Dealer Leverage and Exchange Rates: Heterogeneity Across Intermediaries*

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Abstract

We find that the leverage of primary dealers has predictive power in forecasting exchange rates. Unlike previous studies, we show that dealer heterogeneity matters, conflicting with an assumption of homogeneity implicit in most intermediary asset pricing models. The leverage of foreign-headquartered dealers in the U.S. drives the predictive power on exchange rates, while it is insignificant for U.S.-headquartered dealers. This heterogeneity can be explained by the regulatory constraints of foreign dealers compared to domestic dealers. Additionally, we document that currency market positions are stronger than cross-border lending as the channel through which leverage affects exchange rates.

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1 Introduction

A growing literature on financial intermediaries' role in asset pricing has noted the correlations and predictive power of these intermediaries' positions on various asset prices (Etula, 2013; He et al., 2017; Adrian et al., 2014; Haddad and Muir, 2018; Adrian et al., 2015), and has proposed theories to explain these relationships (Danielsson et al., 2011; Adrian et al., 2016; He and Krishnamurthy, 2013; He et al., 2017). In line with this literature, we find that the changes in leverage of primary dealers have predictive power in forecasting exchange rates.[1] However, we find that this predictive power varies considerably across financial intermediaries and across time, leading us to hypothesize that bank regulations (Du et al., 2018b; Cenedese et al., 2019), and the changing structure of foreign exchange markets (BIS Markets Committee, 2011) may play a role.

In this context, assessing the predictive power of financial intermediaries' leverage on exchange rates may provide some information about the importance of these institutions in financial markets. As the structure of these markets evolves over time, new entrants may displace dealer banks, including primary dealers, from their critical role as marginal buyers and sellers. When this happens, the predictive power of dealers' balance sheets on exchange rates may decrease. Relatedly, financial intermediaries' role in these markets may be transformed by the introduction of new regulations that may change the intensity in which these institutions participate as arbitrageurs.

By analyzing the heterogenous effect of financial intermediaries on exchange rates, we

[1] In this context, the change in leverage is defined as the change in the ratio of assets to net worth, which we proxy by the change in short-term borrowing.

contribute to the emerging literature on the role of intermediaries in asset pricing. In particular, our tests provide information on when and why financial intermediaries may be important for exchange rate determination and how other factors may impair that relation. We empirically test the following questions. What drives the predictability of exchange rates in relation to financial intermediaries' balance sheet capacity? Is there some heterogeneity in the impact of intermediaries on exchange rates? How does regulation affect this impact?

Regarding the first question, there are several channels through which financial intermediaries may affect exchange rates. Demand factors, such as a change in non-financial agents demand for dollars, may drive intermediaries' balance sheets and also exchange rates. A supply driven channel could work through changes in intermediary risk "appetite" (as described in Danielsson et al. (2011); Adrian et al. (2016)) or monetary policy Adrian and Shin (2010); Malamud and Shrimpf (2018), which would lead to increased leverage and increased positions involving foreign currency and foreign lending, a compressed foreign risk premia, and thus lower expected foreign currency returns. The channel described in Gabaix and Maggiori (2015), involves investors' demand for currencies, but also intermediaries' willingness to absorb those imbalances by acting as counterparties on these transactions. Disruptions in financial intermediaries' risk-bearing capacity changes that willingness, and therefore affects expected future currency returns. Understanding the channels through which changes in leverage are associated with exchange rates allows us to better evaluate these channels.

Regardless of whether demand-driven or supply-driven channels are at play, financial intermediary balance sheet constraints are key to their role in asset pricing. Changes in the risk-bearing capacity of intermediaries, who are the marginal buyers (either for themselves

or on behalf of ultimate investors) in specialized markets such as foreign exchange derivatives, may produce an amplification of shocks through their balance sheet capacity, which in turn drives movements in asset prices. However, based on our finding of heterogeneity, we argue that not all intermediaries are created equal in regards to their balance sheet constraints. While some studies (Adrian et al., 2010; He et al., 2017) argue that market-based intermediaries such as broker-dealers are the relevant intermediaries for asset pricing and predicting real economic activity, these papers largely either don't address heterogeneity within those market-based financial intermediaries or note that heterogeneity is not material for the overall predictive power because it is large intermediaries that matter. In contrast, we find substantial heterogeneity even among large broker-dealers, and document that regulation may be affecting the extent to which micro-founded constraints, such as Value-at-Risk (VaR), are the binding constraint across intermediaries and over time (Adrian and Shin, 2010).

To focus on the heterogeneity of financial intermediaries, we use information for primary dealers, which, as noted by He et al. (2017), are some of the most relevant participants in financial markets. [2] The assumption is that these primary dealers are likely to be the marginal buyers in these markets, thus, their book leverage or net worth should matter for the pricing of these securities. However, we argue that even these primary dealers may face regulatory capital constraints that are binding and limit their ability to play the role of marginal participants in asset markets at different points in time. The simplest way to

[2]Primary dealers are a subset of the universe of broker-dealers; they are the designated market makers for U.S. Treasury securities. About half of the primary dealers have parents that are headquartered outside the United States.

assess whether regulatory constraints are binding is to compare the importance of balance sheet changes (either leverage (Adrian et al., 2016) or net worth (He et al., 2017)) for asset pricing in two groups of primary dealers that are faced with different regulatory requirements across time: U.S.-headquartered and foreign-headquartered primary dealers. As discussed in Tarullo (2014), the consolidated regulatory and supervisory framework in the period before the global financial crisis did not address the buildup in vulnerabilities of foreign banking organizations (FBOs) generally and, in the United States specifically, of broker-dealers that were unaffiliated with U.S. bank holding companies, including primary dealers affiliated with FBOs. This regulatory gap may have given these intermediaries room to actively participate in many markets as marginal buyers, until new regulations were imposed under the Basel III agreement (Du et al., 2018b). Regulatory frameworks also have differed across countries even under the Basel framework (Arteta et al., 2019), with intermediaries headquartered outside the U.S. facing less stringent requirements. This may have given foreign primary dealers the capacity to behave in a way similar to that modeled in the traditional financial intermediary models, while U.S. primary dealers were constrained by regulations and did not fit the traditional financial frictions setup. This testable implication may be relevant to determine how net worth (or leverage) should be aggregated to deal with heterogeneous primary dealers and their impact on asset prices.

We test our questions with a few novel datasets. First, in our main tests, broker-dealer leverage is measured by using short-term borrowing and lending information from the oft-used Federal Reserve Bank of New York Government Securities Dealers Reports. In contrast to previous studies, we use microdata to separate U.S.-headquartered and foreign-

headquartered primary dealers. Second, to better understand the channels, we complement that analysis with intermediaries' positions in spot, swaps, futures, and derivatives currency markets from the Treasury Foreign Currency (TFC) data. These data capture the aggregate notional amounts of contracts purchased and sold by individual institutions on a weekly basis, and disaggregated by contract type on a monthly or quarterly frequency. Lastly, we use monthly bank-level cross-border lending positions from the Treasury International Capital (TIC) banking data to assess the impact of financial intermediaries' cross-border positions on exchange rates.

Our most salient finding is that the leverage of foreign-headquartered primary dealers in the United States drives the predictive power for exchange rates. In contrast, the positions of domestic U.S.-headquartered primary dealers have little or no robust predictive power for exchange rates. This result is not driven by correlations during the crisis nor by contemporaneous valuation effects of exchange rates on the measure of leverage for foreign dealers. While this paper focuses on exchange rates, we also present results that show more predictive power for foreign dealer leverage (relative to U.S.-headquartered dealer leverage) for portfolio returns of some other assets as well. These results conflicts with an assumption of homogeneity among intermediaries which, as noted in He et al. (2017), is implicit in most modern intermediary asset pricing models (with Ma (2019) being an exception). It also suggests that empirical results using aggregate data could, in some cases, obscure underlying relationships. Importantly, we also find that currency market positions, including derivatives positions, are likely stronger than cross-border lending as the main channel through which leverage manifests itself in exchange rate changes.

Focusing on the details, in our first set of tests we use a common asset pricing equation to regress 1-month changes in dollar-foreign currency exchange rate pairs (or alternately, excess returns) on lagged primary dealer leverage, measured as the log change of short-term funding positions. [3] We find that primary dealer borrowing significantly forecasts dollar appreciation (or foreign currency depreciation) for a wide range of dollar-foreign currency pairs.[4] Changes in primary dealer short-term *asset* positions similarly forecast dollar appreciation, suggesting that the explanatory power lies with the grossing up and down of dealer balance sheets, i.e. leverage. In particular, it is the foreign primary dealers in the U.S. whose leverage predicts dollar appreciation, as opposed to the U.S. domestic primary dealers. Our results are also economically important, as we find that a 10 percent change in short-term borrowing is associated with a roughly 1 percent 1-month appreciation in the dollar. [5] Further, replicating the He et al. (2017) capital risk factor using the consolidated balance sheets of primary dealers' bank holding companies (BHCs), we also find substantial differences for foreign versus domestic BHCs, with predictive power and theoretical consistency for foreign BHCs. We argue that these heterogeneous results for foreign and domestic dealers could be explained by foreign dealers having more balance sheet capacity relative to domestic dealers during the 2000s, perhaps due to difference in regulatory restrictions.[6]

Next, we examine the association between intermediary leverage, currency market positions of intermediaries, and exchange rates. We find that changes in leverage are positively

[3]We cannot use a true leverage measure, such as broker-dealer sector leverage from the Flow of Funds, because such data are not available separated by foreign and domestic headquartered broker-dealers.
[4]The direction of this prediction is consistent with Adrian et al. (2011) and related literature.
[5]The average (absolute value) 1-month change in foreign dealer borrowing is around 6 percent and the average 1-month exchange rate change is around 2 percent.
[6]We also replicate the predictive regressions reported in He et al. (2017) and find that the heterogeneous relation between primary dealer leverage and asset returns applies to asset classes beyond exchange rates.

and significantly associated with changes in currency market positions for foreign intermediaries in the United States, much less so for domestic intermediaries. On average, a 1 percent change in foreign dealer leverage is associated with a little more than 1 percent change in notional amount of USD and foreign currency swaps (including all forward and spot contracts) by foreign BHCs, and about $\frac{1}{2}$ to $\frac{3}{4}$ of a percent change in notional USD and foreign currency options contracts. Also, changes in some currency positions (both long dollar and short dollar positions) significantly predict dollar appreciation, again more so for positions of foreign than domestic intermediaries. These results could be associated with the structure of the foreign exchange market, where financial intermediaries play an important role. As financial constraints on these financial intermediaries loosen, they may increase their leverage and at the same time, sell FX protection against certain states of the world. This may in turn affect risk premia and exchange rates (Malamud and Shrimpf, 2018; Gabaix and Maggiori, 2015).

Finally, we find that total cross-border lending of foreign dealers (but not domestic dealers or foreign or domestic commercial banks) does significantly forecast dollar appreciation, which could lend credence to a cross-border lending channel. However, this relationship is smaller in size and less significant than that between leverage and exchange rates and the significance of USD-denominated cross-border lending is primary due to lending to the United Kingdom, which is a hub for global currency markets. Thus, cross-border lending as typically conceived (bank loans to nonfinancial businesses, either directly or on-lent through banks located abroad) has little support as the primary empirical channel between leverage and exchange rates.

2 Literature

While there is a large and diverse body of literature devoted to exchange rate forecasting,[7] our paper mainly draws insights from the burgeoning literature on intermediary asset pricing models to assess the testable implications of the proposed theories. The basic premise of these models is that financial intermediaries, rather than households, are the marginal investors determining asset prices. In particular, our paper draws on models of balance sheet capacity, such as Danielsson et al. (2011), which ties intermediary leverage to risk premia and thus, future expected returns on assets.

However, there are significant differences among the models in this relatively new literature, including some contradictory implications. He et al. (2017), referred to hereafter as HKM, and Adrian et al. (2016), both directly address alternate theories.[8] For example, these models disagree on whether net worth or leverage is the more appropriate measure of the risk-taking capacity of financial intermediaries, whether intermediary leverage is procyclical or countercyclical, and whether the leverage price of risk is positive or negative.[9] Our findings suggest that the aggregation of intermediaries depending on regulatory constraints, and the timing of the sample as regulations change, could affect the sign of results. The models, of course, are necessarily simplifications and, as noted in HKM, likely both debt and equity constraints affect intermediaries. The differences between foreign and domestic dealers may

[7] Rossi (2013) provides a summary; more recently, Calomiris and Mamaysky (2019) briefly outline different approaches and provide a list of more recent references

[8] Related papers behind these differences include He and Krishnamurthy (2013) and Brunnermeier and Sannikov (2014), focusing on equity constraints, and Brunnermeier and Pedersen (2009), Adrian et al. (2014), Adrian and Shin (2013), and Danielsson et al. (2011), focusing on debt constraints and leverage.

[9] Adrian et al. (2016) finds a positive leverage price of risk whereas HKM finds a positive equity price of risk, the inverse of leverage.

prove a valuable lever with which to better understand these constraints.

Our paper provides new empirical facts against which competing models can be evaluated, along the lines of other empirical studies in this literature. Several recent papers have established the relevance of intermediary positions for pricing a variety of assets. Etula (2013) shows that broker-dealer leverage, translated into effective risk aversion, can predict commodity prices. Adrian et al. (2014) calculate a stochastic discount factor from broker-dealer leverage shocks to price equity and Treasury bond portfolios and similarly, Adrian et al. (2016) use dealer leverage to price equity and bond portfolios. HKM use dealer capital ratio shocks to argue that intermediaries, such as dealers, are the marginal pricers across a range of assets, including foreign currencies. Adrian et al. (2011) show that excess volatility in foreign exchange risk premium is associated with balance sheet funding liquidity. Finally, the most similar paper to ours, Adrian et al. (2015) find that short-term wholesale borrowing predicts exchange rates.

Our primary contribution in this literature is the heterogeneity between domestic and foreign dealers. Papers that use dealer leverage to price assets rely on changes in balance sheet constraints over time, but do not consider differences in balance sheet constraints among dealers. An exception is HKM, who compare the asset pricing performance for primary dealer versus non-primary dealer capital ratios. They find that primary dealers are special, but argue that this is because they are large and substantially active across a wide range of assets, in contrast to much smaller non-primary dealers. However, we find that, even among primary dealers, balance sheet positions for domestic and foreign primary dealers load differently on exchange rates, which adds another dimension to the effect of

heterogeneous financial intermediaries' balance sheet constraints on asset prices.

Our paper also differs from the most closely related paper, Adrian et al. (2015), in a few ways, both conceptual and methodological, aside from our heterogeneity finding. First, our specifications use first differences rather than linear detrending to avoid nonstationarity in our regressors and of course we are able to extend our sample to 2018. While they find inconsistent results with dealer borrowing in the form of repos and stronger results with bank borrowing in the form of commercial paper, we find the opposite: strong results for dealer repo borrowing and insignificant results for commercial paper. Our results highlighting the dealer leverage measure (repo borrowing) is consistent with other Adrian et al. studies (such as Adrian et al. (2016)) that focus on dealers and not commercial banks (who fund with commercial paper) as key intermediaries for pricing. Second, we can explain the post-crisis changes in the leverage/exchange rate relationship, which Adrian et al. (2015) note, but do not explain. Finally, we use additional data sources to explore the channel linking dealer leverage and exchange rates.

3 Data

3.1 Short-term borrowing and lending of primary dealers

Ideally, we'd want to use the leverage of primary dealers as our key independent variable. However, given that most primary dealers are subsidiaries of large holding companies that also contain large commercial banks, only consolidated balance sheet data are available for research. While the intermediary asset pricing literature often broadly refers to banks as

intermediaries, some papers, including HKM, argue that primary dealers in particular are perfect candidates for intermediaries that act as marginal investors because they tend to be the largest and most active dealer banks across a range of financial markets.[10] Therefore, we use the short-term funding of primary dealers as a proxy for dealer leverage. Adrian et al. (2015), as well as others, argue that short-term funding of dealers is a good proxy for their leverage, as repurchase agreements and securities lending are a large portion of their balance sheet and such short-term instruments are the easiest to use to move leverage up and down.

For our main regressions we use the weekly report of dealer financing (FR 2004C) from the FRBNY Government Securities Dealer Reports for 2001-2018:Q3. These data provide primary dealers' repurchase agreements (repo) and securities lent, on the funding side of dealers' balance sheets, and reverse repo and securities borrowed, on the asset side. The survey separates positions by three maturity categories (overnight and continuing, term less than 30 days, term 30+ days) and by the type of underlying security. In addition to the aggregate data, which are available publically, we use the confidential microdata to separate the reporters into foreign-headquartered and domestic U.S.-headquartered based on the nationality of the ultimate parent company.[11] As shown in Table 1, the mean and standard deviation over the sample of aggregate borrowing and lending for the two groups are similar. The trends over time for the two groups are also broadly similar (Figure 1).

Comparing these primary dealer repo data (also used by Adrian et al. (2015)) with Flow of Funds data on dealer repos and leverage (used by Adrian et al. (2016)), shows that

[10] Although HKM do argue that consolidated balance sheet data should be used, our evidence on the predictive power of dealer repos but not bank-issued CP and also dealer cross-border lending but not bank cross-border lending suggests that we want to focus on the balance sheet of the dealer subsidiary.

[11] Legal structure data on financial intermediaries is available on the National Information Center (NIC) website.

changes in primary dealer repos are highly correlated with changes in overall dealer sector repos (70% correlation) and also dealer sector leverage (see Figure 2; 67% correlation).

3.2 Exchange rates

Our dependent variable for the majority of regressions throughout the paper is the 1-month percentage change in the spot exchange rate for each of 23 bilateral dollar foreign-currency pairs (or alternately, the excess returns for these currencies), including 9 advanced country currencies and 14 emerging market currencies. The complete list of currency pairs is included in Table 5. The average monthly return over the sample and across all currency pairs is approximately zero (see Table 1), consistent with the fact that the broad dollar at the end of the sample, in 2018, stands roughly at the same level it was in 2001, at the beginning of our sample.

3.3 Currency market position data

We investigate the channel linking dealer leverage and exchange rates using the Treasury Foreign Currency (TFC) data, also called the Consolidated Foreign Currency Report of Major Market Participants.[12] These data collect notional amounts of foreign exchange contracts outstanding, including unsettled spot, forward, and swap contracts, futures contracts on organized exchanges, and options contracts. The report separates amounts into contracts purchased and contracts sold (by contract type for monthly and quarterly data; weekly data collects only total contracts purchased and total contracts sold). Both sides of a foreign

[12]These data are published in the quarterly Treasury Bulletin.

exchange transaction is reported. For example, a purchase of dollars against a sale of euros would be reported under both dollar contracts (measured in dollars) and euro contracts (measured in euros). The mean values for these data are reported in Table 2. Not surprisingly, the largest positions are in swaps (or spot and forwards), and the value of U.S. dollar contracts far exceeds that of any single other currency (once units are converted to the same currency), followed by euro and yen.

These data capture only major market participants, with weekly and monthly reporting by reporters that meet a threshold of $50 billion notional in contracts.[13] While the reporting panel theoretically includes any type of entity, the high threshold suggests that large financial intermediaries likely dominate the data, thus likely overlapping significantly with the primary dealer panel. We use microdata to separate the reporting panel into entities with domestic and foreign ultimate parents.

3.4 Cross-border lending data

In section 6, we investigate the role of cross-border lending using the banking part of the Treasury International Capital (TIC) data, also known as TIC B form reports. These data are on a locational basis, which means they record any financial position between financial entities located in the United States and counterparties abroad (both claims and liabilities). Therefore, the reporters include the U.S. offices of U.S.-headquartered banks and broker-dealers, foreign bank branches, and foreign bank subsidiaries and broker-dealers (see Table 1 for summary statistics). The claims positions consist primarily of loans, including repos,

[13] Contracts are reported on a gross basis, even those with the same customer under netting agreements and those with affiliates. All reporters are located in the United States.

as well as small amounts of short-term securities, and therefore can be described as cross-border lending, including lending to non-banks as well as inter-bank and intra-bank lending.[14] Broker-dealers were added to this banking report starting in 2001 because of their substantial positons in cross-border repos.[15] Reporting is unconsolidated even among U.S.-located offices in that commercial banks and broker-dealers with the same parent bank holding company report separately.[16] As with the primary dealer data, we first show results using the aggregate data, which are public, and then use confidential microdata to separate broker-dealers from commercial banks and also domestic-headquartered from foreign-headquartered reporters.

4 Results

4.1 Primary dealer leverage and exchange rates

For our main regressions, we test the predictive power of the leverage of different groups of dealers using the following, commonly used, forecasting equation for exchange rates:

$$\Delta ExRate_{i,t} = \beta_0 + \beta_1 \Delta lnDealerSTBorr_{t-1} + \beta_2 RateDiff_{i,t-1} + \beta_3 X_{t-1} + \beta_4 X_{i,t-1} + \epsilon_t \quad (1)$$

[14] These data include both short-term positons, such as overnight repos and interbank loans, and medium-to-long term business loans.

[15] Since not all broker-dealers entered the TIC data in 2001, some enter in 2002 and 2003, we construct two alternate reporter panels, one containing dealer reporters as of March 2001 and a second containing dealer reporters as of February 2003. We aggregate the data for each of these reporter groups to get two alternative timeseries, each a consistent panel over time, for the aggregate dealer data. The results in Table 13 use the February 2003 panel of dealers. Using the March 2001 panel of foreign dealers instead would result in similar sized but statistically insignificant coefficients for foreign dealer claims in all columns of Table 13.

[16] Commercial banks report at the bank level, broker-dealers report for themselves, and bank holding companies report on behalf of any other non-bank, non-dealer entities within their legal structure.

where $\Delta ExRate_{i,t}$ is the 1-month percent change in the bilateral dollar-foreign currency exchange rate i at time t; $\Delta lnDealerSTBorr_{t-1}$, our leverage proxy, is the 1-month log change in overnight and continuing repos and securities lending of primary dealers at time $t-1$ (which we call short-term borrowing); $RateDiff_{i,t-1}$ is the differential between the Fed Funds rate and the short-term policy rate for the country of currency i; X_{t-1} is a set of controls at time $t-1$ that do not vary by currency; and finally $X_{i,t-1}$ is a set of controls at time $t-1$ that do vary by currency. The key variable in the specification equation, $\Delta lnDealerSTBorr_{t-1}$, represents the various aggregations we use for dealer short term borrowing: total, foreign dealer, domestic dealer, or both.

Table 3 shows the results of panel specification (1) where the currencies are pooled (results for each currency are discussed below). Panel regressions include currency fixed effects and cluster standard errors by month and currency.[17] The first column of Table 3 has only the control variables, including the interest rate differential. Controls that vary by currency are, first, the 1-year change in the differential of equity returns between the stock markets in the U.S. and the country of the currency and second, the lagged change in exchange rate.[18] Additional controls are the Fed Funds rate, the 1-month change in the Fed Funds rate, the VIX, the 1-month change in the VIX, and the log of the Federal Reserve's QE purchases (which are highly significant).[19] All control variables are first lags as noted in equation (1).

The second column adds our key variable, short-term borrowing of dealers, aggregating

[17] We use the estimator for multiple fixed effects and clusters of Correia (2017).

[18] Stock market indexes to calculate returns for each country come from Datastream.

[19] Results are similar using longer-term moving average of the VIX. Data on QE purchases comes from the Federal Reserve Board's H.4.1 release on the Fed's balance sheet, as the change in line item "Securities Held Outright". As a robustness check, we have also used Wu-Xia shadow rates when calculating the interest rate differential and excluded the QE purchases; results are similar.

all primary dealers (public data), as others in the literature might do. Dealer short-term borrowing is statistically significant, and improves the R2 from 0.03 to 0.06. The dependent variable is defined as the change in dollars per unit of foreign currency, thus a negative change indicates foreign currency deprecation, or dollar appreciation, with higher borrowing (i.e. leverage). This sign is consistent with Adrian et al. (2015) and other Adrian et al. papers.[20] Our primary contribution is shown in column 3, which separates the dealer data into short-term borrowing of foreign dealers and that of domestic dealers, including both in the regression (columns 4 and 5 show them separately). All of the negative and significant predictive power of dealer borrowing comes from the foreign dealer variable, with a similar size coefficient and more significance relative to the variable that includes all dealers.[21] Separating the dealer data into foreign and domestic dealers improves the R^2 from 0.06 to 0.08. The foreign dealer coefficient is economically meaningful, with a 10 percent change in short-term borrowing forecasting a little less than 1 percent 1-month depreciation of foreign currency (or appreciation in the dollar).[22,23] For reference, the average (absolute value) 1-

[20]The sign is negative here and positive in Adrian et al. (2015) for their change in exchange rate regressions because our exchange rate definition is the reverse of theirs. They reverse their signs to the same definition as ours when looking at excess returns, and get a negative coefficient.

[21]Note that this result does not come from a relationship between foreign dealers balance sheets and their home currencies. First, foreign dealers are headquartered in advanced countries covering just five currencies, while the effect holds for more than 20 currencies (see Table 5). Second, running the same regression but matching dealers to their home currencies (not shown) gives a coefficient on short-term borrowing of just -0.026, compared to -0.085 in the baseline result, and an R^2 below 0.04, compared to 0.08 in the baseline. Third, running a first stage regression of foreign primary dealer short-term borrowing on contemporaneous exchange rate changes, then using only the residual of foreign dealer borrowing as the predictor in our main specification, gives an almost identical coefficient on residual foreign dealer borrowing as on foreign dealer borrowing in the baseline. In addition, the result does not come from quarter-end effects; the result is similar after removing quarter-ends from the sample.

[22]Specifically, a 10 percent change in borrowing forecasts a 0.85 percent 1-month depreciation in our main specification and over 0.9 percent depreciation in some other specifications.

[23]Term repo and term securities lending positions, however, do not have the forecasting power shown by overnight and continuing positions. This is consistent with broker-dealers using primarily very short-term funding when levering up.

month change in foreign dealer borrowing is around 6 percent and the average 1-month exchange rate change is around 2 percent. Lastly, this result is not driven by extreme observations or correlations during the crisis, as shown in Figure 3a, which is discussed in section 4.3.

Finally, the last column of Table 3 adds the Treasury premium variable of Du et al. (2018a) as an explanatory variable, as suggested in a working paper by Engel and Wu (2019).[24] The Treasury premium is significant, but does not detract from the significance of the foreign dealer borrowing variable. We do not include this variable in our preferred specification because it is available for fewer emerging market currencies than our other data and therefore significantly reduces sample size.

Table 4 uses an alternative for the dependent variable: excess returns on bilateral currency pairs.

$$\Delta ExcessRet_{i,t} = \beta_0 + \beta_1 \Delta lnDealerSTBorr_{t-1} + \beta_3 X_{t-1} + \beta_4 X_{i,t-1} + \epsilon_t \tag{2}$$

Naturally, the interest rate differential and other short rate controls are excluded as they are incorporated in the dependent variable. Foreign currency excess returns are defined as the carry plus the foreign currency exchange rate return:

$$\Delta ExcessRet_{i,t} = (Rate_{i,t} - Rate_{U.S.,t}) + \Delta ExRate_{i,t} \tag{3}$$

[24]The Treasury premium is the deviation from covered interest parity between government bond yields in the U.S. and the relevant foreign country. We take this measure from the paper data provided on Du's website.

The same short-term rates are used as in specification (1). The results from specification (2) show similar size and significance for the dealer borrowing variables as specification (1).

Table 5 summarizes the results of separate regressions on each of the 23 dollar-foreign currency bilateral pairs, using Newey-West standard errors (see online appendix table OA1 for full results). The table indicates the significance level of the key variable in each bilateral regression, first for total primary dealer short-term borrowing in column 1, then for domestic dealer borrowing in column 2, and for foreign dealer borrowing in column 3. Only two of the bilateral pairs are predicted significantly by borrowing of domestic dealers and these have the opposite sign, whereas every pair is predicted significantly by foreign dealer borrowing and each one has a negative sign, as in the panel regression. These results substantially support the finding that the predictive power over the sample comes primarily from foreign dealers.

Foreign dealer borrowing also performs relatively well out of sample (not shown in tables), calculating an out-of-sample R^2 as $R^2 = 1 - \frac{(\Sigma_t(\hat{r}_{t+1|t} - r_{t+1})^2}{\Sigma_t(\bar{r}_t - r_{t+1})^2}$ (where $\hat{r}_{t+1|t}$) is the predicted 1-month change in exchange rate (or excess return) at $t+1$ given data as of date t, and r_t is the mean exchange rate change using historical data up through date t. Starting with 2 years of training data and expanding the sample each period, the average out-of-sample R^2 for our preferred specification (as in column 3 of Table 3) is 0.14 compared to 0.09 with only the controls (as in column 1 of Table 3).

Finally, to guage the time horizon of the effect of dealer leverage on exchange rates, we used a weekly version of specification (1) with additional lags of dealer leverage both as a single linear regression and using the linear local projection (LLP) approach, and also ran

a VAR with endogenous variables: the change in the Fed funds rate, the change in foreign dealer leverage, and the change in the broad dollar (in that order).[25] The impulse responses (shown in online appendix figures OA1 and OA2) suggest that the significant negative effect of dealer leverage on exchange rates lasts between one and two months, with the cumulative effect peaking around 5 or 6 weeks.

4.2 Alternative specifications

In Table 6, we explore some alternative explanatory variables to better understand the result. First, column 1 repeats the specification from Table 3, column 3, with both foreign and domestic dealer borrowing. The second column replaces this with foreign and domestic dealer short-term *lending* (specifically, overnight and continuing reverse repos and securities borrowing, which are assets). Similar to the results with dealer borrowing, foreign dealer lending is negative and significant while domestic dealer lending is positive and insignificant for predicting the percent change in exchange rates. The similar results for dealer short-term *assets* as for short-term borrowing suggests that it is the grossing up (or down) of short-term positions, i.e. leverage, that has predictive power.

The final two columns of Table 6 substitute the explanatory variable "change in financial CP outstanding" (short-term borrowing by banks) instead of dealer borrowing.[26] The last column separates CP by foreign and domestic issuance and separates domestic issuance into

[25]The broad dollar VAR also includes exogenous variables the VIX and the level of the Fed funds rate. Separate VARs for each exchange rate (not shown) using endogenous variables: the change in the policy rate differential, the change in foreign dealer leverage, and the change in the exchange rate, shows a significant response (at the 90% confidence interval) of the exchange rate to a dealer leverage shock for more than half of the 23 exchange rates.

[26]Data on weekly commercial paper (CP) outstanding is released by the Federal Reserve Board based on DTCC data.

that of foreign banks and U.S. entities. Contrary to Adrian et al. (2015), we generally do not find that CP significantly predicts exchange rates. Our specification in this table differs from theirs primarily in that they use linearly detrended CP outstanding, which is nonstationary, whereas we use first differences, and that our sample extends into more recent years.

Given that, generally speaking, dealers use repos for short-term wholesale funding whereas commercial banks typically use more CP for short-term wholesale funding, the difference in sign and significance between repo borrowing and CP borrowing also suggests that dealers more than commercial banks are responsible for the leverage/exchange rate association. This is consistent with papers in the literature, including Adrian et al. (2016) and HKM, that argue that dealers are the most relevant intermediaries for asset pricing.

Finally, Table 7 presents further evidence of robust heterogeneity between foreign and domestic intermediaries. Given the debate in the literature regarding which balance sheet measures are most relevant to intermediaries role in asset pricing, we replicate the "capital risk factor" —essentially a market-based capital ratio —from HKM using publically available data on the consolidated balance sheets of primary dealers.[27] We then calculate the capital risk factor separately for foreign and domestic BHCs. While the aggregate capital risk factor is insignificant for our specification (column 2), the foreign dealer capital risk factor is positive and significant whereas the domestic dealer capital risk factor is significantly negative or insignificant (columns 3-5).[28] Theoretically, the leverage (short-term borrowing)

[27]This measure is constructed with innovations to the capital ratio from an AR1, but is closely related to the change in the natural log of the capital ratio. We achieve a 97% correlation with the aggregate capital ratio series available on Manela's website.

[28]We replicated the capital ratio calculation from HKM as closely as possible. Using the capital ratios or capital risk factor supplied on Manela's website in our specification yields a small insignificant negative (not shown) rather than the small insignificant positive using our aggregate calculation, both statistically indistinguishable from zero.

variable (column 1) and capital risk factor should have opposite signs, and we find that indeed they do for foreign primary dealers.[29]

While further analysis would be needed, these opposite-signed results for foreign and domestic dealers raise the possibility that foreign/domestic differences could reconcile the puzzle of contradictory signs between HKM and Adrian et al. (2016) depending on the composition of their samples.

4.3 Balance sheet capacity, regulatory constraints and foreign vs domestic dealers

We hypothesize that the difference between domestic and foreign dealers' explanatory power for exchange rates could arise from differences in balance sheet capacity resulting from regulatory differences, particularly in the pre-crisis period. We argue that stronger regulatory constraints could be more binding than market-based balance sheet constraints (such as VaR), thus dampening the procyclicality of affected dealers and limiting feedback loops with prices. Relatedly, Cenedese et al. (2019) (following on Du et al. (2018b)) argue that post-crisis regulation generally, and the leverage ratio particularly, caused the breakdown of covered interest parity by constraining dealer balance sheets.

Using total assets and equity-to-asset ratios from SNL for primary dealers, we conclude that foreign dealers in the United States had faster average asset growth and nearly 50 percent higher average leverage from 2001-2006 relative to domestic dealers (Table 8).[30] The leverage

[29]For robustness, results (not shown) for the capital risk factor are very similar when predicting excess returns (as in Table 4) rather than exchange rate percent change.

[30]We flip SNL's equity-to-asset ratio to obtain an asset-to-equity ratio as a measure of leverage.

of the two sets of dealers converged with the 2008 crisis and both sets continued to delever as post-crisis regulatory reforms were implemented, however, foreign dealers delevered more slowly than domestic dealers at times, with foreign leverage ratios about 10% higher during 2010-2013.

We compare this pattern of the timeline of convergence in foreign and domestic dealer leverage to the timeline of the strength of predictive power of foreign dealer leverage for exchange rates. The explanatory power of foreign dealer leverage on exchange rates comes primarily from the 2001-2011 period. This is shown by the coefficients with confidence intervals (Figure 3a) from 4-year rolling pooled regressions with the specification from the second column of Table 3. The x-axis on the figures represents the beginning date of the 4-year sample. The explanatory power for foreign dealers falls off steeply beginning with the 4-year regression window of about 2009-2012 due to rising standard errors, and loses significance around the window of 2010-2013, although the coefficient stays around -0.1 until the 2012-2015 window.[31] In contrast, domestic dealers' positions (the blue line in 3b) have marginally significant explanatory power briefly in the pre-crisis period, roughly 2002-2005, then become insignificant for most of the sample and even significantly positive at the end of the sample. This timeline for the predictive power is consistent with foreign dealers having less regulatory constraints on balance sheet size prior to the European banking crisis and then increased constraints on balance sheet size with the banking crisis and the implementation of post-crisis regulatory changes, including Basel III and the Volcker rule, which were phased in between 2011-2016.

[31] Foreign dealer short-term lending, the asset side, has a similar significance pattern to short-term borrowing (Figure 4). Investigating shorter and longer rolling windows shows similar overall patterns.

We next present two additional tests to support the hypothesis that regulation could be behind foreign/domestic differences and the waning predictive power over time. First, the difference in predictive power between foreign and domestic dealers is strongest when leverage is rising, suggesting that we are looking for a constraint that binds on foreign and domestic dealers differently when leverage is rising but not when it is falling. This is true of a regulatory constraint. Table 9 shows results using our baseline specification 1 but splitting the sample into months when leverage is increasing and months when it is decreasing. Note that, although the number of observations happens to be similar, months when foreign dealer leverage is increasing (columns 1 and 2) are not the same sample as months when domestic dealer leverage is increasing (columns 3 and 4).[32] The coefficient for foreign dealer leverage is always negative and significant across all subsamples, ranging from -0.06 to -0.12. In contrast, the domestic dealer coefficient looks like the foreign dealer coefficient, with a significant -0.14 (column 8), when their own leverage is falling, but becomes smaller and insignificant in the subsample where foreign dealer leverage falling (column 6), and flips sign, becoming opposite that of foreign dealers, when their own leverage is rising (column 4). Therefore, dealers overall have the strongest feedback from balance sheet changes to exchange rates when leverage is falling, but only foreign dealers also have a strong feedback from balance sheets to exchange rates when their leverage is rising. These results are consistent with domestic dealers being more constrained by regulation during leverage upswings.

Second, we find that the predictive power of leverage on exchange rates changes sharply and significantly for U.K. banks, but not other banks, in the months following the January

[32]In fact, the leverage of the two types of dealers only moves in the same direction about half of the time.

2016 introduction of the U.K. leverage ratio framework (which Cenedese et al. (2019) argue is plausibly exogenous). Table 10 uses our baseline specification, but separates dealers into U.K. headquartered dealers and all other primary dealers. We then interact the U.K. dealer leverage and all other dealer leverage variables with two time dummies, one for the 12 months prior to the introduction of the U.K. leverage ratio framework and one for the 6 months following the introduction. The U.K. dealers have a significant coefficient of -0.05 for the sample as a whole, then a coefficient not significantly different for the 12 months prior, but a large significant coefficient of the opposite sign for the 6 months following the regulatory change. In contrast, the coefficients for the leverage of other dealers are not significantly different before or after the U.K. regulatory change.[33]

The evidence presented thus far suggests that dealer leverage predicts exchange rates but that predictability as a general phenomenon is limited to foreign dealers. Further, the special role of foreign dealers is at least partly because foreign dealers had more balance sheet capacity to take advantage of arbitrage opportunities during the period where predictability is strongest. Both the difference between domestic and foreign dealers and the waning predictive effect following Basel III and other post-crisis regulation suggests that the type of risk-management balance sheet constraint, such as VaR, in intermediary asset pricing models may only be the binding constraint for some intermediaries, some of the time. If the regulatory constraint is more binding, especially as leverage rises, these intermediaries

[33]Separating the non-U.K. dealers into other foreign and domestic, such that there are three leverage variables, gives the same sign results for U.K. dealers, but the post-change coefficient become smaller and insignificant. However, running the same regression using the full micro-data (at the reporter level), and using a dummy variable interacted with reporter leverage to identify U.K. dealers, gives a significant positive coefficient for U.K. dealer leverage post-change, and other coefficients consistent with Table 10, regardless of whether or not other dealers are separated.

may no longer be the marginal investor, (in other words, they are constrained from taking the arbitrage positions and managing leverage in the manner that the models capture) and therefore lose predictive power.

4.4 Heterogeneous capital and return predictions across asset classes

Our tests so far have focused on the predictability of exchange rates and exchange rate returns using primary dealer leverage as the main predictor. This section explores whether heterogeneity in intermediary leverage matters for the pricing of risk across asset classes. HKM explore the importance of heterogeneity across primary dealers, but focusing more on their size and their marginal importance across markets rather than the regulatory restrictions and investor bases that these primary dealers face. As noted previously, the country of origin of the primary dealers may matter for forecasting exchange rate using intermediary leverage because different banks may face different consolidated regulations at a given point in time. In this section, we test whether these differences in leverage across intermediaries matter for forecasting other asset returns.

Table 11 presents monthly predictive regressions using the same portfolios as in HKM for the following assets: U.S. corporate bonds, sovereign bonds, equities, CDS, options, FX, and commodities. We use monthly return information between 2001 and 2012 and estimate a simple forecasting regression with the average portfolio return as the dependent variable and our short-term borrowing measures, for foreign and domestic primary dealers, as the main regressor.[34] Given this specification, we would expect a negative relation between

[34]This specifications is similar to the one reported in equation (12) in HKM, using the change in leverage as in HKM's "AEM" specifications.

short-term borrowing and expected returns, consistent with both Adrian et al. (2014) and also with the intuition given in HKM that high leverage periods are associated with lower expected returns.[35]

Panel A includes the logged short-term borrowing measures for domestic and foreign primary dealers as regressors, while panel B adds quadratic transformations of those measures, as suggested in HKM. We find that our leverage measure for foreign primary dealers has a negative and significant coefficient for four of the seven asset portfolios in these monthly predictive regressions. In contrast, we find no significant coefficients for the domestic leverage measure. This is consistent with our hypothesis that subgroups of market participants can act as marginal buyers across markets depending on their balance sheet capacity. However, we do not find as much evidence of a significant relation between foreign leverage and the one-year ahead portfolio returns (not shown), consistent with the near term predictability, less than one quarter, in our main exchange rate-focused specifications.

Panel B introduces a quadratic transformation for the domestic and foreign leverage measure. After introducing this quadratic term, we find that leverage or its quadratic term enter with a negative and significant coefficient in the returns of all seven asset classes tested. Similar to panel A, we find that domestic primary dealer leverage only enters with a significant coefficient in two of the cases, but with the opposite expected sign.

We also estimate Fama-MacBeth regressions to explain the pricing of risk premia across asset classes using our leverage factors. These estimations, shown in online appendix table

[35]HKM claim that the coefficient in their equation (12) should be positive if periods of low capital (high leverage) are associated with lower expected returns, but in fact, using that logic, the coefficient should be negative because the coefficient in their equation (12) is on leverage, not capital.

OA6, do not yield large systematic differences between foreign and domestic dealers, but these estimates are unstable over time and across the two subsets of primary dealers given both a shorter time series than used in HKM and the small sample size of portfolios.

In sum, the results in this section provide additional evidence supporting the hypothesis that financial intermediaries have heterogeneous effects on asset prices, across different asset classes.

5 Foreign and domestic dealer currency market positions

Returning to exchange rates, Adrian et al. (2015) argue that since foreign dealer leverage predicts exchange rates in the same direction across both high-interest rate and low-interest rate currencies the story is not strictly one of carry trades. We find the same result, nonetheless, our analysis suggests that, while perhaps not carry trade per se, some type of foreign currency arbitrage is a likely candidate as a channel. To investigate this we use the Treasury Foreign Currency (TFC) data and look first at how gross amounts outstanding in a variety of currency contracts are associated with dealer leverage and then how these contracts predict exchange rates.

Figure 5 summarizes results (see online appendix table OA2 for full results) from a set of regressions using the following specification:

$$\Delta LnFXPosition\_For_{i,t} = \beta_0 + \beta_{1a}\Delta lnDealerSTBorr\_For_{t-1} + \beta_{1b}\Delta lnDealerSTBorr\_For_t + \beta_2 X_{t-1} + \beta_3 X_{i,t-1} + \epsilon_t \quad (4)$$

where "*_For*" represents the sample of foreign entities; we run regressions separately for domestic entities. We also separate USD leg of contracts from the foreign currency leg, running separate regressions (note that the USD regressions have no currency dimension, whereas the foreign currency regressions are panel data). Because the frequency is monthly and we expect new borrowing to potentially translate into other balance sheet activity faster than a 1-month lag, we include both contemporaneous and lagged borrowing, but focus on contemporaneous results. USD regressions use Newey-West standard errors and panel FX regressions use fixed effects and clustered standard errors by currency and month. These regressions include all of the same controls used in Table 3 (for panel regressions) or Table 5 (for USD regressions), including the lag of the dependent variable.

Figure 5 has a bar for the coefficient on short-term borrowing for each regression. For *foreign dealers*, on the right side of the figure, borrowing is significantly associated with increases in every USD contract type contemporaneously, and more sparsely for foreign currency contract types. [36] The consistently positive coefficients suggest that when borrowing increases, all currency positions increase, not just long or short positions vis-à-vis USD. Results for domestic dealers are discussed below.

[36] Coefficients for the 1-month lag of short-term borrowing, not shown, are positive in all but one case for foreign dealers (mixed signs for domestic dealers) and with ten significant coefficients out of the sixteen.

We then hone in on the contemporaneous associations at the monthly frequency by using the weekly data (for which only all purchases and all sales are reported). Table 12 uses the same specification as in Figure 5 except it includes contemporaneous and weekly lags. Table 12 (see online appendix table OA3 for full results) shows that currency market positions of foreign dealers respond to changes in short-term borrowing mostly within the same week, with a 1-week lag, and, to a lesser extent, with a 2-week lag. Further lags are usually insignificant.

These results for foreign dealers may not be surprising, given that many types of positions are likely to increase as dealers gross up balance sheets. However, they contrast sharply with the results for domestic dealers, which are shown at the monthly frequency on the left side of Figure 5 and at the weekly frequency on the bottom half of Table 12. At the monthly frequency, the sign of the correlation for domestic dealers is inconsistent across the different positions and most coefficients are insignificant. At the weekly frequency, domestic dealers again show inconsistent signs and sparse significance with much smaller coefficients.

Next we ask whether these currency market positions predict exchange rates. We use panel specification (1), except substituting currency positions for short-term borrowing. We summarize the results for the monthly frequency in Figure 6 (see online appendix table OA4 for full results). Once again, it is the positions of foreign entities that have notably more predictive power on exchange rates overall relative to positions of domestic entities. The foreign coefficients are, again, consistently signed, whereas the domestic coefficients are mixed. Finally, the direction of exchange rate prediction by foreign dealer leverage is the same regardless of whether the contract type is a long dollar or short dollar position.

Taken together, this evidence reinforces the result that foreign dealers behave differently. Furthermore, it suggests that currency positions may indeed be the channel through which foreign dealer leverage manifests itself in exchange rates. This channel suggests a slightly different story than one driven by cross-border bank lending, although both channels may involve the risk premia on foreign currencies compared to USD.

6 Cross-border lending

Cross-border lending is another potential channel between dealer leverage and exchange rates. Adrian et al. (2015) argue that a decrease in the risk premia in USD assets results in lower USD funding costs, allowing dealers to increase leverage and invest in more risky assets, including foreign currency denominated loans abroad. If cross-border lending is a primary channel, then it should predict exchange rates at least as strongly as leverage or short-term borrowing does. We use the TIC banking data to investigate this channel and find that it is somewhat less convincing than currency market positions. The hypothesis we are testing is: when dealers borrow, are cross-border loans the assets they then acquire with those funds that links the borrowing to future exchange rates?

In theory, we might expect to see the strongest effects with cross-border lending denominated in foreign currency. But in fact, those positions dont appear to be the best candidate for the channel we are looking for because they are small (roughly 5-10% that of dollar-denominated cross-border lending) and primarily denominated in euro and yen (whereas the predictive effect holds for two dozen currencies). Furthermore, and unfortunately, foreign

currency loans are only collected quarterly in the TIC data and, as noted above, the negative effect of leverage on exchange rates peaks between one and two months, well short of the quarterly frequency.[37]

However, dollar-denominated lending is collected monthly and one could imagine a significant effect on exchange rates if that dollar lending affected global liquidity generally, or more specifically, if the dollar lending was then on-lent in foreign currency. This could happen either through banks' internal capital markets to foreign subsidiaries or through local banks in foreign countries, as proposed in the "double decker" model (Bruno and Shin, 2015). Therefore, we investigate below the effect of dollar-denominated cross-border lending. The monthly TIC BC data reports dollar-denominated claims by banks and dealers located in the United States on counterparties abroad by country of counterparty. These data represent mainly loans and reverse repos, but include all type of claims except long-term securities and derivatives. As noted above, we use microdata to separate claims by reporter type.

We first use a panel specification like equation (1), substituting cross-border claims for short-term dealer borrowing; the results are in Table 13. In the first column, the dependent variable is total (dollar-denominated) cross-border claims across all reporters and all countries (this aggregate timeseries is public). This variable is insignificant in predicting exchange rates, as is cross-border claims of all dealers (excludes banks), in the second column. But in the third and fourth columns we separate the claims data further and see that, once again, foreign dealers are the only subset of reporters for which cross-border claims significantly

[37]Running the baseline regression plus the foreign currency cross-border lending variable at the quarterly frequency (see online appendix table OA5), we do find a significant but small (-0.02) coefficient on foreign currency lending. However, this effect seems independent of the leverage effect at that frequency, as neither coefficient affects the other, and it is difficult to interpret the cross-border lending variable in this context because the leverage coefficient itself typically changes sign at the quarterly frequency.

predict exchange rates. As with dealer borrowing, increases (decreases) in foreign dealer cross-border lending predicts dollar appreciation (depreciation). However, the size of the coefficient is less significant and roughly half as large as the coefficient on dealer short-term borrowing from Table 3. Furthermore, in the fifth and sixth columns, we see that the significance of cross-border lending by foreign dealers disappears when short-term borrowing of dealers is included. Conversely, including cross-border lending does not diminish the predictive power of borrowing. Also note that the insignificance of cross-border lending by banks precludes stories where cross-border lending is still the main channel but dealers lend new funds to banks, who then lend abroad.[38]

Thus far, we've used only cross-border lending aggregated across all destination countries, in other words, with no country dimension. If cross-border lending was the channel, the strongest results should come by matching the destination country of the cross-border lending with the exchange rate for that country, as follows:

$$\Delta ExRate_{i,t} = \beta_0 + \beta_0 \Delta lnCrossBdLend_{i,t-1} + \beta_2 RateDiff_{i,t-1} + \beta_3 X_{t-1} + \beta_4 X_{i,t-1} + \epsilon_t \tag{5}$$

where the key difference with equation (1) is the subscript i on cross-border lending. This matching by currency and lending destination is easily accomplished with the country breakdown of the TIC data. However, we haven't included a table on these results because

[38]These bank variables are also insignificant when entered alone in the regression with just controls (not shown).

this specification actually weakens the significance of the cross-border lending variables, yielding no significance on cross-border lending by foreign dealers or any other subset of reporters.[39]

Digging a little deeper, we find in fact that most of the power that foreign dealer cross-border lending does have to predict exchange rates comes from lending that is destined for the United Kingdom. The United Kingdom is notable in this context because London, in addition to New York, hosts globally predominant foreign exchange markets for a wide range of currencies. We used the following specification, trying both the pooled panel approach and separate regressions for each bilateral currency pair.

$$\Delta ExRate_{i,t} = \beta_0 + \beta_0 \Delta lnCrossBdLend_{k,t-1} + \beta_2 RateDiff_{i,t-1} + \beta_3 X_{t-1} + \beta_4 X_{i,t-1} + \epsilon_t \tag{6}$$

The only difference here from specification (5) is that cross-border lending has subscript k instead of i. Rather than matching lending destination country to currency i, we ran separate regressions for each destination country or region, k. We kept major economies separate but grouped emerging markets and other smaller economies into regions, generating a total of 12 countries or regions to test. As shown in Table 14a, cross-border lending to the United Kingdom significantly predicts exchange rates for 14 of the 23 currencies tested. Canada is the only other notable country, with lending to Canada significantly predicting exchange

[39] We tried a variety of measures to remove noise from the cross-border lending data, such as removing positions with financial centers like the Cayman Islands, considering only cross-border repos, excluding intra-bank positions, using only intra-bank positions, etc. We were unable to obtain significant coefficients for the cross-border country-currency matched variable.

rates for 6 currencies. In contrast, for most other locations, cross-border lending to that location either did not predict any exchange rates, including its home currency, or only predicted one or two currencies significantly (see Table 14b). Not surprisingly, then, the United Kingdom is the only location for which cross-border lending significantly predicts exchange rates in a pooled regression across currencies (not shown).

The disappointing results for cross-border lending and the unique role of lending to the United Kingdom suggest that cross-border lending, typically understood as loans to foreign corporations or to foreign banks which on-lend to local firms, may not be the channel at work. The data on currency positions and the significance of lending to the United Kingdom, potentially into currency market positions in London, instead support currency arbitrage as a channel.

7 Conclusions

We have shown substantial differences in the explanatory power of foreign and domestic primary dealers for predicting exchange rates. This difference is consistent across the multiple data sources and specifications we use to explore the channels linking dealer leverage and exchange rates. This result contradicts an implicit assumption of intermediary homogeneity in the intermediary asset pricing literature and therefore provides a new empirical fact to challenge the models in that literature. We argue that for some intermediaries and in some periods, a regulatory constraint may be more binding and override the asset price predictability generated by risk-management constraints embedded in intermediary asset

pricing models. Therefore, we suggest that other factors, such as regulatory constraints, should be considered in the aggregation of intermediaries when analyzing their role in asset pricing.

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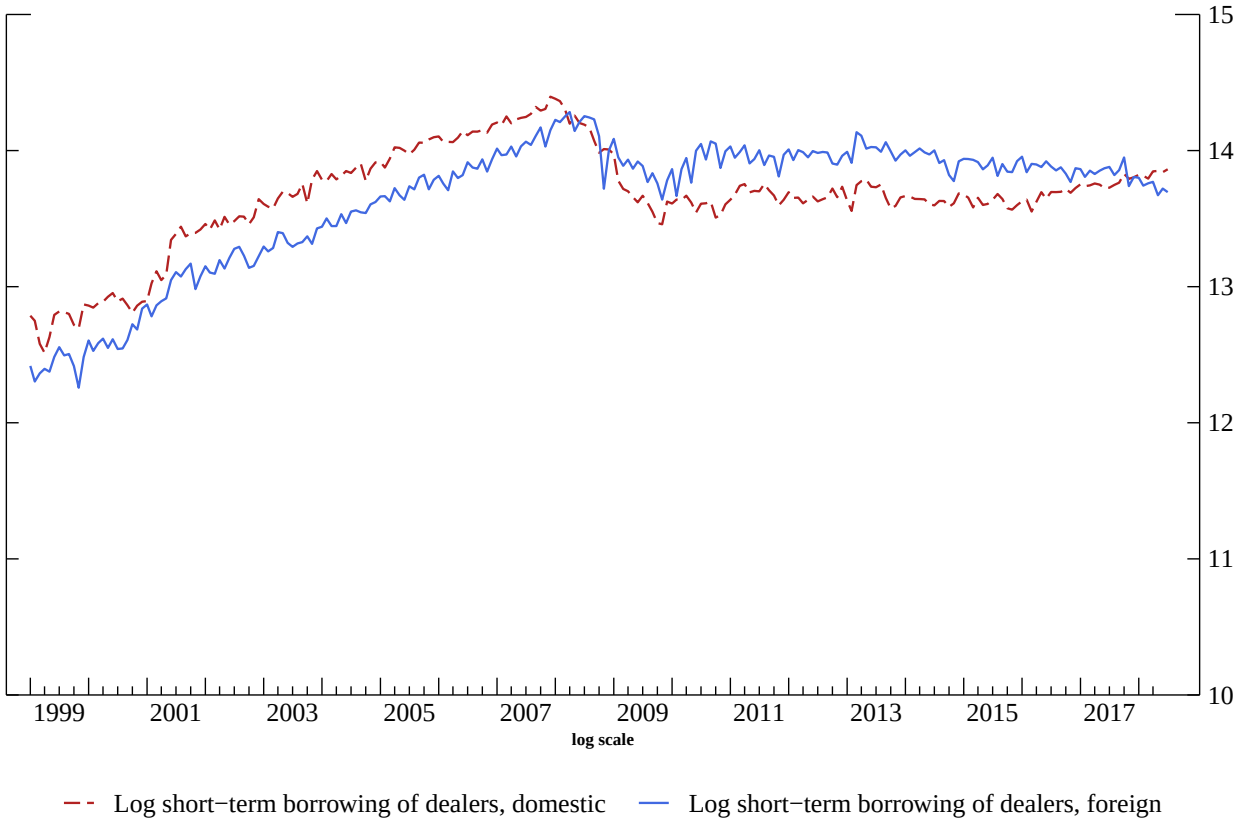

Figure 1: Log short-term borrowing of Foreign vs Domestic Primary Dealers

Note: Short-term borrowing is defined as overnight and continuing repurchase agreements and securities lending agreements. Foreign dealers are those with foreign bank parents, whereas domestic dealers are U.S.-headquartered. Source: FR2004C Government Securities Dealer Reports.

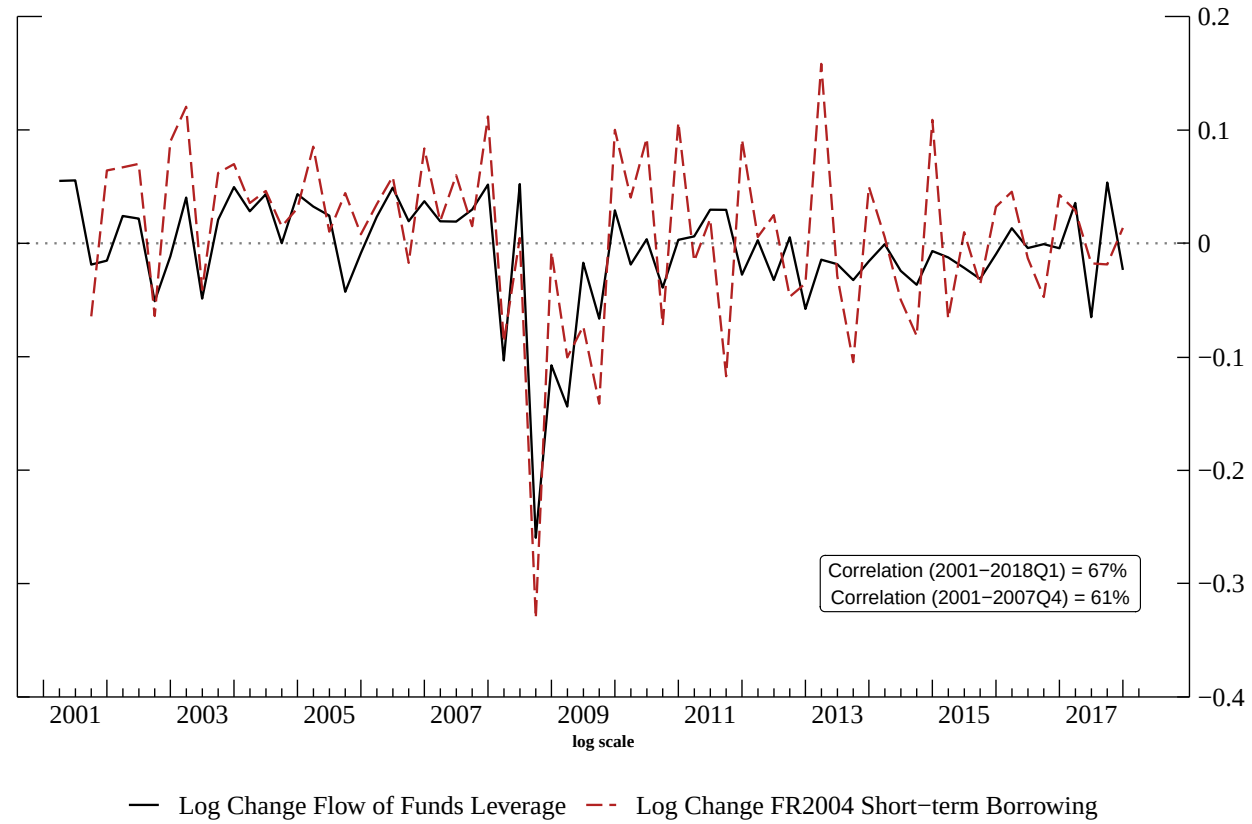

Figure 2: Flow of Funds Dealer Leverage & Primary Dealer Short-Term Borrowing

Note: Short-term borrowing is defined as overnight and continuing repurchase agreements and securities lending agreements. Source: U.S. Flow of Funds and FR2004C Government Securities Dealer Reports.

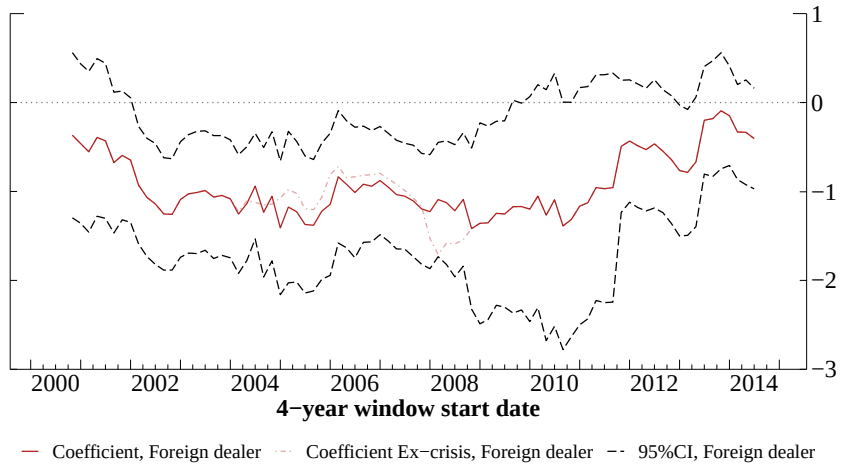

Figure 3a: Coefficient for ST Borrowing for Foreign Dealers

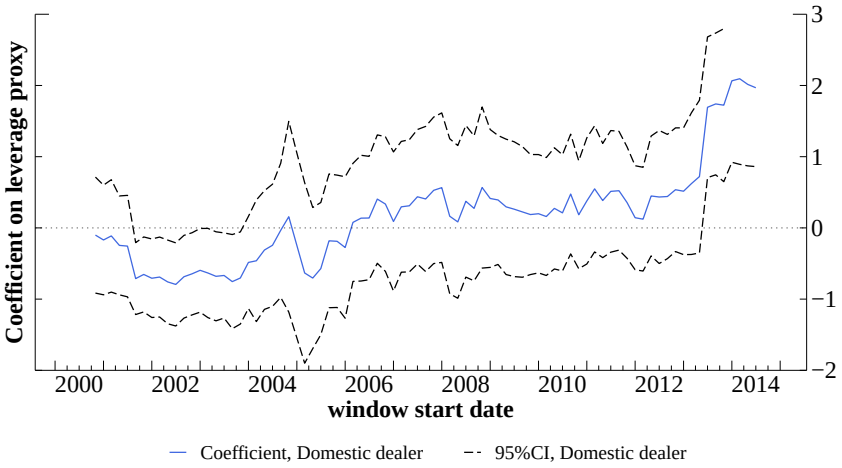

Figure 3b: Coefficient for ST Borrowing for Domestic Dealers

Note: Figures 3a - 3b show coefficients for key explanatory variable (for foreign and domestic dealers, respectively) from 48-month rolling window regressions of the 1-month exchange rate change (pooling 23 currency pairs) on the shown variable(s) and controls.

$$\Delta ExRate_{i,t} = \beta_0 + \beta_1 \Delta lnDealerSTBorr_{t-1} + \beta_3 X_{t-1} + \beta_4 X_{i,t-1} + \epsilon_t \tag{7}$$

Controls include: the lagged dependent variable; lagged Fed funds rate; change in lagged Fed funds rate; lagged policy rate differential between countries in currency pair; change in lagged policy rate differential; lagged VIX; lagged equity market return differential between countries in currency pair; lag change in log Federal Reserve holdings of securities (QE).

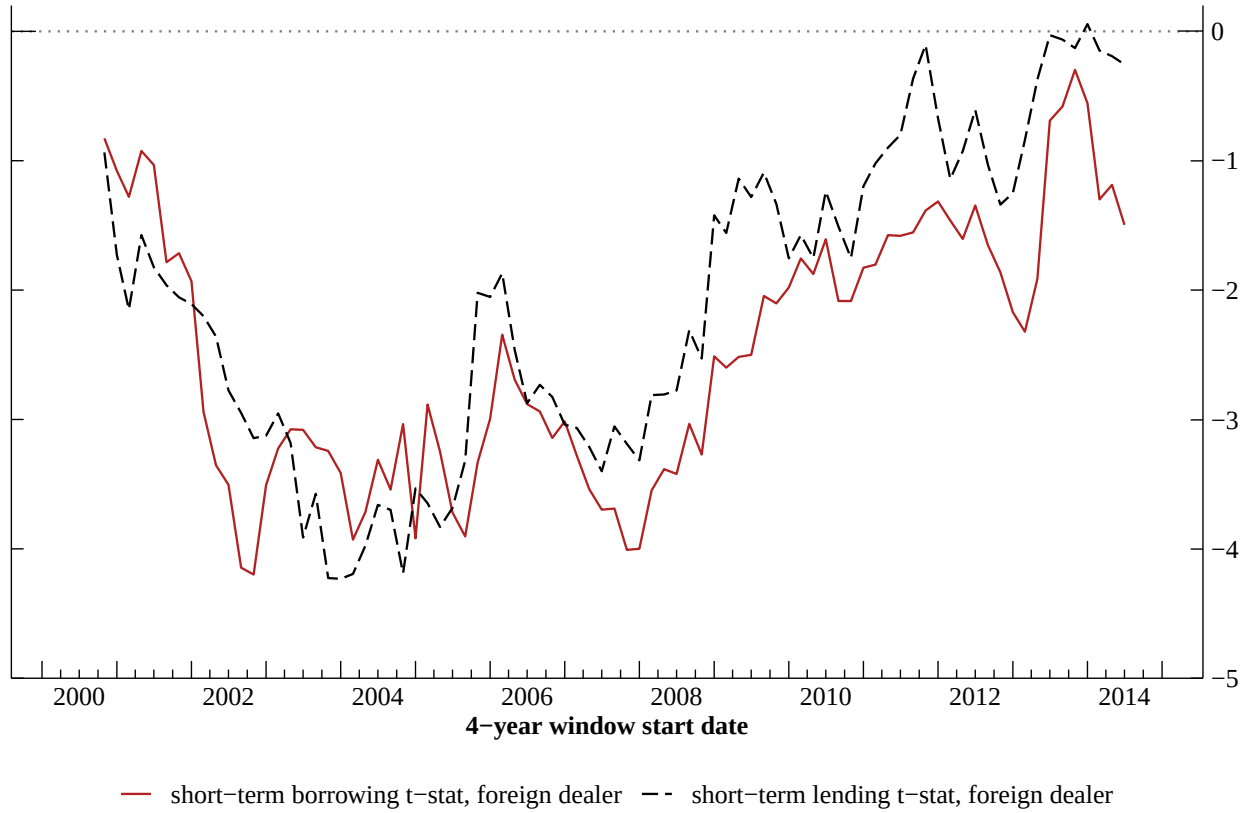

Figure 4: T-Statistics for Foreign Dealers for ST Borrowing and Lending

Note: Figure shows coefficients or t-statistics for key explanatory variables from 48-month rolling window regressions of the 1-month exchange rate change (pooling 23 currency pairs) on the shown variable(s) and controls. Controls include: the lagged dependent variable; lagged Fed funds rate; change in lagged Fed funds rate; lagged policy rate differential between countries in currency pair; change in lagged policy rate differential; lagged VIX; lagged equity market return differential between countries in currency pair; lag change in log Federal Reserve holdings of securities (QE).

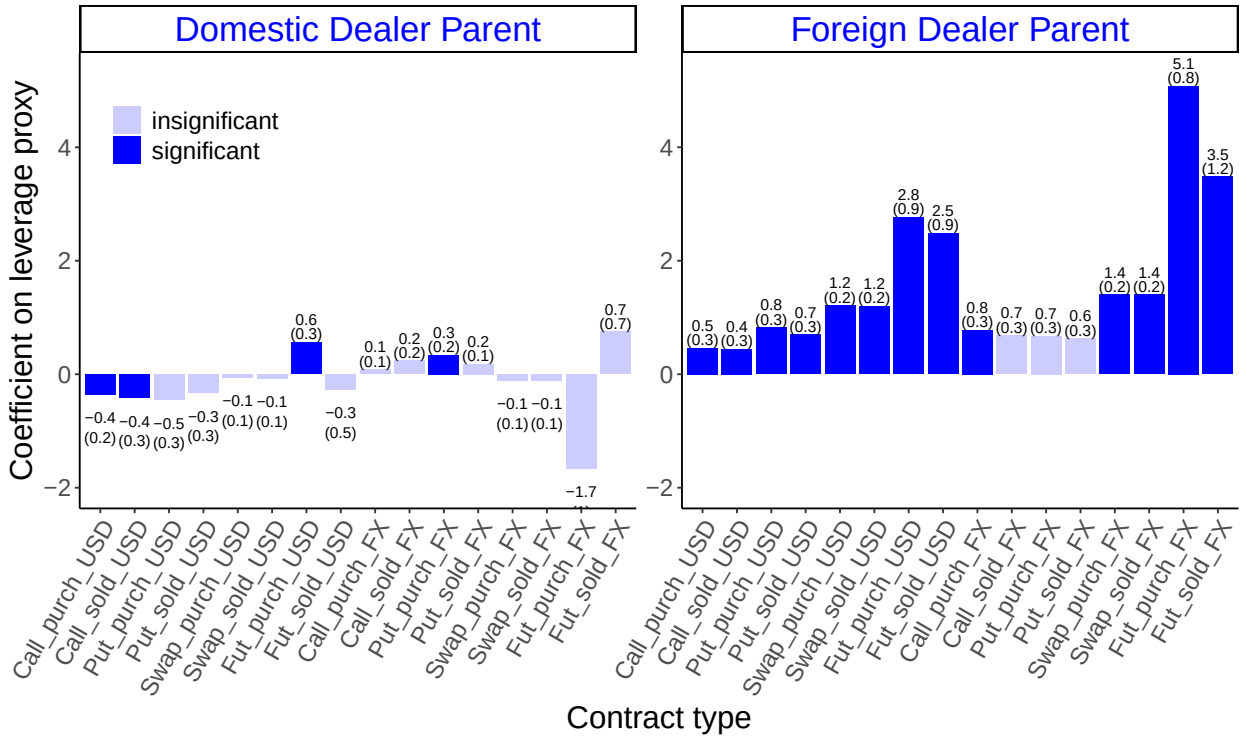

Figure 5: Coefficients for ST Borrowing; Association with Positions in Currency Market Contracts

Note: Figure shows coefficients for contemporaneous short-term borrowing (leverage proxy) in separate regressions where the dependent variable is the natural log of the notional amount outstanding in that contract type.

$$\Delta LnFXPosition\_For_{i,t} = \beta_0 + \beta_1 \Delta lnDealerSTBorr\_For_t + \beta_2 X_{t-1} + \beta_3 X_{i,t-1} + \epsilon_t \quad (8)$$

The contract types distinguish instrument, whether the contract was bought or sold, and whether the currency leg is in USD or a foreign currency. See section 5 for details on and controls for the different specifications for USD contract regressions (which are timeseries only) and foreign currency contract regressions (which are panel). Variables labeled "swaps" include values for swap, futures, and spot contracts. Full results are in online appendix table OA2.

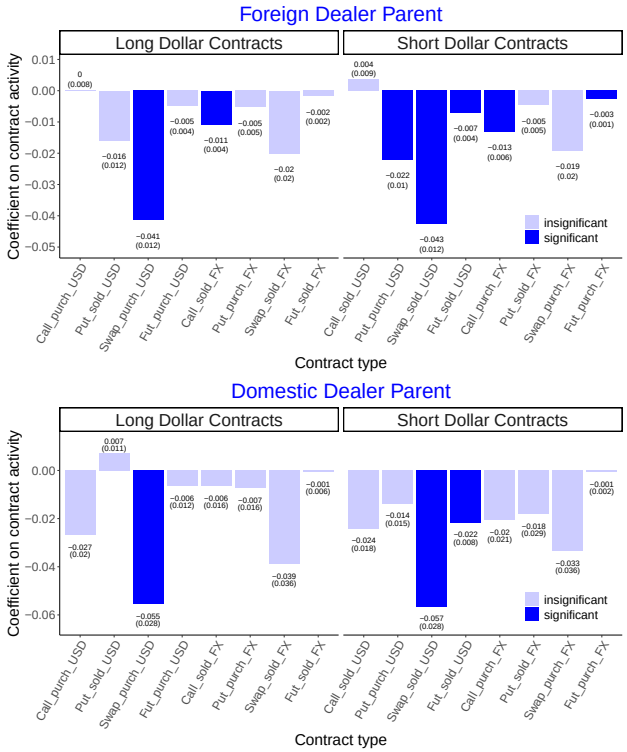

Figure 6: Coefficients for Currency Market Positions: Predicting Exchange Rates

Note: Figure shows coefficients for lagged currency market contract amounts in separate regressions where the dependent variable is 1-month exchange rate change.

$$\Delta ExRate_{i,t} = \beta_0 + \beta_1 \Delta lnFXPosition\_For_t + \beta_2 \Delta lnFXPosition\_For_{t-1} + \beta_3 X_{t-1} + \beta_4 X_{i,t-1} + \epsilon_t \quad (9)$$

For USD legs of contracts, the dependent variable has a panel data of 23 dollar/foreign currency pairs. For foreign currency legs of contracts, the dependent variable is the exchange rate change for the currency of the contract, where each of 5 major foreign currencies are represented. Controls include: the lagged dependent variable; lagged Fed funds rate; change in lagged Fed funds rate; lagged policy rate differential between countries in currency pair; change in lagged policy rate differential; lagged VIX; lagged equity market return differential between countries in currency pair; lag change in log Federal Reserve holdings of securities (QE). Full results are in online appendix table OA4.

Table 1: Summary statistics of main regression variables

Statistic	N	Mean	St. Dev.
Change in dollar/foreign exchange rate*	4,876	0.0002	0.03
Exchange rate excess return*	4,748	0.04	0.1
Short rate differential*	4,749	−0.6	1.9
Stock return differential, 1 yr*	4,836	−0.0001	0.01
Du et al. CIP deviation 10yr*	3,444	−0.003	0.3
Short-term borrowing of primary dealers, foreign**	212	993,003.7	270,413.9
Short-term borrowing of primary dealers, domestic**	212	970,860.4	268,167.9
Short-term lending of primary dealers, foreign**	212	625,991.5	163,327.2
Short-term lending of primary dealers, domestic**	212	626,382.8	213,856.2
VIX	212	0.2	0.1
Fed funds rate*	212	0.02	0.02
Fed QE purchases**	211	11,768.9	39,529.2
Financial CP outstanding, domestic issue**	212	389,491.8	118,407.1
Financial CP outstanding, foreign issue**	212	190,877.1	60,773.8
HKM capital risk factor foreign BHCs	212	−0.001	0.1
HKM capital risk factor domestic BHCs	212	−0.001	0.1
Cross-border lending, foreign dealers**	155	340,795.4	100,655.5
Cross-border lending, domestic dealers**	155	268,365.6	119,147.0
Cross-border lending, foreign banks**	180	1,005,581.0	253,191.9
Cross-border lending, domestic banks**	180	447,758.4	154,858.6

* In decimal form, such that 100 basis points = 0.01

** In millions of dollars

Table 2: Treasury foreign currency data: Mean aggregate values

	USD	EUR	CHF	GBP	JPY	CAD
Foreign exchange swaps, forwards, spot contracts purchased	17,106	4,759	786	1,319	375,491	757
Foreign exchange swaps, forwards, spot contracts sold	16,872	4,790	800	1,344	380,197	764
Foreign exchange futures purchased	34	11	3	3	1,083	2
Foreign exchange futures sold	36	8	2	5	782	3
Put options written	2,310	525	142	88	75,894	76
Call options written	2,148	485	166	75	58,820	71
Call options purchased	2,136	455	130	75	56,669	63
Put options purchased	1,986	534	180	88	76,654	88

Note: Data are in billions of currency units

Table 3: Predicting Exchange Rates with Dealer Borrowing
All Currencies

	Exchange Rate Percent Change (1-month)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
lag chg log s.t. borrowing, all		-0.094***					
		(-3.50)					
lag chg log s.t. borrowing, foreign			-0.087***	-0.084***			-0.093***
			(-4.89)	(-4.81)			(-5.03)
lag chg log s.t. borrowing, domestic			0.021		0.001		0.034
			(0.93)		(0.03)		(1.34)
lag log Fed QE purchases	0.001	0.002*	0.002*	0.002*	0.001	0.001	0.002*
	(1.60)	(2.01)	(1.90)	(1.98)	(1.60)	(1.62)	(1.87)
lag Fed Funds rate	0.090	0.125*	0.133*	0.137*	0.090	0.108	0.151*
	(1.25)	(1.77)	(1.88)	(1.97)	(1.23)	(1.39)	(1.99)
lag short rate differential	-0.001*	-0.001**	-0.001**	-0.001**	-0.001*	-0.001*	-0.001**
	(-1.93)	(-2.25)	(-2.28)	(-2.36)	(-1.91)	(-1.82)	(-2.35)
lag chg Fed Funds rate	1.070*	1.314**	1.533***	1.521***	1.070*	1.413**	1.915***
	(1.94)	(2.48)	(3.16)	(3.11)	(1.94)	(2.30)	(3.60)
lag chg short rate differential	-0.005*	-0.004	-0.006**	-0.005**	-0.005*	-0.005*	-0.006**
	(-1.80)	(-1.44)	(-2.47)	(-2.10)	(-1.84)	(-1.90)	(-2.54)
lag chg in VIX	-0.102*	-0.085	-0.098*	-0.093*	-0.102*	-0.112*	-0.110*
	(-1.86)	(-1.55)	(-1.84)	(-1.77)	(-1.83)	(-1.92)	(-1.95)
lag VIX	0.058**	0.053**	0.063***	0.060***	0.059**	0.068**	0.074***
	(2.41)	(2.39)	(2.95)	(2.84)	(2.43)	(2.58)	(3.18)
lag 1-year chg stock return differential	0.026	0.028	0.034	0.032	0.026	-0.000	0.002
	(1.05)	(1.13)	(1.38)	(1.34)	(1.04)	(-0.01)	(0.05)
lag chg exch rate	0.011	0.022	0.024	0.024	0.011	-0.018	-0.005
	(0.30)	(0.59)	(0.66)	(0.67)	(0.30)	(-0.46)	(-0.13)
chg Du et al. CIP deviation 10y						-0.017*	-0.015*
						(-2.04)	(-1.99)
r2	0.040	0.063	0.081	0.080	0.040	0.065	0.110
p	0.059	0.004	0.000	0.000	0.082	0.058	0.001
N	4728	4728	4728	4728	4728	3375	3375

t statistics in parentheses

Note: The dependent variable is the one-month percent change in the dollar/foreign currency exchange rate, with a panel of 23 currency pairs. Dealer short-term borrowing is the aggregate overnight and continuing repurchase agreements and securities lending agreements of the specified subset of primary dealers in the United States.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Predicting Excess Rates with Dealer Borrowing
All Currencies

	Excess Return (1-month)				
	(1)	(2)	(3)	(4)	(5)
lag chg log s.t. borrowing, all		-0.084**			
		(-2.47)			
lag chg log s.t. borrowing, foreign			-0.082***		
			(-3.58)		
lag chg log s.t. borrowing, domestic			0.034		
			(1.12)		
lag chg log s.t. lending, foreign				-0.054***	
				(-2.92)	
lag chg log s.t. lending, domestic				0.037	
				(1.42)	
lag chg log cp					0.040
					(0.92)
lag log Fed QE purchases	0.002***	0.003***	0.003***	0.003***	0.002***
	(4.95)	(4.99)	(5.07)	(5.70)	(4.22)
lag chg Fed Funds rate	0.300	0.508	0.714	0.598	0.233
	(0.51)	(0.88)	(1.30)	(1.09)	(0.39)
lag chg in VIX	0.021	0.039	0.024	0.025	0.028
	(0.33)	(0.60)	(0.38)	(0.40)	(0.45)
lag VIX	0.081**	0.074**	0.085***	0.087***	0.083***
	(2.79)	(2.69)	(3.25)	(3.22)	(2.97)
lag 1-year chg stock return differential	0.061**	0.063**	0.069**	0.067**	0.062**
	(2.31)	(2.27)	(2.58)	(2.53)	(2.23)
lag excess return	0.553***	0.565***	0.565***	0.558***	0.552***
	(3.66)	(3.77)	(3.79)	(3.73)	(3.63)
r2	0.556	0.562	0.568	0.564	0.557
p	0.000	0.000	0.000	0.000	0.000
N	4718	4718	4718	4718	4707

t statistics in parentheses

Note: The dependent variable is the one-month exchange rate excess return, with a panel of 23 currency pairs. Dealer short-term borrowing is the aggregate overnight and continuing repurchase agreements and securities lending agreements of the specified subset of primary dealers in the United States.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Coefficient on short-term borrowing by currency pair

Dependent variable: 1-month percent change in exchange rate				
Independent Variable: 1-month lag of log change in dealer short-term borrowing				
	(1)		(2)	
Currency	All Dealers	Currency	Domestic Dealers	Foreign Dealers
USD/AUD	-0.11**	USD/AUD	0.05	-0.12***
USD/CAD	-0.08**	USD/CAD	-0.00	-0.06**
USD/EUR	-0.11***	USD/EUR	0.00	-0.08***
USD/JPY	-0.04	USD/JPY	0.04	-0.06**
USD/NZD	-0.11*	USD/NZD	0.05	-0.12***
USD/NOK	-0.14***	USD/NOK	-0.01	-0.11***
USD/SEK	-0.12***	USD/SEK	0.01	-0.09***
USD/CHF	-0.11**	USD/CHF	-0.02	-0.08**
USD/GBP	-0.15***	USD/GBP	-0.03	-0.11***
USD/CLP	-0.07*	USD/CLP	-0.00	-0.06*
USD/COP	-0.11**	USD/COP	0.10*	-0.14***
USD/CZK	-0.11**	USD/CZK	-0.01	-0.08*
USD/HUF	-0.19***	USD/HUF	-0.06	-0.12***
USD/INR	-0.09***	USD/INR	-0.01	-0.07***
USD/IDR	-0.11**	USD/IDR	-0.01	-0.08**
USD/KRW	-0.14***	USD/KRW	0.06*	-0.15***
USD/PHP	-0.03	USD/PHP	0.02	-0.04**
USD/PLN	-0.18***	USD/PLN	-0.03	-0.13***
USD/SGD	-0.07***	USD/SGD	0.01	-0.06***
USD/ZAR	-0.15**	USD/ZAR	0.02	-0.14***
USD/TWD	-0.03*	USD/TWD	0.02	-0.04***
USD/THB	-0.03	USD/THB	0.01	-0.03*
USD/TRY	-0.12**	USD/TRY	0.03	-0.11***

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Each row represents a separate OLS regression (Newey West standard errors) on a separate exchange rate pair; the cell(s) show the coefficients of the key independent variable, lag of log change in dealer borrowing, for each case. "Dealer short-term borrowing" is the overnight and continuing repurchase agreements and securities lending agreements of primary dealers in the U.S. Control variables include: lagged dependent variable; lagged Fed funds rate; lagged policy rate differential between countries in currency pair; change in lagged Fed funds rate; change in lagged policy rate differential; lagged VIX; lagged equity market return differential between countries in currency pair; lag change in log Federal Reserve holdings of securities (QE). Full results are in online appendix table OA1.

Table 6: Predicting Exchange Rates: Alternative Variables
All Currencies

	Exchange Rate Percent Change (1-month)				
	(1)	(2)	(3)	(4)	(5)
lag chg log s.t. borrowing, foreign	-0.087***				
	(-4.89)				
lag chg log s.t. borrowing, domestic	0.021				
	(0.93)				
lag chg log s.t. lending, foreign		-0.062***			
		(-3.94)			
lag chg log s.t. lending, domestic		0.027			
		(1.13)			
lag 1-mth chg log finCP outstnd			0.038		
			(1.10)		
lag 1-mth chg log finCP outst, domestic issue				0.057	
				(1.61)	
lag 1-mth chg log finCP outst, dom issue, fbo					0.023
					(0.96)
lag 1-mth chg log finCP outst, dom issue, dom					0.024
					(0.75)
lag 1-mth chg log finCP outst, foreign issue				-0.018	-0.017
				(-0.80)	(-0.77)
lag log Fed QE purchases	0.002*	0.002**	0.001	0.001	0.001
	(1.90)	(2.36)	(1.36)	(1.26)	(1.25)
lag Fed Funds rate	0.133*	0.109	0.088	0.083	0.082
	(1.88)	(1.51)	(1.13)	(1.08)	(1.06)
lag short rate differential	-0.001**	-0.001**	-0.001	-0.001	-0.001
	(-2.28)	(-2.19)	(-1.16)	(-1.18)	(-1.14)
lag chg Fed Funds rate	1.533***	1.416***	1.048*	1.128*	1.108*
	(3.16)	(2.90)	(1.73)	(1.88)	(1.81)
lag chg short rate differential	-0.006**	-0.006**	-0.005	-0.005	-0.004
	(-2.47)	(-2.51)	(-1.50)	(-1.43)	(-1.39)
lag chg in VIX	-0.098*	-0.097*	-0.102*	-0.105*	-0.105*
	(-1.84)	(-1.81)	(-1.90)	(-1.95)	(-1.92)
lag VIX	0.063***	0.065***	0.061**	0.061**	0.060**
	(2.95)	(2.97)	(2.63)	(2.70)	(2.54)
lag 1-year chg stock return differential	0.034	0.031	0.040	0.038	0.037
	(1.38)	(1.31)	(1.31)	(1.22)	(1.21)
lag chg exch rate	0.024	0.015	0.005	0.013	0.012
	(0.66)	(0.40)	(0.13)	(0.32)	(0.30)
r2	0.081	0.069	0.043	0.046	0.045
p	0.000	0.006	0.055	0.048	0.073
N	4728	4728	4649	4649	4649

t statistics in parentheses

Note: The dependent variable is the one-month percent change in the dollar/foreign currency exchange rate, with a panel of 23 currency pairs. Dealer short-term borrowing is the aggregate overnight and continuing repurchase agreements and securities lending agreements of the specified subset of primary dealers in the United States.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Predicting Exchange Rates: Consolidated Capital Ratios
Monthly, All Currencies

	Exchange Rate Percent Change (1-month)				
	(1)	(2)	(3)	(4)	(5)
lag chg log s.t. borrowing, foreign	-0.087***				
	(-4.89)				
lag chg log s.t. borrowing, domestic	0.021				
	(0.93)				
lag HKM capital risk factor all BHCs		0.031			
		(1.16)			
lag HKM capital risk factor foreign BHCs			0.091**	0.045	
			(2.21)	(1.64)	
lag HKM capital risk factor domestic BHCs			-0.047		0.012
			(-1.61)		(0.56)
lag log Fed QE purchases	0.002*	0.001	0.001	0.001	0.001
	(1.90)	(1.39)	(1.18)	(1.28)	(1.54)
lag Fed Funds rate	0.133*	0.106	0.117	0.114	0.096
	(1.88)	(1.40)	(1.63)	(1.52)	(1.28)
lag short rate differential	-0.001**	-0.001*	-0.001*	-0.001*	-0.001*
	(-2.28)	(-1.89)	(-1.98)	(-1.89)	(-1.91)
lag chg Fed Funds rate	1.533***	1.122*	1.334**	1.200*	1.070*
	(3.16)	(1.95)	(2.15)	(2.02)	(1.92)
lag chg short rate differential	-0.006**	-0.005*	-0.005*	-0.005*	-0.005*
	(-2.47)	(-1.79)	(-2.01)	(-1.86)	(-1.78)
lag chg in VIX	-0.098*	-0.107*	-0.118**	-0.111*	-0.103*
	(-1.84)	(-1.97)	(-2.15)	(-2.05)	(-1.89)
lag VIX	0.063***	0.067**	0.071**	0.071***	0.062**
	(2.95)	(2.70)	(2.79)	(2.83)	(2.53)
lag 1-year chg stock return differential	0.034	0.026	0.023	0.025	0.026
	(1.38)	(1.10)	(1.01)	(1.10)	(1.08)
lag chg exch rate	0.024	0.008	0.006	0.007	0.010
	(0.66)	(0.21)	(0.15)	(0.16)	(0.26)
r2	0.081	0.044	0.053	0.048	0.041
p	0.000	0.063	0.040	0.043	0.083
N	4728	4728	4728	4728	4728

t statistics in parentheses

Note: The dependent variable is the one-month percent change in the dollar/foreign currency exchange rate, with a panel of 23 currency pairs. Dealer short-term borrowing is the aggregate overnight and continuing repurchase agreements and securities lending agreements of the specified subset of primary dealers in the United States. The HKM capital risk factor is defined in He, Kelly, and Manela (2017) as the innovations from an AR1 of the aggregate market-based capital ratio of primary dealers.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8: Average Leverage of Primary Dealers

Years	Foreign	Domestic
2001-2006	60	41
2007-2009	40	40
2010-2013	30	28
2014-2017	20	24

Note: Leverage measure is the asset to equity ratio, with each dealers' ratio weighted by total assets to obtain a weighted average.
Source: Annual SNL data for primary dealers

Table 9: Predicting Exchange Rates by Direction of Dealer Borrowing

	Leverage Increasing			
	Foreign Dealers: lag change s.t. borrowing >0		Domestic Dealers: lag change s.t. borrowing >0	
Independent variables	(1)	(2)	(3)	(4)
lag chg log s.t. borrowing, foreign dealers	-0.08*	-0.08*		-0.06**
	(-1.87)	(-1.95)		(-2.72)
lag chg log s.t. borrowing, domestic dealers		0.06*	0.03	0.06
		(1.84)	(0.56)	(1.27)
R2	0.036	0.048	0.016	0.038
N	2226	2226	2221	2221
	Leverage Decreasing			
	Foreign Dealers: lag change s.t. borrowing <0		Domestic Dealers: lag change s.t. borrowing <0	
Independent variables	(5)	(6)	(7)	(8)
lag chg log s.t. borrowing, foreign dealers	-0.09**	-0.09**		-0.12***
	(-2.37)	(-2.35)		(-4.73)
lag chg log s.t. borrowing, domestic dealers		-0.04	-0.17***	-0.14**
		(1.10)	(-3.01)	(-2.66)
R2	0.053	0.056	0.084	0.152
N	1925	1925	1930	1930

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Each column represents a separate regression of the specification [1] (as in Table 1 , column 3) but restricting the sample by the criteria noted at the column head. The cells show the coefficient(s) of the key independent variable, lag of log change in dealer borrowing, foreign or domestic, for each case. "Dealer short-term borrowing" is the overnight and continuing repurchase agreements and securities lending agreements of primary dealers in the U.S. Control variables include: lagged dependent variable; lagged Fed funds rate; lagged policy rate differential between countries in currency pair; change in lagged Fed funds rate; change in lagged policy rate differential; lagged VIX; lagged equity market return differential between countries in currency pair; lag change in log Federal Reserve holdings of securities (QE).

Table 10: Effect of January 2016 U.K. Leverage Ratio Framework
All Currencies

	Exchange Rate Percent Change (1-month)
	(1)
lag chg log s.t. borrowing, U.K. dealers	-0.050**
	(-2.49)
interaction: lag chg log s.t. borrowing, U.K. dealers * year 2015 dummy	0.090
	(0.82)
interaction: lag chg log s.t. borrowing, U.K. dealers * first half 2016 dummy	0.691**
	(2.83)
lag chg log s.t. borrowing, all dealers ex U.K.	-0.022
	(-1.32)
interaction: lag chg log s.t. borrowing, all dealers ex U.K. * year 2015 dummy	0.004
	(0.09)
interaction: lag chg log s.t. borrowing, all dealers ex U.K. * first half 2016 d	0.032
	(0.57)
lag log Fed QE purchases	0.002**
	(2.37)
lag Fed Funds rate	0.146**
	(2.21)
lag short rate differential	-0.015
	(-0.98)
lag chg Fed Funds rate	1.458**
	(2.77)
lag chg short rate differential	0.149
	(0.75)
lag chg in VIX	-0.083
	(-1.63)
lag VIX	0.059***
	(2.93)
lag 1-year chg stock return differential	0.030
	(1.20)
lag chg exch rate	0.025
	(0.70)
r2	0.082
p	0.001
N	4185

t statistics in parentheses

Note: The dependent variable is the one-month percent change in the dollar/foreign currency exchange rate, with a panel of 23 currency pairs. Dealer short-term borrowing is the aggregate overnight and continuing repurchase agreements and securities lending agreements of the specified subset of primary dealers in the United States.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 11: Predicting Monthly Portfolio Returns with Dealer Borrowing

Panel A: Linear term only

	(1) FF25	(2) USCorpBnds	(3) SovBnds	(4) Options	(5) CDS	(6) Commod	(7) FX
lag chg log s.t.borrow, foreign	-7.12	-2.70***	-3.69*	-7.23	-1.39***	-5.73*	0.01
	(-1.38)	(-3.49)	(-1.95)	(-1.38)	(-3.29)	(-1.79)	(0.00)
lag chg log s.t.borrow, domestic	-3.21	-0.96	-0.67	-4.46	-0.44	5.14	-2.45
	(-0.42)	(-0.60)	(-0.21)	(-0.73)	(-0.35)	(1.17)	(-0.96)
Constant	0.95*	0.63***	0.93***	0.17	0.25***	0.43	0.32
	(1.93)	(5.17)	(3.75)	(0.46)	(3.56)	(1.06)	(1.54)
p	0.345	0.003	0.143	0.114	0.005	0.140	0.606
N	165	153	145	154	143	165	130

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Panel B: Linear and squared terms

	(1) FF25	(2) USCorpBnds	(3) SovBnds	(4) Options	(5) CDS	(6) Commod	(7) FX
lag chg log s.t.borrow, foreign	-9.68**	-2.86***	-3.66**	-10.04**	-1.40***	-6.42**	-1.47
	(-2.24)	(-3.48)	(-2.28)	(-2.39)	(-3.05)	(-2.12)	(-1.12)
lag chg log s.t.borrow, foreign, sqrd	-69.48**	1.27	13.92*	-87.41***	0.21	-13.13	-30.59***
	(-2.59)	(0.29)	(1.83)	(-5.85)	(0.07)	(-0.97)	(-6.67)
lag chg log s.t.borrow, domestic	-4.71	-1.71	-2.24	-3.35	-0.78	4.01	-2.50
	(-0.62)	(-1.09)	(-0.69)	(-0.56)	(-0.59)	(0.86)	(-1.07)
lag chg log s.t.borrow, domestic, sqrd	103.49	23.43*	39.15	29.88	11.25	47.95	33.71**
	(1.51)	(1.87)	(1.33)	(0.65)	(1.31)	(1.37)	(2.51)
Constant	1.14**	0.53***	0.65**	0.81*	0.21***	0.36	0.41*
	(2.16)	(3.77)	(2.06)	(1.97)	(2.76)	(0.78)	(1.79)
p	0.033	0.000	0.012	0.000	0.013	0.112	0.000
N	165	153	145	154	143	165	130

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Portfolio returns are the average of the returns in each asset class for portfolios used in He, Kelly, Manela (2017) (HKM). Foreign and domestic dealer leverage is measured as the log change in overnight and continuing repurchase and securities lending aggreements by primary dealers. All results are for monthly returns over 2001-2012 unless noted otherwise. Coefficients multiplied by 100 as in HKM.

Table 12: Weekly: Short-term borrowing predicting foreign currency positions significance of key coefficients

		change in ln value of contracts					
		USD leg of contracts			FX leg of contracts		
Dependent Variable		all purchases	all sales	Net FV of options	all purchases	all sales	Net FV of options
Independent Variable							
Foreign Dealers short-term borrowing	contemporaneous	0.61***	0.60***	1.82*	0.92***	0.92***	-0.06
	1-week lag	0.84***	0.83***	2.29**	1.03***	1.13***	-0.15
	2-week lag	0.31**	0.29**	0.03	0.36**	0.41***	-1.00
Domestic Dealers short-term borrowing	contemporaneous	0.20**	0.20**	4.00	0.19*	0.19*	0.23
	1-week lag	0.24	0.25	-5.23	0.19	0.19	1.78
	2-week lag	-0.13	-0.12	-4.18	-0.24***	-0.26***	2.15

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Each cell represents the significance of the coefficient of the independent variable listed on the left in an OLS regression (Newey West standard errors) with the dependent variable indicated by the column. "All purchases" and "all sales" refer to the change in ln value of any purchased or sold (respectively) currency option, future, or spot contract. Regressions with foreign dealer borrowing variables (the top two rows) are run separately from regressions with domestic dealer borrowing variables (the bottom two rows). The contemporaneous and lagged versions of dealer borrowing variables are included together in the same regression. Control variables in each regression include: lagged dependent variable; lagged Fed funds rate; lagged policy rate differential between countries in currency pair; change in lagged Fed funds rate; change in lagged policy rate differential; lagged VIX; lagged equity market return differential between countries in currency pair; lag change in log Federal Reserve holdings of securities (QE). Full results are in online appendix table OA3.

Table 13: Predicting Exchange Rates: Cross-Border Lending
All Currencies

	Exchange Rate Percent Change (1-month)					
	(1)	(2)	(3)	(4)	(5)	(6)
lag chg log cross-border lending, all	-0.019					
	(-0.33)					
lag chg log cross-border lending, all dealers		-0.018				
		(-1.45)				
lag chg log cross-border lending, foreign dlrs			-0.046**	-0.044**	-0.010	-0.008
			(-2.62)	(-2.59)	(-0.55)	(-0.43)
lag chg log cross-border lending, domestic dlrs			0.020	0.018		0.013
			(1.31)	(1.18)		(0.93)
lag chg log cross-border lending, foreign banks				0.092		0.068
				(1.71)		(1.30)
lag chg log cross-border lending, domestic banks				-0.026		-0.042
				(-0.80)		(-1.40)
lag chg log s.t. borrowing, foreign					-0.090***	-0.094***
					(-4.20)	(-4.05)
lag chg log s.t. borrowing, domestic					0.024	0.017
					(0.89)	(0.61)
lag log Fed QE purchases	0.001	0.001*	0.002**	0.001*	0.002*	0.001
	(1.60)	(1.73)	(2.11)	(1.72)	(1.87)	(1.56)
lag Fed Funds rate	0.134	0.174**	0.236***	0.224**	0.232***	0.232***
	(1.54)	(2.19)	(2.93)	(2.79)	(2.92)	(2.90)
lag short rate differential	-0.001	-0.001	-0.002**	-0.002*	-0.002**	-0.002*
	(-0.95)	(-0.87)	(-2.11)	(-2.00)	(-2.11)	(-1.86)
lag chg Fed Funds rate	1.090*	1.265*	0.877	0.803	1.367**	1.178*
	(1.77)	(1.97)	(1.32)	(1.20)	(2.10)	(1.91)
lag chg short rate differential	-0.005	-0.005**	-0.004**	-0.004**	-0.005**	-0.005**
	(-1.53)	(-2.08)	(-2.15)	(-2.08)	(-2.44)	(-2.53)
lag chg in VIX	-0.120*	-0.116*	-0.145**	-0.138**	-0.130*	-0.126*
	(-2.05)	(-1.97)	(-2.19)	(-2.09)	(-1.93)	(-1.88)
lag VIX	0.067**	0.073***	0.088***	0.095***	0.083***	0.091***
	(2.65)	(2.94)	(3.18)	(3.56)	(3.17)	(3.54)
lag 1-year chg stock return differential	0.041	0.044	0.055	0.062*	0.060*	0.069*
	(1.38)	(1.58)	(1.66)	(1.84)	(1.80)	(1.98)
lag 1-year chg TED spread	-0.002	-0.003	-0.015	-0.015	-0.004	-0.005
	(-0.12)	(-0.19)	(-0.91)	(-0.91)	(-0.22)	(-0.29)
lag chg exch rate	0.007	0.005	-0.010	-0.025	-0.002	-0.013
	(0.17)	(0.11)	(-0.21)	(-0.51)	(-0.04)	(-0.27)
r2	0.047	0.053	0.083	0.095	0.112	0.127
p	0.103	0.045	0.000	0.095	0.000	0.127
N	4029	3989	3489	3489	3489	3489

t statistics in parentheses

Note: The dependent variable is the one-month percent change in the dollar/foreign currency exchange rate, with a panel of 23 currency pairs. Cross-border lending is all dollar-denominated claims of banks and broker-dealers located in the United States on counterparties abroad, excluding long-term securities and derivatives. Dealer short-term borrowing is the aggregate overnight and continuing repurchase agreements and securities lending agreements of the specified subset of primary dealers in the United States.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 14a

Dependent variable: 1-month percent change in exchange rate	
Independent Variable: 1-month lag of log change in Cross-border lending to U.K. by foreign dealers	
	p-value
AUD/USD	**0.025**
CAD/USD	**0.000**
EUR/USD	0.249
JPY/USD	**0.000**
NZD/USD	**0.002**
NOK/USD	**0.084**
SEK/USD	0.262
CHF/USD	**0.000**
GBP/USD	0.787
CLP/USD	**0.055**
COP/USD	**0.078**
CZK/USD	0.427
HUF/USD	0.899
INR/USD	0.485
IDR/USD	**0.000**
KRW/USD	0.658
PHP/USD	**0.061**
PLN/USD	**0.017**
SGD/USD	**0.007**
ZAR/USD	**0.015**
TWD/USD	**0.000**
THB/USD	0.188
TRY/USD	0.227

Note: Each row represents a separate OLS regression (Newey West standard errors) on a separate exchange rate pair; the cell(s) show the significance of the key independent variable, lag of log change in cross-border lending to U.K. by foreign dealers, for each case. **All coefficients are negative.** Control variables include: lagged dependent variable; lagged Fed funds rate; lagged policy rate differential between countries in currency pair; change in lagged Fed funds rate; change in lagged policy rate differential; lagged VIX; lagged equity market return differential between countries in currency pair; lag change in log Federal Reserve holdings of securities (QE).

Table 14b

Number of currencies for which dollar-denominated lending to country or region predicts dollar appreciation with p-value<0.10

Country/Region	# of currencies
U.K.	14
Canada	6
Japan	2
Switzerland	3
Australia	2
Non-Euro Advanced Europe	1
Latin America	1
Asia	2
Eastern Europe	1

Note: All other countries and regions tested have no significant predictive power.