] To calculate bootstrapped standard errors, we simulate $y_{i,t} = \alpha_i + \beta_i f_t + \varepsilon_{i,t}$ and $f_t = \mu + \sum_{i=1}^{p} A_i f_{t-i} + u_t$, where $y_{i,t}$ is the excess return on the i-th currency, α_i is the constant, β_i is the vector of factor loadings, f_t denotes the risk factors following a p-order VAR process, $\varepsilon_{i,t}$ are idiosyncratic residuals, and $u_t \sim N(0, \Sigma)$. We estimate this system, and use the parameter estimates to generate $1,000$ time-series by jointly resampling $\varepsilon_{i,t}$ and u_t. Since the panel is unbalanced, we carefully resample the same dates across all individual currencies, and then remove the missing values before running FMB regressions.

our results, which are qualitatively identical regardless of whether the currency portfolios are dollar-neutral or not. Indeed, the US may be seen as an interesting exception to our story in this paper, especially during the recent crisis, because it is one of the largest external debtors in the world and yet it appreciated strongly during the crisis when instead the carry trade experienced a large drawdown. Part of the explanation may be that the US, which has a substantial currency mismatch on its balance sheet, borrows in domestic currency and is generally considered a safe reserve currency (see Maggiori, 2013 for a theoretical discussion on this 'reserve currency paradox'). In any event, we find it comforting that our results hold when using four alternative base currencies.

Removing Illiquid Currencies. Tables A.8 and A.9 display the results from building the global imbalance portfolio (and running asset pricing tests) using a sample where currencies with limited liquidity are removed. Specifically, using the latest *BIS Triennial Survey*, we select the most liquid currencies and name this sample 'developed and emerging countries,' which is an intermediate sample (in terms of size) between the two samples analyzed in the paper till now.[36] We hypothesize that while forward rates may be available for a large number of currencies, there would have been low liquidity in many of them. Additionally, the imposition of capital controls in a number of the emerging market nations might have made it impossible to engage in a carry trade strategy at some points in time. If this is the case, we would anticipate that the asset pricing results for a limited subset of the most liquid currencies would show an improvement over and above the full sample.

Table A.8 shows that there are no qualitative changes to the properties of the global imbalance strategy as reported in Table 1, but the performance of the strategy is enhanced, reaching a Sharpe ratio of 0.95. Table A.9 reports cross-sectional asset pricing results, which are highly comparable to the results in Table 2.

Portfolios Sorted on Real Interest Rate Differentials. We also find that the global imbalance risk factor prices portfolios of currencies sorted on real (as opposed to nominal) interest rate differential relative to the US; the results are reported in Tables A.10 and A.11 of the Internet Appendix. At time t, we allocate currencies to five portfolios according to

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[36] This is the set of currencies employed by Deutsche Bank for its global carry trade (Global Currency Harvest) strategy.

their inflation-adjusted forward discount $fd_t - E_t(\pi^*_{t+1} - \pi_{t+1})$, where π^*_{t+1} and π_{t+1} denote the one-month foreign and domestic inflation rates at time $t+1$, respectively, and E_t is the conditional expectations operator given information at time t. This is equivalent to sorting currencies according to their real, rather than nominal, interest rate differential. Since π^*_{t+1} and π_{t+1} are not observed at time t, we construct inflation forecasts by simply using current inflation, that is we set $E_t(\pi^*_{t+1} - \pi_{t+1}) = \pi^*_t - \pi_t$.[37] Currencies with the lowest real interest rate differential are assigned to Portfolio 1, whereas currencies with the highest real interest rate differential are assigned to Portfolio 5.

Table A.10 reports descriptive statistics for the portfolios described above, while Table A.11 reports asset pricing tests where we use the same DOL and IMB risk factors as in the core analysis. The global imbalance risk premium remains positive and statistically different from zero, with estimates comparable to the ones reported in earlier tests. The cross-sectional R^2 remains high, and we cannot reject the null hypothesis that the pricing errors are zero as well as the null hypothesis that the HJ distance is zero. Overall, these results are largely comparable to our core findings in Table 2. We confirm higher risk premia for currency portfolios whose returns comove positively with the global imbalance factor, and lower risk premia for currency portfolios exhibiting a negative covariance with the global imbalance factor.

Independent Double Sort. Our global imbalance factor is constructed by sequentially sorting currencies first with respect to the net foreign asset positions to GDP (nfa), and then with respect to the percentage share of foreign liabilities in domestic currency (ldc). A natural question to ask is whether the information in the global imbalance factor is driven by nfa or ldc, or both. To address this point, we construct a factor that captures only the information arising from nfa and a factor that summarizes only the signal coming from ldc. We will refer to these factors as NFA and LDC, respectively. Figure A.1 in the Internet Appendix reports a visual description of how we construct these factors. We use 6 portfolios, except for the subset of developed countries where we are restricted to use only 4 portfolios. At the end of each month, currencies are first sorted in two baskets using the net foreign asset positions to GDP (nfa), and then in 3 baskets using the percentage share of foreign liabilities in domestic currency (ldc). The NFA factor is computed as the average return on the low nfa portfolios

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[37] This assumption is empirically motivated since inflation is a very persistent process and current inflation is highly correlated with future inflation at the monthly frequency.

(P_3, P_4 and P_5) minus the average return on the high nfa portfolios (P_1, P_2 and P_3) whereas the LDC factor is computed as the average return on the low ldc portfolios (P_3, and P_6) minus the average return on the high ldc portfolios (P_1, and P_4). We use a similar procedure for the developed countries sample.

We report the summary statistics of these portfolios' excess returns along with the NFA and LDC factors in Table A.14 in the Internet Appendix. The excess return per unit of volatility risk on both factors tends to be comparable when we inspect the subset of developed countries (the SR equals 0.34 for NFA and 0.38 for LDC). When we move away from developed countries, the LDC factor tends to outperform the NFA factor: the LDC (NFA) factor displays an SR of 0.78 (0.59) when we add the most liquid emerging market currencies to the set of developed countries, and an SR of 0.71 (0.28) when we consider the full set of currencies.[38]

Table A.15 in the Internet Appendix presents asset pricing tests based on a linear three-factor model that comprise the DOL, NFA and LDC factors. As test assets, we continue to use the five carry trade portfolios used in the core analysis. Panel A reports cross-sectional tests. The market price of risk is positive and statistically significant for both NFA and LDC, regardless of the methodology used, when we focus on all countries and developed and emerging countries. Results are mixed for the subset of developed countries: the market price of risk is always positive and statistically significant for NFA, and positive and significant for LDC only for GMM_1 and FMB. In addition to relying on standard asset pricing estimates, we run a simple model comparison to understand whether one set of factors drives out another in the spirit of Cochrane (2005). Specifically, we compare the three-factor model above (unrestricted model) to a two-factor model that contains either DOL and NFA (restricted 1) or DOL and LDC (restricted 2). We compare the unrestricted model to each restricted model using a simple χ^2 difference test (*D-test*) that uses the same weighting matrix – the one resulting from the unrestricted model. We report in brackets the p-values for the null hypothesis that either restricted 1 or restricted 2 are correct when compared to the unrestricted model. We reject the null in each case for all countries and developed and emerging countries, thus suggesting

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[38] Note that here we report summary statistics for portfolios gross of transaction costs. Otherwise, we would need to report both long and short net positions for the same portfolio as NFA and LDC require different combinations of long and short portfolios. In Table A.15, however, we use risk factors net of transaction costs in order to make results comparable with our core analysis.

that both NFA and LDC are important for these sets of countries. For developed countries, we reject the null hypothesis for restricted 1 (with a *p-value* of 0.04) but fail to reject the null hypothesis for restricted 2 (with a *p-value* of 0.12). This suggests that NFA may be more important than LDC for major economies.

Panel B of Table A.15 reports least square estimates obtained from running time-series regressions. Results show that NFA and LDC are both important for all countries and developed and emerging countries. For developed countries, NFA tends to be more important, although LDC remains statistically significant for low-yielding currencies.

Finally, we appreciate that the use of a three-factor model on such a small cross-section presents small sample problems, and for this reason we carry out the asset pricing test using the 20- and 25-currency portfolios used earlier as test assets. Estimation of the three-factor model with NFA and LDC confirms that in this larger cross-section of currency returns both NFA and LDC are priced (results are qualitatively identical to the ones in Table A.15).

Overall, the evidence in this section confirms that both sorting variables used in our global imbalance strategy and for the purpose of constructing the IMB factor contribute to the price of global imbalance risk, and reflect slightly different aspects of this source of risk. The sorting procedure used in the core analysis allows us to combine the information in nfa and ldc in a simple fashion, and to construct a single risk factor that captures these two different aspects of the evolution of global imbalances across countries. In fact, we also note that the pricing errors from the two-factor model used in the core analysis (e.g. Table 2) are lower than the pricing errors from the three-factor model used in Table A.15.

8 Conclusions

The large and sudden depreciation of high-interest currencies in the aftermath of the Lehman Brothers' collapse has revived interest in the risk-return profile of the carry trade, a popular strategy that exploits interest rate differentials across countries. If high-interest rate currencies deliver low returns when consumption is low, then currency excess returns simply compensate investors for higher risk exposure and carry trade returns reflect time-varying risk premia. While the recent empirical literature has established that there is systematic risk in carry trades, it is silent about the economic determinants underlying currency premia.

This paper tackles exactly this issue by shedding empirical light on the *macroeconomic* forces driving currency risk premia. Motivated by the theoretical insights of Gabaix and Maggiori (2014), we show that sorting currencies on net foreign asset positions and a country's propensity to issue external liabilities in domestic currency generates a large spread in returns. In fact, a risk factor that captures exposure to global imbalances and the currency denomination of external liabilities explains the bulk of currency excess returns in a standard asset pricing model. The economic intuition for this risk factor is simply that net debtor countries offer a currency risk premium to compensate investors willing to finance negative external imbalances. This means that carry trade returns are actually driven by two different, albeit related, sources of risk premia: the first is related to the familiar interest rate differentials, and the second is related to the evolution of net foreign asset positions and their currency of denomination.

We also show that, when global risk aversion spikes, net debtor nations experience a sharp currency depreciation, corroborating the notion that carry trade investors take on global imbalance risk. Moreover, global imbalance risk appears to be priced pervasively, in addition to carry portfolios, in other cross-sections of currency returns as well as in several cross-sections of returns in other major asset markets.

Overall, we provide empirical support for the existence of a meaningful link between exchange rate returns and macroeconomic fluctuations, uncovering a fundamental and theoretically motivated source of risk driving currency returns.

Table 1. Descriptive Statistics: Global Imbalance Portfolios

The table presents descriptive statistics of currency portfolios sorted on time $t-1$ net foreign asset position to gross domestic product (nfa), and the share of foreign liabilities in domestic currency (ldc). The first portfolio (P_1) contains the top 20% of all currencies with high nfa and high ldc (creditor nations with external liabilities mainly in domestic currency) whereas the last portfolio (P_5) contains the top 20% of all currencies with low nfa and low ldc (debtor nations with external liabilities mainly in foreign currency). IMB is a long-short strategy that buys P_5 and sells P_1. The table also reports the first order autocorrelation coefficient (ac_1), the annualized Sharpe ratio (SR), the maximum drawdown (mdd), the frequency of portfolio switches ($freq$), the average forward discount or interest rate differential relative to the US (fd), the average nfa, and the average ldc. t-statistics based on Newey and West (1987) standard errors with Andrews (1991) optimal lag selection are reported in brackets. Excess returns are expressed in percentage per annum and adjusted for transaction costs. The portfolio are rebalanced monthly from October 1983 to June 2014. See Section 3 for a detailed description of data sources and data construction, and Figure 1 for a detailed description of the portfolio construction.

	P_1	P_2	P_3	P_4	P_5	IMB	P_1	P_2	P_3	P_4	P_5	IMB
	All Countries						*Developed Countries*					
mean	0.92	3.51	1.40	3.57	5.32	4.40	0.67	2.45	3.06	3.46	4.65	3.98
t-stat	[0.60]	[2.18]	[1.10]	[2.39]	[2.73]	[3.51]	[0.37]	[1.31]	[1.77]	[2.00]	[2.38]	[3.26]
med	1.20	2.69	3.52	4.24	6.79	4.94	1.24	2.73	3.66	3.87	6.90	5.27
sdev	7.80	8.71	6.52	7.92	10.05	6.43	9.90	10.25	9.33	9.06	10.29	6.76
skew	−0.16	−0.03	−0.86	−0.48	−0.27	0.17	0.05	−0.07	−0.26	−0.16	−0.28	−0.53
kurt	3.56	3.95	6.42	5.49	4.36	6.17	3.56	3.27	3.90	6.08	3.66	5.17
ac_1	0.08	0.05	0.09	0.06	0.08	0.09	0.06	0.02	0.05	0.08	0.06	−0.01
SR	0.12	0.40	0.22	0.45	0.53	0.68	0.07	0.24	0.33	0.38	0.45	0.59
mdd	0.46	0.29	0.33	0.26	0.30	0.20	0.54	0.36	0.34	0.32	0.31	0.26
$freq$	0.03	0.04	0.04	0.04	0.03		0.02	0.02	0.02	0.02	0.03	
fd	−0.54	1.20	2.02	3.50	6.80		−1.32	−0.76	1.81	2.15	2.23	
nfa	0.43	0.14	0.10	−0.46	−0.56		0.41	0.31	0.04	−0.37	−0.37	
ldc	0.63	0.47	0.44	0.47	0.28		0.61	0.46	0.48	0.49	0.34	

Table 2. Asset Pricing Tests: Global Imbalance Risk

The table presents cross-sectional asset pricing results for the linear factor model based on the dollar (DOL) and the global imbalance (IMB) risk factor. The test assets are excess returns to five carry trade portfolios sorted on the one-month forward discounts. IMB is a long-short strategy that buys the currency (top 20%) of debtor nations with external liabilities mainly in foreign currency, and sells the currencies (top 20%) of creditor nations with external liabilities mainly in domestic currency. *Panel A* reports GMM (first and second-stage) and Fama-MacBeth (FMB) estimates of the factor loadings b, the market price of risk λ, and the cross-sectional R^2. Newey and West (1987) standard errors with Andrews (1991) optimal lag selection are reported in parentheses whereas Shanken (1992) standard errors are reported in brackets. χ^2 denotes the test statistics (with p-value in brackets) for the null hypothesis that all pricing errors are jointly zero. HJ refers to the Hansen and Jagannathan (1997) distance (with simulated p-value in brackets) for the null hypothesis that the HJ distance is equal to zero. *Panel B* reports least-squares estimates of time series regressions with Newey and West (1987) and Andrews (1991) standard errors in parentheses. Excess returns are in annual terms and adjusted for transaction costs. The portfolios are rebalanced monthly from October 1983 to June 2014. See Section 3 for a detailed description of data sources and data construction, and Figure 1 for a detailed description of the global imbalance risk factor.

Panel A: Factor Prices

	b_{DOL}	b_{IMB}	λ_{DOL}	λ_{IMB}	R^2	$RMSE$	χ^2	HJ	b_{DOL}	b_{IMB}	λ_{DOL}	λ_{IMB}	R^2	$RMSE$	χ^2	HJ
	All Countries								*Developed Countries*							
GMM_1	−0.07	1.53	0.02	0.07	0.87	1.70%	4.92	0.14	0.16	0.85	0.02	0.05	0.91	1.12%	1.15	0.06
	(0.29)	(0.54)	(0.01)	(0.02)			[0.18]	[0.16]	(0.22)	(0.47)	(0.02)	(0.02)			[0.77]	[0.80]
GMM_2	−0.02	1.48	0.02	0.07	0.74	1.76%	4.89		0.19	0.97	0.02	0.05	0.88	1.13%	1.06	
	(0.29)	(0.54)	(0.01)	(0.02)			[0.19]		(0.21)	(0.46)	(0.02)	(0.02)			[0.79]	
FMB	−0.07	1.52	0.02	0.07	0.87	1.70%	4.92		0.16	0.85	0.02	0.05	0.91	1.12%	1.16	
	(0.25)	(0.46)	(0.01)	(0.02)			[0.18]		(0.19)	(0.39)	(0.02)	(0.02)			[0.77]	
	(0.24)	(0.44)	(0.01)	(0.02)					[0.18]	[0.37]	[0.02]	[0.02]				

Panel B: Factor Betas

	α	β_{DOL}	β_{IMB}	R^2	α	β_{DOL}	β_{IMB}	R^2
P_1	−0.01	1.00	−0.33	0.80	0.01	0.97	−0.46	0.74
	(0.01)	(0.05)	(0.04)		(0.01)	(0.04)	(0.06)	
P_2	−0.02	0.99	−0.17	0.83	−0.01	1.01	−0.16	0.82
	(0.01)	(0.04)	(0.03)		(0.01)	(0.04)	(0.04)	
P_3	0.01	1.05	−0.10	0.85	−0.01	0.97	0.01	0.86
	(0.01)	(0.03)	(0.02)		(0.01)	(0.03)	(0.03)	
P_4	−0.01	1.04	0.12	0.82	−0.01	0.97	0.14	0.83
	(0.01)	(0.04)	(0.05)		(0.01)	(0.03)	(0.04)	
P_5	0.01	0.90	0.46	0.74	0.01	1.02	0.52	0.77
	(0.01)	(0.05)	(0.08)		(0.01)	(0.04)	(0.06)	

Table 3. Forward Discounts and Global Imbalances

The table presents results from cross-sectional regressions of average forward discount (or interest rate differential relative to the US) on the average (i) net foreign asset position to gross domestic product (nfa), (ii) share of foreign liabilities in domestic currency (ldc), (iii) inflation differential relative to the US, (iv) output gap, and (v) a constant. White (1980) corrected standard errors are reported in parentheses. See Section 3 for a detailed description of data sources and data construction.

	Dependent variable: forward discount			
	(1)	(2)	(3)	(4)
nfa	−0.141	−0.075	−0.127	−0.072
	(0.036)	(0.017)	(0.037)	(0.017)
ldc	−0.221	0.089	−0.302	0.064
	(0.465)	(0.169)	(0.482)	(0.169)
inflation differential		0.969		0.959
		(0.043)		(0.045)
output gap			0.074	0.021
			(0.033)	(0.009)
constant	0.298	−0.209	0.349	−0.190
	(0.253)	(0.082)	(0.265)	(0.083)
Adjusted R^2	0.05	0.86	0.07	0.86

Table 4. Portfolios Sorted on Betas

The table presents descriptive statistics of β-sorted currency portfolios. Each β is obtained by regressing individual currency excess returns on the global imbalance risk factor using a 36-month moving window that ends in period $t-1$. The first portfolio (P_1) contains the top 20% of all currencies with the lowest betas whereas the last portfolio (P_5) contains the top 20% of all currencies with the highest betas. H/L denotes a long-short strategy that buys P_5 and sells P_1. Excess returns are expressed in percentage per annum. The table also reports the first order autocorrelation coefficient (ac_1), the annualized Sharpe ratio (SR), the maximum drawdown (mdd), the frequency of portfolio switches ($freq$), the average net foreign asset position to gross domestic product (nfa), the share of foreign liabilities in domestic currency (ldc), the *pre*- and *post*-formation forward discount or interest rate differential relative to the US (fd), the *pre*-formation βs (with standard deviations in parentheses) and the *post*-formation βs (with standard errors in parentheses). t-statistics based on Newey and West (1987) standard errors with Andrews (1991) optimal lag selection are reported in brackets. The sample runs from October 1983 to June 2014. See Section 3 for a detailed description of data sources and data construction.

	P_1	P_2	P_3	P_4	P_5	H/L	P_1	P_2	P_3	P_4	P_5	H/L
	All Countries						*Developed Countries*					
mean	−0.54	2.18	3.85	3.10	4.67	5.21	−1.02	3.61	2.47	2.33	4.92	5.93
t-stat	[−0.38]	[1.49]	[2.39]	[1.59]	[2.38]	[2.83]	[−0.51]	[1.80]	[1.31]	[1.40]	[2.33]	[2.76]
med	−0.29	2.47	3.53	4.53	4.27	5.79	−1.23	3.18	5.25	3.51	6.77	6.94
sdev	6.62	7.62	8.18	9.10	9.61	9.11	9.74	10.29	9.25	8.51	10.59	10.79
skew	0.17	0.13	−0.59	−0.42	−0.43	−0.30	0.01	−0.06	−0.36	−0.26	−0.32	−0.31
kurt	3.90	3.98	5.56	4.18	4.77	3.55	3.65	3.98	3.71	4.07	5.28	4.37
ac_1	0.13	0.03	0.09	0.15	0.12	0.11	0.11	0.05	0.11	0.06	0.09	0.07
SR	−0.08	0.29	0.47	0.34	0.49	0.57	−0.10	0.35	0.27	0.27	0.46	0.55
mdd	0.49	0.35	0.18	0.30	0.26	0.20	0.65	0.36	0.30	0.27	0.33	0.42
$freq$	0.10	0.14	0.15	0.14	0.07	0.17	0.10	0.15	0.13	0.10	0.04	0.14
nfa	0.45	−0.03	−0.02	−0.11	−0.41		0.47	0.28	−0.04	−0.18	−0.49	
ldc	0.53	0.50	0.48	0.46	0.41		0.57	0.49	0.47	0.46	0.46	
pre-fd	−0.36	0.55	2.13	2.60	4.30		−1.53	−0.02	0.89	1.45	3.04	
post-fd	−0.35	0.56	2.11	2.59	4.24		−1.51	0.00	0.84	1.43	3.04	
pre-β	−0.22	0.14	0.51	0.78	1.35		−0.94	−0.50	−0.28	0.05	0.67	
	(0.35)	(0.47)	(0.66)	(0.76)	(0.76)		(0.97)	(0.96)	(0.88)	(0.67)	(0.57)	
post-β	−0.30	−0.31	−0.09	0.07	0.31		−0.57	−0.19	0.03	0.12	0.59	
	(0.05)	(0.04)	(0.04)	(0.05)	(0.06)		(0.05)	(0.03)	(0.04)	(0.04)	(0.05)	

Table 5. Determinants of Spot Exchange Rate Returns

The table presents results from fixed-effects panel regressions. We use discrete exchange rate returns at monthly frequency as dependent variable. Exchange rates are defined as units of US dollars per unit of foreign currency such that a positive return denotes a foreign currency appreciation. The set of independent variables includes the net foreign asset position to gross domestic product (nfa), the share of foreign liabilities in domestic currency (ldc), the forward discount or interest rate differential relative to the US (fd), the monthly change in the VIX index (ΔVIX), and a dummy variable that equals one if ΔVIX is greater than one standard deviation as estimated across the entire sample, and zero otherwise (ΔVIX *dummy*). Robust standard errors are clustered at country level and reported in parentheses. The superscripts *a*, *b* and *c* denote statistical significance at 10%, 5% and 1% level, respectively. The sample runs from January 1986 to June 2014. See Section 3 for a detailed description of data sources and data construction.

	Dependent variable: nominal exchange rate returns					
	(1)	(2)	(3)	(4)	(5)	(6)
nfa (lagged 12 months)	−0.043	−0.040	−0.015	-0.158^{b}	-0.159^{b}	−0.113
	(0.069)	(0.072)	(0.076)	(0.071)	(0.073)	(0.071)
ΔVIX	-0.143^{c}	-0.143^{c}	-0.126^{c}			
	(0.017)	(0.017)	(0.019)			
$\Delta VIX \times nfa$ (lagged 12 months)	0.069^{c}	0.069^{c}	0.058^{c}			
	(0.018)	(0.018)	(0.017)			
ldc (lagged 12 months)		−0.092	−0.327		0.027	−0.105
		(0.226)	(0.203)		(0.266)	(0.221)
fd (lagged 1 month)			-0.004^{b}			−0.001
			(0.002)			(0.003)
$\Delta VIX \times fd$ (lagged 1 month)			−0.001			
			($< .001$)			
ΔVIX *dummy*				-1.119^{c}	-1.119^{c}	-0.903^{c}
				(0.243)	(0.244)	(0.268)
ΔVIX *dummy* $\times nfa$ (lagged 12 months)				0.731^{c}	0.731^{c}	0.563^{c}
				(0.265)	(0.264)	(0.247)
ΔVIX *dummy* $\times fd$ (lagged 1 month)						-0.012^{b}
						(0.006)
Additional Variables: Constant and lagged exchange rate returns	*YES*	*YES*	*YES*	*YES*	*YES*	*YES*
Adjusted R^2	0.08	0.08	0.08	0.02	0.02	0.02
Observations	8960	8960	8960	9112	9112	9112

Table 6. Risk Bearing Capacity and Global Imbalance Portfolios

This table presents results from time-series regressions. In *Panel A*, we regress monthly currency excess returns to the *global imbalance portfolios* (see Table 1) on a constant and the monthly changes in the VIX index. In *Panel B*, we regress the exchange rate return component to the *global imbalance portfolios* on a constant and the monthly changes in the VIX index. Newey and West (1987) standard errors with Andrews (1991) optimal lag selection are reported in parentheses. The sample runs from January 1986 to June 2014. See Section 3 for a detailed description of data sources and data construction, and Figure 1 for a detailed description of the portfolio construction.

	Panel A: Currency Excess Returns				
	P_1	P_2	P_3	P_4	P_5
ΔVIX	-0.037	-0.059	-0.144	-0.146	-0.148
	(0.036)	(0.044)	(0.034)	(0.034)	(0.054)
Constant	0.102	0.312	0.157	0.326	0.493^c
	(0.117)	(0.129)	(0.094)	(0.115)	(0.146)
Adjusted R^2	0.01	0.01	0.15	0.11	0.07

	Panel B: Spot Exchange Rate Returns				
	P_1	P_2	P_3	P_4	P_5
ΔVIX	-0.035	-0.057	-0.143	-0.143	-0.143
	(0.037)	(0.045)	(0.035)	(0.033)	(0.054)
Constant	0.127	0.187	-0.027	0.027	-0.092
	(0.166)	(0.128)	(0.094)	(0.116)	(0.147)
Adjusted R^2	0.00	0.01	0.15	0.10	0.07

Table 7. Asset Pricing Tests: Currency Strategies

The table presents asset pricing results for the *carry trade portfolios* (sorted on the one-month forward discounts), the *global imbalance portfolios* (sorted on the net foreign assets to gross domestic product ratio and the share of foreign liabilities in domestic currency), the *momentum portfolios* (sorted on the past three-month exchange rate returns), the *value portfolios* (sorted on the past five-years exchange rate returns), the *risk reversal portfolios* (sorted on the one-year 25 delta currency option risk reversal), the *20 currency portfolios* (all except the *risk reversal* portfolios), and the *25 currency portfolios* (all portfolios). These portfolios' excess returns are used as test assets whereas the dollar (DOL) and the global imbalance (IMB) act as risk factors. We report first-stage GMM estimates of the factor loadings b, the market price of risk λ, and the cross-sectional R^2. Newey and West (1987) standard errors with Andrews (1991) optimal lag selection are reported in parentheses. HJ is the Hansen and Jagannathan (1997) distance (with simulated p-value in brackets) for the null hypothesis that the HJ distance is equal to zero. Excess returns are in annual terms and adjusted for transaction costs. The portfolios are rebalanced monthly from October 1983 (or January 1996) to June 2014. See Section 3 for a detailed description of data sources and data construction.

Portfolios	Sample	b_{DOL}	b_{IMB}	λ_{DOL}	λ_{IMB}	R^2	HJ
5 Carry Trade	10/83 – 06/14	−0.07	1.53	0.02	0.07	0.87	0.14
		(0.29)	(0.54)	(0.01)	(0.02)		[0.16]
5 Global Imbalance	10/83 – 06/14	0.30	0.63	0.03	0.04	0.75	0.17
		(0.26)	(0.29)	(0.01)	(0.01)		[0.92]
5 Momentum	10/83 – 06/14	0.31	0.22	0.02	0.02	$< .01$	0.16
		(0.30)	(0.75)	(0.01)	(0.03)		[0.04]
5 Value	10/83 – 06/14	0.01	1.33	0.02	0.07	0.66	0.14
		(0.30)	(0.53)	(0.01)	(0.02)		[0.18]
5 Risk Reversal	01/96 – 06/14	−0.12	1.55	0.02	0.09	0.96	0.04
		(0.44)	(0.93)	(0.02)	(0.05)		[0.97]
20 Currency	10/83 – 06/14	0.12	0.97	0.02	0.05	0.53	0.81
		(0.27)	(0.36)	(0.01)	(0.01)		[0.17]
25 Currency	01/96 – 06/14	−0.08	1.38	0.02	0.08	0.65	0.93
		(0.41)	(0.38)	(0.01)	(0.01)		[0.86]

Table 8. Asset Pricing Tests: Bond, Currency, Commodity and Equity Strategies

The table presents asset pricing results for the *currency portfolios* defined in Table 6, the Fama and French (2012) *size and book-to-market (momentum) global portfolios*, the *international bond portfolios* (sorted on redemption yields), and the Yang (2013) *commodity portfolios*. These portfolios' excess returns are used as test assets whereas the set of risk factor includes the dollar (DOL), the global imbalance (IMB), the Fama and French (2012) factors (MKT, SMB, HML , and WML), the high-minus-low international bond factor (IB), and the high-minus-low commodity factor (COM). We report first-stage GMM estimates of the factor loadings b, the market price of risk λ, and the cross-sectional R^2. Newey and West (1987) standard errors with Andrews (1991) optimal lag selection are reported in parentheses. HJ is the Hansen and Jagannathan (1997) distance (with simulated p-value in brackets) for the null hypothesis that the HJ distance is equal to zero. Excess returns are in annual terms. See Section 3 for a detailed description of data sources and data construction.

Panel A: Size and Book-to-Market Global Portfolios

	Sample	b_{MKT}	b_{SMB}	b_{HML}	b_{DOL}	b_{IMB}	λ_{MKT}	λ_{SMB}	λ_{HML}	λ_{DOL}	λ_{IMB}	R^2	HJ
20 Currency + 25 Size and Book-to-Market	07/90-06/14	0.16	0.47	0.98	−0.22	1.19	0.06	0.02	0.07	0.02	0.07	0.78	0.96
		(0.21)	(0.36)	(0.43)	(0.50)	(0.39)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)		[0.38]
25 Currency + 25 Size and Book-to-Market	01/96-06/14	0.25	0.47	1.06	−0.61	1.45	0.07	0.01	0.08	0.02	0.09	0.84	1.02
		(0.34)	(0.40)	(0.50)	(0.74)	(0.35)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)		[0.20]

Panel B: Size and Momentum Global Portfolios

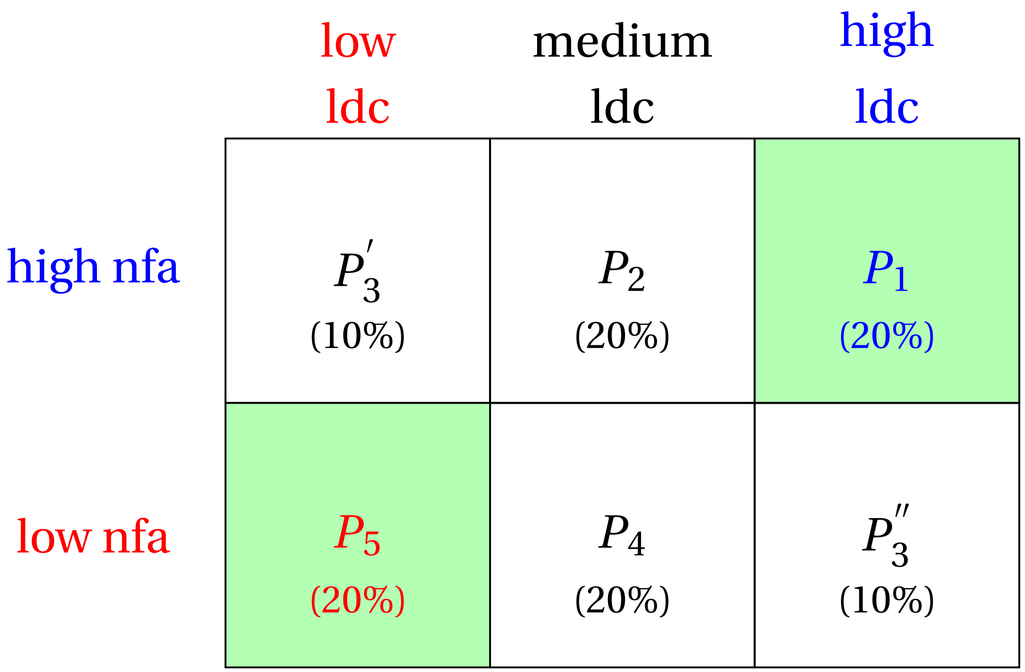
	Sample	b_{MKT}	b_{SMB}	b_{WML}	b_{DOL}	b_{IMB}	λ_{MKT}	λ_{SMB}	λ_{WML}	λ_{DOL}	λ_{IMB}	R^2	HJ
20 Currency + 25 Size and Momentum	11/90-06/14	0.41	0.77	0.63	−0.39	1.24	0.09	0.04	0.10	0.02	0.07	0.83	0.98
		(0.24)	(0.37)	(0.31)	(0.42)	(0.36)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)		[0.34]
25 Currency + 25 Size and Momentum	01/96-06/14	0.37	0.62	0.60	−0.48	1.52	0.10	0.04	0.11	0.02	0.09	0.86	1.02
		(0.31)	(0.42)	(0.34)	(0.57)	(0.37)	(0.03)	(0.01)	(0.02)	(0.01)	(0.01)		[0.22]

Panel C: International Bond Portfolios

	Sample	b_{IB}	b_{DOL}	b_{IMB}	λ_{IB}	λ_{DOL}	λ_{IMB}	R^2	HJ
20 Currency + 5 International Bond	10/83-06/14	2.03	0.01	0.90	0.06	0.02	0.05	0.63	0.92
		(0.87)	(0.38)	(0.40)	(0.01)	(0.01)	(0.01)		[0.48]
25 Currency + 5 International Bond	01/96-06/14	3.08	−0.43	1.37	0.08	0.02	0.07	0.64	1.02
		(0.92)	(0.47)	(0.45)	(0.01)	(0.01)	(0.01)		[0.26]

Panel D: Commodity Portfolios

	Sample	b_{COM}	b_{DOL}	b_{IMB}	λ_{COM}	λ_{DOL}	λ_{IMB}	R^2	HJ
20 Currency + 7 Commodity	10/83-12/98	0.17	0.16	0.86	0.09	0.02	0.06	0.37	0.89
		(0.14)	(0.51)	(0.43)	(0.04)	(0.01)	(0.01)		[0.59]
25 Currency + 7 Commodity	01/96-12/98	0.28	0.01	1.25	0.15	0.02	0.09	0.61	0.96
		(0.19)	(0.78)	(0.51)	(0.03)	(0.01)	(0.01)		[0.41]



	low ldc	medium ldc	high ldc
high nfa	$P_3^{'}$ (10%)	P_2 (20%)	P_1 (20%)
low nfa	P_5 (20%)	P_4 (20%)	$P_3^{''}$ (10%)

Figure 1. Global Imbalance Portfolios: Construction

This chart describes the construction of the global imbalance portfolios. At the end of each month, currencies are first grouped into two baskets using the net foreign asset position to gross domestic product (nfa), and then into 3 baskets using the share of foreign liabilities in domestic currency (ldc). The nfa breakpoint is the median value whereas the ldc breakpoints are the 40^{th} and 80^{th} percentiles. The first portfolio (P_1) contains the top 20% of all currencies with high nfa and high ldc (creditor nations with external liabilities mainly in domestic currency) whereas the last portfolio (P_5) contains the top 20% of all currencies with low nfa and low ldc (debtor nations with external liabilities mainly in foreign currency). The portfolios $P_3^{'}$ and $P_3^{''}$ are intermediate portfolios containing each 10% of all currencies, and are aggregated into the portfolio P_3. The global imbalance factor (IMB) is constructed as the average return on P_5 minus the average return on P_1. We use 5 portfolios rather than 6 portfolios as we have a limited number of currencies in *developed countries*. Figure A.1 in the Internet Appendix describes the construction of the IMB factor based on 6 (4) portfolios for *all countries* (*developed countries*).

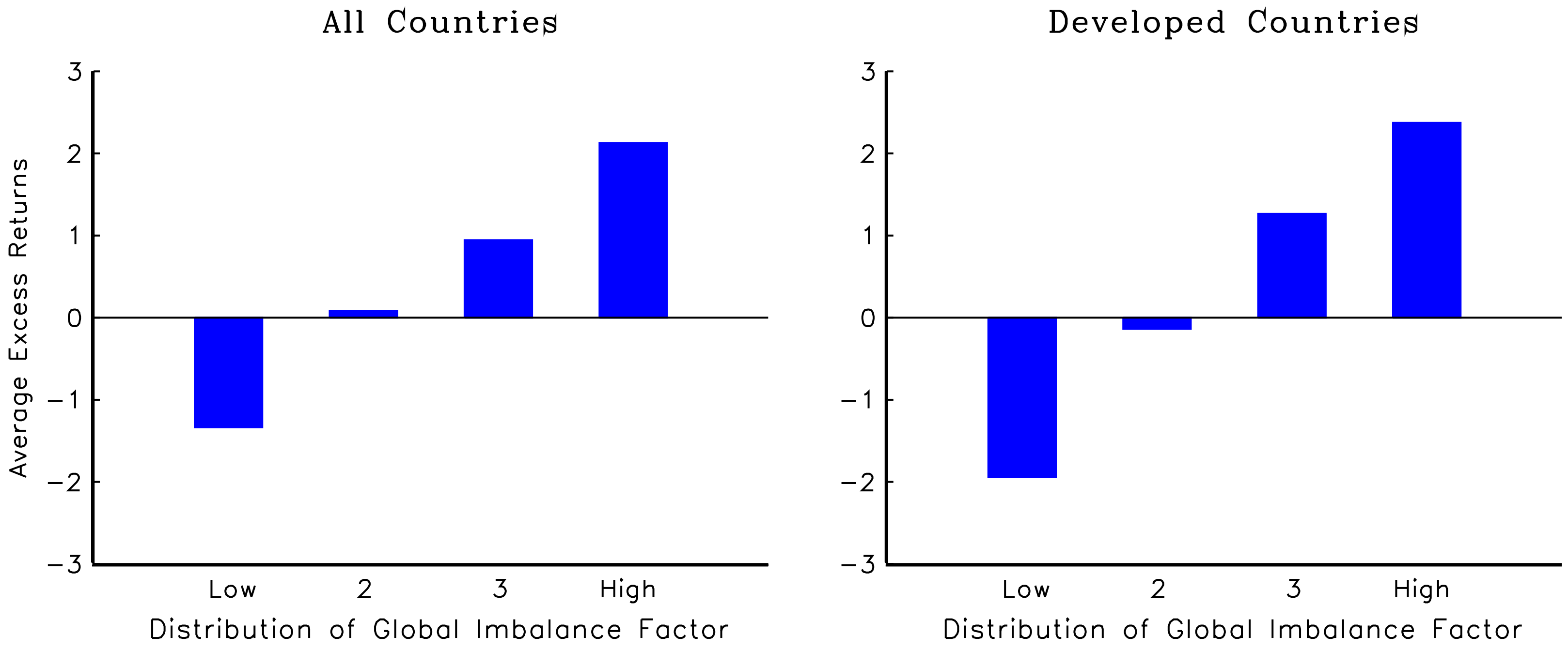


Figure 2. Carry Trade Returns and Global Imbalance Risk

The figure presents average excess returns for carry trade returns conditional on the global imbalance risk factor being within the lowest to highest quartile of its sample distribution. Excess returns are expressed in percentage per month. The sample runs from October 1983 to June 2014.

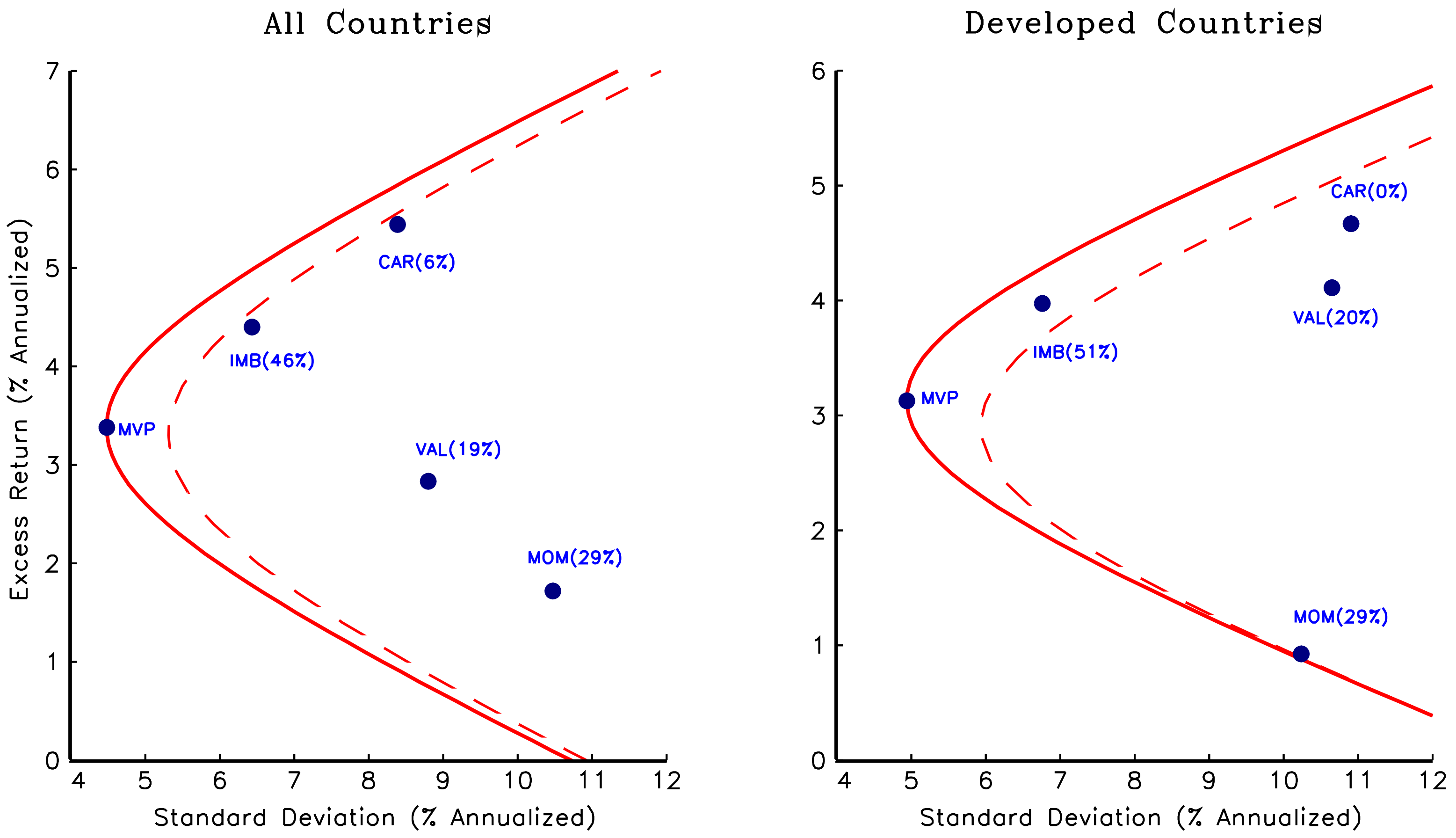


Figure 3. Global Minimum Variance Portfolio

The figure presents the global minimum variance portfolio (MVP) and the efficient frontier (*solid line*) built using a set of currency strategies formed using $t-1$ information. CAR is the carry strategy that buys (sells) the top 20% of all currencies with high (low) interest rate differential relative to the US dollar. Similarly, IMB is the global imbalance strategy that buys (sells) the currencies of debtor nations with external liabilities mainly in foreign currency (currencies of creditor nations with external liabilities mainly in domestic currency), MOM is the momentum strategy that buys (sells) currencies with high (low) past 3-month exchange rate return, and VAL is the value strategy that buys (sells) currencies with low (high) past 5-year exchange rate return. The portfolio weights are reported in parentheses and computed as $w = (\Sigma^{-1}\iota)/(\iota'\Sigma^{-1}\iota)$ where Σ is the $N \times N$ covariance matrix of the strategies' excess returns, ι is a $N \times 1$ vector of ones, and N denotes the number of strategies. The *dashed line* denotes the efficient frontier when we exclude the IMB strategy from the investment opportunity set. Excess returns are adjusted for transaction costs and expressed in percentage per annum. The strategies are rebalanced monthly from October 1983 to June 2014.

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Table A.1. Descriptive Statistics: Carry Trade Portfolios

The table presents descriptive statistics of currency portfolios sorted on time $t-1$ forward discounts or interest rate differential relative to the US (fd). The first portfolio (P_1) contains the top 20% of all currencies with low fd (low-yielding currencies) whereas the last portfolio (P_5) contains the top 20% of all currencies with high fd (high-yielding currencies). CAR is a long-short strategy that buys P_5 and sells P_1. The table also reports the first order autocorrelation coefficient (ac_1), the annualized Sharpe ratio (SR), the maximum drawdown (mdd), the frequency of portfolio switches ($freq$), the average fd, the average net foreign asset position to gross domestic product (nfa), and the average share of foreign liabilities in domestic currency (ldc). t-statistics based on Newey and West (1987) standard errors with Andrews (1991) optimal lag selection are reported in brackets. Excess returns are expressed in percentage per annum and adjusted for transaction costs. The portfolio are rebalanced monthly from October 1983 to June 2014. See Section 3 for a detailed description of data sources and data construction.

	P_1	P_2	P_3	P_4	P_5	CAR	P_1	P_2	P_3	P_4	P_5	CAR
	All Countries						*Developed Countries*					
mean	0.47	0.05	2.38	2.27	5.91	5.44	0.65	0.93	1.93	2.59	5.31	4.67
t-stat	[0.33]	[0.04]	[1.55]	[1.34]	[3.10]	[3.20]	[0.36]	[0.49]	[1.11]	[1.47]	[2.41]	[2.24]
median	0.82	1.53	2.87	2.98	8.53	7.67	−0.67	1.91	3.55	3.33	5.30	7.48
sdev	7.79	7.66	8.10	8.67	9.28	8.39	9.98	9.64	9.12	9.51	11.39	10.90
skew	0.16	−0.16	−0.30	−0.59	−0.42	−0.86	0.33	0.01	−0.07	−0.42	−0.19	−0.95
kurt	4.22	3.73	4.12	5.66	4.67	5.02	3.76	3.60	3.86	4.69	4.28	5.38
ac_1	0.01	0.03	0.07	0.10	0.13	0.13	0.00	0.07	0.08	0.04	0.11	0.07
SR	0.06	0.01	0.29	0.26	0.64	0.65	0.06	0.10	0.21	0.27	0.47	0.43
mdd	0.42	0.37	0.37	0.35	0.31	0.33	0.55	0.45	0.38	0.29	0.37	0.38
$freq$	0.19	0.28	0.31	0.33	0.17		0.13	0.26	0.32	0.24	0.13	
fd	−1.69	−0.86	0.93	3.30	9.28		−2.05	−1.01	0.31	1.61	4.04	
nfa	0.53	0.06	−0.15	−0.35	−0.39		0.60	0.00	−0.10	−0.08	−0.39	
ldc	0.52	0.50	0.43	0.43	0.40		0.54	0.55	0.44	0.43	0.41	

Table A.2. Portfolio Composition

The table presents the composition of the five carry trade and global imbalance portfolios. In *Panel A* and *Panel B*, we report the top six currencies (with the frequency in parentheses) entering each portfolio. *Panel C* presents the probability that a given currency enters simultaneously the same carry trade and global imbalance portfolio. The portfolios are rebalanced monthly from October 1983 to June 2014.

All Countries					*Developed Countries*				
P_1	P_2	P_3	P_4	P_5	P_1	P_2	P_3	P_4	P_5
Panel A: Carry Trade Portfolios									
JPY [0.18]	CAD [0.08]	GBP [0.08]	AUD [0.07]	ZAR [0.13]	CHF [0.42]	NLG [0.14]	DKK [0.20]	GBP [0.17]	NZD [0.35]
CHF [0.16]	DKK [0.08]	NOK [0.06]	NZD [0.06]	TRY [0.10]	JPY [0.40]	EUR [0.14]	CAD [0.15]	NOK [0.16]	AUD [0.25]
SGD [0.12]	SGD [0.06]	CAD [0.05]	MXN [0.05]	BRL [0.06]	DEM [0.06]	CAD [0.10]	GBP [0.14]	SEK [0.15]	ITL [0.12]
HKD [0.09]	EUR [0.06]	KRW [0.05]	HUF [0.05]	MXN [0.05]	DKK [0.03]	DEM [0.10]	SEK [0.11]	AUD [0.14]	NOK [0.10]
CNY [0.05]	SEK [0.05]	HKD [0.05]	GBP [0.05]	HUF [0.05]	CAD [0.03]	SEK [0.08]	NOK [0.10]	CAD [0.12]	GBP [0.08]
MYR [0.04]	NLG [0.04]	NZD [0.05]	PHP [0.04]	NZD [0.05]	NLG [0.02]	DKK [0.07]	FRF [0.07]	DKK [0.08]	SEK [0.06]
Panel B: Global Imbalance Portfolios									
CHF [0.11]	GBP [0.10]	AUD [0.11]	HUF [0.09]	TRY [0.11]	CHF [0.26]	CHF [0.20]	NOK [0.29]	CAD [0.28]	DKK [0.30]
HKD [0.10]	JPY [0.09]	NOK [0.10]	NZD [0.09]	PHP [0.09]	JPY [0.26]	JPY [0.19]	AUD [0.25]	SEK [0.22]	NZD [0.22]
EUR [0.10]	CHF [0.08]	SGD [0.08]	PLN [0.07]	DKK [0.09]	DEM [0.16]	NLG [0.16]	GBP [0.17]	NZD [0.22]	SEK [0.19]
JPY [0.09]	NLG [0.07]	GBP [0.07]	MXN [0.06]	SEK [0.08]	EUR [0.12]	FRF [0.13]	EUR [0.11]	AUD [0.11]	GBP [0.18]
SGD [0.09]	FRF [0.06]	HKD [0.07]	TND [0.06]	NZD [0.08]	CAD [0.10]	DKK [0.13]	ITL [0.11]	NOK [0.09]	ITL [0.06]
CNY [0.08]	ILS [0.06]	CAD [0.06]	MYR [0.06]	ISK [0.07]	FRF [0.07]	GBP [0.09]	BEF [0.03]	ITL [0.04]	AUD [0.04]
Panel C: Joint Probability									
[0.45]	[0.25]	[0.24]	[0.26]	[0.38]	[0.47]	[0.28]	[0.19]	[0.25]	[0.41]

Table A.3. Asset Pricing: Global Imbalance Risk with Constraints

This table re-estimates the linear factor model of Table 2 while including the global imbalance factor as one of the test assets as suggested by Lewellen, Nagel and Shanken (2010). We report GMM (first and second-stage) and Fama-MacBeth (FMB) estimates of factor loadings b, market price of risk λ, and cross-sectional R^2. Newey and West (1987) standard errors with Andrews (1991) optimal lag selection are reported in parentheses whereas Shanken (1992) standard errors are reported in brackets. χ^2 denotes the test statistics (with p-value in brackets) for the null hypothesis that all pricing errors are jointly zero. HJ refers to the Hansen and Jagannathan (1997) distance (with simulated p-value in brackets) for the null hypothesis that the HJ distance is equal to zero. Excess returns are in annual terms and adjusted for transaction costs. The portfolios are rebalanced monthly from October 1983 to June 2014.

	b_{DOL}	b_{IMB}	λ_{DOL}	λ_{IMB}	R^2	$RMSE$	χ^2	HJ	b_{DOL}	b_{IMB}	λ_{DOL}	λ_{IMB}	R^2	$RMSE$	χ^2	HJ
	Developed Countries								*All Countries*							
GMM_1	0.17	0.75	0.02	0.04	0.91	1.22%	1.56	0.07	0.06	1.03	0.02	0.05	0.79	2.31%	7.08	0.17
	(0.21)	(0.33)	(0.02)	(0.01)			[0.82]	[0.85]	(0.27)	(0.31)	(0.01)	(0.01)			[0.13]	[0.10]
GMM_2	0.20	0.73	0.02	0.05	0.96	1.36%	1.53		0.11	0.91	0.02	0.07	0.95	2.88%	6.85	
	(0.21)	(0.26)	(0.02)	(0.01)			[0.82]		(0.26)	(0.27)	(0.01)	(0.01)			[0.14]	
FMB	0.17	0.75	0.02	0.04	0.91	1.22%	1.56		0.06	1.03	0.02	0.05	0.79	2.31%	7.07	
	(0.19)	(0.23)	(0.02)	(0.01)			[0.82]		(0.24)	(0.28)	(0.01)	(0.01)			[0.13]	
	[0.17]	[0.25]	[0.02]	[0.01]					[0.22]	[0.26]	[0.01]	[0.01]				

Table A.4. Country-Level Asset Pricing Tests: Global Imbalance Risk

This table presents cross-sectional asset pricing results for individual currency excess returns. The linear factor model includes the dollar (DOL) and the global imbalance (IMB) risk factor. IMB is a long-short strategy that buys the currency (top 20%) of debtor nations with external liabilities mainly in foreign currency and sells the currencies (top 20%) of creditor nations with external liabilities mainly in domestic currency. The test assets are use country-level unconditional and conditional excess returns. The unconditional excess return for each currency pair is computed as $RX_{t+1} = (F_t - S_{t+1})/S_t$, where S_t denotes the spot exchange rate and F_t is the one-month forward rate. The conditional excess return is calculated as $RX_{t+1} = \gamma \times (F_t - S_{t+1})/S_t$, where $\gamma = 1$ when $F_t > S_t$ (foreign interest rate is higher than US interest rate) and $\gamma = -1$ when $F_t < S_t$ (foreign interest rate is lower than US interest rate). The table reports estimates of the market price of risk λ, the cross-sectional R^2 and the root mean squared error ($RMSE$) obtained via Fama-MacBeth procedure with robust regressions in the first and second step to account for outliers in individual currency excess returns. Bootstrapped standard errors are reported in parentheses. We use a block-bootstrap algorithm based on 1,000 repetitions. Excess returns are in annual terms and run at monthly frequency from October 1983 to June 2014.

Unconditional Excess Returns				Conditional Excess Returns			
λ_{DOL}	λ_{IMB}	R^2	$RMSE$	λ_{DOL}	λ_{IMB}	R^2	$RMSE$
All Countries							
0.04	0.06	0.34	28.4	0.04	0.07	0.25	35.9
(0.02)	(0.02)			(0.02)	(0.02)		
Developed Countries							
0.03	0.05	0.64	4.6	0.05	0.08	0.32	7.4
(0.02)	(0.02)			(0.03)	(0.02)		

A.5. Determinants of Excess Currency Returns

The table presents results from fixed-effects panel regressions. We use discrete currency excess returns at monthly frequency as dependent variable. The set of independent variables includes the net foreign asset position to gross domestic product (nfa), the share of foreign liabilities in domestic currency (ldc), the monthly change in the VIX index (ΔVIX), and a dummy variable that equals one if ΔVIX is greater than one standard deviation as estimated across the entire sample, and zero otherwise (ΔVIX *dummy*). Robust standard errors are clustered at country level and reported in parentheses. The superscripts a, b and c denote statistical significance at 10%, 5% and 1% level, respectively. The sample runs from January 1986 to June 2014. See Section 3 for a detailed description of data sources and data construction.

	Dependent variable: currency excess returns			
	(1)	(2)	(3)	(4)
nfa (lagged 12 months)	0.001	0.031	−0.110	−0.084
	(0.071)	(0.088)	[0.069)	(0.077)
ΔVIX	-0.145^c	-0.145^c		
	(0.017)	(0.017)		
$\Delta VIX \times nfa$ (lagged 12 months)	0.069^c	0.069^c		
	(0.018)	(0.018)		
ldc (lagged 12 months)		-0.751^b		-0.630^b
		(0.291)		(0.292)
ΔVIX *dummy*			-1.130^c	-1.127^c
			(0.243)	(0.243)
ΔVIX *dummy* $\times\, nfa$ (lagged 12 months)			0.719^c	0.718^c
			(0.261)	(0.260)
Additional Variables: Constant and lagged excess currency return	YES	YES	YES	YES
Adjusted R^2	0.08	0.08	0.02	0.02
Observations	8960	8960	9112	9112

Table A.6. Global Imbalance Portfolios and Other Pricing Currencies

The table presents descriptive statistics of currency portfolios sorted on time $t-1$ net foreign asset position to gross domestic product (nfa), and the share of foreign liabilities in domestic currency (ldc) when the pricing currency is not the US dollar. The first portfolio (P_1) contains the top 20% of all currencies with high nfa and high ldc (creditor nations with external liabilities mainly in domestic currency) whereas the last portfolio (P_5) contains the top 20% of all currencies with low nfa and low ldc (debtor nations with external liabilities mainly in foreign currency). IMB is a long-short strategy that buys P_5 and sells P_1. The table also reports the first order autocorrelation coefficient (ac_1), the annualized Sharpe ratio (SR), the maximum drawdown (mdd), the frequency of portfolio switches ($freq$), the average forward discount (fd), the average nfa, and the average ldc. t-statistics based on Newey and West (1987) standard errors with Andrews (1991) optimal lag selection are reported in brackets. Excess returns are expressed in percentage per annum and adjusted for transaction costs. The portfolio are rebalanced monthly from October 1983 to June 2014. See Section 3 for a detailed description of data sources and data construction, and Figure 1 for the portfolio construction.

	P_1	P_2	P_3	P_4	P_5	IMB	P_1	P_2	P_3	P_4	P_5	IMB
	CHF as pricing currency						*DEM-EUR as pricing currency*					
mean	0.48	1.73	0.38	2.45	4.34	3.85	−0.29	1.39	−0.14	1.92	3.91	4.20
t-stat	[0.40]	[1.47]	[0.19]	[1.50]	[2.65]	[3.04]	[−0.25]	[1.55]	[−0.08]	[1.40]	[2.82]	[3.06]
median	0.28	2.23	2.58	2.80	5.63	3.14	−1.83	1.50	1.68	1.72	2.66	4.38
sdev	6.75	6.65	10.24	9.03	8.52	6.11	6.31	4.95	8.88	7.60	6.92	6.56
skew	−0.06	−0.15	−0.19	−0.44	0.17	0.53	0.29	0.34	−0.02	−0.41	0.82	0.41
kurt	4.48	4.03	4.36	3.84	4.78	7.45	5.22	3.87	4.92	4.06	7.60	6.61
ac_1	−0.05	−0.04	0.07	0.01	0.07	0.15	0.01	−0.01	0.07	−0.01	0.13	0.14
SR	0.07	0.26	0.04	0.27	0.51	0.63	−0.05	0.28	−0.02	0.25	0.57	0.64
mdd	0.30	0.23	0.44	0.31	0.27	0.23	0.42	0.16	0.43	0.37	0.22	0.24
$freq$	0.02	0.03	0.03	0.04	0.03		0.02	0.03	0.04	0.04	0.03	
fd	1.95	3.31	3.77	5.36	8.33		0.55	2.04	2.56	4.18	7.17	
nfa	0.26	0.07	0.09	−0.47	−0.57		0.43	0.15	0.09	−0.47	−0.56	
ldc	0.62	0.45	0.44	0.47	0.28		0.61	0.45	0.44	0.47	0.28	

continued

Table A.6. Global Imbalance Portfolios and Other Pricing Currencies *(continued)*

	P_1	P_2	P_3	P_4	P_5	IMB	P_1	P_2	P_3	P_4	P_5	IMB
	GBP as pricing currency						*JPY as pricing currency*					
mean	−1.24	0.60	−0.80	1.25	3.17	4.41	1.27	3.41	1.41	3.61	5.64	4.37
t-stat	[−0.82]	[0.41]	[−0.46]	[0.80]	[2.09]	[3.38]	[0.69]	[1.69]	[0.60]	[1.65]	[2.38]	[3.43]
median	−2.25	−1.44	0.24	1.86	3.00	4.38	2.58	5.96	5.11	7.14	7.27	4.29
sdev	7.48	7.76	9.35	8.89	8.41	6.26	9.92	10.38	11.86	11.77	11.70	6.18
skew	0.57	0.87	0.13	0.28	0.91	0.39	−0.44	−0.50	−0.57	−0.68	−0.43	0.78
kurt	6.27	6.02	6.09	5.21	7.88	6.74	5.32	4.60	4.52	5.06	4.08	8.20
ac_1	0.12	0.08	0.05	−0.05	0.02	0.15	0.05	0.09	0.08	0.06	0.12	0.14
SR	−0.17	0.08	−0.09	0.14	0.38	0.70	0.13	0.33	0.12	0.31	0.48	0.71
mdd	0.56	0.39	0.55	0.43	0.30	0.24	0.37	0.29	0.49	0.48	0.38	0.23
$freq$	0.02	0.03	0.03	0.04	0.03		0.02	0.03	0.03	0.04	0.03	
fd	−2.30	−0.71	0.21	1.74	4.74		2.53	4.39	4.45	6.32	9.14	
nfa	0.39	0.15	0.12	−0.47	−0.57		0.41	0.13	0.09	−0.47	−0.57	
ldc	0.63	0.47	0.44	0.47	0.28		0.62	0.45	0.45	0.47	0.28	

Table A.7. Asset Pricing Tests and Other Pricing Currencies

The table presents cross-sectional asset pricing results for the linear factor model based on the dollar (DOL) and the global imbalance (IMB) risk factor when the pricing currency is not the US dollar. The test assets are excess returns to five carry trade portfolios sorted on the one-month forward discounts. IMB is a long-short strategy that buys the currency (top 20%) of debtor nations with external liabilities mainly in foreign currency, and sells the currencies (top 20%) of creditor nations with external liabilities mainly in domestic currency. *Panel A* reports GMM (first and second-stage) and Fama-MacBeth (FMB) estimates of the factor loadings b, the market price of risk λ, and the cross-sectional R^2. Newey and West (1987) standard errors with Andrews (1991) optimal lag selection are reported in parentheses whereas Shanken (1992) standard errors are reported in brackets. χ^2 denotes the test statistics (with p-value in brackets) for the null hypothesis that all pricing errors are jointly zero. HJ refers to the Hansen and Jagannathan (1997) distance (with simulated p-value in brackets) for the null hypothesis that the HJ distance is equal to zero. *Panel B* reports least-squares estimates of time series regressions with Newey and West (1987) and Andrews (1991) standard errors in parentheses. Excess returns are in annual terms and adjusted for transaction costs. The portfolios are rebalanced monthly from October 1983 to June 2014. See Section 3 for a detailed description of data sources and data construction, and Figure 1 for the portfolio construction.

Panel A: Factor Prices

	b_{DOL}	b_{IMB}	λ_{DOL}	λ_{IMB}	R^2	$RMSE$	χ^2	HJ	b_{DOL}	b_{IMB}	λ_{DOL}	λ_{IMB}	R^2	$RMSE$	χ^2	HJ
	CHF as pricing currency								*DEM-EUR as pricing currency*							
GMM_1	−0.03	0.97	0.01	0.04	0.78	2.22%	4.08	0.12	0.13	0.91	0.00	0.05	0.81	2.33%	5.92	0.14
	(0.22)	(0.34)	(0.01)	(0.01)			[0.40]	[0.30]	(0.29)	(0.31)	(0.01)	(0.01)			[0.21]	[0.15]
GMM_2	−0.03	0.94	0.01	0.05	0.95	2.37%	4.06		0.04	0.87	0.00	0.05	0.96	2.56%	5.79	
	(0.22)	(0.29)	(0.01)	(0.01)			[0.40]		(0.29)	(0.27)	(0.01)	(0.01)			[0.22]	
FMB	−0.03	0.96	0.01	0.04	0.78	2.22%	4.08		0.13	0.91	0.00	0.05	0.81	2.33%	5.92	
	(0.21)	(0.28)	(0.01)	(0.01)			[0.40]		(0.28)	(0.27)	(0.01)	(0.01)			[0.21]	
	[0.21]	[0.26]	[0.01]	[0.01]					[0.27]	[0.24]	[0.01]	[0.01]				

Panel B: Factor Betas

	α	β_{DOL}	β_{IMB}	R^2	α	β_{DOL}	β_{IMB}	R^2
P_1	−0.01	0.94	−0.27	0.78	−0.01	0.86	−0.31	0.71
	(0.01)	(0.04)	(0.05)		(0.01)	(0.05)	(0.04)	
P_2	−0.02	0.93	−0.15	0.81	−0.02	0.88	−0.13	0.73
	(0.01)	(0.05)	(0.04)		(0.01)	(0.06)	(0.03)	
P_3	−0.01	0.89	−0.03	0.78	−0.01	0.82	−0.02	0.67
	(0.01)	(0.03)	(0.04)		(0.01)	(0.04)	(0.03)	
P_4	−0.02	0.95	0.21	0.78	−0.02	0.93	0.20	0.65
	(0.01)	(0.04)	(0.06)		(0.01)	(0.06)	(0.05)	
P_5	0.00	1.25	0.27	0.74	0.01	1.42	0.27	0.69
	(0.01)	(0.05)	(0.09)		(0.01)	(0.07)	(0.08)	

continued

Table A.7. Asset Pricing Tests and Other Pricing Currencies *(continued)*

Panel A: Factor Prices

	b_{DOL}	b_{IMB}	λ_{DOL}	λ_{IMB}	R^2	$RMSE$	χ^2	HJ	b_{DOL}	b_{IMB}	λ_{DOL}	λ_{IMB}	R^2	$RMSE$	χ^2	HJ
	GBP as pricing currency								*JPY as pricing currency*							
GMM_1	−0.12	1.02	0.00	0.05	0.87	2.10	5.97	0.15	0.01	1.05	0.02	0.05	0.73	2.31	6.43	0.15
	(0.24)	(0.34)	(0.01)	(0.01)			[0.20]	[0.19]	(0.18)	(0.30)	(0.02)	(0.01)			[0.17]	0.16
GMM_2	−0.17	1.09	−0.01	0.05	0.95	2.12	5.89		0.08	0.95	0.02	0.05	0.89	2.39	6.08	
	(0.22)	(0.30)	(0.01)	(0.01)			[0.21]		(0.17)	(0.28)	(0.02)	(0.01)			[0.19]	
FMB	−0.12	1.02	0.00	0.05	0.87	2.10	5.97		0.01	1.05	0.02	0.05	0.73	2.31	6.42	
	(0.21)	(0.28)	(0.01)	(0.01)			[0.20]		(0.17)	(0.28)	(0.02)	(0.01)			[0.17]	
	[0.21]	[0.26]	[0.01]	[0.01]					[0.15]	[0.26]	[0.02]	[0.01]				

Panel B: Factor Betas

	α	β_{DOL}	β_{IMB}	R^2	α	β_{DOL}	β_{IMB}	R^2
P_1	−0.01	1.02	−0.32	0.81	−0.01	0.93	−0.23	0.89
	(0.01)	(0.03)	(0.04)		(0.01)	(0.02)	(0.04)	
P_2	−0.02	1.00	−0.19	0.84	−0.02	0.99	−0.14	0.92
	(0.01)	(0.03)	(0.03)		(0.01)	(0.01)	(0.03)	
P_3	−0.01	0.98	−0.07	0.81	−0.01	1.00	−0.07	0.90
	(0.01)	(0.03)	(0.03)		(0.01)	(0.02)	(0.03)	
P_4	−0.02	0.98	0.23	0.77	−0.02	1.02	0.17	0.89
	(0.01)	(0.03)	(0.06)		(0.01)	(0.02)	(0.05)	
P_5	0.00	1.00	0.35	0.62	0.01	1.07	0.27	0.80
	(0.01)	(0.06)	(0.08)		(0.01)	(0.03)	(0.09)	

Table A.8. Descriptive Statistics of Global Imbalance Portfolios: Subset of Currencies

The table presents descriptive statistics of currency portfolios sorted on time $t-1$ net foreign asset position to gross domestic product (nfa), and the share of foreign liabilities in domestic currency (ldc). The first portfolio (P_1) contains the top 20% of all currencies with high nfa and high ldc (creditor nations with external liabilities mainly in domestic currency) whereas the last portfolio (P_5) contains the top 20% of all currencies with low nfa and low ldc (debtor nations with external liabilities mainly in foreign currency). IMB is a long-short strategy that buys P_5 and sells P_1. The table also reports the first order autocorrelation coefficient (ac_1), the annualized Sharpe ratio (SR), the maximum drawdown (mdd), the frequency of portfolio switches ($freq$), the average forward discount (fd), the average nfa, and the average ldc. t-statistics based on Newey and West (1987) standard errors with Andrews (1991) optimal lag selection are reported in brackets. Excess returns are expressed in percentage per annum and adjusted for transaction costs. The sample *Developed & Emerging Currencies* comprises the currencies of developed economies plus the most liquid emerging market currencies. The portfolio are rebalanced monthly from October 1983 to June 2014. See Section 3 for a detailed description of data sources and data construction, and Figure 1 for a detailed description of the portfolio construction.

	P_1	P_2	P_3	P_4	P_5	IMB
	Developed & Emerging Currencies					
$mean$	1.18	2.58	2.08	3.49	7.62	6.45
t-$stat$	[0.69]	[1.46]	[1.36]	[2.01]	[3.89]	[4.21]
$median$	1.13	1.99	2.59	4.23	8.85	7.85
$sdev$	9.14	9.63	8.33	9.05	10.55	6.76
$skew$	0.04	−0.09	−0.40	−0.50	−0.71	−0.60
$kurt$	3.11	3.69	4.73	5.91	5.09	6.41
ac_1	0.05	0.04	0.04	0.08	0.06	0.18
SR	0.13	0.27	0.25	0.39	0.72	0.95
mdd	0.51	0.37	0.32	0.32	0.31	0.28
$freq$	0.02	0.03	0.03	0.03	0.02	
fd	−0.66	0.06	2.06	4.05	7.74	
nfa	0.26	0.26	0.10	−0.42	−0.41	
ldc	0.64	0.48	0.44	0.50	0.33	

Table A.9. Asset Pricing Tests and Global Imbalance Risk: Subset of Currencies

The table presents cross-sectional asset pricing results for the linear factor model based on the dollar (*DOL*) and the global imbalance (*IMB*) risk factor. The test assets are excess returns to five carry trade portfolios sorted on the one-month forward discounts. *IMB* is a long-short strategy that buys the currency (top 20%) of debtor nations with external liabilities mainly in foreign currency, and sells the currencies (top 20%) of creditor nations with external liabilities mainly in domestic currency. *Panel A* reports GMM (first and second-stage) and Fama-MacBeth (FMB) estimates of the factor loadings b, the market price of risk λ, and the cross-sectional R^2. Newey and West (1987) standard errors with Andrews (1991) optimal lag selection are reported in parentheses whereas Shanken (1992) standard errors are reported in brackets. χ^2 denotes the test statistics (with p-value in brackets) for the null hypothesis that all pricing errors are jointly zero. HJ refers to the Hansen and Jagannathan (1997) distance (with simulated p-value in brackets) for the null hypothesis that the HJ distance is equal to zero. *Panel B* reports least-squares estimates of time series regressions with Newey and West (1987) and Andrews (1991) standard errors in parentheses. Excess returns are in annual terms and adjusted for transaction costs. The portfolios are rebalanced monthly from October 1983 to June 2014. In *Developed & Emerging Currencies*, both test assets and risk factors are constructed using the currencies of developed economies as well as the most liquid emerging market currencies. See Section 3 for a detailed description of data sources and data construction.

Panel A: Factor Prices

	b_{DOL}	b_{IMB}	λ_{DOL}	λ_{IMB}	R^2	$RMSE$	χ^2	HJ
	Developed and Emerging Currencies							
GMM_1	0.09	1.12	0.03	0.06	0.90	1.69	2.91	0.11
	(0.24)	(0.37)	(0.02)	(0.02)			[0.57]	[0.67]
GMM_2	0.18	1.33	0.03	0.05	0.96	2.27	2.39	
	(0.23)	(0.32)	(0.02)	(0.02)			[0.66]	
FMB	0.09	1.11	0.03	0.06	0.90	1.69	2.92	
	(0.20)	(0.29)	(0.02)	(0.02)			[0.57]	
	[0.19]	[0.25]	[0.02]	[0.01]				

Panel B: Factor Betas

	α	β_{DOL}	β_{IMB}	R^2
P_1	−0.01	0.99	−0.26	0.78
	(0.01)	(0.05)	(0.04)	
P_2	−0.02	1.00	−0.18	0.83
	(0.01)	(0.04)	(0.03)	
P_3	0.00	1.04	−0.07	0.84
	(0.01)	(0.03)	(0.03)	
P_4	−0.02	1.03	0.18	0.82
	(0.01)	(0.04)	(0.05)	
P_5	0.01	0.93	0.39	0.72
	(0.01)	(0.06)	(0.07)	

Table A.10. Descriptive Statistics: Currencies Sorted by Real Interest Rates

The table presents descriptive statistics of currency portfolios sorted on time $t-1$ real interest rate differentials (one-month forward discounts adjusted for inflation differentials). The first portfolio (P_1) contains the top 20% of all currencies with low real interest rate differentials whereas the last portfolio (P_5) contains the top 20% of all currencies with high interest rate differentials. H/L is a long-short strategy that buys P_5 and sells P_1. The table also reports the first order autocorrelation coefficient (ac_1), the annualized Sharpe ratio (SR), the maximum drawdown (mdd), the frequency of portfolio switches ($freq$), the average forward discounts (fd), the average net foreign asset position to gross domestic product (nfa), and the average share of foreign liabilities in domestic currency (ldc). t-statistics based on Newey and West (1987) standard errors with Andrews (1991) optimal lag selection are reported in brackets. Excess returns are expressed in percentage per annum and adjusted for transaction costs. The portfolio are rebalanced monthly from October 1983 to June 2014. See Section 3 for a detailed description of data sources and data construction.

	P_1	P_2	P_3	P_4	P_5	H/L	P_1	P_2	P_3	P_4	P_5	H/L
	All Countries						*Developed Countries*					
mean	−0.25	0.84	2.28	3.29	4.82	5.07	0.77	0.77	1.22	4.11	4.64	3.87
t-stat	[−0.17]	[0.58]	[1.47]	[2.06]	[2.55]	[3.02]	[0.43]	[0.43]	[0.68]	[2.28]	[2.04]	[1.79]
median	0.72	1.64	3.56	3.74	5.63	7.23	−0.71	0.96	2.56	5.28	6.39	8.28
sdev	8.01	7.77	8.13	8.30	9.15	8.36	9.90	9.83	9.18	9.80	11.27	11.19
skew	0.00	−0.22	−0.30	−0.39	−0.29	−0.55	0.32	0.03	−0.20	−0.30	−0.28	−0.94
kurt	4.08	3.90	4.22	4.64	5.11	4.97	3.80	3.65	4.12	4.39	4.29	5.16
ac_1	0.00	0.06	0.07	0.08	0.15	0.15	−0.01	0.00	0.10	0.04	0.11	0.07
SR	−0.03	0.11	0.28	0.40	0.53	0.61	0.08	0.08	0.13	0.42	0.41	0.35
mdd	0.41	0.42	0.32	0.29	0.31	0.35	0.50	0.50	0.38	0.26	0.38	0.41
$freq$	0.17	0.26	0.26	0.25	0.13		0.14	0.26	0.30	0.25	0.15	
fd	−1.35	−0.75	1.10	3.13	8.65		−1.98	−0.91	0.28	1.58	3.93	
nfa	0.40	0.05	−0.12	−0.29	−0.34		0.57	−0.01	−0.08	−0.10	−0.37	
ldc	0.53	0.49	0.44	0.42	0.39		0.55	0.51	0.49	0.40	0.42	

Table A.11. Asset Pricing Tests: Test Assets Sorted by Real Interest Rates

The table presents cross-sectional asset pricing results for the linear factor model based on the dollar (DOL) and the global imbalance (IMB) risk factor. The test assets are excess returns to five currency portfolios sorted on the one-month real interest rate differentials. IMB is a long-short strategy that buys the currency (top 20%) of debtor nations with external liabilities mainly in foreign currency, and sells the currencies (top 20%) of creditor nations with external liabilities mainly in domestic currency. *Panel A* reports GMM (first and second-stage) and Fama-MacBeth (FMB) estimates of the factor loadings b, the market price of risk λ, and the cross-sectional R^2. Newey and West (1987) standard errors with Andrews (1991) optimal lag selection are reported in parentheses whereas Shanken (1992) standard errors are reported in brackets. χ^2 denotes the test statistics (with p-value in brackets) for the null hypothesis that all pricing errors are jointly zero. HJ refers to the Hansen and Jagannathan (1997) distance (with simulated p-value in brackets) for the null hypothesis that the HJ distance is equal to zero. *Panel B* reports least-squares estimates of time series regressions with Newey and West (1987) and Andrews (1991) standard errors in parentheses. Excess returns are in annual terms and adjusted for transaction costs. The portfolios are rebalanced monthly from October 1983 to June 2014. See Section 3 for a detailed description of data sources and data construction.

Panel A: Factor Prices

	b_{DOL}	b_{IMB}	λ_{DOL}	λ_{IMB}	R^2	$RMSE$	χ^2	HJ	b_{DOL}	b_{IMB}	λ_{DOL}	λ_{IMB}	R^2	$RMSE$	χ^2	HJ
	All Countries								*Developed Countries*							
GMM_1	0.06	1.01	0.02	0.05	0.85	1.73%	5.48	0.13	0.18	0.72	0.02	0.04	0.74	2.09%	6.30	0.13
	(0.26)	(0.32)	(0.01)	(0.01)			[0.24]	[0.34]	(0.21)	(0.33)	(0.02)	(0.01)			[0.18]	[0.30]
GMM_2	0.07	0.71	0.02	0.08	0.98	3.29%	4.25		0.26	0.68	0.02	0.04	0.81	2.09%	6.09	
	(0.25)	(0.27)	(0.01)	(0.01)			[0.37]		(0.21)	(0.26)	(0.02)	(0.01)			[0.19]	
FMB	0.06	1.01	0.02	0.05	0.85	1.73%	5.46		0.17	0.72	0.02	0.04	0.74	2.09%	6.30	
	(0.24)	(0.28)	(0.01)	(0.01)			[0.24]		(0.19)	(0.22)	(0.02)	(0.01)			[0.18]	
	[0.22]	[0.26]	[0.01]	[0.01]					(0.17]	[0.25]	[0.02]	[0.01]				

Panel B: Factor Betas

	α	β_{DOL}	β_{IMB}	R^2	α	β_{DOL}	β_{IMB}	R^2
P_1	−0.02	1.03	−0.25	0.80	0.00	0.95	−0.49	0.74
	(0.01)	(0.04)	(0.04)		(0.01)	(0.05)	(0.06)	
P_2	−0.01	1.03	−0.22	0.86	−0.02	1.02	−0.06	0.82
	(0.01)	(0.03)	(0.03)		(0.01)	(0.04)	(0.04)	
P_3	0.00	1.06	−0.07	0.87	−0.01	0.97	−0.05	0.85
	(0.01)	(0.04)	(0.04)		(0.01)	(0.03)	(0.04)	
P_4	0.00	0.99	0.11	0.81	0.01	1.00	0.14	0.83
	(0.01)	(0.05)	(0.06)		(0.01)	(0.03)	(0.05)	
P_5	0.00	0.86	0.44	0.69	0.00	0.98	0.51	0.73
	(0.01)	(0.05)	(0.07)		(0.01)	(0.05)	(0.06)	

Table A.12. Descriptive Statistics: Even Number of Global Imbalance Portfolios

The table presents descriptive statistics of currency portfolios sorted on time $t-1$ net foreign asset position to gross domestic product (nfa), and the share of foreign liabilities in domestic currency (ldc). The first portfolio contains the top 20% of all currencies with high nfa and high ldc (creditor nations with external liabilities mainly in domestic currency) whereas the last portfolio contains the top 20% of all currencies with low nfa and low ldc (debtor nations with external liabilities mainly in foreign currency). IMB is a long-short strategy that buys the last portfolio and sells the first portfolio. The table also reports the first order autocorrelation coefficient (ac_1), the annualized Sharpe ratio (SR), the maximum drawdown (mdd), the frequency of portfolio switches ($freq$), the average forward discount (fd), the average nfa, and the average ldc. t-statistics based on Newey and West (1987) standard errors with Andrews (1991) optimal lag selection are reported in brackets. Excess returns are expressed in percentage per annum and adjusted for transaction costs. The portfolio are rebalanced monthly from October 1983 to June 2014. See Section 3 for a detailed description of data sources and data construction. Figure A.1 provides a detailed description of the portfolio construction.

	P_1	P_2	P_3	P_4	P_5	P_6	IMB	P_1	P_2	P_3	P_4	IMB
	All Countries							*Developed Countries*				
$mean$	0.61	2.84	3.44	1.76	3.08	5.74	5.12	0.75	2.83	3.02	4.36	3.61
t-$stat$	[0.43]	[1.67]	[2.27]	[1.29]	[1.83]	[3.00]	[3.82]	[0.40]	[1.55]	[1.83]	[2.24]	[2.90]
$median$	0.88	2.33	3.70	4.71	4.64	6.39	6.04	0.67	3.34	4.54	5.58	4.30
$sdev$	7.38	9.18	8.16	7.17	9.31	9.82	6.54	9.75	9.98	8.91	10.18	6.90
$skew$	−0.13	−0.05	−0.21	−0.48	−1.33	−0.03	0.50	0.05	−0.17	−0.22	−0.26	−0.57
$kurt$	3.36	4.38	4.14	5.45	10.38	4.68	6.77	3.68	3.24	5.32	3.70	5.25
ac_1	0.08	0.05	0.06	0.07	0.01	0.10	0.13	0.07	0.03	0.05	0.07	0.01
SR	0.08	0.31	0.42	0.25	0.33	0.58	0.78	0.08	0.28	0.34	0.43	0.52
mdd	0.49	0.31	0.24	0.34	0.36	0.29	0.22	0.56	0.27	0.32	0.34	0.26
$freq$	0.03	0.04	0.04	0.04	0.04	0.03	0.06	0.02	0.02	0.02	0.03	0.05
fd	−0.71	0.79	1.73	2.47	3.97	6.89		−1.04	0.19	2.09	2.29	
nfa	0.42	0.19	0.26	−0.23	−0.45	−0.59		0.35	0.31	−0.38	−0.35	
ldc	0.64	0.51	0.37	0.52	0.44	0.27		0.60	0.40	0.55	0.35	

Table A.13. Asset Pricing Tests: Global Imbalance Risk

The table presents cross-sectional asset pricing results for the linear factor model based on the dollar (DOL) and the global imbalance (IMB) risk factor. The test assets are excess returns to five carry trade portfolios sorted on the one-month forward discounts, and are the same as in Table 2. IMB is a long-short strategy that buys the currency of debtor nations with external liabilities mainly in foreign currency, and sells the currencies of creditor nations with external liabilities mainly in domestic currency, and is based on six (four) portfolios for *All* (*Developed*) *Countries*. *Panel A* reports GMM (first and second-stage) and Fama-MacBeth (FMB) estimates of the factor loadings b, the market price of risk λ, and the cross-sectional R^2. Newey and West (1987) standard errors with Andrews (1991) optimal lag selection are reported in parentheses whereas Shanken (1992) standard errors are reported in brackets. χ^2 denotes the test statistics (with p-value in brackets) for the null hypothesis that all pricing errors are jointly zero. HJ refers to the Hansen and Jagannathan (1997) distance (with simulated p-value in brackets) for the null hypothesis that the HJ distance is equal to zero. *Panel B* reports least-squares estimates of time series regressions with Newey and West (1987) and Andrews (1991) standard errors in parentheses. Excess returns are in annual terms and adjusted for transaction costs. The portfolios are rebalanced monthly from October 1983 to June 2014. See Section 3 for a detailed description of data sources and data construction. Figure A.1 provides a detailed description of the portfolio construction.

Panel A: Factor Prices

	b_{DOL}	b_{IMB}	λ_{DOL}	λ_{IMB}	R^2	$RMSE$	χ^2	HJ	b_{DOL}	b_{IMB}	λ_{DOL}	λ_{IMB}	R^2	$RMSE$	χ^2	HJ
	All Countries								*Developed Countries*							
GMM_1	−0.10	1.62	0.02	0.08	0.83	1.89	4.70	0.15	0.17	0.80	0.02	0.05	0.90	1.16	1.24	0.07
	(0.29)	(0.59)	(0.01)	(0.02)			[0.20]	[0.12]	(0.22)	(0.44)	(0.02)	(0.02)			[0.74]	[0.76]
GMM_2	−0.04	1.61	0.02	0.07	0.68	1.96	4.65		0.21	0.91	0.02	0.05	0.86	1.16	1.14	
	(0.29)	(0.58)	(0.01)	(0.02)			[0.20]		(0.21)	(0.43)	(0.02)	(0.02)			[0.77]	
FMB	−0.10	1.62	0.02	0.08	0.83	1.89	4.70		0.17	0.80	0.02	0.05	0.90	1.16	1.24	
	(0.26)	(0.48)	(0.01)	(0.02)			[0.19]		(0.19)	(0.37)	(0.02)	(0.02)			[0.74]	
	[0.24]	[0.47]	[0.01]	[0.02]					[0.18]	[0.35]	[0.02]	[0.02]				

Panel B: Factor Betas

	α	β_{DOL}	β_{IMB}	R^2	α	β_{DOL}	β_{IMB}	R^2
P_1	−0.01	0.99	−0.26	0.78	0.00	1.00	−0.48	0.76
	(0.01)	(0.05)	(0.04)		(0.01)	(0.04)	(0.06)	
P_2	−0.02	1.00	−0.18	0.83	−0.01	1.04	−0.17	0.82
	(0.01)	(0.04)	(0.03)		(0.01)	(0.04)	(0.04)	
P_3	0.00	1.04	−0.07	0.84	−0.01	0.99	0.00	0.86
	(0.01)	(0.03)	(0.03)		(0.01)	(0.03)	(0.03)	
P_4	−0.02	1.03	0.18	0.82	−0.01	0.99	0.15	0.82
	(0.01)	(0.04)	(0.05)		(0.01)	(0.03)	(0.05)	
P_5	0.01	0.93	0.39	0.72	0.01	1.06	0.50	0.78
	(0.01)	(0.06)	(0.07)		(0.01)	(0.04)	(0.05)	

Table A.14. Decomposing the Global Imbalance Risk Factor

The table presents descriptive statistics of currency portfolios sorted on time $t-1$ information. For *All Countries* (and *Developed & Emerging Countries*), currencies are first grouped into two baskets using the net foreign asset position to gross domestic product (nfa), and then into three baskets using the share of foreign liabilities in domestic currency (ldc). The NFA factor is constructed as the average return on the low nfa portfolios (P_3, P_4 and P_5) minus the average return on the high nfa portfolios (P_1, P_2 and P_3). The LDC factor is computed as the average return on the low ldc portfolios (P_3, and P_6) minus the average return on the high ldc portfolios (P_1 and P_4). For *Developed Countries*, currencies are first grouped into two baskets using nfa, and then into two baskets using ldc. The NFA factor is constructed as the average return on the low nfa portfolios (P_3 and P_4) minus the average return on the high nfa portfolios (P_1 and P_2). The LDC factor is computed as the average return on the low ldc portfolios (P_2, and P_4) minus the average return on the high ldc portfolios (P_1, and P_3). The table also reports the first order autocorrelation coefficient (AC_1), the annualized Sharpe ratio (SR), the maximum drawdown in percent (MDD), the frequency of portfolio switches ($freq$), the average forward discount (fd), the average nfa, and the average ldc. t-statistics based on Newey and West (1987) standard errors with Andrews (1991) optimal lag selection are reported in brackets. Excess returns are expressed in percentage per annum. The portfolio are rebalanced monthly from October 1983 to June 2014. See Section 3 for a detailed description of data sources and data construction. Figure A.1 provides a detailed description of the portfolio construction.

	P_1	P_2	P_3	P_4	P_5	P_6	NFA	LDC	P_1	P_2	P_3	P_4	NFA	LDC
	All Countries								*Developed Countries*					
mean	0.55	2.92	3.52	1.85	3.21	5.90	1.32	3.51	0.70	2.90	3.09	4.43	1.96	1.77
t-stat	[0.38]	[1.71]	[2.33]	[1.35]	[1.91]	[3.09]	[1.46]	[3.82]	[0.37]	[1.58]	[1.87]	[2.27]	[1.86]	[2.11]
median	0.88	2.35	3.70	4.72	4.64	6.39	1.55	3.72	0.67	3.34	4.63	5.76	2.24	2.26
sdev	7.37	9.18	8.17	7.17	9.31	9.82	4.80	4.96	9.75	9.98	8.91	10.19	5.83	4.63
skew	−0.13	−0.05	−0.21	−0.47	−1.33	−0.04	−0.44	0.10	0.05	−0.17	−0.22	−0.26	−0.40	−0.05
kurt	3.36	4.38	4.15	5.45	10.41	4.69	3.88	4.58	3.68	3.25	5.32	3.71	3.88	3.39
ac_1	0.09	0.05	0.05	0.07	0.01	0.09	0.06	0.05	0.07	0.03	0.05	0.07	−0.01	−0.01
SR	0.07	0.32	0.43	0.26	0.34	0.60	0.28	0.71	0.07	0.29	0.35	0.43	0.34	0.38
mdd	0.49	0.30	0.24	0.33	0.36	0.29	0.27	0.15	0.56	0.27	0.31	0.34	0.20	0.14
$freq$	0.03	0.04	0.04	0.04	0.04	0.03			0.02	0.02	0.02	0.03		
fd	−0.76	0.84	1.80	2.53	4.07	7.03			−1.09	0.24	2.15	2.34		
nfa	0.42	0.19	0.26	−0.23	−0.45	−0.59			0.35	0.31	−0.38	−0.35		
ldc	0.64	0.51	0.37	0.52	0.44	0.27			0.60	0.40	0.55	0.35		
	Developed & Emerging Countries													
mean	0.91	2.22	2.54	2.15	4.17	8.59	3.08	4.03						
t-stat	[0.54]	[1.18]	[1.57]	[1.30]	[1.95]	[4.34]	[3.04]	[4.03]						
median	1.31	1.77	2.87	5.33	5.32	10.33	2.89	4.44						
sdev	8.82	10.17	8.81	8.58	11.55	10.67	5.22	5.16						
skew	0.08	−0.06	−0.18	−0.61	−0.84	−0.68	−0.52	0.02						
kurt	3.31	3.80	3.91	6.55	6.39	4.93	4.03	3.96						
ac_1	0.06	0.05	0.04	0.08	0.05	0.05	0.09	0.10						
SR	0.10	0.22	0.29	0.25	0.36	0.81	0.59	0.78						
mdd	0.56	0.39	0.26	0.32	0.42	0.33	0.18	0.16						
$freq$	0.03	0.03	0.03	0.03	0.03	0.02								
fd	−0.68	−0.28	1.21	2.86	5.25	8.32								
nfa	0.22	0.32	0.35	−0.36	−0.39	−0.42								
ldc	0.65	0.51	0.36	0.55	0.44	0.30								

Table A.15. Asset Pricing and Independent Double Sort

The table presents cross-sectional asset pricing results for the linear factor model based on the dollar (DOL), the net foreign asset (NFA), and the share of foreign liability in domestic currency(LDC) risk factors. The test assets are excess returns to five carry trade portfolios sorted on the one-month forward discounts (the same as in Table 2). NFA and LDC are described in Table A.15. *Panel A* reports GMM (first and second-stage) and Fama-MacBeth (FMB) estimates of the factor loadings b, the market price of risk λ, and the cross-sectional R^2 (b and λ for the DOL are statistically insignificant, and we do not report them to save space). χ^2 denotes the test statistics for the null hypothesis that all pricing errors are jointly zero whereas HJ refers to the Hansen and Jagannathan (1997) distance for the null hypothesis that the HJ distance is equal to zero. We bold the statistic when fail to reject the null at 5% significance level. *D-test* denotes the χ^2 difference test for the null hypothesis that the restricted model ($b_{NFA} = 0$ or $b_{LDC} = 0$) is correct (with p-values based on Newey and West (1987) and Andrews (1991) in brackets). *Panel B* reports least-squares estimates of time series regressions. The superscript a, b, and c indicate statistical significance at 10%, 5% and 1% level, respectively, using Newey and West (1987) standard errors with Andrews (1991) optimal lag selection. Excess returns are in annual terms and adjusted for transaction costs. The portfolios are rebalanced monthly from October 1983 to June 2014. See Section 3 for a detailed description of data sources and data construction, and Figure A.1 for the portfolio construction.

Panel A: Factor Prices

	NFA	LDC	R^2	χ^2	HJ	NFA	LDC	R^2	χ^2	HJ	NFA	LDC	R^2	χ^2	HJ
	All Countries					*Developed & Emerging*					*Developed Countries*				
b_{GMM1}	1.10^b	1.56^c	0.80	**6.28**	**0.17**	0.93^b	1.26^c	0.92	**1.64**	**0.08**	0.70^a	0.63	0.87	**2.51**	**0.09**
λ_{GMM1}	0.02^b	0.04^c				0.03^c	0.04^c				0.02^b	0.02^b			
b_{GMM2}	0.85^b	1.41^c	0.78	**5.65**		1.13^c	1.34^c	0.95	**1.27**		0.59^a	0.55	0.92	**2.35**	
λ_{GMM2}	0.02^b	0.05^c				0.02^b	0.04^c				0.03^b	-0.01			
b_{FMB}	1.09^c	1.56^c	0.80	**6.28**		0.93^c	1.25^c	0.92	**1.65**		0.69^b	0.63^a	0.87	**2.49**	
λ_{FMB}	0.02^b	0.05^c				0.03^c	0.04^c				0.02^b	0.02^b			
D-test	[0.03]	[< .01]				[< .01]	[< .01]				[0.04]	[0.12]			

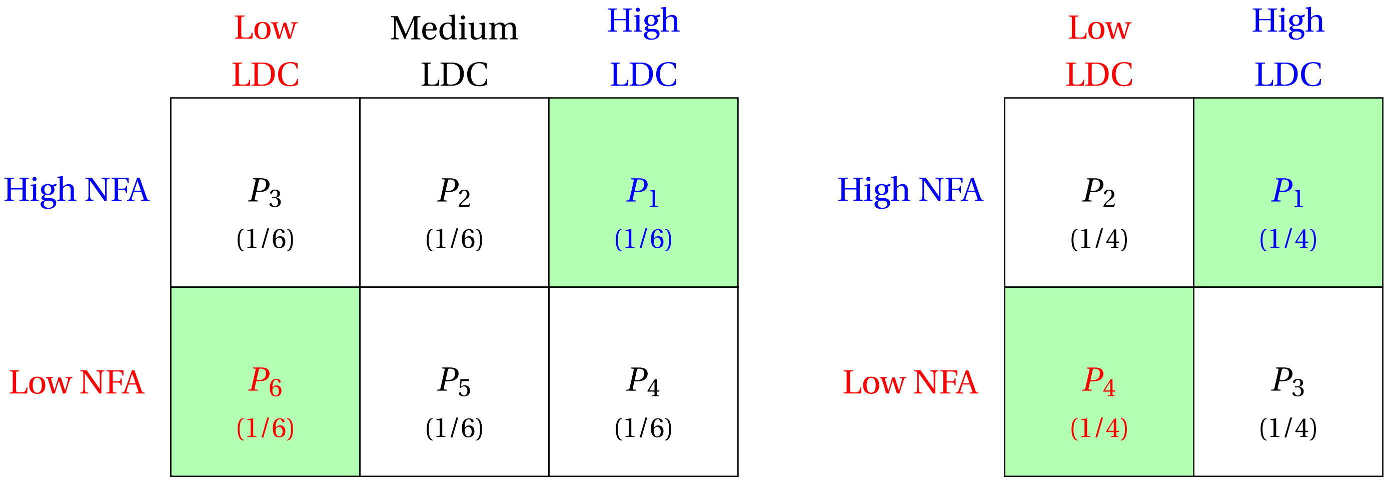
Panel B: Factor Betas

	α	β_{DOL}	β_{NFA}	β_{LDC}	R^2	α	β_{DOL}	β_{NFA}	β_{LDC}	R^2	α	β_{DOL}	β_{NFA}	β_{LDC}	R^2
	All Countries					*Developed Countries*					*Developed Countries*				
P_1	-0.01^a	0.95^c	-0.47^c	-0.17^b	0.81	0.01	0.94^c	-0.63^c	-0.14^a	0.82	0.01	0.90^c	-0.59^c	-0.24^c	0.76
P_2	-0.02^c	1.02^c	-0.12^b	-0.27^c	0.83	-0.01^a	1.00^c	-0.28^c	-0.12^b	0.84	-0.01^a	1.00^c	-0.18^c	-0.12	0.82
P_3	0.01	1.04^c	-0.14^c	-0.08^a	0.85	-0.01	1.00^c	-0.12^c	0.05	0.88	-0.01	0.95^c	-0.04	0.08	0.86
P_4	-0.01^a	1.02^c	0.08	0.18^b	0.82	-0.02^a	1.11^c	0.22^c	0.06	0.86	-0.01	1.00^c	0.22^c	0.04	0.84
P_5	0.01	0.97^c	0.65^c	0.29^c	0.76	0.00	0.96^c	0.87^c	0.15^b	0.79	0.01	1.14^c	0.74^c	0.08	0.81

Table A.16. Global Equity Realized Volatility

The table presents results from fixed-effects panel regressions. We use discrete exchange rate returns at monthly frequency as dependent variables. Exchange rates are defined as units of US dollars per unit of foreign currency such that a positive return denotes a foreign currency appreciation. The set of independent variables includes the net foreign asset position to gross domestic product (nfa), the share of foreign liabilities in domestic currency (ldc), the forward discount or interest rate differential relative to the US (fd), the monthly change in the realized volatility of the MSCI World index ($\Delta RVOL$), and a dummy variable that equals one if $\Delta RVOL$ is greater than one standard deviation as estimated across the entire sample, and zero otherwise ($\Delta RVOL$ *dummy*). Robust standard errors are clustered at country level and reported in parentheses. The superscripts a, b and c denote statistical significance at 10%, 5% and 1% level, respectively. The sample runs from October 1983 to June 2014. See Section 3 for a detailed description of data sources and data construction.

	Dependent variable: nominal exchange rate returns					
	(1)	(2)	(3)	(4)	(5)	(6)
nfa (lagged 12 months)	−0.057	−0.053	−0.032	−0.092	−0.091	−0.073
	(0.073)	(0.076)	(0.078)	(0.064)	(0.066)	(0.066)
$\Delta RVOL$	-0.069^c	-0.069^c	-0.061^c			
	(0.010)	(0.010)	(0.010)			
$\Delta RVOL \times nfa$ (lagged 12 months)	0.033^b	0.033^b	0.027^b			
	(0.012)	(0.012)	(0.013)			
ldc (lagged 12 months)		−0.089	−0.286		−0.027	−0.167
		(0.243)	(0.219)		(0.243)	(0.221)
fd (lagged 1 month)			−0.003			−0.002
			(0.002)			(0.002)
$\Delta RVOL \times fd$ (lagged 1 month)			−0.001			
			(< .001)			
$\Delta RVOL$ *dummy*				-1.236^c	-1.236^c	-1.175^c
				(0.212)	(0.213)	(0.234)
$\Delta RVOL$ *dummy* $\times nfa$ (lagged 12 months)				0.682^c	0.682^c	0.640^c
				(0.241)	(0.241)	(0.249)
$\Delta RVOL$ *dummy* $\times fd$ (lagged 1 month)						−0.003
						(0.004)
Additional Variables: Constant and lagged exchange rate returns	*YES*	*YES*	*YES*	*YES*	*YES*	*YES*
Adjusted R^2	0.03	0.03	0.03	0.02	0.02	0.02
Observations	9112	9112	9112	9112	9112	9112



(a) All Countries (b) Developed Countries

Figure A.1. Global Imbalance Risk Factor with an Even Number of Portfolios

This chart describes the construction of the global imbalance risk factor (IMB) when we use an even number of portfolios. Figure a) reports the construction for *all countries*. At the end of each month, currencies are first sorted in two baskets using the net foreign asset position to gross domestic product (nfa), and then in 3 baskets using the share of foreign liabilities in domestic currency (ldc). The nfa breakpoint is the median value whereas the ldc breakpoints are the 33^{th} and 63^{th} percentiles. The IMB factor is constructed as the average return on P_6 - the portfolio with low nfa and low ldc (debtor nations with external liabilities mainly in foreign currency) - minus the average return on P_1 - the portfolio with high nfa and high ldc currencies (creditor nations with external liabilities mainly in domestic currency). The global imbalance risk factor is then decomposed into the NFA factor computed as the average return on the low nfa portfolios (P_3, P_4 and P_5) minus the average return on the high nfa portfolios (P_1, P_2 and P_3), and the LDC factor constructed as the average return on the low ldc portfolios (P_3 and P_6) minus the average return on the high ldc portfolios (P_1 and P_4). Figure b) reports the construction for *developed countries*. At the end of each month, currencies are first sorted first in two baskets using nfa, and then in two baskets using ldc. The breakpoints for both nfa and ldc are the median values. The IMB factor is constructed as the average return on P_4 minus the average return on P_1. The NFA factor is constructed as the average return on low nfa portfolios (P_3 and P_4) minus the average return on the high nfa portfolios (P_1 and P_2), and the LDC factor is computed as the average return on the low ldc portfolios (P_2 and P_4) minus the average return on the high ldc portfolios (P_1 and P_3).