FX Dealer Constraints and External Imbalances *

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January 2025

Abstract

We empirically test Gabaix and Maggiori (2015)'s prediction that currencies are repriced by the country's external capital dependence when financial constraints of FX intermediaries change. Using solvency indicators, we develop a novel intermediary constraints index capturing risk-bearing capacity. We find that constraints are a priced risk factor in currency portfolios sorted by countries' net foreign assets. Portfolios of external debtors (creditors) have higher (lower) intermediary risk premia, but pay lower (higher) returns when constraints tighten. Tightening constraints are associated with a depreciation of countries with low net foreign assets, particularly emerging markets with high net debt and low FX reserves.

JEL-Classification: E44, F31, F32, F37, G12, G15
Keywords: Foreign Exchange, Financial Intermediation, Net Foreign Assets

[*]We thank Andreas Freitag (discussant), Jean-Yves Gnabo, Rodrigo Sekkel (discussant) and Dennis Umlandt and seminar and conference participants at TU Dresden, Ruhr University Bochum, EAYE Annnual Meeting 2024, ICMAIF 2024, RWI Essen, University of Namur, Utrecht University, and IWH Macroeconometric Workshop 2024 for valuable feedback.

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1 Introduction

The foreign exchange (FX) market is the world's biggest over-the-counter (OTC) market, dominated by a few large market makers. These FX dealers play a crucial role in absorbing excess currency inventory. When constraints of the intermediary tighten, for instance, due to a deterioration in solvency, its risk-bearing capacity is impaired, and the marginal value of wealth increases (He et al., 2017). The incentives to intermediate risky trades and absorb customer order flow imbalances on their balance sheet subsequently reduce and are often followed by an increase in the required risk premia.

The relevance of intermediaries' risk management for exchange rate determination is stressed in the recent literature. Gabaix and Maggiori (2015) show that the limited risk-bearing capacity of intermediaries generates risk-adjusted currency returns. As ultimate risk takers, financiers profit from imbalances in net foreign assets (NFA) by intermediating capital flows from creditor countries (with positive NFA) to debtor countries (with negative NFA). In financial market equilibrium, tighter financial constraints are associated with higher risk premia charged by the intermediaries to clear the countries' capital accounts.

We aim to contribute to this literature by testing these predictions by Gabaix and Maggiori (2015). Based on a novel index of financial constraints of major FX intermediaries, we investigate the role of intermediary constraints for the pricing of currencies sorted on their NFA position. Our primary hypothesis suggests that currencies are repriced according to the country's external capital dependence when financial constraints of FX intermediaries change. The construction of our novel index of intermediary constraints is guided by the fact that ultimate risk-taking in the FX market is concentrated among large financial institutions which are active in dealing, investing, and lending to currency speculators. These are typically global banks, such as JP Morgan, Citibank, Deutsche Bank, or UBS, that account for the majority of trading volume in the FX market. They actively bear currency risk by maintaining currency inventory and – most importantly – lending to other institutions like hedge funds and investment funds, which employ leveraged currency speculation strategies involving both long and short positions in various currencies. As a result, a significant part of the value at risk of dealer banks is driven by currency risk (Gabaix and Maggiori, 2015). Financial constraints impose limitations on global dealer banks to fund global intermediation between currencies with negative NFA and those with positive NFA. Due to their limited risk-bearing capacity, tightening financial constraints will lead to a repricing of currencies based on countries' long-term demand for global financing measured by their NFA.

This paper empirically tests the theoretical predictions of Gabaix and Maggiori (2015) using a sample of 39 currencies from January 2004 to December 2021. We construct a comprehensive index of the financial constraints for the top 10 FX dealer banks using various market-based solvency measures, including capital ratios, 5-year CDS spreads, Value-at-risk, and the FX market implied volatility index (VXY).

Using the two-stage procedure from Fama and MacBeth (1973), we find that FX dealer financial constraints are a priced risk factor in currency portfolios sorted on countries' NFA. High NFA portfolios load positively on FX intermediary constraints, while risky low NFA portfolios load negatively. The factor price of intermediary risk is approximately -0.09%, and statistically significant. This implies that an asset with a beta of one (e.g., high NFA currency portfolio) earns a negative risk premium of 1.08% per annum. The intermediary asset pricing model has a good fit, supporting our hypothesis that excess returns to imbalance portfolios can be interpreted as compensation for the exposure to the limited risk-bearing capacity of intermediaries. Investors demand higher returns on currencies of countries with low NFA since they perform poorly when FX dealers face tighter constraints, while they accept lower returns on high NFA currencies, as these provide a hedge against unfavorable changes in external financing conditions. The return contribution is especially driven by a strong currency appreciation of high NFA countries when constraints tighten.

A panel interaction model analysis confirms these results. We observe that a decrease in the risk-bearing capacity of intermediaries is followed by an immediate depreciation of net external debtor currencies relative to net external creditor currencies. The rate of currency depreciation decreases with countries' NFA when constraints of FX dealers tighten. The depreciation is more pronounced for currencies of countries with low NFA levels (between -1 and 1 to GDP), while currencies with moderate NFA levels (between 1 and 5.5 to GDP) show no significant effect. Currencies of countries with high NFA levels (above 5.5 to GDP) significantly appreciate under tighter intermediary constraints. Further, the depreciation of debtor currencies is more profound for emerging markets and countries with low FX reserves. The effect is driven primarily by net external debt positions, which includes assets that banks primarily intermediate. Currencies of countries with negative net external debt positions are especially adversely affected by tightening constraints.

A battery of sensitivity analyses, including alternative definitions of intermediary constraints index, risk factors, and sample compositions, confirm the robustness of our results.

Related literature. This paper contributes to a few strands of literature, most notably on understanding macroeconomic determinants of exchange rates and intermediary asset pricing.

Della Corte et al. (2016) present empirical evidence that a country's external balance drives currency excess returns. A "global imbalance" strategy long currencies with low NFA and short currencies with high NFA generates significant excess returns. The authors also regress exchange rate changes on the interaction of NFA with the implicit volatility in the equity market (VIX) and FX market (VXY). They find that during times of increased market volatility, net external debtor countries experience a currency depreciation, unlike creditor countries. Della Corte et al. (2016) acknowledge not directly to test Della Corte et al. (2016) theory's hypothesis and that financial market volatility does not necessarily reflect financial constraints faced by intermediaries. In our paper, we examine the interaction between NFA and the financial constraints of FX dealer banks. While the financial constraints of dealer banks may typically tighten in times of crisis and heightened market volatility as measured by the VIX, it is essential to emphasize that both measures are definitely distinct. Some dealer banks may benefit from higher financial market volatility by generating higher revenue or from expansionary monetary policy while other dealer banks may suffer from a deterioration of their assets. In a robustness check, we find that the impact of the VIX interacted with NFA on exchange rate returns is much smaller than the impact of the intermediary constraints interacted with NFA.

As net external debtor countries typically pay a risk premium, Lane and Milesi-Ferretti (2001) highlight the inverse relationship between real interest rates across countries and long-run NFA positions. Della Corte et al. (2012) show that external imbalances between countries can help predict exchange rate returns. Gardberg (2022) adds to the findings of Della Corte et al. (2016) by splitting NFA positions into different asset classes. She finds that it is the net foreign debt position which drives the response of exchange rate returns to fluctuations in the VIX, while net FDI or net foreign portfolio equity positions with their risk sharing role do not. Habib and Stracca (2012) investigate the safe haven behavior of currencies by interacting NFA with financial market volatility and show that countries with better external positions tend to have currencies that appreciate during volatile times. The bottom line is that investors demand a premium for holding currencies of countries with negative NFA in times of financial distress capital retrenchment is associated with currency devaluation. Challenging the exorbitant duty hypothesis of Gourinchas and Rey (2007), Dahlquist et al. (2022) establish that US investors even benefit in times of global stress, as the exchange rate adjusted value of their home biased portfolio is revaluated as a result from US dollar appreciation.

This paper focuses on intermediary shocks of FX dealers being priced in exchange rates based on countries' external imbalances. Reitz and Umlandt (2021) find that tightening balance sheet constraints of FX dealers – measured by innovations to equity capital ratios (as He et al., 2017) – significantly explain excess returns to carry trades that long high-interest-rate currencies and short low-interest-rate currencies. Our paper is distinct in several aspects. First, instead of focusing on carry trade returns, we investigate the cross-section of excess returns to external imbalance portfolios sorted on NFA for a direct test of Gabaix and Maggiori (2015)'s hypothesis. Second, since equity ratio-based constraints may not completely reflect financial constraints faced by FX dealer banks, we derive a more nuanced intermediary constraints index. We complement the equity capital ratio by also incorporating credit default spreads (CDS) because the largest share of banks' financing comes from debt instruments. We also account for the value-at-risk (VaR) to assess the bank's assessment of default risk. Moreover, we include the VXY to measure potential risk in the FX market. By considering these four indicators in a principal component analysis (PCA), we aim to capture different dimensions of the financial constraints of intermediaries.

On theoretical intermediary asset pricing, the paper is related to the literature on the implications of equity risk (e.g., Brunnermeier and Pedersen, 2009; Adrian and Boyarchenko, 2012; Adrian et al., 2014) and leverage risk (e.g., He and Krishnamurthy, 2012, 2013; Brunnermeier and Sannikov, 2014; Bernanke and Gertler, 1989). Both model types imply that low intermediary asset growth is associated with high risk premia to incentivize intermediaries to increase their investments in risky assets. In an empirical asset pricing framework, He et al. (2017) show that equity capital ratio innovations of New York Fed's primary dealers are a priced risk factor in many asset classes, such as stocks, bonds, commodities, and currencies. The intuition is that a decrease in the intermediary's net worth impairs the risk-bearing capacity and requires a higher compensation to take on risk.

Other empirical approaches emphasize the importance of FX dealers' financial constraints for the pricing of exchange rates. Barbiero et al. (2024) employ novel trading desk data and show that shocks to FX dealers' risk limits are associated with lowered net FX holdings, higher charged bid ask spreads, and an adjustment in currency returns. Fang and Liu (2021) show that a volatility shock to domestic assets tightens the VaR constraints of domestic FX dealers. The resulting decline in domestic asset prices, associated with higher expected returns, leads to a depreciation of the domestic currency. Liao and Zhang (2024) focus on a hedging channel to connect the cross-section of currency returns with countries' NFA. When expected exchange rate volatility increases, investors desire to hedge a larger fraction of their net foreign dollar holdings resulting in larger currency appreciation of countries with higher NFA. Haddad and Muir (2021) find that balance sheet risk causally affects asset prices, especially in highly intermediated markets. Adrian et al. (2015) presents that loosening funding constraints of intermediaries raise their risk appetite and lowers risk premia on risky foreign currencies. Further, part of the US dollar volatility is associated with balance sheets of financial institutions (Adrian et al., 2011). Bianchi et al. (2021) show that FX dealers' demand for liquid dollar assets influences exchange rate returns. When dollar funding liquidity is constrained, the convenience yield on the dollar rises, causing foreign currencies to depreciate against it. Becker et al. (2023) examine the impact of cross-currency lending on exchange rates, finding that increased net international lending in USD-denominated loans (relative to foreign currency loans) leads to a US dollar appreciation. This effect is more pronounced since the Global Financial Crisis (GFC) and during periods of tighter US monetary policy. Malamud et al. (2024) show how mark-ups in an imperfectly competitive market for FX intermediation can explain exchange rate dynamics. Du et al. (2018) and Cenedese et al. (2021) document that regulatory changes faced by intermediaries pronounce violations of covered interest rate parity (CIP) and affect the charging of their clients. Correa and DeMarco (2019) investigate FX dealer heterogeneity and find that higher leverage of primary FX dealers based outside the US forecasts foreign currency depreciation against the US dollar, whereas US-based FX dealers have less predictive power. Beckmann and Reitz (2023) analyze FX forecasts, finding that risk premiums derived from FX derivatives or FX dealer balance sheets are key drivers of the forecasts. While these papers reveal insights into the relevance of FX intermediary constraints for currency pricing, they do not focus on the repricing of risk according to NFA positions.

The literature on empirical FX asset pricing focuses on risk factors generated from a cross-section of currency portfolio returns. The seminal paper by Lustig et al. (2011) shows that the cross-section is driven by two factors: the average level of the FX market returns and the returns to a high-minus-low carry trade.[1] The literature on linear factor models has employed alternative second currency risk factors, for instance, volatility (Menkhoff et al., 2012a), momentum (Menkhoff et al., 2012b), correlations (Mueller et al., 2017), and downside risk (Lettau et al., 2014). We borrow from this literature and contribute by investigating the pricing power of intermediary constraints for currency portfolios sorted on NFA. More importantly, while the previous literature calculates risk factors from the time-series of currency returns themselves, we introduce an exogenous source of risk with an intuitive economic interpretation.

The paper is organized as follows. Section 2 derives our intermediary constraints index. Section 3 generates a cross-section of currency portfolios sorted on NFA. Section 4 conducts asset pricing tests of the intermediary constraints risk factor for currency portfolios. Section 5 provides a panel regression analysis with interactions between NFA and changes in the intermediary constraints index. Section 6 concludes.

[1] The first factor is called the "dollar risk factor" and is the average excess return on all foreign currencies available. The second factor is the "carry trade risk factor" and is the excess return to a high-minus-low carry trade strategy where the investor goes long in the portfolio of currencies with the highest interest rates and short in the lowest interest rate currency portfolio.

2 Intermediary constraints

2.1 Data

Euromoney FX survey. We identify major FX dealer banks by using the Euromoney FX survey published annually by Euromoney magazine. The survey is the most comprehensive representation of the wholesale FX consumption and FX consumption volumes (in the year 2022, 1,062 responses represent a total of $99trn FX liquidity consumption). Interbank trading is excluded from the survey to capture all FX liquidity consumption activity from the consumers themselves. The vast majority of respondents to the Euromoney FX Survey are consumers only in the wholesale FX market. Respondents are typically non-financial corporations, real money asset managers, insurance companies, asset owners (e.g., pension funds), leveraged/hedge funds, and non-market-making banks (e.g., trust/central banks). The survey question of interest asks to name the top FX dealers by volume and the volume traded with these providers. See Table A.1 for an overview of the top 10 FX dealer banks ranked at least once as top 10 from 1979 to 2022. We do not include non-bank financial liquidity providers (i.e., XTX or Jump Trading). Figure A.1 reports the time-series of aggregated markets shares according to the survey.[2]

Components of intermediary constraints index. The following lists the components of our measure for top 10 FX dealer banks' constraints:

- **Capital ratio** is computed following He et al. (2017) and Reitz and Umlandt (2021) as market equity relative to the sum of market equity and book debt retrieved from Datastream for each dealer bank. As book debt is available only at a quarterly frequency, we use monthly observation of market equity together with the most recently available quarterly observation of book debt. The capital ratio of bank i in month t is computed as

$$\eta_{it} = \frac{Market\ Equity_{it}}{Market\ Equity_{it} + Book\ Debt_{it}}. \tag{1}$$

  Figure 1 plots the time-series of average capital ratios.

- **Credit default spreads (CDS)** with 5-year maturity is retrieved from Datastream for each dealer bank. The spreads are mid iBoxx prices given in bps and denominated in US dollar for US banks and Euro for European and UK domiciled banks. Figure 2 plots the time-series of average CDS.

- **Value-at-risk (VaR)** is retrieved from the financial statements and BankFocus for each

[2] From 1991 to 1995, market shares are not reported by the survey and are therefore linearly interpolated.

dealer. The frequency is quarterly. We use VaR relative to banks' book value of equity (i.e., common equity). Figure 3 plots the time-series of average VaR.

- **Implied volatility index of FX market (VXY)**, analogous to the VIX, is a tradable volatility index designed by JP Morgan. It measures aggregate volatility in the FX market through a turnover-weighted index of G7 currency volatility based on three-month at-the-money forward options. The frequency is daily sampled on a monthly basis. We complement our intermediary constraints index with the market-wide factor. Figure 4 plots the time-series of the VXY.

The components capture various constraints on the intermediation activities of FX dealer banks. Intermediaries may reduce their market-making activities when they incur trading losses in specific positions or face funding constraints that affect the entire dealer. For instance, adverse innovations to the capital ratio or higher CDS premia on outstanding debt affect the internal funding abilities of the institutions. Dealers might be compelled to scale back their market-making or proprietary trading due to self-imposed or regulatory-driven limits on VaR. A deterioration of dealers' solvency will reduce their own engagement in currency risk and limit their lending to other currency speculators, such as hedge funds and investment funds. A higher VXY index indicates a higher risk of extreme exchange rate returns and thus higher risk of incurring losses with FX market making. Higher values of the four components indicate a deterioration of the solvency of FX dealers, which increases financial constraints on FX market making.

Tightening financial constraints of FX dealers should be associated with a retrenchment from risky investment currencies (i.e., low NFA currencies) to funding currencies (i.e., high NFA currencies) leading lower excess returns on risky currencies. In contrast, in times of relaxed financial constraints and ample funding of currency speculation, we expect high excess returns on risky currencies with low NFA.

Figure 5 comprises all components of our intermediary constraints index (equity capital ratio is multiplied by -1 for a more straightforward interpretation). The starting point of our intermediary constraints index is January 2004, the first time when all four components were available. All variables move in the same direction and have correlations from 13% to 87% (see Table 1). During times of distress (e.g., the financial crisis of 2007/08 or the corona pandemic), the variables peak, implying tightening financial constraints.

2.2 Intermediary constraints index construction

We build an index in two steps to empirically measure FX dealer banks' intermediary constraints. First, we create four aggregated time-series based on cross-sectional averages of the top 10 FX dealer banks, including their i. equity capital ratio, ii. CDS, iii. VaR, and iv. VXY. The top 10 FX dealer banks are adjusted yearly when the new Euromoney survey is released. In our baseline index, the dealer banks enter the index with equal weights, i.e., an average of the top 10's capital ratios, CDS, and VaR.[3] In addition, we include the implied volatility index, VXY. In the second step, we follow Huang et al. (2021) and conduct a PCA of the four components to extract the first principal component as our measure for intermediary constraints. Table 2 and Table 3 show that the first principal component (λ_1) explains around 63% of the total variance of the individual dealer constraint time-series and that all four variables have positive and equal loadings.[4]

We use the first principal component as our intermediary constraints index, named $IntCon$ in the following. Our intermediary constraints index captures a range of different variables related to the risk-bearing capacity of FX dealers. PCA allows one to extract common information of all these four components and to obtain a monthly index of financial constraints on FX dealer banks' intermediation activity. We standardize the index to have a standard deviation of 1. Figure 6 shows the time-series of the $IntCon$ and $\Delta IntCon$. A higher value indicates a deterioration of dealer banks' solvency, i.e., a higher level of financial constraints.

3 Currency returns and external imbalance portfolios

3.1 Currency returns

Exchange rate data. We use daily spot and one-month forward exchange rates vis-á-vis the US dollar from Reuters via Datastream and sample end-of-month rates from January 2004 to December 2021. The full sample comprises 39 countries: Australia (AUD), Brazil (BRL), Canada (CAD), Chile (CLP), China (CNY), Colombia (CLP), Czechia (CZK), Denmark (DKK), Egypt (EGP), Eurozone (EUR), Hong Kong (HKD), Hungary (HUF), India (INR), Indonesia (IDR), Israel (ILS), Japan (JPY), Kasachstan (KZT), Kuwait (KWD), Malaysia (MYR) Mexico (MXN), Morocco (MAD), New Zealand (NZD), Norway (NOK), Peru (PEN), Philippines (PHP), Poland (PLN), Romania (RON), Russia (RUB), Saudi Arabia (SAR), Singapore (SGD), South Africa (ZAR), South Korea (KRW), Sweden (SEK), Switzerland (CHF), Thailand (THB), Tunisia (TNB), Turkey (TRY), Ukraine (UAH), and United Kingdom (GBP).

Currency returns. We define log spot and forward exchange rates in units of foreign currency i per one unit of US dollar at time t as s_{it} and f_{it}, respectively. An increase in s_{it} indicates a

[3] In Section 5.2.1, we show that our results are robust to alternative weightings by corresponding market shares from Euromoney and relative total assets. Our findings are also not affected when using an index with the 17 dealer banks that were ranked top 10 at least once since 2004 to have a consistent index composition.

[4] The Kaiser-Meyer-Olkin criterion exceeds the critical threshold of 0.50, and in Bartlett's test of sphericity, we can reject the null of the correlation matrix being equal to the identity matrix at the 1% level.

foreign currency depreciation against the US dollar. From the perspective of a US investor, the log currency excess returns rx_{it+1} on buying currency i in the forward market at time t and selling it in the spot market after one month, in $t+1$, is computed as

$$rx_{it+1} = f_{it} - s_{it+1}, \tag{2}$$

which is equivalent to the log forward discount minus the change in the spot exchange rate: $rx_{it+1} = f_{it} - s_{it} - \Delta s_{it+1}$. If CIP holds, the forward discount is approximately equal to the interest rate differential $f_{it} - s_{it} \approx i_{it} - i_t$, where i_{it} and i_t denote the foreign and US nominal risk-free interest rates, respectively.[5] The log currency excess return is approximately equal to the interest rate differential minus the spot exchange rate change

$$rx_{it+1} \approx i_{it} - i_t - \Delta s_{it+1}. \tag{3}$$

In the empirical analysis, we study the behavior of currency excess returns (rx) and currency exchange rate changes (Δs).

3.2 External imbalance portfolios

External wealth data. We use annual foreign assets and liabilities from Lane and Milesi-Ferretti (2007, 2018). Foreign assets are the US dollar value of assets a country owns abroad, consisting of portfolio equity and debt investment (divided into portfolio debt and other investments such as loans, deposits, trade credits), foreign direct investment (FDI), financial derivatives, and central bank FX reserves. Foreign liabilities are the US dollar value of domestic assets owned by foreigners and are defined analogously except for currency reserves. In accordance with the conventions in the balance of payments statistics, external assets and liabilities are defined based on residence, not nationality.

We measure external imbalances – the external capital dependence of a country – with a country's net foreign assets (NFA) relative to gross domestic product (GDP). Figure 7 plots the average external imbalances of the countries in our sample. Some countries have large negative NFA (e.g., Tunisia, Hungary, New Zealand, Australia), indicating a high level of dependence on foreign investors. In the spirit of Gabaix and Maggiori (2015), those currencies would be viewed as risky, FX market makers will attach higher risk weights leading to depreciation in times of financial distress. Most countries are debtors, while net creditor countries are the notorious safe haven countries such as Japan, Switzerland, and Hong Kong, as well as oil exporting countries such as Kuwait, Norway,

[5] We follow Lustig et al. (2011) and Della Corte et al. (2016) and remove observations with large deviations from CIP. We filtered the following observations: Egypt from November 2011 to August 2013; Indonesia from February 2001 to May 2005; Russia from December 2008 to January 2009; Kazakhstan from November 2008 to February 2009.

and Saudi Arabia.

Portfolio construction. Following Lustig et al. (2011) and others, we use portfolios of excess returns – instead of individual currencies – to explain cross-sectional variation of returns in later asset pricing tests. The motivation to use portfolios of sorted assets is to reduce the impact of idiosyncratic variance of individual currencies. Sorting currencies into portfolios according to common characteristics should help to identify a source of systematic risk and improve the estimation of standard errors.

Currencies are ranked and sorted into equal-weighted portfolios based on a country-specific characteristic. We follow Della Corte et al. (2016) by building monthly *external imbalance portfolios* of currencies sorted on countries' prior-year NFA to GDP, multiplied by (-1). The portfolios are ranked from positive to negative external wealth. Portfolio 1 (IMB1) contains the currencies of creditor countries, and Portfolio 4 (IMB4) contains the currencies of debtor countries. Table 4 summarizes the currency composition of the imbalance portfolios. The turnover is relatively low, implying a persistence of NFA over time.

Portfolio summary statistics. Table 5 reports descriptive statistics of the cross-section of external imbalance portfolios. The interest rates monotonically increase from the creditor (IMB1) to the debtor (IMB4) countries, resulting in an average interest rate spread of 564 basis points. According to the UIP condition, the average change in the spot exchange rates should equal the average forward discount. Currencies in the last portfolio trade at a forward discount of 518 basis points but only depreciate by 304 basis points, adding up to an average currency excess return of 214 basis points. The 564 basis point interest rate differential translates into an average spread in currency excess returns of 208 basis points.

4 Intermediary asset pricing and external imbalance portfolios

4.1 Intermediary constraints in a two-factor asset pricing model

There is a growing body of theoretical and empirical research on the role of financial intermediaries for asset prices (e.g., He and Krishnamurthy, 2013; He et al., 2017; Brunnermeier and Sannikov, 2014; Gabaix and Maggiori, 2015; Reitz and Umlandt, 2021). The fundamental concept of asset pricing suggests that the price of an asset is determined by its distribution of payoff across economic states, and stochastic discount factors (SDF) summarize these state prices (Cochrane, 2009). The starting point of intermediary asset pricing models in the spirit of He and Krishnamurthy (2013) is that a specialist manages the financial intermediary and represents the insiders/decision-makers of the bank and forms an intermediary with the households. The marginal investor, whose SDF prices assets, is assumed to be a financial intermediary. The marginal value of the wealth of the intermediary serves as a plausible pricing kernel, denoted as m, for a cross-section of assets

$$\mathbb{E}_t\left[m_{t+1} rx_{t+1}\right] = 0, \tag{4}$$

where rx_{t+1} are excess returns (here: $rx_{t+1} = f_t - s_{t+1}$) and $m_{t+1} = \frac{u'(c_{t+1})}{u'(c_t)}$ satisfies the above Euler equation. Intermediary asset pricing models are ultimately consumption-based asset pricing models where the intermediary is the representative investor. Financial constraints on the intermediary enter the SDF and influence the marginal utility. When the intermediary experiences a negative shock, such as a lower equity capital ratio, higher regulatory capital requirements, or large portfolio losses, its risk-bearing capacity is impaired, and its utility from an additional unit of wealth rises (He et al., 2017). In high marginal utility states, the intermediary's capacity to absorb losses is limited, and the intermediary highly values assets that still provide positive returns. In the FX market, currencies that depreciate when the intermediary's marginal utility is high are considered as risky and should provide higher expected excess returns to compensate for the downside risk. Conversely, currencies that appreciate when the intermediary faces tightening financial constraints act as hedges and are expected to provide lower excess returns. The covariance of currency returns with determinants affecting the intermediary's marginal utility gives the magnitude of risk premia.

In linear factor models in the spirit of Cochrane (2009), the SDF is a linear function of a set of risk factors. The average returns of portfolios can be attributed to risk premia determined by their exposure to these factors that capture common variation in individual portfolio returns. We follow intermediary asset pricing theories of He et al. (2017) and Reitz and Umlandt (2021) and propose a SDF composed of two risk factors.

First, a standard economic growth term capturing the aggregate level of wealth in the economy W_t. The factor generally states that W_t is negatively related to the marginal value of wealth, i.e., investors dislike currencies that depreciate during bad times. Second, a factor on the wealth of the financial intermediary I_t. The intuition is that tightening financial constraints inhibit the intermediary's risk-bearing capacity, increasing the marginal value of wealth. The two-factor asset pricing Euler equation for expected currency excess returns is

$$\mathbb{E}_t\left[rx_{t+1}\right] = \beta_t^W \lambda_t^W + \beta_t^I \lambda_t^I, \tag{5}$$

where β's are the exposure of the currency portfolios to the factors, and λ^W and λ^I are the prices of market risk and intermediary risk, respectively.

We estimate both risk factors empirically. Motivated by Lustig et al. (2011) and Reitz and

Umlandt (2021), we measure FX market risk W_t with a return-based factor derived from a portfolio investing equally in every currency available. The factor is the so-called "dollar risk factor" DOL. The "intermediary risk factor" I_t is estimated by innovations in our financial constraints index $\Delta IntCon$. Remember, $\Delta IntCon > 0$ implies tightening FX dealer constraints. The hypothesis of Gabaix and Maggiori (2015)'s model predicts that high-yielding currencies (of countries with low NFA) have a negative risk exposure β^I, while low-yielding currencies (of countries with high NFA) have a positive risk exposure β^I. The price of intermediary risk λ^I is expected to be negative.

4.2 Empirical asset pricing tests for external imbalance portfolios

We test the pricing power of the two-factor SDF conducting traditional asset pricing tests on the cross-section of four currency portfolios sorted on countries' NFA. The test assesses whether differences in the exposure to intermediary constraints risk across imbalance portfolios can explain the variation in their expected excess returns. The estimation follows the two-stage procedure of Fama and MacBeth (1973) (FMB). In the first stage, we estimate betas for each imbalance portfolio i from time-series regressions of its portfolio excess returns, rx_{it}, on a constant, the dollar risk factor DOL_t, and the intermediary risk factor $\Delta IntCon_t$

$$rx_{it} = \alpha_i + \beta_i^{DOL} DOL_t + \beta_i^{\Delta IntCon} \Delta IntCon_t + \varepsilon_{it} \text{ for } i = 1, ..., 4, \tag{6}$$

where β^{DOL} and $\beta^{\Delta IntCon}$ are respective risk exposures. In the second stage, we estimate the factor risk prices by running cross-sectional regressions of average excess portfolio returns on the betas

$$rx_i = \lambda^{DOL} \hat{\beta}_i^{DOL} + \lambda^{\Delta IntCon} \hat{\beta}_i^{\Delta IntCon} + \epsilon_i \text{ for } i = 1, ..., 4, \tag{7}$$

where λ^{DOL} and $\lambda^{\Delta IntCon}$ are respective risk prices.

Time-series results. Panel A of Table 6 reports the estimated exposures of the imbalance portfolios to the risk factors. Standard errors are based on Newey and West (1987).

The betas for the dollar factor are statistically significant and range from 0.6 to 1.3, as documented by Lustig et al. (2011). In line with the hypothesis of Gabaix and Maggiori (2015)'s model, we find that the intermediary risk beta $\beta^{\Delta IntCon}$ is positive for IMB1 (countries high NFA) and negative for IMB4 (countries with low NFA). Especially the first portfolio has a relatively high and statistically significant exposure to the intermediary risk factor. Currencies of countries with high NFA tend to pay off positively in times of tightening financial constraints of FX dealer banks and provide a hedge against constrained times. The negative signs of all other portfolios imply that these currencies generate relatively low returns when the intermediary constraints index increases. This can be interpreted that risk premia to external imbalance portfolios are partially compensating for high exposure to risk coming from financial intermediaries.[6]

Cross-sectional results. Next, we address whether intermediary constraints can explain the excess returns to imbalance portfolios. Panel B of Table 6 presents results from the second–stage FMB and first-stage GMM cross-sectional regressions. The reported standard errors are based on both the Newey and West (1987) approach and the Shanken (1992) adjustment.

The risk price of the dollar factor is positive but insignificant, confirming the results of Lustig et al. (2011), Menkhoff et al. (2012a), Reitz and Umlandt (2021), and other studies. The factor price of intermediary risk $\lambda^{\Delta IntCon}$ is statistically significant at the ten-percent level and negative with a risk price of -0.09% (i.e., -1.08% per annum). This means that an asset with a beta of one (e.g., high NFA currencies in IMB1) pays a negative risk premium of 1.08% per annum. The FX dealer banks' exposure to financial constraints can be seen as a source of risk that needs to be compensated by a premium. The negative factor risk price translates into lower risk premia for high NFA portfolios whose returns positively co-move with changes in the intermediary constraints index. In contrast, low NFA portfolio returns with a negative covariance with the changes in the intermediary constraints index demand a risk premium. This aligns with our hypothesis that excess returns to imbalance portfolios can be interpreted as compensation for intermediary risk. Investors demand a high return on currencies of countries with low NFA since they perform poorly when FX dealer banks' constraints tighten, while investors accept low returns on currencies of countries with high NFA since these currencies provide a hedge against unfavorable changes in external financing conditions.

The two-factor model yields an adequate cross-sectional fit with R^2 of more than 70%. The results are especially remarkable because the intermediary risk factor is not derived from a time-series of currency excess returns itself (e.g., as the carry trade factor in Lustig et al., 2011 or the volatility factor in Menkhoff et al., 2012a) but is an exogenous source of risk with a solid ability to explain cross-sectional differences in average currency returns.[7] The magnitude of the risk prices and exposures and the cross-sectional fit support the hypothesis predicted by the model of Gabaix and Maggiori (2015). The financial conditions of intermediaries matter systematically for currency pricing.

[6]In a robustness check, we use rolling windows of two years in the time-series regression to obtain rolling beta estimates. Rolling windows capture time-varying risk exposures, providing a dynamic view of an asset's changing relationship with the financial constraints of FX dealers. We find that the following cross-sectional regression results remain robust with our baseline findings. The estimation results are available from the authors upon request.

[7]A high cross-sectional fit is not unusual given a cross-section consisting of only four portfolios. For example, Reitz and Umlandt (2021) report an R^2 of over 90% using a capital ratio risk factor to price carry trade portfolios. We address this issue by considering a larger cross-section of currency portfolios in Section 4.3.1.

Moreover, we can use the fitted parameters to calculate the expected excess return $\mathbb{E}(rx_i) = \lambda^{DOL}\beta_i^{DOL} + \lambda^{\Delta IntCon}\beta_i^{\Delta IntCon}$. For the high-yielding currency portfolio IMB4 (with low NFA), the expected annualized return implied by the model is 1.97%.[8] The return share contributed by the exposure to intermediary risk is $12 \times \lambda^{\Delta IntCon} \times \beta_{IMB4}^{\Delta IntCon} = 12 \times (-0.09) \times (-0.09) = 0.09\%$. In case of the low-yielding portfolio IMB1 (with high NFA), the expected annualized return implied by the model is -0.04%.[9] The market risk premium of IMB1 due to exposure to the dollar factor of 0.89% is offset by an annual intermediary risk premium of -0.94%.

The larger return reward for FX intermediary risk gained by high NFA currencies may be explained by higher FX trading volume and FX lending positions in currencies such as the Japanese yen or the Swiss franc in times of financial distress. Repricing of risk followed by increased constraints of FX dealer banks may therefore especially pronounced for currencies of high NFA countries.

4.3 Robustness tests

4.3.1 Alternative currency portfolios

To test the pricing ability of the intermediary constraints risk factor $\Delta IntCon$ beyond the four imbalance portfolios in Section 4.2, we consider a broader cross-section of alternative portfolios sorted on different signals (i.e., test assets). While the model by Gabaix and Maggiori (2015) predicts explanatory power explicitly for imbalance portfolios, a broader cross-section of portfolios including additional test assets helps us to improve statistical power. The most prominent currency trading strategy uses carry trade portfolios, which are widely investigated in the asset pricing literature (e.g., Lustig et al., 2011; Lettau et al., 2014; Reitz and Umlandt, 2021). In addition, we include common portfolio sorts in FX markets based on momentum and value. Table A.3 describes the different currency investment strategies that provide the test assets.

Table 7 presents the cross-sectional estimation results for the larger cross-section of 16 portfolios in the two-factor model. The estimated price of intermediary risk is one-third larger compared to the small sample of four external imbalance portfolios. The results seem stronger regarding their significance with GMM standard errors. However, the cross-sectional fit declines when considering additional test assets. Figure 8 presents the predicted excess return with the actual excess returns that allow to observe the cross-sectional pricing errors. The short-term momentum portfolios show a downward sloping relation. As reported in Reitz and Umlandt (2021), a overall decrease in R^2 can be attributed to the failure of intermediary constraints to explain momentum portfolios. The excess returns to the other portfolio sorts appear to be reasonably priced at least in the lower

[8] The observed annualized mean excess return of IMB4 is 2.14% as reported in Table 5.

[9] The observed annualized mean excess return of IMB1 is 0.06% as reported in Table 5.

tail, i.e., the portfolios follow almost an ascending trend from the first to the fourth portfolio. In summary, our empirical results remain robust in the larger cross-section of test assets, confirming the relevance of financial intermediaries' constraints for determining returns to currency portfolios.

4.3.2 Alternative currency risk factors

Introducing the new risk factor $\Delta IntCon$ raises questions for its explanatory power beyond that of other established risk factors documented by the literature. To address this, we rerun our baseline analysis from Section 4.2 but with alternative risk factors. Therefore, we substitute the second risk factor or add a third risk factor in Eq. 6 and Eq. 7 in addition to DOL.

First, we consider the most prominent tradeable risk factor, i.e., the carry trade factor proposed by Lustig et al. (2011), which is the high-minus-low return (HML) to portfolios sorted on forward discounts, i.e., a strategy that buys currencies with the highest interest rates and borrows in currencies with the lowest interest rates.[10] The HML factor is expected to have a quite good pricing ability because it is constructed as the difference to high- and low-interest-rate currencies, which represents the behavior of interest rate differentials on external imbalance portfolios. We expect the explanatory power of the exogenous risk factor $\Delta IntCon$ to decrease when including the HML factor. Second, we consider the nontradable (i.e., non-return-based) factor introduced by Reitz and Umlandt (2021), called *FXcore10*, which captures innovations to capital ratios of the top ten FX dealers identified by the Euromoney FX survey. The capital ratios are calculated as shown in Eq. 1.[11] We expect the pricing ability of $\Delta IntCon$ to exceed that of *FXcore10*, because a more comprehensive risk factor should capture a broader set of information relevant for exchange rates beyond that information in capital ratios. Third, we use the intermediary capital ratio proposed by He, Kelly, and Manela (2017) (HKM), which measures the aggregate market capitalization-weighted capital ratio of all holding companies associated with institutions from the New York Fed's primary dealers list.[12] We define shocks to the standardized average capital ratio of primary dealers as the HKM factor. This exercise allows a comparison of our results with a broader dealer group that includes a large number of periphery dealers. Given that the top 10 FX dealer banks are also associated with New York Fed primary dealers, our $\Delta IntCon$ factor is embedded in HKM. Nevertheless, we observe a modest correlation of 0.66 between HKM and $\Delta IntCon$, indicating differences in the group composition and the components each index reflects.

The factor horse races of different factor models are presented in Table 8. The tests allow us to validate if our new factor $\Delta IntCon$ provides useful information in addition to what is already

[10]See Table A.3 for the formation of the four carry trade portfolios.

[11]For the asset pricing tests, we multiply the capital ratios by -1 to make our hypothesis in Section 4.1 to hold, i.e., the price of intermediary risk λ^I is expected to be negative.

[12]The primary dealer capital ratio by He et al. (2017) is constructed as in Eq 1.

covered in other factors. As test assets, we use four external imbalance currency portfolios from the baseline asset pricing results.

The first model shows the cross-sectional results of a two-factor SDF that includes DOL and HML. The positive estimate of the price of the carry trade factor of 0.39% implies higher (lower) risk premia for external imbalance portfolios whose returns positively (negatively) comove with the HML factor. The price of risk λ^{HML} is statistically significant at the five-percent level. The cross-sectional fit in terms of R^2 is with 68% lower than for the two-factor SDF that includes DOL and $\Delta IntCon$ (see Table 6). In the second model, we estimate a three-factor model that includes the DOL, $\Delta IntCon$, and HML factors. When the HML factor is included, the price of the intermediary factor $\Delta IntCon$ becomes insignificant, which implies that constraints of financial intermediaries do not have additional explanatory power for external imbalance portfolios beyond what is already covered in HML. Since the HML factor represents a technical factor that is able to adequately price carry trades from low- to high-interest-rate currencies, it is not surprising that the $\Delta IntCon$ factor derived from from exogenous sources (and not returns themselves) looses it's ability to explain excess returns. However, the R^2 increases from 68% to 92% when including $\Delta IntCon$ as a third risk factor. In summary, even if the statistical significance of $\lambda^{\Delta IntCon}$ disappears, the financial constraints of intermediary's risk-bearing capacity contribute to a better explanation of returns to external imbalance portfolios and provide an economic intuition behind risk premia.

Next, we move to the intermediary constraints factor *FXcore10* presented in Reitz and Umlandt (2021). The third model shows the results of a two-factor SDF that includes DOL and *FXcore10*. We find no statistical significance of capital ratio innovations of top 10 FX dealers as a risk factor for currency portfolios sorted on NFA/GDP. In contrast, Reitz and Umlandt (2021) show that the intermediary balance sheet risk factor is priced in a cross-section of carry trade portfolios. In the fourth model, we include $\Delta IntCon$ and *FXcore10* simultaneously. We find that the more comprehensive intermediary constraints risk factor $\Delta IntCon$ outperforms the *FXcore10* factor. The $\Delta IntCon$ is statistically significant at the five-percent level, while the *FXcore10* factor remains insignificant. Even if both factors contain to some extent the same information (correlation of 0.68%), considering only capital ratios of FX dealers as the driver of their risk-bearing capacity provides an incomplete picture for currency pricing.[13]

Finally, we evaluate the performance of the primary dealer capital ratio proposed by He et al. (2017). The fifth model estimates a two-factor SDF with DOL and HKM, where we find that the

[13] In another robustness check, we employ a top 3 index as risk factor in the asset pricing analysis as Reitz and Umlandt (2021) (instead of our baseline top 10 index). The cross-sectional results remain unchanged, which suggests that the increasing competition in the FX market has made more dealers relevant. Limiting the analysis to top 3 dealers may underestimate the growing influence of additional market makers, supporting the validity of the top 10 index.

HKM factor is insignificant. This suggests that the capital ratios of a broader dealer group do not explain variations in returns to external imbalance portfolios. When considering both factors simultaneously – HKM and $\Delta IntCon$ – in a three-factor model as reported sixth model, the risk price for $\Delta IntCon$ remains statistically significant, while HKM continues to be insignificant. This horse race supports the hypothesis that only the constraints of top 10 FX dealer banks matter for systematic currency pricing conditional on NFA/GDP. Including HKM alongside $\Delta IntCon$ does not improve the model's explanatory power for external imbalance portfolios. Our FX-specific intermediary constraints factor outperforms the general capital ratio factor of a broader set of periphery dealers as applied in He et al. (2017). The results show that the relevant information for pricing currencies conditional on NFA/GDP is captured by market-based solvency measures (i.e., capital ratio, CDS, VaR, VXY) of a few top dealer banks, rather than the constraints of periphery dealers.

5 Exchange rates when constraints are tight

5.1 Empirical analysis

The model of Gabaix and Maggiori (2015) shows that increasing financial constraints of financiers deteriorate their risk-bearing capacity. This leads to currency depreciation of net external debtor countries, while the opposite is true for creditor countries. In this section, we use an interaction model to find out empirical thresholds of a country's NFA level at which tightening constraints actually lead to currency depreciation or appreciation. We use the changes in the intermediary constraints index $\Delta IntCon$ as a measure of the willingness of financiers to absorb currency risk.

First, we estimate the following panel regression

$$y_{it} = \alpha + \gamma_i + \delta_\tau + \beta_1 \Delta IntCon_t + \beta_2 NFA_{it-12} + \beta_3(\Delta IntCon_t \times NFA_{it-12}) + \zeta X_{it} + \epsilon_{it}, \quad (8)$$

with y_{it} being the monthly log spot exchange rate change Δs_{it} of currency i against the US dollar between $t+1$ at t, i.e., $\Delta s_{it+1} = s_{it} - s_{it+1}$. Thus, $\Delta s < 0$ implies a foreign currency depreciation. Later, we also consider the currency excess returns rx_{it} according to Eq. (3) as the dependent variable y_{it}, i.e., $rx_{it+1} \approx i_{it} - i_t - \Delta s_{it+1}$.

α is a constant, γ_i is a country fixed effect, and δ_τ is a time fixed effect (year or quarter). $\Delta IntCon_t$ is the one-month change in the intermediary constraints index, NFA_{it-12} is the one-year lagged NFA to GDP of country i, and X_{it} is a collection of control variables. β and ζ are estimated coefficients and ϵ_{it} is the error term. The interaction term estimates the currency's response conditional on NFA to changes in the financial constraints of FX dealers. In order to avoid a reverse causality problem where exchange rate changes affect external assets and liabilities, we use one-year lagged NFA to GDP to study the exchange rate impact conditional on NFA. For all control variables that are available annually, we use the one-year lag, while for variables that are available monthly or quarterly, we use a one-month or one-quarter lag.

Table A.2 presents a complete and detailed description of all control variables and the respective source. Some variables are only available at an annual frequency, wherefore we retrieve monthly observations by maintaining the annual values constant until new observations become available. Table 9 reports descriptive statistics for all the variables used in empirical analysis.

Baseline results. The results of Eq. (8) are reported in Table 10. The specifications 1 to 5 use exchange rate changes and the specifications 6 to 10 currency excess returns as dependent variables. All standard errors are clustered by currency and month.

The first column estimates only the unconditional effect of $\Delta IntCon$ on exchange rate changes. The coefficient (β_1) is negative and statistically significant at the one-percent level. This indicates that tighter financial constraints of FX dealer banks are associated with a currency depreciation on average. An increase in our financial constraints index by one standard deviation leads, on average, to a currency depreciation by abound 2.93%, which corresponds to more than 90% of the standard deviation of Δs in our sample, which is economically significant.

In the second column, we estimate a version of Eq. (8) including the interaction with NFA, without time fixed effects and additional control variables. We just control for currency fixed effects. The coefficient on the interaction term (β_3) is statistically significant at the one-percent level and positive.[14] The interaction model reveals that tightening dealer constraints have heterogeneous effects on exchange rates conditional on countries' NFA. Higher levels of a country's NFA can cushion the negative impact of tightening FX dealer constraints on the currency. Debtor countries (NFA < 0) depreciate further in bad times, while creditor countries (NFA > 0) experience less currency depreciation or even appreciation. We include several control variables in column 3, and the results remain robust. In columns 4 and 5, we also add year and quarter fixed effects, respectively. The estimated interaction coefficient increases to 1.03.

The marginal effects of the fifth specification are presented in Figure 9. The marginal effect is upward sloping, meaning that a one standard deviation increase in the intermediary constraints index leads to more pronounced depreciation of currencies with lower NFA. For currencies of countries with NFA levels between -1 and 1 to GDP, we detect a significant depreciation when financial constraints tighten. For currencies with NFA levels between 1 and 5.5 to GDP, we

[14] We also include NFA to control for the country's financing needs. The estimated coefficient of NFA (β_2) gives the exchange rate impact of NFA if $\Delta IntCon = 0$.

detect no significant effect, while for currencies with NFA above 5.5 to GDP, we find significant appreciation when constraints tighten. Apparently, FX dealers reprice currency risk according to external capital dependence of countries when their risk absorbing capabilities change.

The specifications in the columns 6 to 10 of Table 10 repeat the analysis using currency excess returns. The results remain similar compared to using spot exchange rate changes. This provides evidence that changes in the intermediary constraints index drive excess returns to NFA currency portfolios via exchange rate changes and not via interest rate differentials.[15]

Country subsamples. We also consider a subsample of developed countries (G10) as Della Corte et al. (2016) that includes Australia, Canada, Denmark, Eurozone, Japan, New Zealand, Norway, Sweden, Switzerland, and the United Kingdom. The subsample of developing and emerging countries (EME) includes all other countries of the full sample. The results are presented in the first and second columns of Table 11. The estimated interaction coefficient is statistically significant at the one-percent level for EME currencies, while the effect is insignificant for G10 currencies. This indicates that the repricing of currency risk is dominated by developing and emerging countries in our sample. The result resembles the findings in the literature that sudden capital flow stops are typically an emerging market phenomenon (see Levchenko and Mauro, 2007). In times of tightening FX dealer constraints, emerging markets typically suffer most from retrenchments of foreign capital, particularly the most external capital market-dependent countries with low NFA. This suggests that the heterogeneity in our baseline results originates from differences across countries in our sample.

Crisis subsamples. In the third and fourth columns of Table 11, we split the full sample period between a crisis period (January 2004 to September 2008) and a post-crisis period (October 2008 to December 2021). To make the financial constraints of dealer banks during both time periods comparable, we standardize the time-series of our intermediary constraints index separately to a standard deviation of 1 in each subsample. The coefficients of the interaction terms are almost identical in both periods. One could expect that the relationship between exchange rates and external imbalances has become stronger after the financial crisis because banks have to scale back their foreign lending faster when they face financial constraints, e.g., due to regulatory changes. On the other side, counteracting effects on exchange rates in the post-crisis period could exist due to higher risk tolerance of banks as well as due to yield-seeking-behavior in a low-interest-rate environment.

[15] The following analyses are performed for exchange rate changes and currency excess returns. We only report the estimates on the exchange rate changes for the sake of brevity but results are available from the authors upon request.

Asset classes. In the next step, we disentangle different types of asset classes in the NFA position of countries. In general, international capital flows are procyclical, which tends to amplify business cycle fluctuations and trigger financial turmoil (see, among others, Broner et al., 2013; Kaminsky et al., 2004). However, the procyclicality across different types of asset classes can vary, and the structure of a country's external capital dependence might influence how the exchange rate responds to tighter FX dealer constraints.

While net portfolio equity and FDI are relatively stable and less sensitive to sudden stops, debt investments exhibit a strong procyclicality and flighty behavior (e.g., Gardberg, 2022; Avdjiev et al., 2022; Brunnermeier et al., 2012; Levchenko and Mauro, 2007). Equity and FDI investors typically employ lower leverage and maintain a long-term focus than debt investors, as their investments involve more risk and profit sharing, discouraging outflows during financial crises. Foreign equity investors absorb valuation losses during a financial crisis. In contrast, a large proportion of debt investments is intermediated by banks, whose lending activities are influenced by their balance sheets' risk-bearing capacity. Therefore, countries with substantial net foreign debt positions are expected to have currencies more vulnerable to changes in the intermediary constraints index than countries with large net foreign equity and FDI positions.

Table 12 presents the results from the exercise in Eq. (8) repeated for different types of NFA classes to GDP (i.e., net foreign portfolio equity, net FDI, net foreign debt, or net foreign portfolio debt and net other foreign debt investments such as loans, deposits, trade credits). The estimated coefficients of the interactions with net portfolio equity and net FDI in the first and second columns are insignificant. By contrast, the third column reports that the interaction with net foreign debt is statistically significantly positive at the one-percent level. This implies that especially countries with negative net foreign debt positions are sensitive to changes in the intermediary constraints index and depreciate when FX dealer banks face increasing financial constraints. In contrast, positive net foreign debt positions are associated with a less sharp currency depreciation. Compared with the interaction coefficient with NFA documented in Table 10, the impact of a one-standard-deviation change in the intermediary constraints index is almost twice as large for net foreign debt relative to general NFA.

In column 4, we add all NFA classes and separate net foreign debt investments by portfolio debt and other debt investments. Interestingly, the estimated coefficient on the interaction with net foreign equity is statistically significant at the ten-percent level and turns negative, perhaps reflecting the role of equity as a buffer for losses and showing a countercyclical behavior of equity investors where foreign debt is (partly) substituted by foreign equity in economic downturns. Further, we observe that net portfolio debt mainly drives the positive interaction between changes in the intermediary constraints index and net foreign debt. The notion of the capital flows that are intermediated by financial intermediaries, namely portfolio debt, determine the vulnerability of exchange rates to changes financing constraints.

FX reserves. For the pricing of exchange rate FX reserves are a particularly relevant part of external wealth. The stock of domestic central bank holdings of liquid foreign currency assets can act as an insurance mechanism in times of crisis and strengthen the stability of a currency. When a sudden capital flow stop occurs, the domestic central bank can relieve depreciation pressure on the domestic currency by using FX interventions. Active exchange rate management may also be a viable tool for the central bank to dampen currency repricing conditional on a country's NFA.

We test whether the level of FX reserves affects the impact of tightening FX dealer constraints on exchange rates. We split the sample into two subsamples indicating whether a country has a FX reserve to imports ratio below or above the median. In Table 13, the first column estimates the regression in Eq. (8) for countries with low FX reserves and the second column for countries with high FX reserves. The interaction coefficient between changes in the intermediary constraints index and NFA is much higher for low-reserve currencies than for high-reserve currencies. Countries with low FX reserves experience a stronger currency depreciation conditional on their NFA than countries with high FX reserves.

Figure 10 and Figure 11 plot for both samples the average marginal effects of a one-standard-deviation-increase in the intermediary constraints index conditional on a country's NFA. The results support the evidence we gained in the regression. The exchange rate effect is more negative for low FX reserve currencies than high reserve currencies. For instance, currencies of countries with NFA to GDP of -1% depreciate in a 95% confidence interval on average by 4.54% when their FX reserves are low, while countries with the same NFA but high FX reserves depreciate on average only by 3.26%. That being said, currencies of countries with high FX reserves are less prone to the dealer banks constraints cycle than countries with low reserves.

Financial openness. The financial openness of a country may also explain the heterogeneous impact of changes in the intermediary constraints index on exchange rates conditional on NFA. We follow Habib and Stracca (2012) and measure financial openness by the sum of gross foreign assets and liabilities relative to GDP. Broner et al. (2013) show that total gross capital flows retrench during crises. We split the sample into two subsamples indicating whether a country has gross foreign assets and liabilities relative to GDP below or above the median. Columns 3 and 4 of Table 13 show the results, respectively. The results indicate a significant effect for financially open countries, where the size of the interaction effect is similar to the baseline findings. For the country sample with low financial openness, the interaction effect is larger but not statistically significant. While countries with lower degrees of financial openness are less dependent on foreign capital, they may also be less able to attract capital in times of tighter financial constraints.

5.2 Robustness tests

5.2.1 Alternative intermediary constraints

VIX versus intermediary constraints index. We compare the explanatory power of our intermediary constraints index with the VIX index, a measure of global volatility risk.[16] While the VIX is a general indicator for perceived risk in international financial markets, our financial intermediary index is dedicated to measuring the stability of major financial intermediaries in the FX market. In column 1 of Table 14, we run the regression of Eq. (8) with changes in the standardized VIX index time-series instead of the intermediary constraints index. The estimated interaction coefficient is statistically significant at the one-percent level and positive. Della Corte et al. (2016) and Gardberg (2022) have documented these findings. In column 2, we add both risk measures in a horse race: the VIX index and the intermediary constraints index.[17] The estimated interaction coefficient with changes in the intermediary constraints index remains robust. Meanwhile, the results for the VIX index go in a similar direction. Higher financial stress in financial markets – as indicated by a higher VIX – is associated with a depreciation of currencies, especially of countries with negative and low NFA. Comparing the size of the interaction effects, we find that the economic impact of our intermediary constraints index is three times as large as for the VIX index. Thus, it appears that currencies of debtor countries suffer under financial stress per se, but the deterioration of FX dealer stability appears to be even more relevant. While VIX captures overall financial market risk and volatility, the intermediary constraints index focuses on the intermediary sector that has relevant information in its own right. Our index provides more targeted insights into the mechanisms driving exchange rates, particularly during periods of heightened stress within the intermediary sector. Outside investors as demanders of liquidity in the FX market may reprice currencies in terms of financial stress according the to the NFA position. Intermediaries in the FX market, as the ultimate suppliers of liquidity in the FX market, will have to consider their own financial solvency into this currency repricing calculus. It therefore seems not too surprising that the intermediary constraints index has more explanatory power for exchange rate returns than the VIX.

[16] The VIX index comes from the Chicago Board Options Exchange and measures the implied volatility of S&P 500 index options.

[17] We checked for multicollinearity between both risk measures with the variance inflation factor. Both time-series have no collinear relationship in a regression specification with year fixed effects.

Index weightings and compositions. While our baseline index equally weights the top 10 FX dealer banks, we also build alternative intermediary constraints indices by varying the weightings and index compositions by (1) banks market share reported by the Euromoney survey, (2) banks share in total assets, (3) a constant set of 17 dealers that was ranked at least once top 10 after 2004, (4) a top 3 index with the top three FX dealers ($FXcore$ in Reitz and Umlandt (2021)), and (5) the HKM index for a broad set of dealers by He et al. (2017). In Table 15, we estimate various versions of Eq. (8) using alternative weightings and compositions.

While the results of the first three specifications align with our baseline results, the interaction effects in the fourth specification are smaller. We find less explanatory power of an index capturing financial constraints of top 3 FX dealer banks compared to an index with top 10 banks for exchange rate changes. These findings highlight that, due to increasing competition in the market over time, more dealers have become relevant for currency pricing. It is worth to note that Reitz and Umlandt (2021) find that including balance sheet information beyond the top three dealer does not improve the performance of the FX dealer model. Our focus, however, is on a broader set of solvency indicators of financial intermediaries, which may reveal a lower correlation among the top 3 and top 10 FX dealers. Further, the interaction coefficient of NFA/GDP with the HKM index by He et al. (2017) in the fifth specification is smaller than in our baseline estimation, indicating that shocks to capital ratios of FED primary dealers contain less information for currency repricing in times of tightening constraints. A broader set of intermediaries has less explanatory power for currency markets conditional on countries' external imbalances.

5.2.2 Sensitivity of imbalance risk

Country-by-country. We test whether individual countries drive the results and estimate 39 versions of Eq. (8) by dropping a country in each model. The coefficients of the estimated interaction terms remain statistically significant at the one-percent level in all regressions and range from 0.96 to 1.22. While there is some variation, the results are comparable to the estimated coefficient of 1.03 for the full sample in Table 10. Our results presented in Section 5.1 are not sensitive to some outlier countries.

Year-by-year. We also check whether individual years drive the results and estimate 18 versions of Eq. (8) by dropping year by year. The coefficients of the estimated interaction terms are statistically significant at the one-percent level in all regressions and range from 0.96 to 1.20. Our results are also not sensitive to certain years.

6 Conclusion

A few large dealer banks dominate the currency intermediation on the FX market. These intermediaries play a crucial role in absorbing imbalances in currency supply and demand by market making in the FX market and lending to currency speculators. Since intermediation in the FX market constitutes the risk of incurring losses, tighter constraints on the risk bearing ability of FX intermediaries may trigger a repricing of currency risk. In this paper, we investigate the implications of intermediary constraints of FX dealers on the cross-section of exchange rate returns thereby directly testing the theoretical predictions of Gabaix and Maggiori (2015) empirically. Our primary hypothesis suggests that investors reprice a currency for its external capital market dependence (measured by NFA) during periods of tightening financial constraints of dealer banks. This is supported by the model's theory that the limited risk-bearing capacity of intermediaries generates risk-adjusted currency returns.

We derive an intermediary constraints index to identify periods when dealers' risk-bearing capacity is constrained (e.g., when equity capital ratios are low or credit default spreads are high). First, we find that changes in the intermediary constraints of FX dealers are indeed a priced risk factor in the cross-section of currency portfolios sorted on countries' NFA (i.e., imbalance portfolios). This provides evidence that expected returns to imbalance portfolios can be interpreted as compensation for taking the intermediary risk. Investors demand higher returns on currencies of countries with low NFA, as they perform poorly when FX dealer banks' constraints tighten. Conversely, investors accept lower returns on currencies of countries with high NFA, as they provide a hedge against unfavorable changes in external financing conditions. Second, when the risk-bearing capacity decreases, the currencies of net debtors immediately depreciate relative to the currencies of net external creditors. The currency depreciation is particularly pronounced for currencies of emerging markets, countries with low FX reserves, and countries with large negative external debt positions. This paper contributes to a deeper understanding of financial intermediaries' role in exchange rate determination.

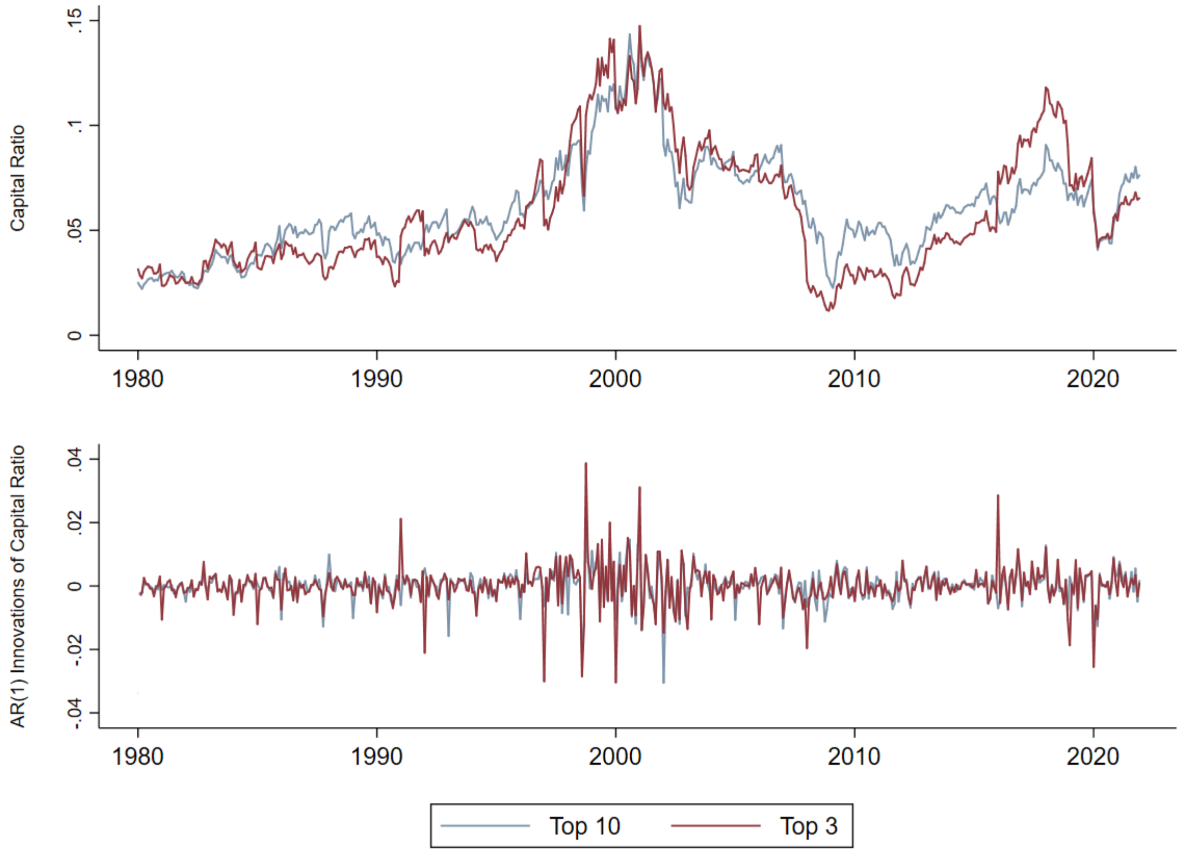

Figure 1: Time-series of capital ratios. The upper figure shows average capital ratios of the top 10 and top 3 FX dealer banks from the Euromoney FX surveys for the years 1979 to 2022. The bottom figure shows growth rates of the capital ratio series derived from AR(1)-innovations.

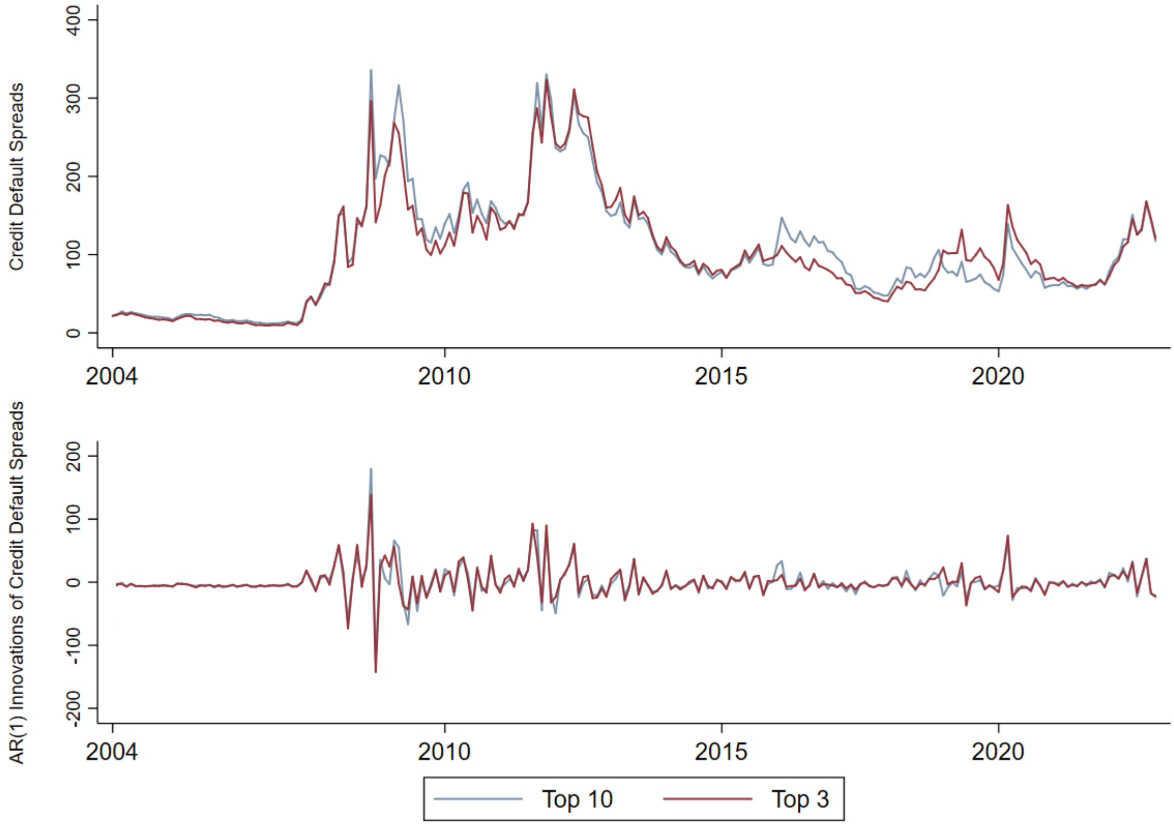

Figure 2: Time-series of credit default spreads. The upper figure shows average credit default spreads of the top 10 and top 3 FX dealer banks from the Euromoney FX surveys for the years 1979 to 2022. The bottom figure shows growth rates of the credit default spread series derived from AR(1)-innovations.

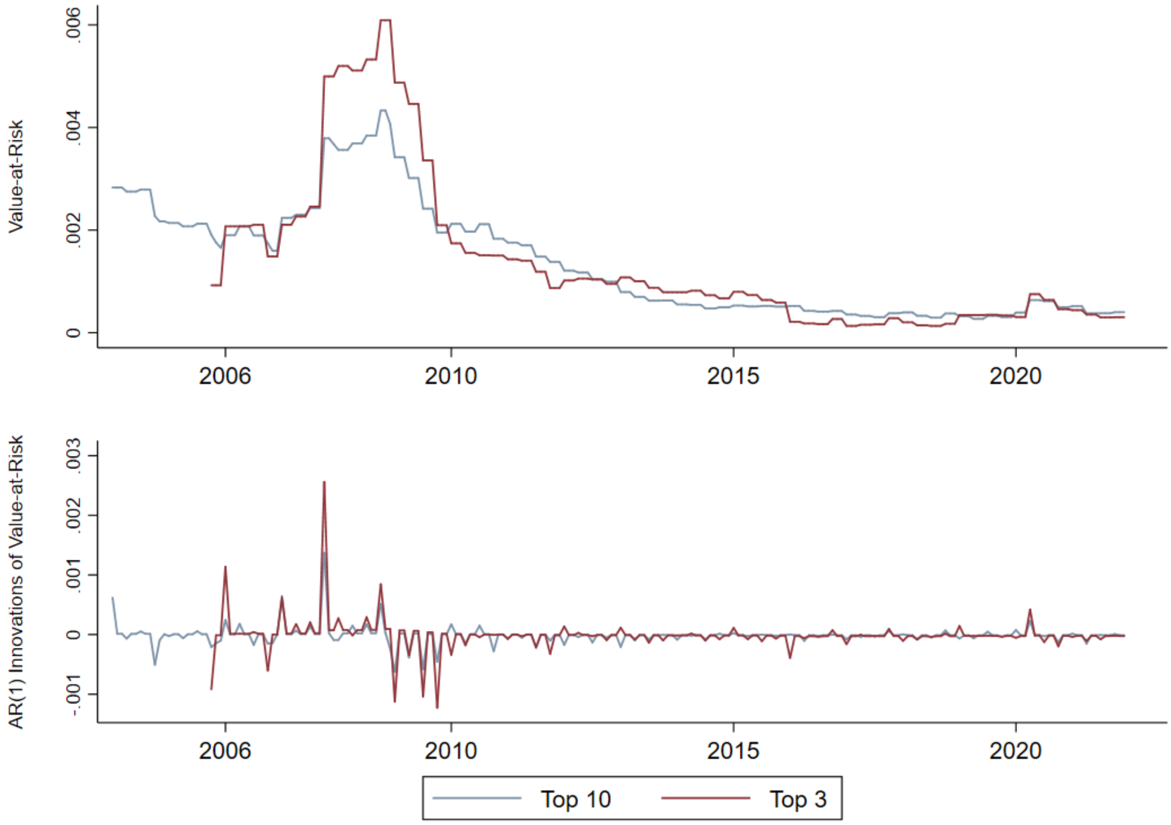

Figure 3: Time-series of value-at-risks. The upper figure shows average value-at-risk relative to book value of equity of the top 10 and top 3 FX dealer banks from the Euromoney FX surveys for the years 1979 to 2022. The bottom figure shows growth rates of the value-at-Risk series derived from AR(1)-innovations.

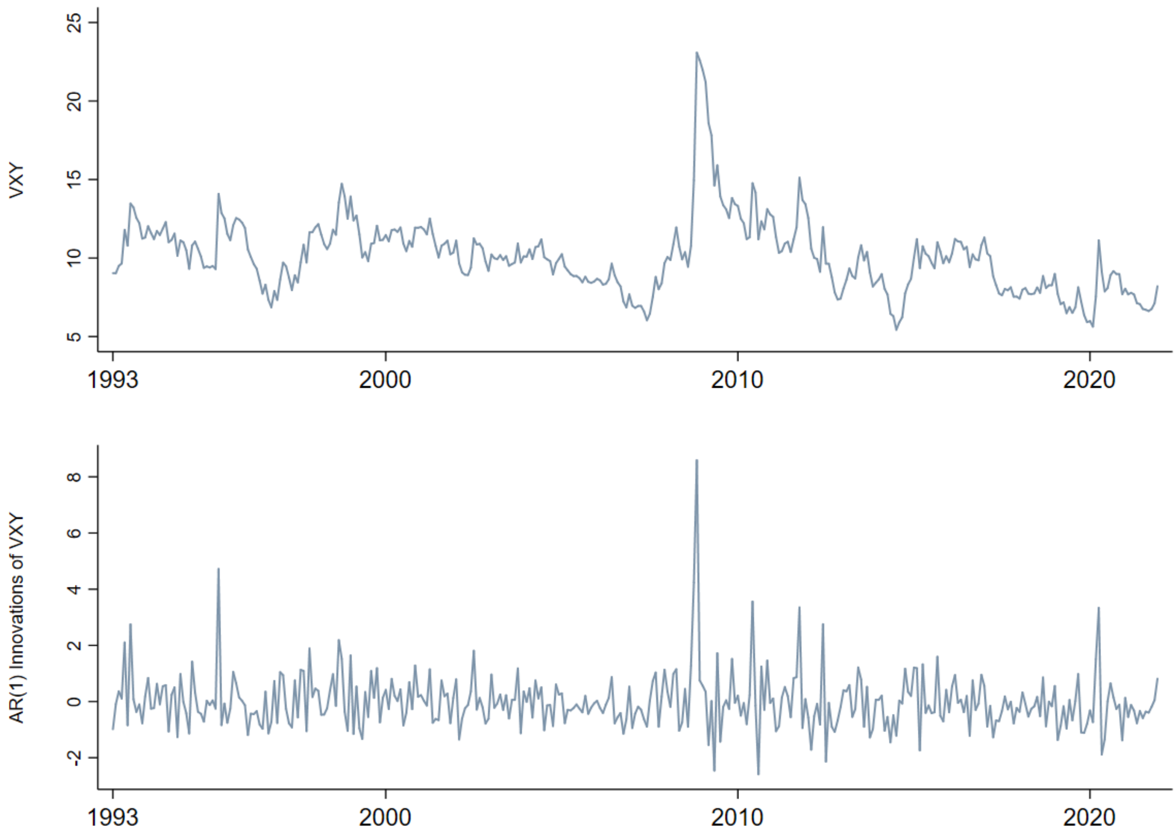

Figure 4: Time-series of VXY. The upper figure shows average VXY and the bottom figure shows growth rates of the VXY series derived from AR(1)-innovations.

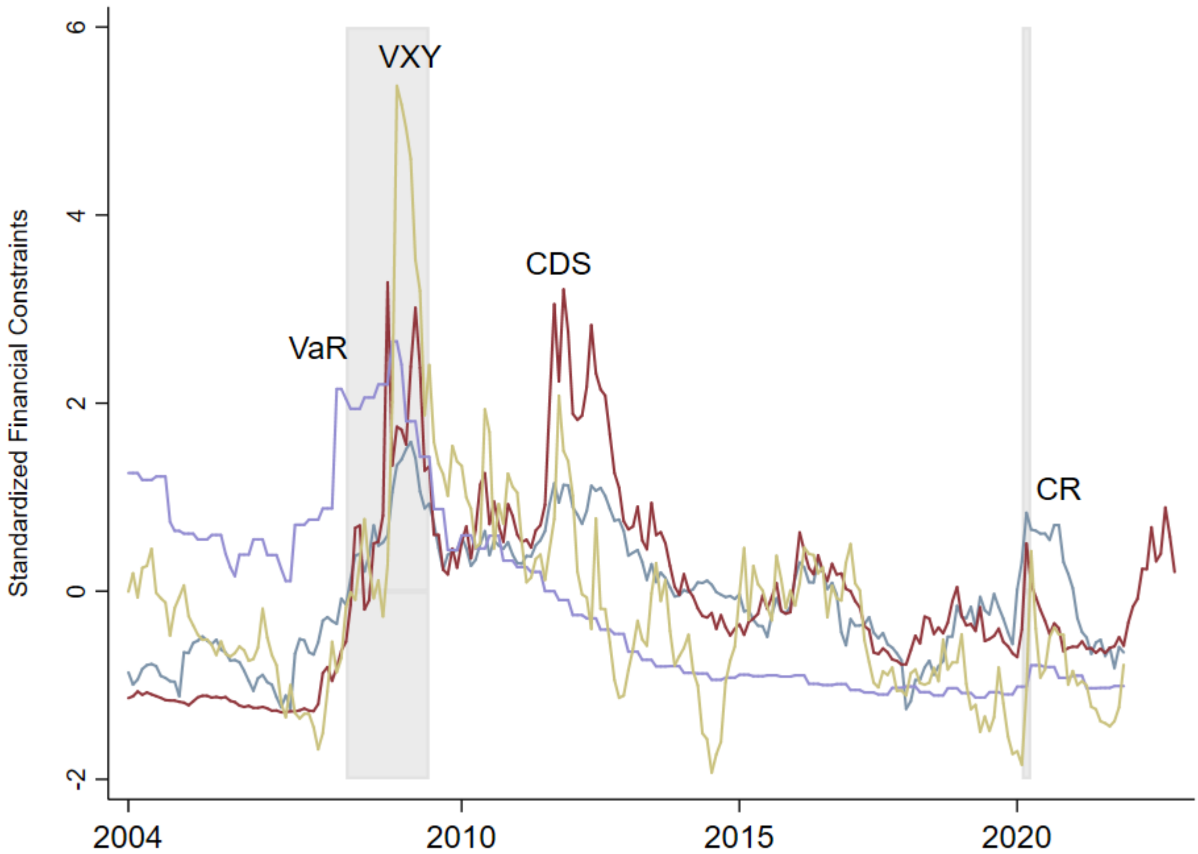

Figure 5: Time-series of components of intermediary constraints index. The figure shows standardized values of all components of the intermediary constraints index of the top 10 FX dealer banks from the Euromoney FX surveys for the years 2004 to 2022. The capital ratio is multiplied by (-1). The gray areas are NBER recessions.

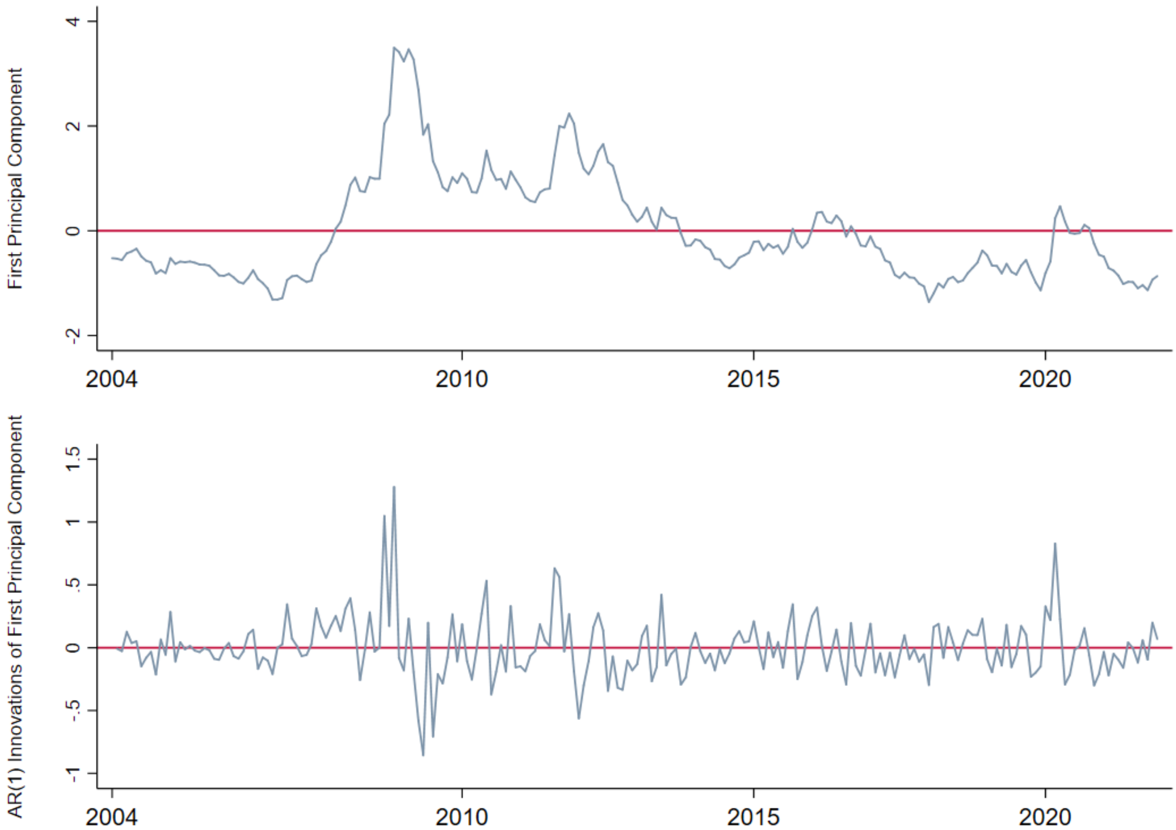

Figure 6: Time-series of intermediary constraints index. The upper figure shows the first principal component after considering four input factors of the top 10 FX dealer banks from the Euromoney FX surveys for the years 2004 to 2022. The bottom figure shows growth rates of the first principal component series derived from AR(1)-innovations.

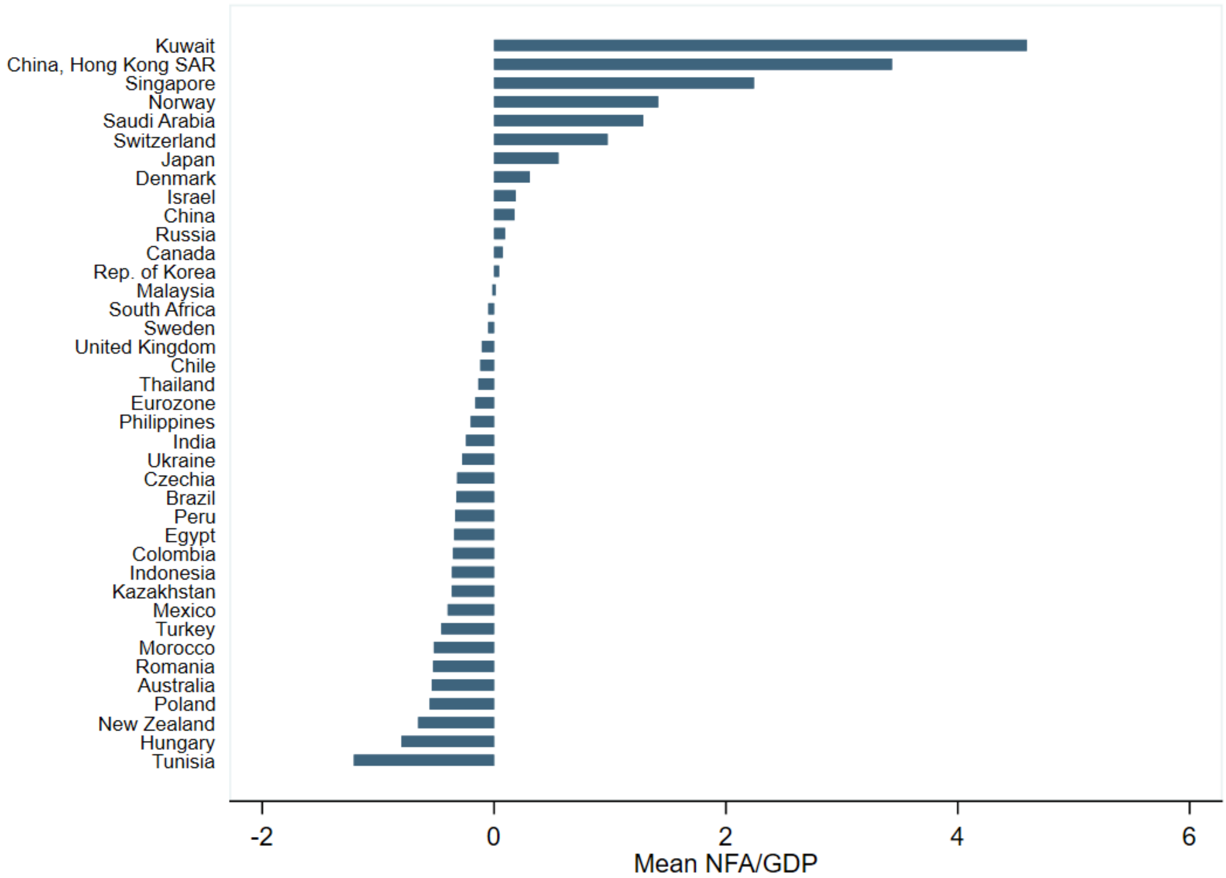

Figure 7: Net foreign assets by country. The figure shows average net foreign assets relative to GDP by country from 2004 to 2021. The data are from Brookings Institution.

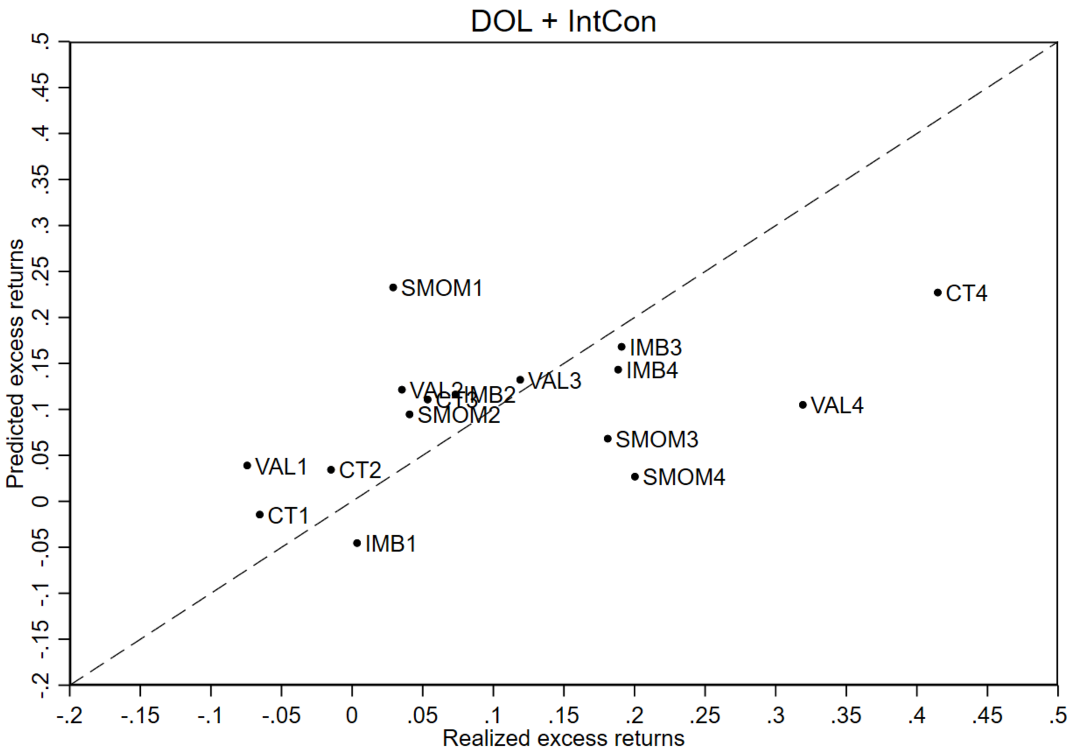

Figure 8: Pricing errors with alternative currency portfolios. The figure shows the cross-sectional pricing errors of the two-factor model including the dollar factor (DOL) and intermediary constraints factor ($\Delta IntCon$) as risk factors.

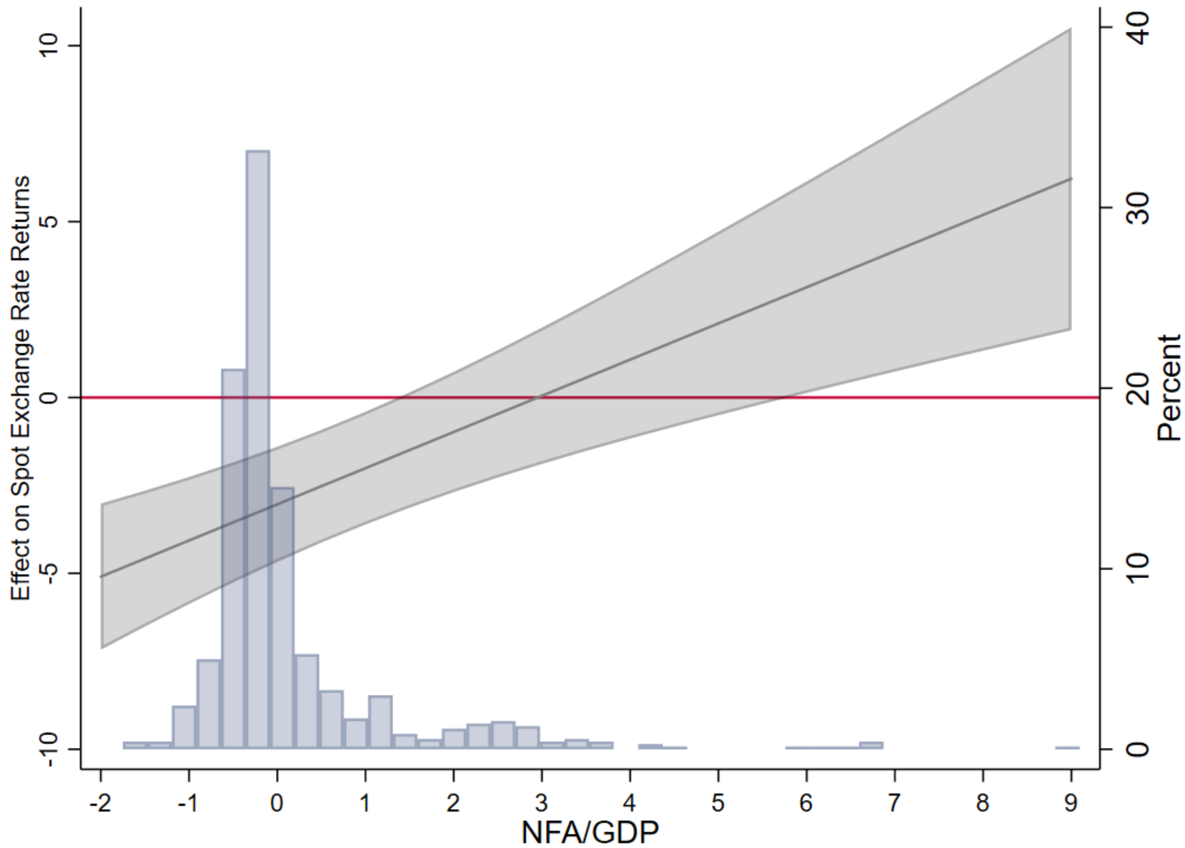

Figure 9: Marginal effects of changes in intermediary constraints index. The figure shows average marginal effects of a one-standard deviation change in the intermediary constraints index on spot exchange rates conditional on NFA to GDP with 95% confidence intervals. The distribution of NFA to GDP is reported on the right y-axis. The regressions are reported in Table 10, column 5.

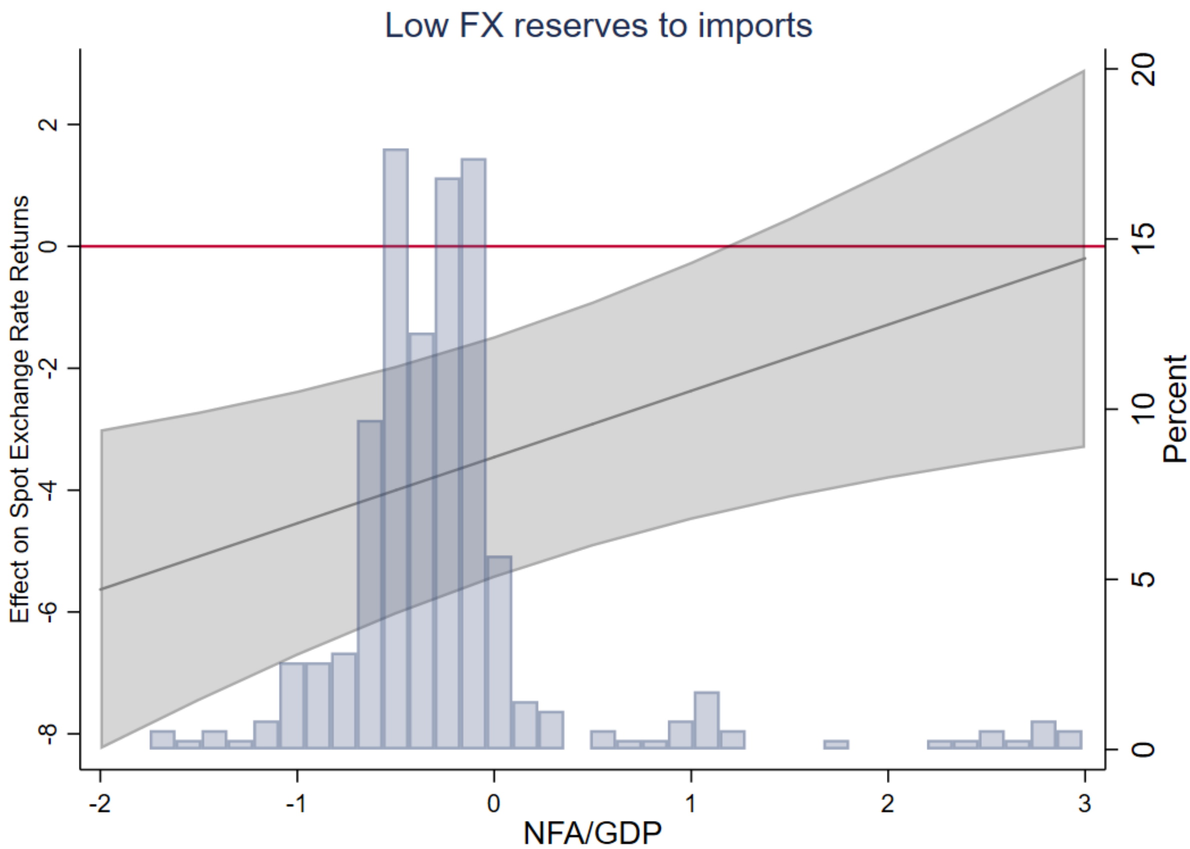

Figure 10: Marginal effects of changes in intermediary constraints index for low FX reserve countries. The figure shows average marginal effects of a one-standard deviation change in the intermediary constraints index on spot exchange rates conditional on NFA to GDP with 95% confidence intervals for countries with FX reserves relative to imports lower than the median. The distribution of NFA to GDP is reported on the right y-axis. The regressions are reported in Table 13, column 1.

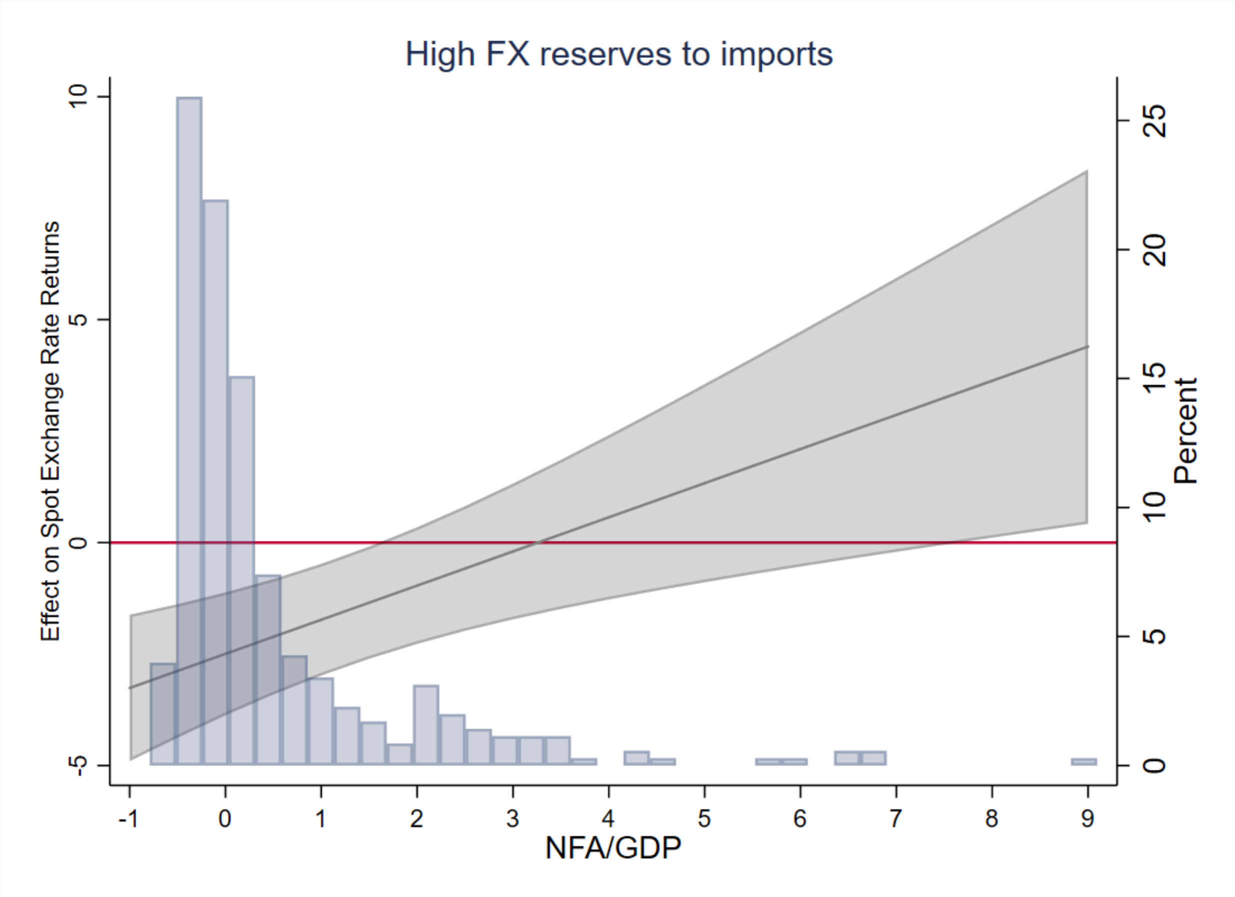

Figure 11: Marginal effects of changes in intermediary constraints index for high FX reserve countries. The figure shows average marginal effects of a one-standard deviation change in the intermediary constraints index on spot exchange rates conditional on NFA to GDP with 95% confidence intervals for countries with FX reserves relative to imports above the median. The distribution of NFA to GDP is reported on the right y-axis. The regressions are reported in Table 13, column 2.

Table 1: Correlation of intermediary constraints components. This table shows the correlation of the components of the intermediary constraints measure of the top 10 FX dealer banks from the Euromoney FX surveys for the years 2004 to 2022.

	(-)Capital ratio	CDS	VaR	VXY
(-)Capital ratio	1.00			
CDS	0.87	1.00		
VaR	0.19	0.13	1.00	
VXY	0.59	0.60	0.52	1.00

Table 2: Principal components. This table shows the lambdas of the principal component analysis using four input variables of the top 10 FX dealer banks from the Euromoney FX surveys for the years 2004 to 2022.

Component	Eigenvalue	Difference	Proportion	Cumulative
λ_1	2.54	1.51	0.63	0.63
λ_2	1.03	0.73	0.26	0.89
λ_3	0.30	0.18	0.08	0.97
λ_4	0.12	.	0.03	1.00

Table 3: Loadings on principal components. This table shows the loadings of the four input variables on the principal components for the top 10 FX dealer banks from the Euromoney FX surveys for the years 2004 to 2022.

Variable	λ_1	λ_2	λ_3	λ_4
(-)Capital ratio	0.56	-0.32	0.36	-0.67
CDS	0.55	-0.38	0.16	0.73
VaR	0.30	0.83	0.47	0.10
VXY	0.54	0.27	-0.79	-0.10

Table 4: Composition of imbalance portfolios. This table presents the currency composition of the four imbalance portfolios. Portfolio 1 (4) contains currencies of countries with the highest (lowest) NFA/GDP. We report the top six currencies and their frequencies entering each portfolio. Portfolios are rebalanced monthly. The sample compromises 39 currencies from January 2004 to December 2021.

Imbalance Portfolios							
IMB1 (high NFA)	Frequency	IMB2	Frequency	IMB3	Frequency	IMB4 (low NFA)	Frequency
CHF	0.11	KRW	0.10	INR	0.09	AUD	0.08
HKD	0.11	MYR	0.10	PEN	0.09	HUF	0.08
JPY	0.11	CAD	0.09	COP	0.07	NZD	0.08
KWD	0.11	SEK	0.09	EUR	0.07	PLN	0.08
NOK	0.11	RUB	0.09	UAH	0.07	TND	0.08
SAR	0.11	ZAR	0.08	BRL	0.06	RON	0.06

Table 5: Currency portfolios sorted on external imbalances. This table presents annualized summary statistics of currency portfolios sorted on prior-year external imbalances. Each month t, the currencies are ranked on countries' NFA/GDP and sorted into four portfolios with equal weights. The log currency excess returns are computed as $rx_{it+1} = f_{it} - s_{it} - \Delta s_{it+1}$, and using covered interest rate parity, the log interest rate differentials are approximately equivalent to the forward discounts $f_{it} - s_{it} \approx i_{it} - i_t$. Exchange rates and returns are reported in US dollar. Mean and standard deviations are percentage points. Foreign exchange data are monthly for 39 countries from January 2004 to December 2021.

	Imbalance Portfolios			
	IMB1 (high NFA)	IMB2	IMB3	IMB4 (low NFA)
NFA/GDP				
mean	1.68	0.01	-0.24	-0.58
Currency excess returns				
mean	0.06	0.88	2.28	2.14
std	7.36	10.07	11.32	12.93
skew	-0.52	-0.58	-2.44	-1.59
Forward discount				
mean	-0.46	1.75	5.17	5.18
std	0.62	1.28	3.43	2.75
Spot change				
mean	0.52	-0.88	-2.89	-3.04
std	7.45	10.09	11.66	12.89

Table 6: Asset pricing results of intermediary constraints risk factor. The table reports the asset pricing results for the linear two-factor model including the dollar risk factor (DOL) and the intermediary risk factor ($\Delta IntCon$). The test assets are excess returns to four external imbalance portfolios sorted on NFA/GDP. Panel A shows results for time-series regressions of excess returns on a constant (α_i), the dollar risk factor β_i^{DOL}, and the intermediary constraints risk factor $\beta_i^{\Delta IntCon}$. The Newey and West (1987) standard errors are reported in parentheses. Panel B reports the factor risk prices λ^{DOL} and $\lambda^{\Delta IntCon}$ obtained by Fama and MacBeth (1973) (FMB) and GMM cross-sectional regressions. There is no constant in the second-stage of FMB regressions. We use first-stage GMM. The standard errors of coefficient estimates are reported in parentheses and base on the Newey and West (1987) (NW) approach or the Shanken (1992) (Sh) adjustment. The data are monthly for 39 countries from January 2004 to December 2021. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Panel A: Factor Betas				
	α_i	β^{DOL}	$\beta^{\Delta IntCon}$	R^2
IMB1 (high NFA)	-0.07*	0.63***	0.89***	0.81
	(0.04)	(0.03)	(0.19)	
IMB2	-0.04	1.03***	-0.11	0.91
	(0.03)	(0.03)	(0.24)	
IMB3	0.08*	0.89***	-0.65	0.86
	(0.04)	(0.06)	(0.45)	
IMB4 (low NFA)	0.03	1.33***	-0.09	0.94
	(0.04)	(0.06)	(0.32)	

Panel B: Factor Prices			
	λ^{DOL}	$\lambda^{\Delta IntCon}$	R^2
FMB			
NW	0.12	-0.09*	0.75
	(0.11)	(0.05)	
Sh	0.12	-0.09**	0.75
	(0.18)	(0.04)	
GMM	0.12*	-0.09	
	(0.06)	(0.08)	

Table 7: Cross-sectional asset pricing results with alternative currency portfolios. The table reports the cross-sectional asset pricing results for the linear two-factor model including the dollar risk factor (DOL) and the intermediary risk factor ($\Delta IntCon$). The test assets are excess returns to 16 portfolios separately sorted on NFA/GDP, forward discounts, short-term momentum, and value. The factor risk prices λ^{DOL} and $\lambda^{\Delta IntCon}$ are obtained by Fama and MacBeth (1973) (FMB) and GMM cross-sectional regressions. There is no constant in the second-stage of FMB regressions. We use first-stage GMM. The standard errors of coefficient estimates are reported in parentheses and base on the Newey and West (1987) (NW) approach or the Shanken (1992) (Sh) adjustment. The data are monthly for 39 countries from January 2004 to December 2021. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	λ^{DOL}	$\lambda^{\Delta IntCon}$	R^2
FMB			
NW	0.10	-0.12***	0.33
	(0.11)	(0.04)	
Sh	0.10	-0.12**	0.33
	(0.18)	(0.05)	
GMM	0.11***	-0.11*	
	(0.03)	(0.06)	

Table 8: Cross-sectional asset pricing results with alternative risk factors. The table reports the cross-sectional asset pricing results for linear two- and three-factor models including the dollar risk factor (DOL), the intermediary risk factor ($\Delta IntCon$), the high-minus-low factor (HML), the innovations to capital ratios of top ten FX dealers (*FXcore10*), and the innovations to capital ratios of dealers from the FED primary dealer list (HKM). The test assets are excess returns to four external imbalance portfolios sorted on NFA/GDP. The factor risk prices λ^{DOL}, $\lambda^{\Delta IntCon}$, λ^{HML}, $\lambda^{FXcore10}$, and λ^{HKM} are obtained by Fama and MacBeth (1973) (FMB) and GMM cross-sectional regressions. There is no constant in the second-stage of FMB regressions. We use first-stage GMM. The standard errors of coefficient estimates are reported in parentheses and base on the Newey and West (1987) (NW) approach or the Shanken (1992) (Sh) adjustment. The data are monthly for 39 countries from January 2004 to December 2021. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	λ^{DOL}	$\lambda^{\Delta IntCon}$	λ^{HML}	$\lambda^{FXcore10}$	λ^{HKM}	R^2
FMB						
NW	0.12		0.39**			0.68
	(0.11)		(0.19)			
	0.12	0.01	0.44*			0.92
	(0.11)	(0.12)	(0.25)			
	0.12			-0.08		0.67
	(0.11)			(0.06)		
	0.12	-0.12**		0.01		0.95
	(0.11)	(0.06)		(0.06)		
	0.12				-0.06	0.79
	(0.11)				(0.05)	
	0.12	-0.13**			0.02	1.04
	(0.11)	(0.06)			(0.05)	
Sh	0.12		0.42**			0.68
	(0.18)		(0.18)			
	0.12			-0.08		0.67
	(0.18)			(0.05)		
	0.12				-0.06	0.79
	(0.18)				(0.04)	
GMM	0.12**		0.38			
	(0.06)		(0.31)			
	0.12**	0.02	0.43			
	(0.06)	(0.32)	(0.79)			
	0.12*			-0.08		
	(0.06)			(0.09)		
	0.12*	-0.12		0.01		
	(0.06)	(0.11)		(0.16)		
	0.11*				-0.07	
	(0.06)				(0.08)	
	0.12**	-0.13			0.02	
	(0.06)	(0.12)			(0.15)	

Table 9: Descriptive statistics of all variables. This table reports the summary statistics of all variables used in the empirical analysis. The frequency is monthly and the sample period is from January 2004 to December 2021. See Table A.2 for definitions and sources of control variables.

Variable	Obs.	Mean	Std. dev.	Min	Max
Exchange rate change (Δs)	8,424	-0.15	3.15	-69.40	18.18
Currency excess return (rx)	8,354	0.12	3.12	-48.90	20.27
Intermediary constraints:					
Level ($IntCon$)	8,424	0	1	-1.36	3.50
Changes ($\Delta IntCon$)	8,385	-0.0016	0.24	-0.86	1.28
NFA to GDP	8,424	0.15	1.18	-1.75	9.10
Difference to US in:					
Inflation	8,424	1.56	4.13	-6.23	61.13
Interest rate	8,424	2.80	4.03	-5.09	29.58
Stock market performance	8,424	0.01	0.05	-0.37	0.43
Money supply growth	8,424	-12.39	70.58	-351.28	122.67
Production growth	8,424	1.98	5.49	-22.38	37.31
Current account to GDP	8,424	0.05	0.08	-0.09	0.51
Log PPP	8,424	1.89	2.24	-2.25	8.47
FX reserves to imports	8,424	0.84	0.75	0.09	5.18
Gross assets and liabilities to GDP	8,424	3.71	4.84	0.54	29.93
CBOE Volatility Index:					
Level (VIX)	8,424	0	1	-1.14	4.85
Changes (ΔVIX)	8,385	0.0003	0.62	-2.31	2.53

Table 10: Regression of spot changes and excess returns on the intermediary constraints index. This table presents results for panel regressions of monthly spot exchange rate returns Δs_{it} and monthly currency excess returns rx_{it} on changes in the intermediary constraints index, one-year lagged NFA to GDP, an interaction term between both variables, and controls. Exchange rates and returns are reported in US dollar. Foreign exchange data are monthly for 39 countries from January 2004 to December 2021. Robust standard errors are clustered by currency and month. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	Δs_{it}	Δs_{it}	Δs_{it}	Δs_{it}	Δs_{it}	rx_{it}	rx_{it}	rx_{it}	rx_{it}	rx_{it}
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$\Delta IntCon$	-2.93***	-3.50***	-3.29***	-3.51***	-3.04***	-2.89***	-3.53***	-3.25***	-3.45***	-3.00***
	(0.84)	(0.60)	(0.73)	(0.81)	(0.83)	(0.85)	(0.60)	(0.74)	(0.82)	(0.85)
NFA/GDP		0.06	0.15*	0.16***	0.16***		-0.01	0.12*	0.14***	0.13***
		(0.07)	(0.08)	(0.06)	(0.05)		(0.06)	(0.07)	(0.05)	(0.05)
$\Delta IntCon \times$ NFA/GDP		0.99***	1.00***	1.01***	1.03***		0.98***	0.99***	1.01***	1.02***
		(0.25)	(0.25)	(0.24)	(0.25)		(0.24)	(0.24)	(0.24)	(0.24)
$\pi_i - \pi_{US}$			0.03	0.03	0.02			0.04*	0.05**	0.04**
			(0.03)	(0.02)	(0.02)			(0.02)	(0.02)	(0.02)
$i_i - i_{US}$			-0.04	-0.01	0.01			0.06*	0.08***	0.10***
			(0.04)	(0.03)	(0.02)			(0.04)	(0.03)	(0.02)
$\Delta\text{stock}_i - \Delta\text{SP500}$			4.38**	4.25**	4.61**			3.94**	3.71**	4.02**
			(1.75)	(1.73)	(1.71)			(1.78)	(1.75)	(1.72)
$\Delta\text{M1}_i - \Delta\text{M1}_{US}$			-0.00	-0.00	0.00			-0.00	-0.00	-0.00
			(0.00)	(0.00)	(0.00)			(0.00)	(0.00)	(0.00)
$\Delta\text{production}_i - \Delta\text{production}_{US}$			0.02*	0.01	0.02*			0.02*	0.01	0.01
			(0.01)	(0.01)	(0.01)			(0.01)	(0.01)	(0.01)
ppp_i			-0.50	-0.08	-0.09			-0.29	0.20	0.20
			(0.41)	(0.34)	(0.32)			(0.42)	(0.33)	(0.33)
$\text{CA}_i - \text{CA}_{US}$			2.66*	0.90	1.07			2.66**	0.80	0.91
			(1.42)	(1.11)	(1.16)			(1.26)	(0.88)	(0.93)
Crisis			-1.09	-1.39	0.62			-1.29	-1.47	0.56
			(2.25)	(2.32)	(1.62)			(2.31)	(2.39)	(1.66)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	No	No	Yes	No	No	No	No	Yes	No
Quarter FE	Yes	No	No	No	Yes	Yes	No	No	No	Yes
Controls	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Num. obs.	8,385	8,385	8,385	8,385	8,385	8,316	8,316	8,316	8,316	8,316
R^2	0.17	0.08	0.09	0.11	0.17	0.17	0.08	0.09	0.11	0.17

Table 11: Regression of spot changes on the intermediary constraints index by country and crisis sample. This table presents results for panel regressions of monthly spot exchange rate returns Δs_{it} on changes in the intermediary constraints index, one-year lagged NFA to GDP, an interaction term between both variables, and controls. The results are presented for four individual subsamples splitting the full sample in currencies of (1) emerging and developing markets (EME) and (2) developed countries (G10) and (3) crisis period (January 2004 to September 2008) and (4) post-crisis period (October 2008 to December 2021). Exchange rates and returns are reported in US dollar. Foreign exchange data are monthly for 39 countries from January 2004 to December 2021. Robust standard errors are clustered by country and month. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	Δs_{it}	Δs_{it}	Δs_{it}	Δs_{it}
	(1)	(2)	(3)	(4)
	EME	G10	Crisis	Post-crisis
$\Delta IntCon$	-2.91***	-3.57**	-1.89**	-3.19***
	(0.76)	(1.26)	(0.76)	(0.96)
NFA/GDP	0.17**	0.01	1.14	0.16**
	(0.06)	(0.22)	(1.06)	(0.07)
$\Delta IntCon \times$ NFA/GDP	1.00***	1.34	1.03***	1.06***
	(0.23)	(1.31)	(0.29)	(0.27)
Country FE	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Num. obs.	6,235	2,150	2,184	6,201
R^2	0.16	0.27	0.19	0.18

Table 12: Regression of spot changes on intermediary constraints indices by asset class. This table presents results for panel regressions of monthly spot exchange rate returns Δs_{it} on changes in the intermediary constraints index, one-year lagged different types of NFA classes (portfolio equity, FDI, debt (portfolio debt and other debt investments)) to GDP, and an interaction term between both variables. Exchange rates and returns are reported in US dollar. Foreign exchange data are monthly for 39 countries from January 2004 to December 2021. Robust standard errors are clustered by country and month. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	Δs_{it}	Δs_{it}	Δs_{it}	Δs_{it}
	(1) Equity	(2) FDI	(3) Debt	(4) All
$\Delta IntCon$	-2.97***	-2.87***	-2.88***	-2.93***
	(0.84)	(0.84)	(0.82)	(0.83)
Net portfolio equity/GDP	0.13*			0.10
	(0.08)			(0.09)
$\Delta IntCon$ × Net portfolio equity/GDP	0.76			-1.39*
	(0.93)			(0.71)
Net FDI/GDP		0.21*		0.11
		(0.12)		(0.09)
$\Delta IntCon$ × Net FDI/GDP		0.33		-0.60
		(1.03)		(0.99)
Net debt/GDP			0.20	
			(0.15)	
$\Delta IntCon$ × Net debt/GDP			1.97***	
			(0.43)	
Net portfolio debt/GDP				-0.01
				(0.18)
$\Delta IntCon$ × Net portfolio debt/GDP				2.63***
				(0.53)
Net other debt/GDP				0.17
				(0.22)
$\Delta IntCon$ × Net other debt/GDP				2.06
				(1.36)
Country FE	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Num. obs.	8,385	8,385	8,385	8,385
R^2	0.17	0.17	0.18	0.18

Table 13: Regression of spot changes on the intermediary constraints index by FX reserves and financial openness. This table presents results for panel regressions of monthly spot exchange rate returns Δs_{it} on changes in the intermediary constraints index, one-year lagged NFA to GDP, an interaction term between both variables, and controls. The results are presented for four individual subsamples splitting the full sample in currencies of countries with (1) FX reserves relative to imports below the median (2) FX reserves relative to imports above the median (3) sum of gross foreign assets and liabilities relative to GDP below the median (4) sum of gross foreign assets and liabilities relative to GDP above the median. Exchange rates and returns are reported in US dollar. Foreign exchange data are monthly for 39 countries from January 2004 to December 2021. Robust standard errors are clustered by country and month. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	Δs_{it}	Δs_{it}	Δs_{it}	Δs_{it}
	(1)	(2)	(3)	(4)
	FX Reserves		Financial openness	
	Low	High	Low	High
$\Delta IntCon$	-3.46***	-2.49***	-2.47***	-3.34***
	(1.01)	(0.70)	(0.81)	(0.93)
NFA/GDP	0.35	0.18***	0.71	0.11***
	(0.31)	(0.05)	(0.57)	(0.04)
$\Delta IntCon \times$ NFA/GDP	1.09**	0.77***	2.17	1.02***
	(0.42)	(0.25)	(1.28)	(0.22)
Country FE	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Num. obs.	4,192	4,193	4,186	4,199
R^2	0.19	0.18	0.17	0.20

Table 14: Regression of spot changes on VIX index and intermediary constraints index. This table presents results for panel regressions of monthly spot exchange rate returns Δs_{it} on changes in the VIX index (and the intermediary constraints index), one-year lagged NFA to GDP, and an interaction term between both variables. Exchange rates and returns are reported in US dollar. Foreign exchange data are monthly for 39 countries from January 2004 to December 2021. Robust standard errors are clustered by country and month. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	Δs_{it}	Δs_{it}
	(1)	(2)
	VIX	VIX & IntCon
Δ VIX	-1.54***	-1.30***
	(0.25)	(0.24)
NFA/GDP	0.15*	0.15**
	(0.07)	(0.07)
Δ VIX × NFA/GDP	0.34***	0.25**
	(0.11)	(0.09)
$\Delta IntCon$		-2.27***
		(0.61)
$\Delta IntCon$ × NFA/GDP		0.75***
		(0.18)
Country FE	Yes	Yes
Year FE	Yes	Yes
Controls	Yes	Yes
Num. obs.	8,385	8,385
R^2	0.15	0.17

Table 15: Regression of spot changes on alternative intermediary constraints indices. This table presents results for panel regressions of monthly spot exchange rate returns Δs_{it} on changes in the intermediary constraints index with different weightings and compositions, one-year lagged NFA to GDP, and an interaction term between both variables. Exchange rates and returns are reported in US dollar. Foreign exchange data are monthly for 39 countries from January 2004 to December 2021. Robust standard errors are clustered by country and month. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	Δs_{it}	Δs_{it}	Δs_{it}	Δs_{it}	Δs_{it}
	(1) Market share	(2) Total assets	(3) Top 17	(4) Top 3	(5) HKM
$\Delta IntCon$	-2.88***	-3.01***	-3.04***	-1.38	-4.40***
	(0.90)	(0.73)	(0.79)	(1.02)	(0.70)
NFA/GDP	0.15***	0.14**	0.14**	0.15***	0.17***
	(0.05)	(0.05)	(0.05)	(0.05)	(0.06)
$\Delta IntCon \times$ NFA/GDP	1.11***	1.07***	1.04***	0.83***	0.82***
	(0.29)	(0.25)	(0.24)	(0.25)	(0.25)
Country FE	Yes	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes
Num. obs.	8,385	8,385	8,385	8,385	8,385
R^2	0.17	0.18	0.18	0.15	0.20

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A Internet Appendix

Internet Appendix for

FX Dealer Constraints and External Imbalances

January 2025

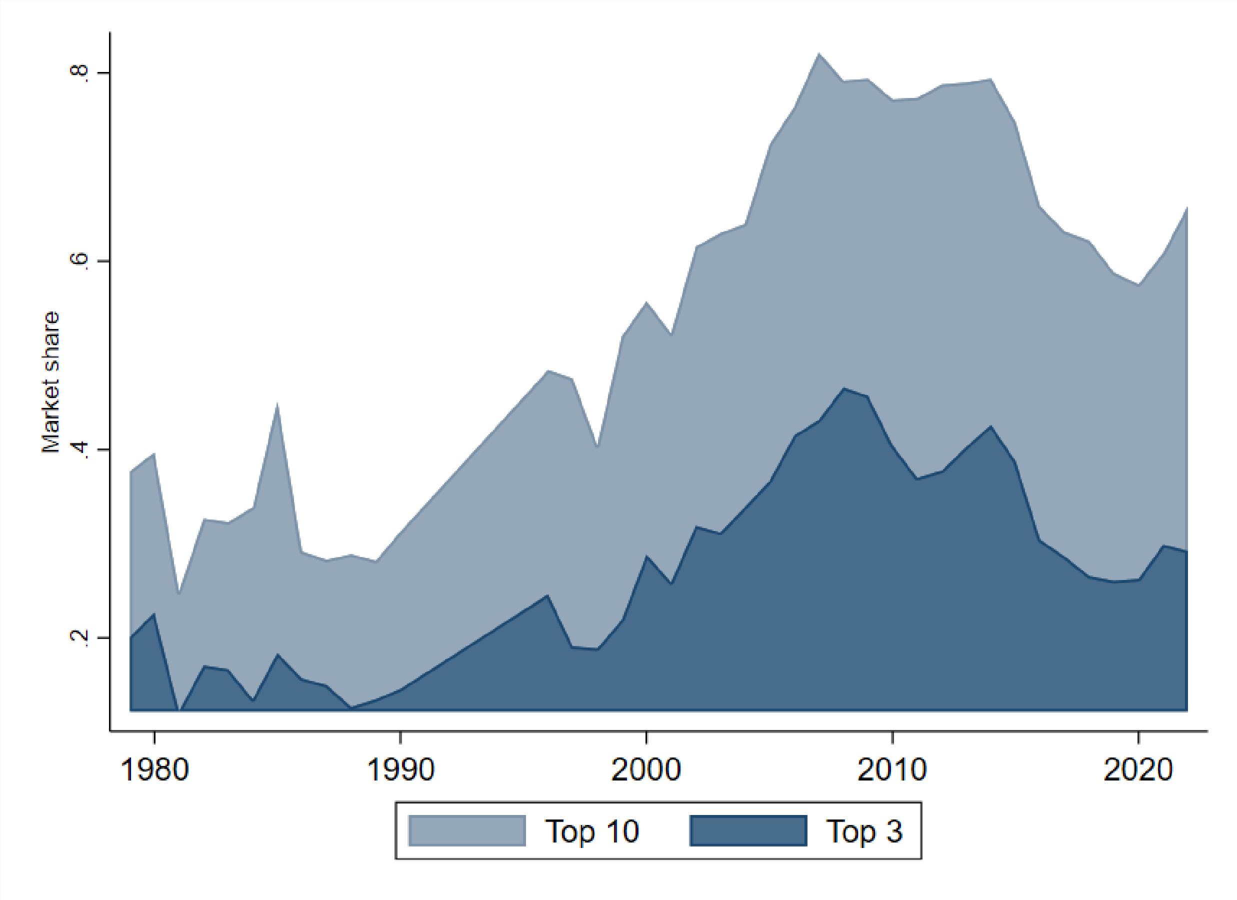

Figure A.1: Time-series of market shares. This figure shows the aggregated market shares of the top 10 and top 3 FX dealer banks from the Euromoney FX surveys for the years 1979 to 2022.

Table A.1: Top 10 FX dealer banks. This table shows the FX dealer banks that are ranked at least once top 10 in the years 1979 to 2022 from the Euromoney FX surveys. The ranking excludes any non-bank financial liquidity providers (i.e., XTX or Jump Trading), which are privately held companies.

ABN	Chemical	HSBC	RBC
ABN Amro	Citi Bank	IBJ	RBS
ANZ	Commonwealth Bank	JP Morgan	SBC
Bank of America	Credit Suisse	JP Morgan Chase	SEB
Bank of Montreal	Dai-Ichi Kangyo	Llyods	Standard Chartered
Bank of New York Mellon	Deutsche Bank	Manufacturers Hanover	State Street
Bankers Trust	First Chicago	Merrill Lynch	UBS
Barclays	Goldman Sachs	Morgan Stanley	WestPac
BNP Paribas	Harris	National Australia	
Chase Manhattan	Hong Kong Bank	NatWest	

Table A.2: Definition and data sources of controls. This table reports in the first column the used control variables in the empirical analysis. The second column specifies the calculation, while the third column reports sources of the data.

Variable	Definition	Source
Inflation	Inflation differentials between country i and the US ($\pi_{it} - \pi_{USt}$) are the differences in monthly year-over-year percentage changes in CPI.	IMF (IFS)
Interest rates	Interest rate differentials between country i and the US ($i_{it} - i_{USt}$) are the differences in monthly immediate interbank rates (3-month interbank rates).	OECD (MEI) and central banks of non-OECD countries (Datastream)
Stock market	Stock market performance of country i versus the US ($\Delta\text{stock}_{it} - \Delta\text{SP500}_t$) is the difference in log changes of local stock market index and the S&P500 index.	OECD (MEI) and local stock market indices of non-OECD countries (Datastream)
Monetary policy	Monetary policy of country i versus the US ($\Delta\text{M1}_{it} - \Delta\text{M1}_{USt}$) is the difference in quarterly year-over-year percentage changes in money supply M1.	Datastream
Production	Economy activity of country i versus the US ($\Delta\text{production}_{it} - \Delta\text{production}_{USt}$) is the difference in quarterly year-over-year percentage changes in the industrial production index.	IMF (IFS)
PPP	Relative purchasing power parity (ppp_{it}) of country i is the annual log implied PPP conversion rate of national currency per US dollar.	IMF (WEO)
Current account	Current account balance relative to GDP of country i versus the US ($\text{CA}_{it} - \text{CA}_{USt}$)	External wealth of nations database
Financial crisis	The crisis dummy (crisis_t) that takes the value of one between September and December 2008, and zero otherwise.	

Table A.3: FX Investment Strategies. This table describes the currency investment strategies that generate the currency portfolios (i.e., test assets) for the empirical analysis. The table provides information on strategy names, signals, and sorting.

Strategy name	Signal
Net Foreign Assets (NFA)	Following Della Corte et al. (2016), at the end of each month t, currencies are allocated into four imbalance portfolios according to countries' net foreign assets (NFA) relative to countries' gross domestic product (GDP), both denominated in US dollar, multiplied by -1. The first portfolio (IMB1) collects currencies of creditor countries, i.e., those with the highest NFA to GDP ratios. The last portfolio (IMB4) collects currencies of debtor countries, i.e., those with the lowest NFA to GDP ratios. Portfolios are rebalanced monthly.
Carry	At the end of each month t, currencies are allocated to four portfolios according to their forward discounts $fd_{it+1} = f_{it} - s_{it}$, where f_{it} and s_{it} are log forward and spot exchange rates of foreign currency i, respectively (Lustig et al., 2011; Menkhoff et al., 2012a). The first portfolio (CT1) contains currencies with the lowest forward discounts and the last portfolio (CT4) contains currencies with the highest forward discounts. Therefore, CT1 (CT4) collects the currencies with the lowest (highest) interest rate differential relative to the US, assuming that CIP holds. The portfolios are rebalanced monthly.
Momentum	Following Menkhoff et al. (2012b) and Asness et al. (2013), at the end of each month t, we build portfolios based on currency excess returns realized over the previous m months, i.e., the formation period. In short-term momentum with a one-month formation period ($m = 1$), for each foreign currency i, the sorting variable (signal) is the previous month currency excess return, rx_{t-1}. While the first portfolio ($MOM_1 1$) contains the currencies with the lowest previous-month excess returns (i.e., the loser currencies over that period), the last portfolio ($MOM_1 4$) contains the currencies with the highest previous-month excess returns (i.e., the winner currencies over that period). Portfolios are rebalanced monthly.
Value	At the end of each month t, currencies are allocated into portfolios based on the lagged real exchange rate (Menkhoff et al., 2017; Asness et al., 2013). Real exchange rates are nominal exchange rates divided by purchasing power parity (PPP) conversion factors from the OECD. The real exchange rates are in terms of foreign currency units per unit of US dollar. A value greater (smaller) one implies an undervaluation (overvaluation) of the foreign currency. The first portfolio (VAL1) contains the over-valued (strong real exchange rates) currencies with respect to PPP and the last portfolio (VAL4) contains under-valued currencies (weak real exchange rates).