Essays in International Finance and Banking

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ABSTRACT

Essays in International Finance

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This dissertation studies the implications of financial intermediaries on international financial markets and bank lending.

Chapter 1 explores the relevance of financial intermediaries for the pricing of foreign exchange. Recent theoretical work has highlighted the importance of financial intermediaries in rationalizing exchange rate movements and I empirically assess whether the theoretical predictions hold true in the data. I show that financial intermediary capital, a proxy for their health and/or risk-bearing capacity, provides an economic source of risk that helps explain both the carry trade and the cross-section of currency returns across a variety of strategies. Currencies that more positively co-move with intermediary capital provide high excess returns as intermediaries must be compensated for currency depreciation and losses at times when their capital erodes and their marginal utility is high. I demonstrate the dominance of intermediary-based asset pricing theories over consumption-based asset pricing theories, thus rationalizing theoretical models with a central role for financial intermediaries in asset markets. I then show that intermediary capital provides one economic source of risk embedded within the more dominant carry factor and serves as an orthogonal source of risk to the global risk embedded within the dollar factor. This paper thus serves as motivation for the further development of open economy models with financial intermediaries and a deeper understanding of the underlying economic sources of risks that underlie the factor structure of exchange rates.

Chapter 2 studies the impact of US monetary policy shocks on international bank lending at the aggregate level. I ask whether country-banking systems that are more exposed

to dollar funding decrease their cross-border lending by more than less exposed countries following contractionary US monetary policy announcements. For a given country borrower, I show that this is indeed the case as a 25 basis point increase in the previous quarter decreases cross-border lending supply growth by 4% more from a country-banking system that is 10% more reliant on dollar funding. This is mainly driven by decreases in cross-border lending to banks and the non-bank private sector, highlighting potential channels for the international transmission of US monetary policy.

Chapter 3 assesses the effects of the US money market fund reform of October 2016 on syndicated bank lending and more broadly examines the relevance of dollar funding from US money market funds. I exploit the heterogeneity in foreign banks' reliance on US money market funds to uncover whether the decline in dollar funding attributed to the reform affected their lending. I find that although larger exposure to US money market dollar funding is attributed with larger declines following the reform, this did not pass through to dollar denominated lending, contrary to conventional wisdom. I find that banks substituted for some of the loss in dollar funding by increasing borrowing from US government money market funds, but this was not sufficient to offset the loss in funding. My results thus suggest that global banks have access to substitute sources of dollar funding that smoothed the loss in dollar funding on lending.

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Chapter 1

Intermediary-Based Asset Pricing and the Cross-Sections of Exchange Rate Returns

1.1 Introduction

Exchange rates have been a long-standing puzzle for researchers in international macroeconomics and finance. Early work by Meese and Rogoff (1983) identified the exchange rate disconnect, namely the failure of empirical models utilizing monetary and macroeconomic fundamentals as regressors to out-perform a random walk in out-of-sample forecasts of exchange rates despite the use of ex-post realized values that theory suggests should be relevant in exchange rate determination. The uncovered interest parity (UIP), one of the main tenets of international finance that dictates exchange rates must adjust in expectation to equate returns across countries with differing interest rates, has also failed as Hansen and Hodrick (1980) and Fama (1984) show that currencies with higher interest rates tend to appreciate rather depreciate, contradicting this basic relationship and giving rise to the forward premium puzzle and the profitable carry trade strategy. Since the advent of these studies, scholars have been in search of a cohesive explanation and mechanism to address these empirical irregularities that contradict the seemingly well-founded theory.

Recent progress has been made on the theoretical front, introducing the notion of financial intermediaries and shocks into open economy models that help alleviate some of the inconsistencies between the models and data (Gabaix and Maggiori 2015, Itskhoki and Mukhin 2017). At the core of these models is the notion that empirically consistent exchange rate movements require the presence of constrained agents who intermediate and participate in foreign exchange markets. Their role as the marginal investors in these markets causes fluctuations in their risk-bearing capacities to influence exchange rate movements and consequently serve a central role in exchange rate determination. The risk-based interpretation suggests that if currencies pay off poorly when these intermediaries are more constrained, precisely when they have lower wealth and highly value an additional unit of wealth, these currencies are deemed as risky and should provide higher expected returns to compensate for this downside risk. From a general equilibrium perspective, risky currencies depreciate upon the realization of negative shocks that erode financial intermediaries' risk-bearing capacity in order to set up a future appreciation that yields higher expected returns in order to incentivize agents to hold these currencies.

Figure 1.1 displays the composition of foreign exchange volume from the Bank for International Settlements Triennial FX survey (2016) over the past decade and a half. The decomposition shows that an overwhelming portion of exchange rate turnover is attributed to financial institutions, with the latest survey in 2016 displaying financial institution turnover of over 90% of the total. The turnover data demonstrates the outsize importance and rele-

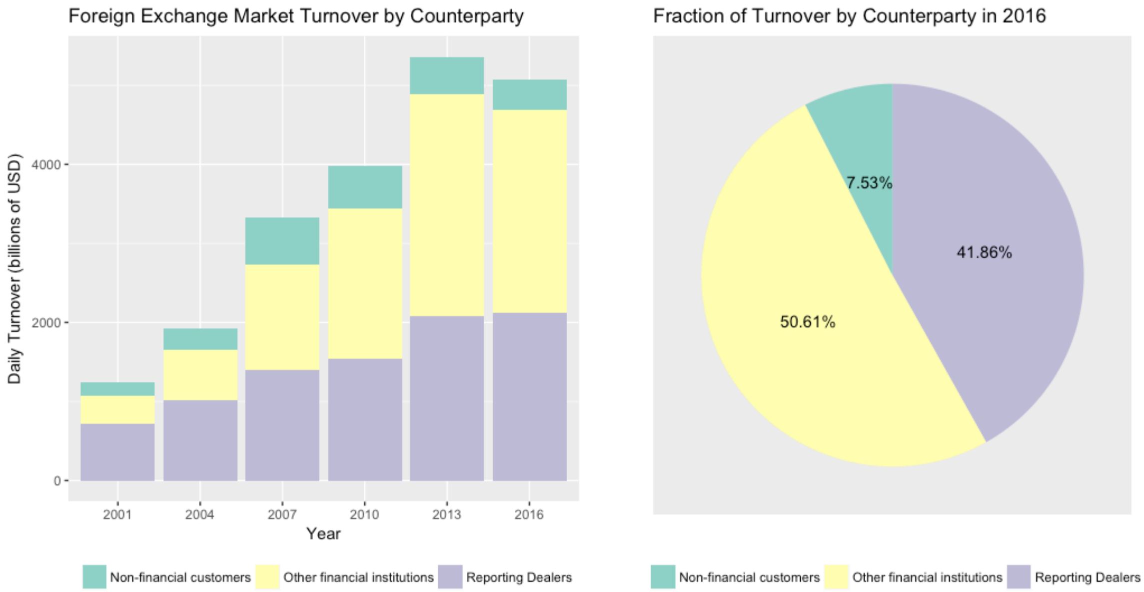


Figure 1.1: Daily Foreign Exchange Turnover Breakdown

Notes: Data comes from the Bank for International Settlements' Triennial FX Survey (2016). Turnover includes all foreign exchange instruments on a net-net basis from all countries to all other countries.

vance of financial intermediaries as holders and traders of foreign exchange, as opposed to households which have historically been of focus in the asset pricing literature.

Motivated by the recent theory and the outsize contribution of financial intermediaries to foreign exchange turnover, I formally ask whether financial intermediaries matter for the pricing of foreign exchange. If the open economy macro-finance theory holds true and financial intermediaries matter, I expect fluctuations in their risk-bearing capacity to be a significantly priced risk factor in the cross-section of exchange rate returns. Furthermore, the theory predicts a positive price of risk as currencies whose returns more positively co-vary with intermediary capital should yield the highest excess returns as compensation for the risk of depreciation and losses when intermediary capital erodes.

I confirm both of these predictions, finding that fluctuations in intermediary capital, a proxy for their risk-bearing capacity, commands a significantly positive risk price for the carry trade and the joint cross-section of a variety of currency portfolios. The significance of intermediary capital risk for the carry trade indicates that the existence of constrained intermediaries at the center of foreign exchange markets may provide one explanation for the failure of the uncovered interest parity as currencies with high interest rates may not depreciate enough and in fact appreciate due to compensation for the risk of larger depreciations and losses when intermediary capital erodes and agents become more constrained. The relevance of intermediary capital for the wider joint cross-section suggests that intermediary capital risk underlies a wide range of exchange rate risk premia and thus serves as a systematic source of global risk. My evidence thus validates open economy models with a central role for financial intermediaries in foreign exchange markets as I confirm the risk-based interpretation of exchange rate risk premia through the lens of financial intermediaries.

Following my confirmation of intermediary-based asset pricing models for exchange rates, I assess their performance in comparison to a traditional consumption-based asset pricing model. This exercise serves to elucidate whether financial intermediaries or households are the most relevant marginal investors, revealing whether models actually require financial intermediaries. I find that intermediary capital risk remains significant for both the carry trade and joint cross-section upon inclusion of consumption growth, consistent with intermediary-based asset pricing as it is intermediary capital risk rather than household consumption risk that prices foreign exchange, in line with intermediaries' roles as the marginal investors.

I also compare fluctuations in intermediary capital to previously identified exchange rate factors, namely the high-minus-low (HML) carry and dollar and global dollar factors of Lustig, Roussanov, and Verdelhan (2011, 2014) and Verdelhan (2018), in order to determine whether the risk-bearing capacity of financial intermediaries serves as one economic explanation for the risk contained within these factors. While factors constructed through portfolio-based methods provide an appealing proxy for underlying and generally unobservable risk factors, the economic sources of these risks are not clearly identified. I seek to fill this void by delineating whether intermediary capital serves as an independent source or one of the many sources of risk contained within these factors, shedding light upon the economic content of the HML carry and global dollar factors. I find that the HML carry factor serves as the most robust pricing factor for exchange rates, subsuming the previously significant intermediary capital risk, thus providing evidence that intermediary capital risk serves as a sub-component of the HML carry factor which contains a wider set of economic shocks and risk. Intermediary capital appears to be an independent and more relevant source of exchange rate risk compared to the dollar and global dollar factors, but intermediary capital does positively co-vary with the latter factor, suggestive that some of the risk contained within the global dollar factor is related to the risk-bearing capacity of financial intermediaries.

Taking a step back, recall that in standard asset pricing theory the value of an asset is determined by the marginal investor's trade-off between current and future consumption in combination with the asset's prospective cash-flows, where the marginal investor is the agent holding the asset. The relative value of consumption is given by the marginal utility or pricing kernel of this agent and thus asset prices and expected returns should jointly fluctuate with her marginal utility. Assets that provide poor returns when the marginal investor encounters low consumption, and equivalently high marginal utility, should provide higher expected returns as otherwise the agent would have no incentive to hold this riskier asset. Traditional asset pricing models have focused on households as the marginal investors, a by-product of representative agent models where households are the sole bearers of assets, and have investigated the relevance of measures of households' marginal utility such as consumption growth to test this theory. These models however have generally failed and/or entertain implausible coefficients for risk aversion (Mehra and Prescott 1985, Lustig and Verdelhan 2007).

The outsize importance of financial intermediaries in the trading and holding of financial assets motivates a shift towards the analysis of the marginal utilities and pricing kernels of these more relevant agents in both theory and empirics, suggesting that we must focus on their presumably central role in asset pricing instead of that of households. The recently well-developed closed-economy macro-finance literature has shown that models with realistic, time-varying risk premia (Brunnermeier and Sannikov 2014, He and Krishnamurthy 2013, Garleanu and Pedersen 2011) hinge on the presence of constrained financial intermediaries as the marginal investors. The level of constraint of these intermediaries, whether through a measure of their leverage, equity capital ratio, or margin requirements, thus enters as a state variable and determinant of their marginal utility and assets are then priced via the following mechanism: when intermediaries are more constrained, their marginal utilities are high as they would prefer higher consumption or wealth but are unable to borrow or lever up due to their constraint. It is then the covariance of asset returns with these determinants of marginal utility that dictates the size and presence of risk premia as assets that provide poor returns during periods of high constraints and consequently high marginal utility must yield larger expected returns to compensate for this downside risk.

This intuition can be extended to foreign exchange markets. When the marginal utility of intermediaries is high, perhaps due to negative shocks that lower their net worth and constrain their ability to trade or absorb losses, currencies that depreciate are considered risky assets as they lose value during bad times and should provide higher expected returns to compensate. Similarly, currencies that appreciate when intermediaries are more constrained should provide lower expected returns as they serve as insurance or hedges in the face of adverse shocks. This risk-based interpretation of exchange rate returns motivates the recent portfolio-based studies of exchange rates and the approach of this paper.

I confirm the validity of this mechanism by looking at the relevance of fluctuations in the capital ratios of financial intermediaries, examining whether these financial shocks are priced into the cross-section of exchange rate returns across portfolios of various strategies above and beyond other economic factors, namely consumption growth and the broader market return, and currency-specific factors such as the HML carry, dollar, and global dollar factors. I construct and employ currency portfolios to mitigate the influence of idiosyncratic country-specific risk and more accurately estimate betas while also assessing whether the risk premia captured by a wide range of cross-sections of currencies may be rationalized by the central role of financial intermediaries, a potential economic source of systematic global risk. While the recent literature has mainly focused on the identification of novel cross-sections of returns and sources of common variation across exchange rates through portfolio-based methods, little has been said about the fundamental economic determinants of the sources of risk that drive the heterogeneity in currency returns. I delineate the relevance of fluctuations in intermediary capital as an economic source of risk embedded in the various cross-sections of foreign exchange returns and assess whether it is distinct from or merely a component of the previously identified risk factors that do not yet have definitive economic interpretations.

As alluded to before, I find that intermediary capital is a significant risk factor for the pricing of the carry trade and joint cross-section of foreign exchange portfolio returns when compared to consumption growth and the broader equity market. Currencies that more positively co-vary with fluctuations in intermediary capital, or high intermediary capital beta currencies, provide higher excess returns and vice-versa, in line with intuition and providing support for the relevance of the risk-bearing capacity of financial intermediaries as an economic source of risk for exchange rates. My results confirm the validity of this mechanism as I show that intermediary capital commands a significant and positive risk price when examining the carry trade in isolation and the joint cross-section of currency portfolios covering a diverse set of risk premia. My findings show that financial intermediaries provide one explanation for the forward premium puzzle and failure of the uncovered interest parity, rationalizing the higher excess returns captured by high interest rate currencies through a risk-based interpretation of exchange rate movements, while also identifying intermediary capital as a source of global risk that underlies a broad set exchange rate risk premia.

I also show that while intermediary capital risk serves as a significant risk factor relative to other proposed economic risk factors, it is subsumed by the portfolio-generated HML carry factor as intermediary capital risk is no longer or only marginally significant upon the inclusion of the robustly priced HML carry risk factor. This finding does not preclude the relevance of intermediary capital risk and in fact clarifies its role in relation to previously identified sources of global risk embedded in the cross-section of exchange rates. The fact that the price of intermediary capital risk is previously significant and subsequently overshadowed by the HML carry risk factor shows that it may be one source of risk contained within the latter factor. Previous studies have shown the relevance of the HML carry risk factor, but have not yet conclusively identified its economic determinants with respect to financial shocks. The results here suggest that HML carry is the dominant risk factor for exchange rates and that intermediary capital shocks are one economic source of risk embedded within it.

In addition to the findings on the interplay of intermediary capital risk with the HML carry risk factor, I also provide an analysis of its connection with the dollar and global dollar factors of Lustig, Roussanov, and Verdelhan (2011) and Verdelhan (2018). I find that intermediary capital risk maintains its relevance when compared to these two factors and that the relevance of the risk embedded in the dollar factors for the cross-section of exchange rates hinges on the isolation of the global risk obtained by parsing out the US-specific component of risk - the global dollar factor is significantly priced in the wider cross-section of currency returns whereas the dollar factor itself is not.

I proceed to formally examine whether intermediary capital shocks explain some component of the HML carry and global dollar factors given that I hypothesize that intermediary capital risk serves an one economic source of shocks embedded in these two factors, while also exploring the relevance of other candidate sources of global risk. I find that intermediary capital is a robust source of risk contained within the HML carry factor, consistent with the economic relevance of intermediary risk for the pricing of foreign exchange. I also document the relevance of other economic sources of risk, namely risk aversion, liquidity, and US real activity for the HML carry factor, in line with previous studies and theory, and the co-movement of intermediary capital, liquidity, and US real activity for the global dollar factor, shedding light upon potential economic sources of risk contained within this less studied factor.

The paper proceeds as follows. Section 1.2 discusses where this paper lies in the broader literature. Section 1.3 describes the core data, portfolio construction methodology, and various summary statistics. Section 1.4 outlines the regression specifications, and displays and discusses the empirical asset pricing results. Section 1.5 examines the economic determinants of the portfolio-based exchange rate factors. Section 1.6 concludes.

1.2 Literature Review

This paper relates to a few strands of literature, most notably that on intermediary-based asset pricing and the portfolio, risk-based studies of exchange rates. More broadly it leans on the intuition from closed economy macro-finance models and seeks to validate recent open economy general equilibrium models that include financial intermediaries and shocks.

The notion of intermediary-based asset pricing has been identified and tested by previous researchers, but a deeper examination of its relevance for exchange rates has not. Adrian, Etula, and Muir (2014) were the first to empirically test for the relevance of intermediaries in asset pricing, using the leverage of the US broker dealer sector as a proxy for the marginal value of wealth of financial intermediaries to find significant prices of intermediary risk for the excess returns of various portfolios of US equities and bonds, and out-performance in a variety of other metrics, above and beyond that of mainstream asset pricing models. He, Kelly, and Manela (2017) perform a more expansive assessment, constructing their proxy for the marginal value of wealth of intermediaries via the net worth, or capital ratio, of primary dealers with the New York Fed, and test their factor on stocks, bonds, credit default swaps, exchange rates, and commodities, finding a significant risk price of intermediary capital. It is important to note that these two seminal papers have conflicting findings as Adrian, Etula, and Muir (2014) find evidence for pro-cyclical leverage and a positive price of intermediary leverage risk, whereas He, Kelly, and Manela (2017) find evidence for counter-cyclical leverage and a positive price of intermediary capital risk. These findings are contradictory as leverage should simply be the inverse of the capital ratio and thus the prices of risk should be inverted as well. While macro-finance models can generate both results depending on whether the intermediary has a debt or equity constraint respectively, I follow He, Kelly, and Manela (2017) as their measure of intermediary shocks is available at the monthly level in contrast to the quarterly frequency of the leverage measure from Adrian, Etula, and Muir (2014). My paper departs from both by shifting focus to the foreign exchange market, employing a wider set of exchange rate cross-sections, and studying the relevance and interplay of intermediary shocks against previously established risk factors in the empirical foreign exchange asset pricing literature in search of an economic interpretation for the global shocks that drive foreign exchange returns.

Related to the connection between financial shocks and exchange rates, Adrian, Etula, and Shin (2015) show that measures of short-term US dollar funding, namely primary dealer repos and commercial paper outstanding, forecast appreciations of the dollar and estimate a dynamic asset pricing model following Adrian, Crump, and Moench (2015) to find significant prices of carry and short-term dollar funding risk for the entire cross-section of individual currency excess returns. I deviate from their work by focusing the relationship between the carry trade and intermediary capital to uncover whether intermediary capital prices the carry trade and thus helps explains the forward premium puzzle, and the joint cross-section of currency portfolios to identify the existence of a systematic global risk factor with a meaningful economic interpretation. I also link the intermediary shocks back to their relationship with the HML carry and global dollar factors.

The empirical international finance literature on exchange rates has shifted towards portfolio-based tests of risk premia and the identification of novel cross-sections of currency excess returns. This was first applied by Lustig and Verdelhan (2007) who form portfolios of currencies based on their interest rate differentials and find significant prices of consumption risk in the cross-section of exchange rate returns, arguing that exposure to US consumption risk explains the carry trade and the forward premium puzzle. Lustig, Roussanov, and Verdelhan (2011) continue this approach and find that the cross-section of carry trade returns is driven by two factors, namely a level and slope factor. They show that sorting currencies by their forward discounts as a proxy for interest rate differentials leads to a monotonic relationship in excess returns by portfolio and identify the high-minus-low (HML) carry factor that is significantly priced in the cross-section and highly correlated with the currency slope factor. In addition, they find that the level factor is highly correlated with the average excess returns of foreign currencies against the dollar and establish this level factor as the dollar factor. Building on Backus, Foresi, and Telmer (2001), they interpret their findings through the lens of an affine model of exchange rates that identifies the necessity of heterogeneous loadings on a global factor that can be proxied by the HML carry factor in order to theoretically generate the cross-section of carry trade returns.

The level or dollar factor is explored in subsequent papers, namely Lustig, Roussanov, and Verdelhan (2014) and Verdelhan (2018). These papers identify cross-sections of currency returns distinct from the carry trade hinged on going long foreign currencies and short the US dollar when the average forward discount is positive, with the risk of depreciation of foreign currencies when bad shocks hit in times with high US volatility and thus high US investor marginal utility. This paper can rationalize this mechanism as US investor marginal utility may be proxied by the risk-bearing capacity of financial intermediaries if they are indeed the marginal investors in currency markets. Verdelhan (2018) highlights the share of systematic variation in bilateral exchange rates, noting the outsize importance of the average change in the US dollar against all foreign currencies, or what he calls the dollar factor, in the explained variation of exchange rate movements. He identifies a separate cross-section based on heterogeneous movements relative to this dollar factor, namely the dollar betas, and establishes the notion of a global dollar factor by taking the difference between high and low dollar beta sorted portfolios to isolate the global risk factor driving this separate cross-section that is purged of US-specific risk. He then finds that this cross-section of dollar portfolios is distinct from the carry trade and rationalizes its existence by positing an affine model with two orthogonal global shocks to generate both cross-sections, each of which can be proxied by the HML carry and global dollar factors. My paper seeks to shed light upon the economic content of these factor in relation to intermediary-based asset pricing.

I borrow from and build upon this line of papers by forming portfolios of currencies as test assets sorted by forward discounts as in Lustig, Roussanov, and Verdelhan (2011), dollar betas as in Verdelhan (2018), and a variety of other cross-sections previously identified in the literature (Asness, Moskowitz, and Pedersen (2013), Menkhoff et al. 2012a, 2012b), and utilize the identified risk factors, namely the HML carry, dollar, and global dollar factors to compare to the intermediary capital shocks. I employ portfolios to reduce the influence of idiosyncratic, country-specific risk and combine portfolios from this diverse set of cross-sections to assess whether financial intermediaries serve as a source of systematic global risk that is present in exchange rate risk premia. My goal is similar to this line of research as I attempt to find another cross-section of currency returns and risk, but also complement it by examining the interplay between the intermediary shocks, previously identified exchange rate factors, and various cross-sections of currency portfolio returns. More importantly, given the portfolio-based approach of identifying risk factors, previous papers do not explicitly identify the economic source of the shocks contained within the HML carry and global dollar risk factors or an explanation of the heterogeneous loadings on these shocks in the lens of affine exchange rate models, although Lustig, Roussanov, and

Verdelhan (2011) and Verdelhan (2018) do draw some connections between equity market volatility and the HML carry factor, and systematic exposure to global capital flows and the global dollar factor, respectively.

There also exists an immense literature on the carry trade and this paper contributes by highlighting that fluctuations in intermediary capital serve as one economic explanation behind its existence. Lustig and Verdelhan (2007) find the significance of US consumption growth, borrowing from Yogo's (2006) D-CAPM model to show that currency portfolios sorted on interest rate differentials align with consumption betas, providing evidence in support of consumption-based asset pricing as applied to foreign exchange. Burnside (2011) debates their findings on the basis of econometric issues, arguing that after accounting for the estimated regressors problem associated with the first-stage consumption betas and properly adjusting standard errors, he finds no significant risk price of consumption growth. My work builds upon both by comparing the relevance of intermediary capital to that of consumption growth, constructing standard errors that correct for the estimated first stage betas, and clarifying whether it is intermediaries or households that price the carry trade and broader cross-section of exchange rate returns. This exercise serves to distinguish between traditional consumption- and intermediary-based asset pricing models and validate whether the introduction of financial intermediaries into open economy models is warranted.

A series of papers examines the relevance of crash risk and peso problems to account for the carry trade. Brunnermeier, Nagel, and Pedersen (2008) identify the negative skewness of the carry trade, revealing the presence of infrequent, but large carry trade draw-downs and show that increases in global risk aversion coincide with carry trade losses. Burnside et al. (2011) argue for the relevance of peso problems as they find that traditional risk factors fail to price the carry trade, while the hedged carry trade provides lower returns compared to the traditional un-hedged version, indicative of compensation for downside risk. They proceed to show that the peso problem stems from high values of the marginal investor's stochastic discount factor in the peso state rather than large losses. Jurek (2014) provides a similar analysis and constructs a crash-neutral carry trade by hedging with out-of-the-money options, but he comes to a different conclusion. He shows that although the hedged carry trade provides slightly lower returns compared to the un-hedged version, there still exist significant excess returns to both and compensation for a peso state can only account for one-third of carry trade returns, which he interprets as an inability of peso problems to fully account for the existence of the carry trade. Lettau, Maggiori, and Weber (2014) document the downside-CAPM model that significantly prices the carry trade and a wide variety of assets, arguing for the asymmetry between risk premia associated with market declines and increases. Farhi and Gabaix (2016) introduce rare disaster risk into an open economy model, suggesting that some countries have higher interest rates because their currencies disproportionately depreciate when disasters arrive and investors must be compensated for this disaster risk through positive expected returns.

This paper connects to this literature by showing that financial intermediaries' risk-bearing capacity can be one way to rationalize crash risk. Burnside et al.'s (2011) finding that marginal utilities are disproportionately high in peso states for which the carry trade is compensated for is consistent with intermediary-based asset pricing as in times when intermediary capital is low and they are constrained, their marginal utility of wealth and thus stochastic discount factor is high, with risk premia sharply rising when intermediaries are almost or fully constrained. One class of peso event can then be financial crises in which intermediaries are constrained and demand higher risk premia, consistent with the closed-economy intermediary-based asset pricing literature. Similarly, down-side and disaster risk can be viewed through the lens of intermediary-based asset pricing as currencies that more positively load onto intermediary capital risk should disproportionately depreciate upon realizations of large negative capital shocks that lead intermediaries to become increasingly or completely constrained.[1] Furthermore, the relevance of global risk-aversion can also be interpreted through intermediary-based asset pricing as intermediaries with lower risk-bearing capacities should endogenously become more risk averse, thus commanding higher risk-premia and I confirm Brunnermeier, Nagel, and Pedersen's (2008) finding that risk aversion is negatively associated with carry trade returns.

Menkhoff et al. (2012), Hassan (2013), Daniel, Hodrick, and Lu (2017), Ready, Roussanov, and Ward (2017), Richmond (2016), and Jiang (2018) provide a variety of alternate explanations for the cross-section of carry trade returns due to volatility risk, country size, dollar and equity risk, commodity exporters, trade networks, and fiscal risks, respectively, and I look to add to this literature by examining whether intermediary capital risk can also provide an economic explanation of the carry trade. I go beyond these papers by assessing whether intermediary capital accounts for not only the carry trade, but also the joint cross-section of a variety of currency portfolios, showing that intermediary-based asset pricing alone provides an elegant and fundamental economic explanation to the forward premium puzzle and reveals an economic risk factor that underlies a wide set of exchange rate risk premia. In addition, the economic interpretations behind the shocks contained in the dollar and global dollar factors identified by Lustig, Roussanov, and Verdelhan (2011) and Verdelhan (2018) are less widely studied and I approach both through the lens of financial intermediaries, and a provide a formal analysis of potential determinants of the global

[1]This paper does not explicitly account for non-linearities in the asset pricing tests. Non-linearities are however explicitly modeled in the closed economy macro-finance literature, e.g. He and Krishnamurthy (2013) and Brunnermeier and Sannikov (2014).

dollar factor.[2]

The empirical intermediary-based asset pricing literature is based predictions from the closed economy macro-finance literature that hinges upon the existence of constrained financial intermediaries. Brunnermeier and Sannikov (2014), He and Krishnamurthy (2013), Danielsson, Shin, and Zigrand (2011), Adrian and Boyarchenko (2012), Garleanu and Pedersen (2011), Brunnermeier and Pedersen (2009) explore macro-finance models with constrained intermediaries whose relative risk-bearing capacities, net worth, and/or leverage matter for the behavior of risk premia and thus asset prices. Most closely related to this paper is He and Krishnamurthy (2013) who construct a model in which financial intermediaries serve as the marginal investors in risky assets as households are restricted from holding these assets and can only gain exposure by funding intermediaries who invest on their behalf. Intermediary net worth, and equivalently risk-bearing capacity, plays a central role as households only invest up to a fraction of the intermediary's net worth, which can be interpreted as providing an incentive for intermediaries to optimally choose their portfolios as poor choices will negatively erode their capital and dry up their funding, leaving them more constrained. Non-linearities arise in the model because when the intermediary becomes fully constrained, risk premia sharply rise, in contrast to the unconstrained region.

The notion of financial intermediaries in macroeconomic models has also been extended to the open economy. Gabaix and Maggiori (2015) develop an open economy model with a constrained global financier/bank that intermediates all international bond trades and show that their model produces intuitive exchange rate movements that emphasize the role of the risk-bearing capacity of financial intermediaries and portfolio flows in exchange rate deter-

[2] In Appendix A.3 I explore whether capital flow elasticities to fluctuations in intermediary capital align with the dollar betas, finding a positive relationship between the two. My results point towards capital flows in relation to intermediary capital as an economic rationale behind the pattern of dollar betas.

mination. Their paper also contains theoretical predictions regarding the carry trade and the risk-bearing capacity of financial intermediaries as they show that carry trade returns erode upon realizations of shocks that negatively impact the intermediary's risk-bearing capacity and that intermediaries must be compensated for holding currencies that depreciate upon the realization of tighter financial conditions - I confirm their theoretical predictions in both asset pricing and standard regression tests. Itskhoki and Mukhin (2017) emphasize the role of financial shocks in general equilibrium open economy models, namely through a UIP wedge, to produce empirically consistent exchange rate movements. The financial shocks in their model can be interpreted as fluctuations in the risk-bearing capacity of financial intermediaries that drive deviations from the UIP as more constrained intermediaries will be less inclined to remove and balance deviations in the UIP and must be compensated via higher expected returns to hold high interest rate currencies that run the risk of depreciation. This paper thus seeks to validate the role of financial intermediaries for consistent exchange rate behavior by measuring whether risks emanating from their existence can account for the cross-sectional heterogeneity in excess returns across currencies and the predictions of the models are borne out in the data. I however abstract from writing down a full structural open economy model with constrained financial intermediaries, leaving that open to future research.

1.3 Data

Currencies

I obtain daily spot and forward data from Datastream, combining Barclays and WM/Reuters data as the former extends farther back but with less currencies, whereas the latter contains the full set of currencies. To remain consistent with previous studies, I splice the datasets in January 1997, using the Barclays data prior to this date and only the WM/Reuters data after. I obtain an end-of-the-month series for each currency from January 1983 to March 2018 subject to availability. All spot and forward rates are expressed in US dollars, or quoted as foreign currency units per dollar. The dataset covers the following countries: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Euro area, Finland, France, Germany, Greece, Hong Kong, Hungary, India, Indonesia, Ireland, Italy, Japan, Kuwait, Malaysia, Mexico, Netherlands, New Zealand, Norway Philippines, Poland, Portugal, Saudi Arabia, Singapore, South Africa, South Korea, Spain, Sweden, Switzerland, Taiwan, Thailand, Turkey, the United Arab Emirates, and the United Kingdom. Countries that adopted the euro are kept until January 1999, and I contrast with the existing literature by omitting the pegged currencies of Hong Kong, Saudi Arabia, and the United Arab Emirates.

To remain consistent with the previous literature, I delete the following observations as in Lustig, Roussanov, and Verdelhan (2011) and corresponding papers due to large failures of covered interest parity: South Africa from July 1985 to August 1985, Malaysia from August 1998 to June 2005, Indonesia from December 2005 to May 2007, Turkey from October 2000 to November 2001, and United Arab Emirates from June 2006 to November 2006. Note that since the financial crisis there have been widespread deviations in covered interest parity (Du, Tepper, Verdelhan 2018), but I abstain from deleting observations in the latter part of the sample given the prevalence of deviations for most developed countries.

Intermediary Capital Shocks

I obtain data on the equity capital ratio of financial intermediaries and the corresponding shocks directly from He, Kelly, and Manela (2017), available at both monthly and quarterly frequencies on Asaf Manela's website. They obtain the set of primary dealers vis-à-vis the New York Fed, namely the financial intermediaries that trade directly with the Federal Reserve in open market operations, from the New York Fed's website. They then hand-match these dealers to balance sheet data on their respective public holding companies from CRSP, Compustat, and Datastream in order to construct the aggregate primary dealer capital ratio, η_t, defined as follows:

$$\eta_t = \frac{\sum_i MarketEquity_{i,t}}{\sum_i (MarketEquity_{i,t} + BookDebt_{i,t})}$$

where $MarketEquity_{i,t}$ is the share price times number of shares outstanding on the last day of the month and $BookDebt_{i,t}$ is total assets less common equity for dealer i in month t.

Note that the capital ratios aggregate and thus value-weight rather than average across dealers. Although the ideal would be to weight each dealer by their relative share of intermediation in each respective asset, my case being foreign exchange, this data is not readily available outside of proprietary surveys, and thus the value weighting serves as second best under the implicit assumption that dealers with larger values of market equity intermediate relatively more in volume.

To obtain the capital ratio shocks, He, Kelly, and Manela (2017) estimate a first order auto-regression on the capital ratio series and take the residual as the shock. Formally:

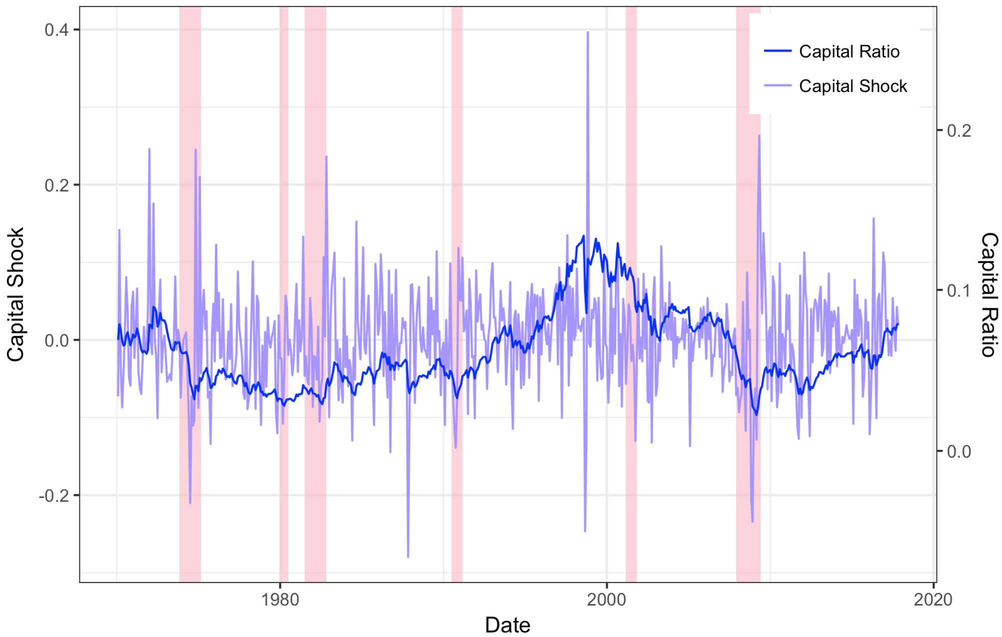


Figure 1.2: Intermediary Capital Ratio and Shock Series

Notes: The shaded bars indicate US NBER recessions.

$$\eta_t = \rho_0 + \rho\eta_{t-1} + u_t \tag{1.1}$$

The shock is then scaled to obtain a growth rate:

$$CShock_t = u_t/\eta_{t-1} \tag{1.2}$$

Figure 1.2 plots the equity capital ratio and capital shock series. We observe that equity capital ratios tend to be pro-cyclical, in line with the intuition that bad shocks to intermediary capital coincide with periods of financial turbulence as evident by the sharp drops during the months containing Black Monday in 1987, the Russian default in 1998, and the Global Financial Crisis in 2008.

Table 1.1 displays the summary statistics for both the level of intermediary capital

Statistic	N	Mean	SD	Min	25th Pct	75th Pct	Max
Capital Ratio	574	0.063	0.024	0.022	0.045	0.076	0.134
Capital Shock	574	0.001	0.068	−0.280	−0.040	0.040	0.396

Table 1.1: Summary Statistics for Intermediary Capital

ratio and capital shocks. We observe that intermediaries on average have 6.3% of equity capital to assets, ranging from as high as 13.4% in 1998 to a low of 2.2% in the midst of the Global Financial Crisis in 2009. Shocks to the capital ratio, as measured by the scaled residual of an autoregressive model, are our primary variables of interest. The series appears stationary, with a mean of .001, but is volatile, ranging from as low as -.28 to .4, with a standard deviation of .068. Economically, these suggest that the largest negative shock reduced the intermediary capital ratio by almost a third of its previous value and a one-standard deviation shock causes the capital ratio to fluctuate by 7%.

Given that the following analysis will be done at the monthly level, it is important to note that most of the variation in the intermediary capital ratio and shock will come solely from fluctuations in the market value of equity as balance sheet data is only available at the quarterly frequency at best. To show that intermediary shocks do not solely come from broad stock market fluctuations, I compute correlations of the intermediary capital shock series with the returns of the S&P 500 financials and excluding financials indices, and the Fama-French global market. Looking at the correlations in Table 1.2, it is apparent that intermediary capital shocks coincide with fluctuations in the financials sector of the S&P 500 and that these shocks are not overwhelming correlated with the broader market, suggestive of some orthogonality in terms of shocks. In other words, some of the variation in the intermediary shock series comes from shocks solely affecting the risk-bearing capacity of financial intermediaries, rather than the entire market and economy.

	CShock	SPX Fin	SPX ex Fin	FF Global
CShock	1.00	0.84	0.49	0.65
SPX Fin	0.84	1.00	0.58	0.70
SPX ex Fin	0.49	0.58	1.00	0.64
FF Global	0.65	0.70	0.64	1.00

Table 1.2: Correlations of Intermediary Shocks and Equity Indices

Notes: Correlations are estimated for the intermediary shock series and the monthly returns of the S&P 500 Financials only, S&P 500 excluding Financials, and Fama French Global Market

Excess Returns

Let s_t and f_t denote the log spot and forward rates respectively defined in foreign currency units per dollar. An increase denotes an appreciation of the dollar and depreciation of the foreign currency in question. Buying or going long a currency by engaging in a forward contract today to buy the foreign currency and sell it on the spot market in the future yields a log excess return of:

$$rx_{t+1} = f_t - s_{t+1}$$

Note that we can decompose this return into gains stemming from exchange rate movements and, if covered interest parity holds, interest rate movements:

$$rx_{t+1} = f_t - s_t + s_t - s_{t+1} \approx i_t^* - i_t - \Delta s_{t+1}$$

where i_t^* is the foreign interest rate and i_t is the US interest rate. The log excess return is thus approximately equal to the interest rate differential less exchange rate depreciation.

Portfolio Construction

As pioneered by Lustig and Verdelhan (2007) for foreign exchange, who were influenced by Fama-French (1993) and the subsequent empirical asset pricing literature, recent studies in the international finance literature have focused on using portfolio methods to identify and explain cross-sections of currency returns. Currencies are ranked and sorted into portfolios based on a country- or currency-specific characteristic such as their forward discount or exposure to a factor, analogous to sorting equities on size or book-to-market ratios, upon which one takes the average excess returns of the currencies in each portfolio. The main benefit of this approach is that the averaging of multiple currencies in each portfolio should purge each portfolio of idiosyncratic country-specific shocks and isolate the variation in excess returns due solely to the criterion of the portfolio sorts and thus relative exposure to a source of risk with the main drawback being the sharp decrease in sample size.[3] In addition as explained in Cochrane (2005), utilizing portfolios of assets rather than the assets themselves enhances the measurement of betas as portfolios tend to have lower residual variance and more stable betas over time, mitigating measurement error issues in the asset pricing tests. Furthermore, given that characteristics may be highly variable for currencies, measuring betas using portfolios sorted by characteristics provides more stable estimates as characteristic-specific betas may be less volatile.

This paper adopts the portfolio construction approach and constructs a variety of currency portfolios in order to examine whether intermediary capital shocks price the carry trade, the broader joint cross-section, and reveal their own cross-section of excess returns. I discuss each in turn.

[3]Note that given the limited number of currencies, this approach of nullifying idiosyncratic risk is of course not as effective compared to equities which are more numerous.

Intermediary Capital Shock Portfolios

In order to determine whether exposure to intermediary shocks constitutes a new and independent cross-section of returns, I construct portfolios of currencies sorted by "intermediary capital shock" betas. I obtain the latter by running the following 36-month rolling window regression:

$$rx_{i,t} = \alpha_i + \beta_i^{CS} CShock_t + \epsilon_{i,t}$$

I sort currencies based on their time-varying co-movements with the intermediary shocks, $\beta_{i,t}^{CS}$, estimated via rolling regressions, and form six portfolios based on these sensitivities. Intuitively, the high portfolio contains currencies that should provide higher excess returns as they provide poor returns when negative intermediary shocks arrive, whereas the low portfolio contains currencies that appreciate or depreciate by relatively less than high beta currencies upon realizations of negative shocks. If the intermediary shocks capture a significant risk factor, we should observe a monotonic relationship between exposures to the risk factor and excess returns. I examine this formally both via summary statistics and asset pricing tests shortly.

High-Minus-Low (HML) Carry Portfolios and Factor

A commonly known yet puzzling trading strategy has been the carry trade. It comprises of going long or purchasing the currencies of countries with high interest rates, typically the Australian or New Zealand dollars, while funding these investments by shorting or selling currencies of countries with lower interest rates, such as the Japanese yen or Swiss franc, in the context of G10 currencies. The carry trade is predicated on the failure of the uncovered interest parity as theory suggests that higher interest rate countries' currencies should depreciate sufficiently to offset interest rate differentials and equate expected returns across currencies, a prediction inconsistent with the data as the strategy yields sizeable returns. This anomaly gives rise to the forward premium puzzle.

To generate the cross-section of portfolios that represent the carry trade, I follow Lustig, Roussanov, and Verdelhan (2011) and sort currencies by their forward discounts, $f_t – s_t$, rebalancing every month. Recall that if covered interest parity holds, then this is approximately equal to the interest rate differential against the dollar, namely $f_t – s_t \approx i_t^* - i_t$, and thus sorting currencies by forward discounts is essentially sorting by interest rates. I split the currencies into 6 portfolios so that the first portfolio contains the lowest interest rate currencies, while the sixth portfolio contains the highest interest rate currencies.

To obtain the HML carry risk factor, I take the difference in the excess returns between the top and bottom portfolios, which is equivalent to going long high interest rate currencies by shorting low interest rate currencies. This is a zero-cost investment that exploits the cross-sectional variation in excess returns contingent on interest differentials and isolates the excess return given if one were to have full exposure to the risk factor embodied in the cross-section of carry trade returns. An investor that is long the carry trade is compensated for taking on the risk that when bad shocks are realized, currencies with high interest rates tend to depreciate, while those with low interest rates tend to appreciate, thus providing poor returns to the strategy during bad times. This rationalizes higher expected returns at all other times as compensation for this risk and the HML carry factor proxies for the underlying global risk factor.[4]

[4]Lustig, Roussanov, and Verdelhan (2011) rationalize the existence of the carry trade in an affine model of exchange rates and show that countries must be heterogeneously exposed to a global shock. Differencing the top and bottom portfolios is equivalent to isolating this global shock.

Dollar Portfolios and Global Dollar Factor

Verdelhan (2018) identifies an additional risk factor and cross-section of currency excess returns, distinct from the carry trade. He first estimates the co-movement of each currency's spot exchange rate changes with the average spot rate changes of all currencies against the dollar, obtaining each currency's dollar beta. He then sorts currencies into six portfolios based on these dollar betas, generating a cross-section of currency portfolios with monotonically increasing levels of co-movement with the average of movements of the dollar which he argues is also monotonically increasing in excess returns. I call these portfolios sorted by dollar betas the dollar portfolios.

Similar to Verdelhan (2018), my dollar portfolios are obtained by first running 36-month window rolling regressions of the excess return of a specific currency against the average excess return of going long all foreign currencies against the dollar. I depart from his construction with spot rates as I find the strategy constructed from the univariate specification with excess returns to be more profitable, but both strategies have the same interpretation - high dollar beta currencies provide higher returns when the dollar depreciates on average against all currencies and vice versa. Thus high dollar beta currencies are those whose excess returns are most sensitive to average changes in the dollar as they depreciate by more than low dollar beta currencies when shocks that cause the dollar to broadly appreciate are realized. For each currency I run:

$$rx_{i,t} = \alpha_i + \beta_i^{Dol} DolRX_t + \epsilon_{i,t}$$

With the rolling regressions, I obtain a set of time-varying dollar betas, $\beta_{i,t}^{Dol}$ for each currency, i, which I use to sort currencies into six portfolios whose excess returns are the average of the excess returns of the currencies contained in each. Furthermore, following Verdelhan (2018), I condition these portfolios by shorting portfolios if the average forward discount of advanced economies is negative as forward discounts may contain information about future returns.

To obtain the global dollar factor, I take the difference between the high and low dollar beta portfolios to obtain a zero-cost investment that goes long high dollar beta currencies and short dollar beta currencies. Differencing the two dollar portfolios purges the US-specific information component of the dollar factor if we assume that all portfolios equally load onto US-specific risk, and isolates the global risk factor that each currency or portfolio is differentially exposed to in the cross-section.[5] Note that in contrast to the dollar strategy itself, I do not take into account going long or short depending on the average level of forward discounts in order to omit information contained in the average forward discounts and isolate the shocks that solely affect average excess returns against the dollar. Although slightly more nuanced, the risk embodied in these portfolios is that when shocks occur that cause the dollar to appreciate, high dollar beta currencies tend to depreciate more than low dollar beta currencies, and thus going long the former and short the latter as a zero-cost strategy bears the risk of poor returns in times of dollar appreciation and justifies higher expected returns at all other times.

Momentum Portfolios

In addition to the intermediary capital, carry, and dollar portfolios, I construct a set of momentum portfolios, following Menkhoff et al. (2012a). Currencies are ranked on their previous month's excess returns with the idea that winners continue their out-performance

[5]Verdelhan (2018) provides a full affine model that illustrates this mechanism formally.

while losers extend their losses. I construct six portfolios as with the other cross-sections, with the highest portfolio containing the currencies that have the largest lagged excess returns and vice-versa for the lowest portfolio. A momentum factor can also be extracted as in the previous cases by taking the difference between the high and low portfolios, forming a zero-cost strategy that goes long previously well-performing currencies and short poor performers.

Volatility Portfolios

Menkhoff et al. (2012b) examine the carry trade from the perspective of foreign exchange volatility, positing that carry trade returns are rationalized because the strategy performs poorly during bouts of high volatility. I construct a measure of monthly foreign exchange volatility as in their paper:

$$\sigma_t^{FX} = \frac{1}{T_t} \sum_{\tau \in T_t} \left[\sum_{i \in N_\tau} \left(\frac{|\Delta s_{\tau,i}|}{N_\tau} \right) \right]$$

where $|\Delta_{\tau,i}|$ is the absolute log change in the spot rate of currency i on day τ. T_t and N_τ signify the number of trading days in a given month and currencies on a given day, respectively. Monthly foreign exchange volatility is equal to the monthly average of the daily averages of absolute daily log spot changes. Volatility-sorted portfolios are then constructed by regressing each currency's excess returns on the residuals of an AR(1) model of the σ_t^{FX} series and sorting currencies by their past β_t^{vol} in a series of rolling regressions, i.e.

$$rx_{i,t} = \alpha_i + \beta_i^{Vol} Vol_t + \epsilon_{i,t}$$

where Vol_t is the residual from the first order autoregression of the volatility series.[6]

Currencies with the largest covariances with volatility innovations should yield low excess returns as they perform similar to hedges against volatility, yielding high returns in bouts of elevated volatility. On the other hand, currencies with little or no covariance with volatility should yield higher excess returns as they may depreciate and pay off poorly when volatility is elevated. Note that the pattern of excess returns and high-minus-low are constructed opposite all of the other portfolios as the "high" portfolio here contains currencies with the lowest exposures and volatility betas.

Value Portfolios

Finally, I construct currency value portfolios as in Asness, Moskowitz, and Pedersen (2013). Currencies are sorted by their value, computed as the 5-year change in purchasing power parity (PPP) or real exchange rate (RER) given by the negative ratio of the log average spot rate from 4.5 to 5.5 years ago and the log spot rate today less the difference in inflation between the foreign country and the US, as measured by changes in the CPI.

$$Value_{i,t} = log\left(\frac{RER_{i,t}}{RER_{i,t-60}}\right) = -log(\frac{\bar{s}_{t-55,t-65}}{s_t}) - \left[log\left(\frac{P_t^f}{\bar{P}_{t-55,t-65}}\right) - log\left(\frac{P_t}{\bar{P}_{t-55,t-65}}\right)\right]$$

The intuition is that currencies with large increases in their PPP have become more undervalued because higher PPP's, equivalent to real exchange rates, imply that the domestic currency is too weak given the relative price levels. The domestic currency eventually needs to appreciate against the dollar in order to push the real exchange rate back to unity and equate purchasing power across currencies, hence investing in the currency now provides

[6] I also construct the portfolios with the difference in the volatility series as the factor and find qualitatively similar results.

good value as it will eventually appreciate and yield higher excess returns down the line.

Note that the construction of these portfolios differs from Asness, Moskowitz, and Pedersen (2013) as I do not focus only on G10 currencies and generate a larger number of portfolios, namely six versus their three.

Portfolio Summary Statistics

Table 1.3 displays summary statistics for each of the portfolios described in the previous sections. Moments are annualized and in percentage terms, namely means are multiplied by 12, whereas standard deviations are multiplied by $\sqrt{12}$. I display each portfolio's mean excess return, standard deviation, and Sharpe ratio to elucidate which strategies appear to be the most profitable before conducting the formal asset pricing tests.

The intermediary capital shock portfolios do not display monotonically increasing mean excess returns but suggest profitability. The top portfolio indeed yields the highest mean return of 2.4%, whereas the bottom portfolio yields a negative return of -1.3%. Combined, a high-minus-low portfolio of going long the top and short the bottom portfolio appears mildly profitable with a mean excess return of 3.5% per annum and a Sharpe ratio of .38. However given the lack of a discernible pattern in mean excess returns across portfolios, it is unlikely that intermediary capital shocks constitute their own cross-section.

The carry and momentum portfolios are almost and definitively monotonically increasing in returns across portfolios with the high-minus-low, or zero-cost-investment, strategies yielding mean excess returns of 7.1% and 6.1% per annum respectively. The pattern of increasing mean excess returns supports the existence of a risk-based explanation of foreign exchange returns as it shows that currencies with higher forward discounts or larger previous momentum, both of which implicitly proxy for larger exposures to some source of global

	1	2	3	4	5	6	HML
Capital							
Mean	-1.31	0.71	-0.19	0.12	0.66	2.37	3.54
SD	8.15	8.68	8.34	8.85	9.16	9.26	9.31
Sharpe	-0.16	0.08	-0.02	0.01	0.07	0.26	0.38
Carry							
Mean	-1.74	-0.48	1.82	2.80	2.26	5.35	7.08
SD	9.72	8.14	8.14	8.65	9.51	10.51	10.29
Sharpe	-0.18	-0.06	0.22	0.32	0.24	0.51	0.69
Dollar							
Mean	0.46	1.84	2.14	2.75	4.68	4.16	3.59
SD	5.34	5.77	8.31	9.93	10.30	11.11	10.54
Sharpe	0.09	0.32	0.26	0.28	0.45	0.37	0.34
Momentum							
Mean	-1.97	0.50	1.44	2.83	2.97	4.07	6.05
SD	12.05	9.12	8.77	8.88	8.71	8.83	11.59
Sharpe	-0.16	0.06	0.16	0.32	0.34	0.46	0.52
Volatility							
Mean	-0.45	1.09	-0.19	0.75	-0.32	2.50	2.99
SD	7.51	7.62	8.36	8.57	9.49	10.82	9.73
Sharpe	-0.06	0.14	-0.02	0.09	-0.03	0.23	0.31
Value							
Mean	-2.86	1.00	0.07	-0.66	3.07	3.63	5.79
SD	12.05	10.08	10.34	9.91	11.12	8.82	11.32
Sharpe	-0.24	0.10	0.01	-0.07	0.28	0.41	0.51

Table 1.3: Portfolio Excess Return Summary Statistics

Notes: Columns (1) - (6) represent the lowest to the highest of the six sorted portfolios for each cross-section. HML reflects the difference in excess returns of the highest portfolio (6) minus the lowest portfolio (1). All moments are annualized, with means multiplied by 12 and standard deviations scaled by $\sqrt{12}$. Sharpe Ratios are taken as the ratio between the two.

risk, grant higher mean excess returns as compensation for greater risk exposure. With Sharpe ratios of .69 and .52 respectively, these strategies appear profitable with decent risk-to-return trade-offs.

For the dollar portfolios, we almost have a monotonic increase in excess returns as we move along portfolios with larger dollar exposure, with the exception of the outsize return in the fifth, or second highest, portfolio. Note that these portfolios are conditional on the average forward discount, namely they are dynamic as I choose whether to go long or short the currencies against the dollar depending on if the average forward discount is positive or negative, respectively. The top portfolio has a mean excess return of 4.2%, while the high-minus-low yields 3.6% per annum with a Sharpe ratio of .34. In contrast to the carry and momentum portfolios, the high-minus-low does worse than simply going long the top portfolio as shorting the bottom portfolio does not yield additional returns.

The top volatility portfolio contains currencies that are the least exposed to foreign exchange volatility and exhibits the highest returns compared to those that are relatively more exposed.[7] This is in line with intuition as the currencies in the bottom portfolio, which have the higher volatility betas, tend to provide higher returns when volatility is high, and thus serve as insurance or a hedge that should yield lower excess returns at all other times. The high-minus-low yields a mean excess return of 3% with a Sharpe ratio of .31, improving upon the return of only the top portfolio due to the shorting of the bottom portfolio.

Finally for the value portfolios, while we do not obtain a strict monotonic pattern in excess returns, we observe a significant spread between the high and low portfolios. The best value portfolio yields a mean excess return of 3.6% per annum, while the worst value portfolio performs poorly with a mean loss of 2.9% per annum. The high-minus-low thus provides significant mean excess returns at 5.8% and a Sharpe ratio of .51, comparable to the momentum cross-section.

Figure 1.3 displays the cumulative returns from investing $1 in each portfolio. As was suggested by the summary statistics, an investor would have increased their initial investments to under $10 and a little over $6 if following the carry trade and momentum

[7] Recall that the top volatility portfolio, namely portfolio 6, contains currencies with the lowest volatility betas, whereas the bottom portfolio contains those with the highest volatility betas. I use this convention to remain consistent with the other portfolios in which the top portfolio contains risky currencies, while the bottom has the least risky.

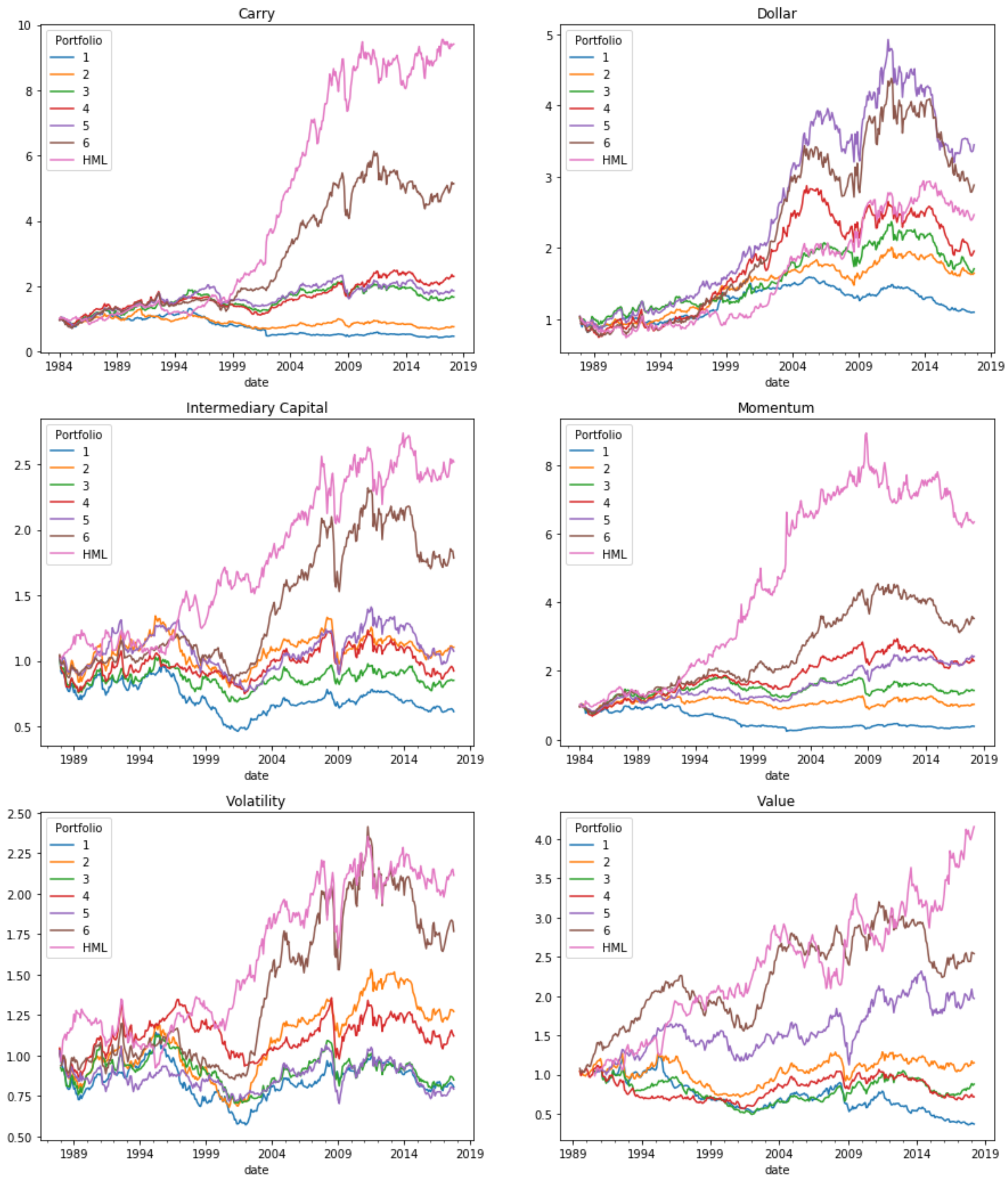


Figure 1.3: Cumulative Returns of FX Portfolio Strategies

Notes: These plots reflect cumulative returns of investing in an individual portfolio in each respective cross-sectional sort. Each portfolio's excess return is calculated as the average excess return of the currencies sorted into the respective portfolio. Portfolio 1 is the lowest sort, Portfolio 6 is the highest sort, and HML is the difference in average excess returns between portfolios 6 and 1.

high-minus-low strategies, respectively. Furthermore for the cross-section of carry and momentum portfolios, the cumulative returns appear to almost be monotonically increasing across portfolios, in line with the summary statistics. This builds support for the existence of a risk-based explanation for the cross-section of returns as it appears that increased loadings or exposure to potential risk factors and shocks are associated with consistently higher returns.

Cumulative returns to the dollar strategy are less impressive, as the initial outlay increases to a little less than three-fold by 2014 before declining persistently since then. An investor would have been better off only going long the top portfolios as indicated by the larger cumulative and excess returns without shorting the bottom portfolio, which recall has positive mean excess returns and erodes profitability. All portfolios however decline from 2015 onwards, presumably due to dollar appreciation.

The intermediary capital portfolios do not display monotonicity in terms of cumulative returns, but the high-minus-low portfolio does steadily increase the initial outlay 2.5 times over the sample period. The cumulative return peaks in 2015 before sharply dropping and stagnating since then. The volatility portfolios display mild capital gains up until 2009 in which we observe a sharp drop for all portfolios. There is a recovery following this sharp drop, but returns essentially stagnate from then on.

Cumulative returns from the value strategy appear consistently profitable, although not to the magnitude of the carry and momentum strategies. An initial investment increases four fold by the end of the sample, but note the periods of persistent declines, most notably from 2004 to 2007, 2010 to 2012, and 2014 to 2015. In contrast to all other strategies, the value strategy is unique in consistently being profitable over the past 3 years.[8]

[8]Note that nearly all of the strategies except value appear to reach peaks in 2010 and have not been nearly as profitable since then. I examine this further in the Appendix A.2 by deconstructing portfolio

1.4 Empirical Results

I shift now to a formal empirical analysis of the relationship between intermediary capital and exchange rate movements. I begin with a brief analysis of exchange rate movements with the intermediary capital shocks and the HML carry and dollar factors to assess whether currencies exhibit the predicted patterns, namely whether risky currencies depreciate and safe haven currencies appreciate when negative capital shocks are realized. I then proceed to conduct asset pricing tests to evaluate the relevance of intermediary capital compared to the market return and consumption growth. My findings align with the theoretical predictions outlined in the introduction and literature review in Sections 1.1 and 1.2, supporting the central role of financial intermediaries in exchange rate determination and providing evidence in favor of open economy, intermediary-based asset pricing models.

The latter part of this section examines the interplay of intermediary capital with the HML carry, dollar, and global dollar factors. My asset pricing tests display the dominance of the HML carry factor as a significant source of risk for exchange rates and the subsumption of intermediary capital risk upon inclusion of the HML carry factor suggests that intermediary capital risk is one of the many sources of risk embedded within the HML carry factor. My results with the dollar and global dollar factor maintain the relevance of financial intermediaries, and show that the global component of dollar risk, as isolated by the global dollar factor, significantly prices the joint cross-section of exchange rate portfolios.

returns into interest rate and exchange rate depreciation components for the pre- and post-2010 periods for each cross-section and find that a combination of compressed interest rate differentials and unfavorable dollar appreciation lead to declines in currency strategy returns.

Spot Changes and Intermediary Shocks

I first examine whether intermediary capital shocks contain any information content beyond that held in the spot changes of the HML carry and dollar factors. The former takes the difference between exchange rate changes of the currencies with the largest and smallest forward discounts, which proxy for interest rate differentials, while the latter reflects the average of all exchange rate changes against the dollar. I estimate the following for each currency:

$$\Delta s_{i,t} = \alpha_i + \beta_i^{HML} HML_{-i,t} + \beta_i^{Dol} Dol_{-i,t} + \beta_i^{CS} CShock_t + \epsilon_{i,t} \tag{1.3}$$

Note that $HML_{-i,t}$ and $Dol_{-i,t}$ exclude the currency on the left-hand-side to avoid regressing on the same variable. This regression estimates the size and direction of exchange rate movements with respect to systematic variation. For example, if the dollar on average appreciates by one percent, β_i^{Dol} yields the amount country i's currency depreciates in percentage terms.

The results for the G11 currencies are displayed in Table 1.4. Column (1) displays the sensitivities of exchange rate movements to the risks contained within carry trade as measured by spot rate movements. We observe a positive co-movement of traditionally risky currencies, such as the Australian and New Zealand dollars, with that of the carry trade, namely when the carry trade appreciates, these currencies do as well, in line with intuition. Similarly for traditional safe haven, low interest rate currencies such as the Japanese yen and Swiss franc, we observe negative coefficients, suggesting that these currencies appreciate when the carry trade is depreciating.

Column (2) displays the systematic co-movements of currencies with the average changes

Table 1.4: Systematic Variation in Exchange Rate Changes (Developed)

Country	HML (1)	Dol (2)	CShock (3)	R2 (HML) (4)	R2 (HML, CS) (5)	R2 (All) (6)
Australia	0.20***	0.80***	-0.08***	8.13%	11.13%	37.02%
Canada	0.10***	0.42***	-0.08***	6.80%	13.66%	32.37%
Switzerland	-0.29***	1.35***	0.09***	0.65%	1.37%	71.92%
Denmark	-0.26***	1.33***	0.03***	0.58%	0.33%	83.87%
Euro	-0.32***	1.35***	0.04**	-0.45%	3.92%	78.91%
United Kingdom	-0.06	0.92***	0.02	-0.13%	-0.32%	47.07%
Japan	-0.28***	0.65***	0.05**	3.49%	3.69%	24.02%
Norway	-0.10***	1.25***	-0.01	-0.20%	0.39%	69.79%
New Zealand	0.02	0.93***	-0.09***	1.75%	5.57%	37.60%
Sweden	-0.14***	1.25***	-0.03*	-0.25%	1.01%	69.10%

Notes: This table displays the coefficients from the regression in Equation 1.3 for the set of developed countries. The first three columns display the respective betas, while the latter three columns display the R^2 of regressions including only the HML, HML and intermediary shock, and the full set of regressors. Standard errors are Newey-West heteroskedasticity auto-correlation consistent with 12 lags.

of the dollar. Here we observe that all coefficients are robustly significant and positive, which is expected given that we are looking at bilateral exchange rates vis-à-vis the dollar. The heterogeneity of the coefficients around 1 is of interest, as the currencies of Australia, Canada, the United Kingdom, Japan, and New Zealand each depreciate less than one-for-one with the average depreciation against the dollar, while those of Switzerland, Denmark, Europe, Norway, and Sweden depreciate by more than the average. There appears to be no commonality for why these currencies move more or less than the average, but this is open to future research.

My contribution is the addition of the intermediary capital shock and the corresponding elasticities. We observe that the Australian, Canadian, and New Zealand dollars all have significant and negative coefficients. Recall that a negative intermediary capital shock means a decrease in the intermediary capital ratio, suggestive of tighter financial conditions and times of higher marginal utility. When primary dealers are hit with negative shocks, the aforementioned currencies tend to depreciate, in line with their reputation as riskier currencies as they yield poor returns when intermediaries need them most. In terms of economic magnitude, a one standard deviation intermediary capital shock is associated with approximately a half of a percent in depreciation. In contrast, if we instead look at the haven currencies, namely the Japanese yen and Swiss franc, we observe positive coefficients, with economic magnitudes of a quarter and a half percent appreciation respectively. Consistent with intuition, safe haven currencies tend to appreciate when negative intermediary capital shocks hit.

Columns (4)–(6) display the R^2's of the regressions with only the HML, HML and intermediary capital shock, and the full specification, respectively. We can see that the intermediary capital shock adds some explained variation, suggesting that intermediary capital shocks provide some additional information content above and beyond that of the carry trade itself. The full specification has quite high R^2's of up to 83% for the Danish krone and 78% for the euro, showing that average changes in the dollar account for an outsize portion of exchange rate movements, as found by Verdelhan (2018). In other words, currencies appear to share a large amount of systematic variation as a lot of their movements are linked to broad movements of the dollar against all currencies.

Table 1.5 displays the results for emerging markets currencies. Column (1) shows that the vast majority of emerging markets currencies positively co-move with the carry trade, the exceptions being the Czech krona, Hungarian forint, and Kuwaiti dinar. Column (2) again shows that all emerging market currencies positively co-move with the average level of the dollar with some level of heterogeneity in magnitude, but the majority moves by less than the average against the dollar. While Column (3) only yields a few significant estimates, note that they are mostly negative and similar in magnitude to the risky advanced economy currencies. If we take the stance that emerging markets currencies are risky,

Table 1.5: Systematic Variation in Exchange Rate Changes (Emerging)

Country	HML (1)	Dol (2)	CShock (3)	R2 (HML) (4)	R2 (HML, CS) (5)	R2 (All) (6)
Czech Republic	-0.31***	1.48***	-0.00	0.01%	3.48%	65.10%
Hungary	-0.16***	1.61***	-0.00	0.96%	6.60%	66.25%
Indonesia	0.21	1.00***	-0.12	2.89%	5.32%	10.76%
India	0.10**	0.50***	-0.01	9.46%	11.46%	34.14%
Korea	-0.07	1.06***	-0.07**	7.51%	16.29%	53.56%
Kuwait	-0.05***	0.21***	0.00	-0.40%	1.01%	36.51%
Mexico	0.19***	0.47***	-0.11***	15.19%	24.91%	34.36%
Malaysia	0.36***	0.70***	0.05**	25.17%	24.74%	48.17%
Philippines	0.23***	0.44***	0.02	12.23%	12.06%	24.74%
Poland	-0.02	1.61***	-0.06**	9.21%	20.46%	74.59%
Singapore	0.00	0.52***	-0.01	0.32%	1.15%	54.34%
Thailand	0.24***	0.66***	0.04	8.32%	7.98%	24.39%
Turkey	0.33***	0.83***	0.01	13.14%	13.44%	29.17%
Taiwan	0.02	0.45***	-0.01	3.80%	7.04%	39.25%
South Africa	0.11	0.99***	-0.08***	2.61%	4.81%	28.44%

Notes: This table displays the coefficients from the regression in Equation 1.3 for the set of emerging countries. The first three columns display the respective betas, while the latter three columns display the R^2 of regressions including only the HML, HML and intermediary shock, and the full set of regressors. Standard errors are Newey-West heteroskedasticity auto-correlation consistent with 12 lags.

this is consistent with theory as negative intermediary capital shocks are associated with emerging markets currency depreciation. Finally as before, we observe a moderate increase in explained variation by adding in the intermediary capital shock, and the average change in the dollar increases the explained variation tremendously.

Pricing of Intermediary Capital Risk

I now conduct an examination of the pricing of intermediary capital risk in the cross-section of foreign exchange returns. I perform a series of asset pricing tests to establish the relevance of intermediary capital as a risk factor, comparing its performance to the market return and global consumption growth in order to establish its role as a fundamental economic source of global risk embedded in the cross-section of foreign exchange returns. I then assess the significance of intermediary capital risk in combination with the HML carry, dollar, and global dollar factors to shed light upon its relationship with these exchange rate factors.

I show the following in turn: First, intermediary capital shocks provide an economic source of risk that underpins the carry trade, robust to the inclusion of consumption growth which reflects the relevance of financial intermediaries' pricing kernels over those of households. Although intermediary capital shocks do not constitute their own, independent cross-section of returns, the results show that they do matter for the carry trade and the joint cross-section of all currency portfolios. Second, the HML carry factor subsumes the risk embedded in the intermediary capital shocks and prices both the carry trade and the entire cross-section of currency portfolios, pointing towards intermediary capital risk as a component of the broader HML carry risk. In addition, the global component of the dollar factor as a proxy for global shocks independent of those contained within the HML carry factor matters for the cross-section of excess returns, whereas the dollar factor, un-purged of US-specific risk, does not.

My estimation of the prices of risk follows the standard two-stage Fama-MacBeth procedure. In the first stage, for each test portfolio I run a time series regression of its excess returns on a constant and the candidate risk factors to obtain a set of portfolio-specific betas. Formally:

$$rx_{i,t} = \alpha_i + \beta_i' f_t + \epsilon_{i,t} \text{ for } i = 1, ..., N \tag{1.4}$$

where f_t is a vector of factors and β_i is the vector of factor loadings for portfolio i, and N is the number of test portfolios. In the second stage, I estimate the prices of risk by running a cross-sectional regression for each time period t and take the average to obtain the final estimates:

$$rx_{i,t} = \lambda_t \beta_i\text{'} + \nu_{i,t} \text{ for } t = 1, ..., T \tag{1.5}$$

The coefficient of interest is $\hat{\lambda} = \sum \hat{\lambda}_t / T$, namely the vector of risk prices for each factor. I estimate the first stage betas with ordinary least squares, and compute the second stage risk prices using the pooled mean group estimator. Per Burnside's (2011) critique of Lustig and Verdelhan (2007), I construct GMM standard errors following Cochrane (2005) to alleviate concerns about standard errors as our second stage regressors, namely the first stage betas, are estimated.[9]

Before diving into the results, note that in contrast to previous studies that use the US market return, I employ the Fama French global market return as my control risk factor. I utilize the Feng et al. (2017) two-pass procedure which employs machine learning techniques as the immense number of pre-existing factors in the empirical asset pricing literature make the selection of baseline factors both tedious and inconsistent given the difference in estimates depending on which factors are included in the asset pricing regressions. I perform this control factor selection procedure as empirical asset pricing studies for exchange rates have not yet carefully found the correct factors to serve as controls in baseline specifications, making studies generally incomparable. I fill this void by formally identifying the Fama French global market return as the most relevant control factor in comparison to other factors for exchange rates, and argue that future studies of exchange rate risk factors

[9] Another option is the Shanken (1992) correction. Suppose we have N test portfolios, K factors, and T periods. Per Cochrane (2005), the Shanken corrected variance-covariance is computed as:

$$V = \frac{1}{T}\left((\beta'\beta)^{-1}\beta'\Sigma\beta(\beta'\beta)^{-1}(1 + \lambda'\Sigma_f^{-1}\lambda) + \Sigma_f \right)$$

where β' is an $N \times K$ matrix containing the estimated betas from the first stage in Equation **??**, $\Sigma = Cov(\epsilon_t',' \epsilon_t)$ is the $N \times N$ variance-covariance matrix of the residuals from Equation 1.4, λ' is an $K \times 1$ vector of the estimated average risk prices from Equation 1.5, and $\Sigma_f = Cov(f_t', f_t)$ is the $K \times K$ variance-covariance matrix of the factors.

should always be compared to this baseline.[10] Interested readers are encouraged to refer to Appendix A.1 where I provide a full discussion of the factor selection procedure.

Intermediary Capital as an Economic Risk Factor

Table 1.6 displays the results from the asset pricing tests of intermediary capital shocks with the global market return and consumption growth to examine the relevance of financial intermediary capital risk in the pricing of foreign exchange risk. I depart from the previous literature by using the Fama French global market return given its survival in the factor selection procedure, and also employ a wider set of exchange rate portfolios when testing for the significance of intermediary capital risk.[11]

Column (1) shows the risk prices estimated on the cross-section of six currency portfolios sorted by intermediary capital shock betas. If intermediary capital risk constitutes its own cross-section of excess returns, I expect a significant and positive price of intermediary capital risk as currencies that depreciate upon realizations of negative intermediary capital shocks provide lower excess returns at bad times and are thus deemed risky, compensating investors for the aforementioned risk by providing higher expected returns at all other times. We do not observe a significant price of intermediary capital risk or the global market, thus eliminating the existence of this independent cross-section of exchange rate excess returns.

However moving to Column (2), we observe a significant price of intermediary risk for the cross-section of carry trade portfolios sorted by forward discounts. Intermediary capital

[10] My selection procedure also highlights the S&P 500 excluding financials as a factor, but for parsimony I only include the results with the global market return given the limited number of test portfolios, especially for the carry trade. The results with this other control factor in lieu of the global market are included in the Appendix A.1 and results are similar.

[11] He, Kelly, and Manela (2017) test their factor against the carry trade and momentum portfolios from Lettau, Maggiori, and Weber (2014) and Menkhoff et al. (2012), finding significant and positive prices of risk. I augment their results by extending the sample period up to the end of 2017 and testing on a wider set of currency portfolios to capture additional cross-sections of exchange rates from the literature.

Table 1.6: Risk Price of Intermediary Capital Shocks vs. Global Market Return and Consumption

	Intermediary Capital	Carry Trade			All Cross-Sections		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\beta_{IntCapital}$	0.011	0.059***	0.042**	0.079	0.026**	0.025**	0.023*
	(0.012)	(0.022)	(0.018)	(0.079)	(0.011)	(0.010)	(0.014)
$\beta_{FFGlobalMkt}$	0.066	0.202		0.326	0.107*		0.154**
	(0.080)	(0.136)		(0.637)	(0.057)		(0.069)
$\beta_{DurableCons}$			−0.049	−0.237		0.085	0.084
			(0.241)	(0.942)		(0.107)	(0.093)
$\beta_{NonDurableCons}$			0.030	0.118		0.077*	0.079**
			(0.041)	(0.309)		(0.044)	(0.033)
Observations	1,968	1,968	2,436	1,968	11,772	11,772	11,772
R^2	0.840	0.808	0.783	0.904	0.625	0.591	0.712

Note: *p<0.1; **p<0.05; ***p<0.01

Notes: This table displays estimates of the risk prices from the second stage of the Fama MacBeth regression. Column (1) displays results for the cross-section of intermediary capital shock beta sorted portfolios, Columns (2)-(4) examine the carry trade, and Columns (5)-(7) show estimates on the entire joint cross-section of currency strategy portfolios. The first stage time series regression is estimated for each portfolio by ordinary least squares, while the second stage involves a cross-sectional regression for each time, t of excess returns on estimated betas across all test assets/portfolios. I employ the second stage using the pooled mean groups estimator. Standard errors are constructed following the GMM methodology as in Cochrane (2005).

risk is priced into the carry trade at 5.9% per annum, implying that high interest rate currency portfolios have high intermediary capital betas as their returns more positively co-move with the intermediary capital shocks, and are thus compensated for the risk of low returns when intermediary capital erodes. This provides support for intermediary capital as a fundamental economic source of risk embedded in exchange rates and provides an explanation for the forward premium puzzle as investors appear to be rewarded for holding high interest rate currencies that run the risk of depreciation when intermediary capital declines. Notice that intermediary capital risk is priced despite the presence of the global market return showing that it contains more information than equity prices - I interpret this as reflecting the outsize importance of intermediary capital as proxying for the risk-bearing capacity of relevant financial intermediaries that theory suggests.

This result is not limited to the cross-section of the carry trade - it also holds for the joint cross-section of all currency portfolios. Column (5) displays the risk price estimates from the sample that simultaneously employs all of the constructed portfolios, namely intermediary capital, carry, dollar, momentum, volatility, and value as described in Section 1.3, each of which presumably captures different sources of risk premia and anomalies in exchange rates. I find a significant price of intermediary capital risk at 2.6% per annum. While smaller in magnitude than the estimate from the carry trade portfolios alone, this finding supports the importance of intermediary capital in the pricing of exchange rates as using the broader set of portfolios identifies one systematic economic source of global risk that is embedded within a wide range of exchange rate risk premia, invariant to the type of sorting and portfolio construction. Furthermore given the low excess returns of all other cross-sections of exchange rates, it is not surprising that I obtain a smaller estimate.[12]

[12] I also test each cross-section independently in the online appendix. None of the other cross-sections of foreign exchange returns exhibit significant intermediary capital risk prices when estimated individually,

An additional finding is the significance of the global market return for the entire cross-section of foreign exchange returns at 10.7% per annum. Previous studies have had difficulties explaining exchange rate excess returns with the market return (Daniel, Hodrick, and Lu 2017), but I find that it is *global* market risk that may be the relevant factor, at least for the wider cross-section of exchange rate excess returns. The significance of this estimate is in line with its relevance as a baseline control factor and supports the two-stage factor selection procedure.

The significance of the intermediary capital shock for the risk pricing of the carry trade and the wider cross-section of foreign exchange excess returns leads one to question whether it is a distinct economic source of risk independent of the consumption growth risk found by Lustig and Verdelhan (2007). One could argue that intermediaries are just a veil for households and that intermediary capital risk may just proxy for household consumption growth risk. If this is true, models with financial intermediaries may then be adding an additional layer of complexity that is not necessarily warranted. I examine this notion by performing my asset pricing tests with US durable and non-durable consumption growth as additional risk factors to determine whether it is consumption growth, intermediary shocks, or a combination of the two that account for excess returns in exchange rates. This exercise clarifies the relevance of financial intermediaries versus households in the pricing of exchange rates.

Column (3) of Table 1.6 displays the results from the Fama MacBeth regressions with intermediary capital shocks and durable and non-durable US consumption growth as risk factors for the carry trade. I find that intermediary risk is still significant and positively priced at 4.2% per annum, while the consumption growth factors are not priced. My

but this could be due to the depressed returns in the past decade.

results show that intermediary capital risk is more important than household consumption risk in explaining the carry trade as investors appear to be compensated for co-movement of exchange rate returns with fluctuations in the financial intermediaries' pricing kernel rather than that of households. My findings validate the notion that open economy models require constrained intermediaries at the center of asset markets in order to account for the failure of the UIP and existence of the forward premium puzzle as the prediction and pattern of high interest rate currencies more positively co-varying with intermediary capital and thus subject to larger relative depreciations upon the realization of negative intermediary capital shocks is borne out in the data.

This finding is again extended to the entire cross-section of foreign exchange portfolios as indicated in Column (6). As before, we find a smaller, but significant price of intermediary risk at 2.5% per annum, verifying the robust importance of intermediary capital risk for the joint cross-section of exchange rate returns. In contrast to estimates with the carry trade alone, I also obtain a positive and significant price of non-durable consumption risk, providing support for Lustig and Verdelhan's (2007) original finding. However given the significance of intermediary risk for both carry and entire cross-sections, I interpret this as highlighting the larger importance of the financial intermediary's pricing kernel over that of the households. It is important to keep in mind that I am not claiming that households are completely irrelevant to pricing exchange rates or asset pricing in general, merely that financial intermediaries may the be more relevant marginal investor given the recent success of the theory and my more robust findings in support of intermediary capital risk. My results provide support for the importance of including constrained financial intermediaries in open economy macro-economic models in order to reconcile some of the inconsistencies between the theory and data.

Columns (4) and (7) serve as robustness checks by controlling for the global market return as well. For the carry trade I find that in contrast to before, none of the factors are now significant as displayed in Column (4). However, I rationalize this finding in two ways: first, note that the global market return is correlated with the intermediary capital shocks as displayed in Table 1.2 and thus its inclusion may dilute the significance of intermediary capital risk, especially if the relevant components of consumption growth and the capital shocks are also partially contained within the global market return. Second, given that I only have six portfolios in the carry trade cross-section, the regression has almost as many regressors as test portfolios - the risk prices may then be mis-estimated and the lack of significance may be a by-product of this.[13]

On the other hand, the full specification in Column (7) for the joint cross-section retains the significance of intermediary capital risk. Risk prices are presumably more precisely estimated in this larger sample given the increased number of portfolios and I find that intermediary capital is again a significant and positively priced risk factor for exchange rates at 2.3% per annum. The risk price of intermediary capital decreases in the level of significance, which I attribute to dilution due to the inclusion of the global market return, which is also significantly priced at 15.4% per annum. Given that non-durable consumption growth remains significantly priced, my results thus suggest that while financial intermediaries have the more robust pricing kernels, the risk embedded in consumption growth also plays a role, consistent with Lustig and Verdelhan (2007) and intuition as one would expect real shocks to be relevant for a wider set of exchange rate risk premia.

To visualize the effectiveness of intermediary capital in pricing the cross-sections of for-

[13] I have also run specifications with only one type of consumption growth risk that include the global market return. I find significance for intermediary capital risk in the specification with only intermediary capital shocks, non-durable consumption growth, and the Fama French global market return.

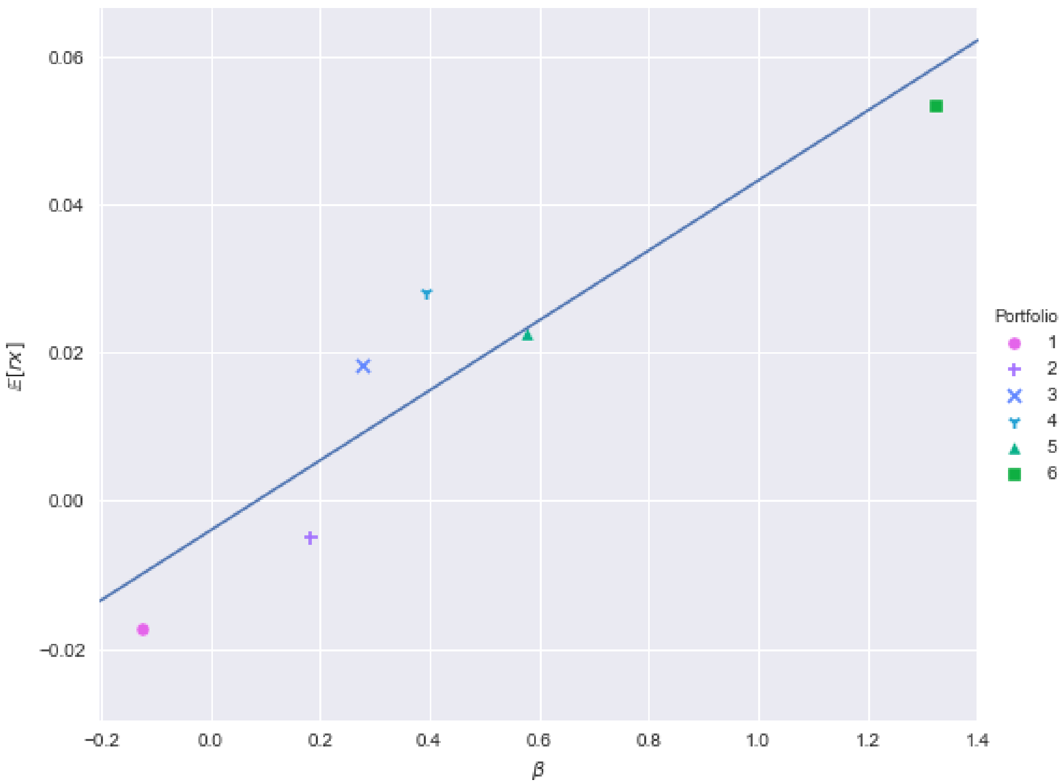


Figure 1.4: Carry Trade Mean Excess Returns and Intermediary Capital Betas

This figure displays the mean excess returns of each portfolio of the carry trade cross-section, namely currencies sorted on forward discounts. The x-axis contains intermediary capital betas, estimated for each portfolio by regressing its excess returns across the whole sample on a constant and the intermediary capital shock. The line reflects the best fit for the relationship between average portfolio returns and betas.

eign exchange, Figures 1.4 and 1.5 display scatter plots of mean portfolio returns against intermediary capital betas. Figure 1.4 shows that the carry trade portfolios are monotonically increasing both in mean excess returns and intermediary capital betas, implying that the carry trade and forward premium puzzle may be explained through the lens of intermediary capital risk as it is apparent that higher interest rate currencies are precisely those that are more exposed to intermediary capital shocks. These currencies enjoy higher excess returns because their larger co-movement with intermediary capital leads to depreciations and losses when intermediary capital erodes, coinciding with times of high intermediary marginal utility that require increased compensation and risk premia for downside risk.

Figure 1.5 displays the analogous plot for the joint cross-section of all currency portfolios. I obtain a similar pattern as with the carry portfolios - high portfolios enjoy higher excess returns and coincide with larger intermediary capital betas, while lower portfolios yield lower excess returns and have lower and even negative intermediary capital betas. Risky currency portfolios are again those that exhibit larger mean excess returns which are rationalized by relatively larger co-movements with intermediary capital, while the safer currency portfolios exhibit low or even negative co-movement with intermediary capital, in line with the intuition that currencies which appreciate upon the realization of negative intermediary capital shocks serve as hedges and should provide lower returns. Although not strict, I do observe a generally monotonic relationship between portfolios and intermediary capital betas as the bottom left, middle, and top right of the plot contain the low and less risky, intermediate, and high and most risky portfolios, respectively.

It is important to note that this pattern holds despite the different measures upon which each cross-section is sorted and constructed. The robust pattern between intermediary capital betas and portfolio excess returns is invariant to the sorting characteristic, lending credence to the notion that intermediary capital risk in fact underpins a wide set of exchange rate risk premia and thus serves a systematic source of global risk. Currency portfolios that are deemed as risky due to their larger exposure to risk factors are also more exposed to fluctuations in intermediary capital, implying that intermediary capital risk is embedded and compensated for in a variety of cross-sections of exchange rates and risk premia.

In summary, I have found that intermediary capital shocks are a significantly priced risk factor for the cross-section of carry trade returns and the wider cross-section of all currency portfolio returns. My results point towards the central role that financial intermediaries play in open economy models in order to give rise to deviations in the UIP and the forward

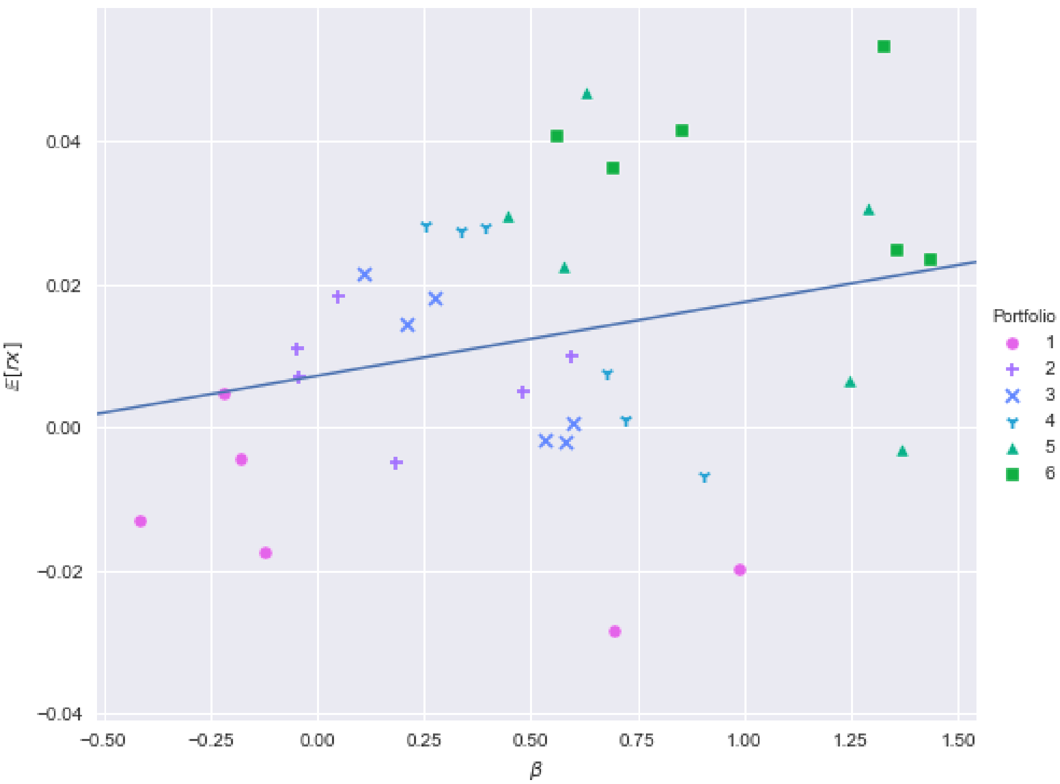


Figure 1.5: Mean Excess Returns and Intermediary Capital Betas

This figure displays the mean excess returns of each portfolio of the joint cross-section of exchange rates, which includes six portfolios for intermediary capital, carry, dollar, momentum, volatility, and value. The x-axis contains intermediary capital betas, estimated for each portfolio by regressing its excess returns across the whole sample on a constant and the intermediary capital shock. The line reflects the best fit for the relationship between average portfolio returns and betas.

premium puzzle as high interest rate currency portfolios provide higher mean excess returns as compensation for larger exposures to fluctuations in intermediary capital. I also show that intermediary capital risk underpins a number of exchange rate risk premia as the positive relationship between intermediary capital betas and risky portfolios holds for the joint cross-section, invariant to the criteria of sorting, thus providing evidence in favor of intermediary risk-bearing capacity as a systematic source of global risk.

Furthermore, I find that intermediary capital risk remains a significantly priced risk factor when compared to household consumption risk, providing evidence in support of financial intermediaries as the marginal investors in open economy asset pricing models as opposed to households. The evidence is strongest for the carry trade as intermediary capital risk is significantly priced whereas consumption risk is not, consistent with the notion that open economy models require constrained intermediaries to resolve some of the discrepancies between theory and empirics. While my results do not preclude the relevance of households in the pricing of exchange rate risk as non-durable consumption growth risk is significantly priced in the joint cross-section, the more robust evidence in favor of intermediary capital risk leans towards the larger relevance of the intermediaries.

Intermediary Shocks vs. Portfolio FX Factors

I now investigate whether intermediary capital shocks provide additional information content and serve as a risk factor beyond previously identified exchange rate risk factors. I estimate the prices of risk for the carry trade and joint cross-section of exchange rate returns using the intermediary capital shocks, HML carry, dollar, and global dollar factors as risk factors. The intuition is that if the HML carry and global dollar factors offer excess returns, the covariances or betas with their returns represent relative exposures to sources of global risk that underlie the existence of excess returns within their respective cross-sections. If intermediary capital shocks serve as a distinct source of risk from these two factors, we expect significant prices of intermediary risk in addition to that of the HML carry, dollar, and global dollar factors. On the other hand, if the risk embedded in intermediary capital shocks is merely a component of these factors, we expect insignificant risk prices as they should be subsumed by factors that contain a wider set of shocks and risk. I show evidence for the latter point, highlighting the role of fluctuations in intermediary capital as an economic source of global risk contained within the HML carry factor.

Column (1) in Table 1.7 compares the intermediary capital shocks and the HML carry

Table 1.7: Risk Price of Intermediary Capital Shocks vs. Exchange Rate Factors

	Carry Trade					All Cross-Sections				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$\beta_{IntCapital}$	0.015	0.056**	0.056***	−0.047	−0.027	0.014	0.031***	0.035**	0.019*	0.023*
	(0.043)	(0.024)	(0.022)	(0.087)	(0.077)	(0.011)	(0.011)	(0.014)	(0.011)	(0.013)
$\beta_{HMLCarry}$	0.078***			0.084***	0.084***	0.070***			0.074***	0.065***
	(0.019)			(0.019)	(0.019)	(0.023)			(0.023)	(0.023)
β_{Dollar}		0.013		0.019			0.016		0.018	
		(0.104)		(0.115)			(0.023)		(0.022)	
$\beta_{GlobalDollar}$			−0.005		0.131			0.088**		0.087**
			(0.190)		(0.219)			(0.040)		(0.038)
$\beta_{FFGlobalMkt}$	0.073	0.293*	0.245	−0.357	−0.327	0.069	0.003	−0.046	−0.066	−0.082
	(0.272)	(0.160)	(0.176)	(0.558)	(0.470)	(0.058)	(0.085)	(0.081)	(0.079)	(0.081)
Observations	1,968	1,968	1,968	1,968	1,968	11,772	11,772	11,772	11,772	11,772
R^2	0.884	0.886	0.883	0.923	0.922	0.647	0.648	0.658	0.670	0.680

*p<0.1; **p<0.05; ***p<0.01

Notes: This table display estimates of the risk prices from the second stage of the Fama MacBeth regression. Columns (1)-(5) display results for the cross-section of the carry trade, while Columns (6)-(10) employ the joint cross-section of all currency strategy portfolios. The first stage time series regression is estimated for each portfolio by ordinary least squares, while the second stage involves a cross-sectional regression for each time, t of excess returns on estimated betas across all test assets/portfolios. I employ the second stage using the pooled mean groups estimator. Standard errors are constructed following the GMM methodology as in Cochrane (2005).

factor for the carry trade portfolios. The HML carry factor completely subsumes the significance of the intermediary capital shock as only HML carry risk is priced into the cross-section of the carry trade at 7.8% per annum whereas the price of intermediary capital risk is now insignificant. This is not surprising as we expect the risks embedded within the carry trade to wholly account for its cross-sectional variation, but it is of interest that intermediary capital risk is now no longer significantly priced. We observe the robust significance of the price of HML carry risk again in the full sample with all cross-sections tested simultaneously at 7% per annum in Column (6). Both estimates are significant at the 1% level, displaying the dominant role of the global risk embedded in the HML carry factor in pricing foreign exchange returns. The global risks proxied by the HML carry factor appear to be important for the pricing of a wide set of exchange rate risk premia, not just the carry trade itself.

The significance of the HML carry factor over the previously significant intermediary capital shocks provides new information about the interaction between these two risk factors. In my baseline specifications I find that intermediary capital shocks serve as the most relevant risk factor in the pricing of both the carry trade and the wider cross-section of exchange rate returns. The fact that the inclusion of the HML carry factor removes this significance and that it takes the place of the intermediary capital risk factor at an even higher level of significance suggests that intermediary capital risk is embedded within the HML carry factor. The HML carry factor appears to contain a broader array of global shocks as evident by its more dominant role in pricing the risks located within the cross-sections of exchange rate returns and intermediary capital shocks merely serve as one economic source of risk contained within it.

Columns (2)-(3) and (7)-(8) of Table 1.7 compare intermediary capital to the dollar and global dollar factors for the carry trade and joint cross-sections, respectively. In both cases, we find the robust significance of the price of intermediary capital risk for the carry and full cross-sections as before at 5.6% and between 3.1% and 3.5% respectively, further supporting the role of intermediary capital as a fundamental economic source of risk. The dollar factor itself fails to serve as significant risk factor, but the global dollar factor enters in as a priced risk factor at 8.8% per annum for the joint cross-section.

The finding that dollar risk is not priced whereas global dollar risk is sheds light upon how heterogeneous exposures to global shocks help explain the cross-section of foreign exchange returns. Despite my early confirmation of Verdelhan's (2018) finding that a large amount of exchange rate fluctuations are explained by average changes in the dollar, I find here that it is only the global component, namely risks that are purged of US-specific risk, that matters for pricing the cross-section. This is surprising as we would expect a risk factor that contains more information to have a higher likelihood of being significantly priced in the cross-section. Note however that Lustig, Roussanov, and Verdelhan (2011) show that the dollar factor is akin to a level factor as all currencies load onto it equally. It is not surprising then that it contains no significant pricing power as there is no heterogeneity in exposure to this risk factor, so it should not account for the cross-sectional heterogeneity in returns. On the other hand, the global component of this factor should be differentially loaded upon as shown by Verdelhan (2018), allowing an assessment of its risk pricing and relevance for the cross-section of exchange rate returns.

Columns (4) and (9) of Table 1.7 display the results of the asset pricing tests with the HML and dollar factors simultaneously as risk factors. It is again apparent that the HML carry factor is the dominant pricing factor as we observe significant prices of risk for the cross-sections of the carry trade and all portfolios at 8.4% and 7.2% per annum respectively. Intermediary capital is again subsumed for the carry trade, but it is marginally significant for the joint cross-section with a risk price of 1.9%. The results show that while intermediary capital serves as a relevant risk factor for both the carry and joint cross-sections in absence of the HML carry factor, the HML carry factor serves as the more dominant pricing factor, either mitigating or eliminating the relevance of intermediary capital entirely. I interpret this as evidence that the HML carry factor encapsulates a wider array of sources of global risk of which intermediary capital is one. Furthermore note that dollar risk is never significantly priced, despite earlier findings that a large amount of exchange rate fluctuations are explained by average changes in the dollar, which presumably represent one source of risk, consistent with my previous findings when comparing intermediary capital and dollar risk without the HML carry factor.

Columns (5) and (10) of Table 1.7 display a similar exercise but instead using the global dollar factor, which recall is the difference in excess returns between high and low dollar-beta currency portfolios. While the dollar factor itself contains information about US-specific shocks as bilateral exchange rates vis-à-vis the dollar must contain some information about the US pricing kernel, when we take the difference between the dollar portfolios, we purge US-specific shocks and isolate the global source of risk present in the average excess returns against the dollar. HML carry risk is again significantly priced for the carry trade and all portfolios at 8.4% and 6.5% per annum respectively. As in the case with the dollar factor, intermediary capital risk is also marginally priced at 2.3% per annum for the joint cross-section, but not the carry. Furthermore note that in contrast to the specification without US risk purged, we now obtain a significant risk price for the global dollar factor for the entire cross-section of foreign exchange returns at 8.7% per annum. This confirms the previous result that global risk is pertinent in the pricing of exchange rate risk and contains risks that are independent of those contained within the HML carry factor.

One might ask whether the marginal significance of intermediary capital risk in the joint cross-section in the specifications in Columns (9) and (10) invalidates the claim that intermediary capital is contained within the HML carry factor as it should be insignificant upon the inclusion of the factor that subsumes it. Concerns may be alleviated under the assumption that the HML carry factor contains a number of risks, which include intermediary capital. It could be the case that there are times when intermediary capital fluctuates, but other risks contained in the HML carry factor also move, nullifying the effect of intermediary capital risk on the carry trade and leaving a net zero effect on the HML carry factor. However if intermediary capital risk is still relevant for exchange rate risk premia, the capital shock alone would capture this variation, whereas it would be overlooked and awash if only proxied by the HML carry factor. I posit that the marginal significance of intermediary capital risk despite the inclusion of the HML carry factor captures this relationship.

Figure 1.6 displays the scatter plot of mean portfolio returns and HML carry betas for all cross-sections. As with the intermediary capital betas, we observe a relatively monotonic relationship between mean portfolio excess returns and exposure to the HML carry factor as measured by each portfolio's HML carry beta. Lower, less risky portfolios are contained in the bottom left of the plot, while the risky, high portfolios occupy the upper right of the plot. The plot thus supports the notion that the HML carry factor contains sources of global risk that currency portfolios are all differentially exposed to, with the most exposed yielding the highest excess returns as compensation for HML carry risk and the least exposed yielding lower returns due to the relative safety in the face of adverse shocks that erode the HML carry factor.

Figure 1.6: Mean Excess Returns and HML Carry Betas

Notes: This figure displays the mean excess returns of each portfolio of the joint cross-section of exchange rates, which includes six portfolios for intermediary capital, carry, dollar, momentum, volatility, and value. The x-axis contains HML carry betas, estimated for each portfolio by regressing its excess returns across the whole sample on a constant and the HML carry factor. The line reflects the best fit for the relationship between average portfolio returns and betas.

My asset pricing tests have thus illuminated the following: first, intermediary capital shocks provide an economic source of risk behind the carry trade and the broader cross-section of currency portfolios, improving upon consumption growth factors despite not constituting their own cross-section. Intermediary capital risk thus provides an explanation for the existence for the carry trade and forward premium puzzle, and provides an economic source of global risk that is systematically contained in a large number of cross-sections of exchange rates and their corresponding risk premia. Second, the HML carry factor subsumes the risk embedded in the intermediary capital shocks and more dominantly prices the carry trade and entire cross-section of currency portfolios, suggesting that intermediary capital risk is contained within the HML carry factor. Third, intermediary capital remains a robust economic source of risk for exchange rates in both the carry and joint cross-section when compared to the dollar and global dollar factors. Finally, the global component of the dollar factor as a proxy for broader global shocks appears more relevant than the dollar factor alone for the joint cross-section of currency portfolios, showing that it is global risk that is priced and that one must fully purge idiosyncratic, country-specific risk to identify this relationship.

1.5 Determinants of the FX Factors

In the previous sections, I showed that intermediary capital shocks price the carry trade and the joint cross-section of currency portfolios, but also found that they were subsumed by the HML carry factor. Given that the latter is formed via portfolio methods and thus its economic determinants and sources of risk are ambiguous, I aim to uncover the economic sources of the shocks contained within it. For completeness, I also examine the sources of shocks contained in the global dollar factor given its outsize role in explained variation of bilateral exchange rate movements.

My approach entails examining the contemporaneous correlations of candidate shocks with the excess returns that proxy for each factor, a simple exercise that identifies the most meaningful shocks behind these risk factors. The candidate shocks are inspired by Verdelhan (2018) who suggests fundamental economic shocks coming from the risk-bearing capacity of intermediaries, US monetary policy, risk aversion, liquidity, and real activity. I proxy for each in turn using the He, Kelly, and Manela (2017) intermediary capital shocks as before, the Nakamura and Steinsson (2018) high frequency identified US monetary policy shocks, changes in the level of the VIX, changes in the Libor-OIS spread, the Chicago Fed's National

Activity Index, and durable and non-durable US consumption growth, respectively. The regression specification is:

$$rx_t = \alpha + \beta' f_t + \epsilon_t \tag{1.6}$$

where

$$f_t = [CShock_t, \Delta DurableC_t, \Delta NonDurableC_t, \Delta VIX_t, \Delta LibOIS_t, CFNAI_t, MPShock_t]$$

.

Table 1.8 displays the results of this regression, where Columns (1)-(4) examine the HML carry factor. The univariate specification in Column (1) shows that intermediary capital shocks indeed positively co-move with the HML carry factor, supporting the notion that fluctuations in intermediary capital are a fundamental economic source of risk contained in the cross-section of the carry trade and equivalently the HML carry factor. Furthermore given that the HML carry factor also prices the entire cross-section of foreign exchange portfolios, this provides further evidence that intermediaries and their capital play a central role in the pricing of broader exchange rate risk.

Column (2) examines the role of consumption growth; if households are relevant and their pricing kernels matter for the existence of the carry trade, I expect a positive and significant correlation of durable and/or non-durable consumption growth with the HML carry factor. Consistent with the asset pricing tests, I find an insignificant correlation between consumption growth and the HML carry factor, whereas intermediary capital shocks remain significantly positive. The evidence again points towards the importance of financial intermediaries over households as the relevant marginal investors whose marginal utilities

Table 1.8: Determinants of Foreign Exchange Factors

	Dependent variable:							
	HML Carry				Global Dollar			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$CShock_t$	0.121***	0.125***	0.103***	0.083***	0.071	0.068	0.200***	0.184***
	(0.021)	(0.021)	(0.031)	(0.032)	(0.045)	(0.045)	(0.045)	(0.039)
$\Delta DurableC_t$		−0.071	−0.013	−0.003		−0.017	−0.102	−0.100
		(0.066)	(0.078)	(0.076)		(0.069)	(0.107)	(0.103)
$\Delta NonDurableC_t$		−0.144	−0.094	−0.104		0.266	0.103	0.117
		(0.194)	(0.339)	(0.334)		(0.261)	(0.484)	(0.480)
ΔVIX_t			−0.041***	−0.038***			−0.027	−0.020
			(0.013)	(0.013)			(0.019)	(0.019)
$\Delta LibOIS_t$			−0.021***	−0.018**			−0.028***	−0.025**
			(0.008)	(0.007)			(0.011)	(0.010)
$CFNAI_t$			0.003*	0.003*			0.004**	0.003*
			(0.002)	(0.001)			(0.002)	(0.002)
$MPShock_t$			−0.119	−0.109			−0.097	−0.078
			(0.085)	(0.085)			(0.093)	(0.092)
$GDol_t$				0.101				
				(0.077)				
HML_t								0.154
								(0.125)
Observations	406	406	147	147	358	358	147	147
R^2	0.072	0.077	0.321	0.331	0.023	0.025	0.332	0.343
Adjusted R^2	0.070	0.070	0.287	0.293	0.020	0.017	0.299	0.305

*p<0.1; **p<0.05; ***p<0.01

Notes: This table displays the estimates of the specification in Equation 1.6. Columns (1)-(4) and Columns (5)-(8) contain the HML carry and global dollar factors as dependent variables, respectively. Standard errors are Newey-West heteroskedasticity and auto-correlation consistent with optimal lag lengths following Andrews (1991) matter for the pricing of foreign exchange and existence of the forward premium puzzle.

Column (3) assesses whether other economic sources of risk are embedded within the HML carry factor and whether they wash out the importance of intermediary capital. Intermediary capital shocks remain a robust component of the HML carry factor, retaining their level of significance and only mildly decreasing in magnitude. For the other economic sources of risk, we observe negative and significant correlations of the HML carry factor with changes in the VIX and Libor-OIS spreads, and a marginally positive correlation with real activity as measured by the Chicago Fed's National Activity Index. Given the VIX's role as a proxy for broader risk aversion and equity market volatility, this finding is consistent with the previous literature that shows the carry trade does poorly at times of high volatility and risk aversion (Brunnermeier, Nagel, and Pedersen 2008, Clarida, Davis, Pedersen 2009). Similarly, the negative relationship between the HML carry return and changes in the Libor-OIS spread suggest that times of higher funding costs and/or low liquidity are associated with poor returns for the carry trade, a finding related to Pastor and Stambaugh (2003).

The significance of the Chicago Fed National Activity Index sheds light upon the relevance of real activity for the HML carry factor. The positive estimate is in line with intuition as we expect real activity to be expanding during good times which coincide with positive excess returns for the carry trade, whereas when adverse real global shocks hit, carry trade returns should erode as currencies that are more exposed to the shocks depreciate while the safer currencies that are used as funding appreciate. This finding is encouraging because while this paper argues for the outsize relevance of financial intermediaries and consequently financial activity, negative shocks that affect real activity and production that should also serve as an additional economic source of global risk are found to be relevant determinants of the dominant HML carry factor that underlies foreign exchange risk.

In terms of explained variation, the univariate specification shows that intermediary shocks account for 7% of the variation in the HML carry factor. Consumption factors do not increase the R^2 or adjusted R^2 by much, again supportive of the dominant role of financial intermediaries over households for the pricing of exchange rate risk. The full specification reaches an adjusted R^2 of 28.7%, showing that while intermediary capital risk is a component of the total risk contained in the HML carry factor, other economic sources of risk such as risk aversion, liquidity, and real activity also play a significant role. However given that these determinants only explain up to a third of the variation in the HML carry factor, there is still much work to be done in uncovering its other economic determinants.

Columns (5)-(8) display similar specifications for the global dollar factor. In the baseline specifications in Columns (5) and (6), I do not find a significant correlation with intermediary capital shocks, suggestive that intermediary capital risk is distinct from that contained within the global dollar factor. However upon controlling for other economic sources of risk, I obtain a positive and significant estimate for the intermediary capital shocks.[14] Given that intermediary capital risk was not subsumed by the global dollar factor in the asset pricing tests yet I find a positive correlation here signifies that while intermediary capital risk may not be wholly contained in the global dollar factor, they do share some common variation, namely shocks that affect intermediary capital may also affect other sources of risk embedded within the global dollar factor.

With regards to the other economic determinants, liquidity, as proxied by the Libor-OIS

[14] Note that the sample size significantly decreases upon controlling for the Libor-OIS spread, which is only available from 2002, and the Nakamura and Steinsson monetary policy shocks which are only available up to 2014. A univariate specification run from 2002 onwards displays a significant price of intermediary capital risk, suggesting that the linkage between the global dollar factor and intermediary capital shocks arose in the last two decades.

spread, is negatively correlated with the global dollar factor, consistent with the intuition that global risk and liquidity are inversely related. In bad times when liquidity becomes thin, investors shift their portfolios towards safer assets and safe haven currencies which include US treasury bonds and the dollar. The dollar appreciates upon the realization of these capital flows and currencies that depreciate the most vis-à-vis the dollar yield poorer excess returns. Given that the global dollar factor reflects being long these currencies, the strategy suffers and the risk of being long currencies more exposed to depreciation against the dollar is realized.

It is surprising that my proxy for real activity, the Chicago Fed National Activity Index, is marginally significant, albeit with the correct positive sign, as the global dollar is presumably purged of US-specific risk. Given the marginal significance, I interpret this finding as reflecting US real activity as a weak proxy for broader global real activity, but it could also be the case that differencing the dollar portfolios does not fully purge the factor from US-specific risk. This could arise if for example currencies pairs vis-à-vis the dollar are differentially exposed to US-specific shocks.[15]

In Columns (4) and (8), I assess whether the global dollar and HML carry factors are jointly determined and significantly co-vary. This specification clarifies whether one of these factors subsumes the other or they share common variation outside of the aforementioned economic determinants. I find that neither serves as a significant covariate with the other, supporting Verdelhan's (2018) finding that these factors represent two orthogonal sources of global risk.

I have thus confirmed the previous hypothesis that intermediary capital is an economic source of risk that is contained within the HML carry factor. My findings on the relevance of

[15]This however is inconsistent with Verdelhan's (2018) baseline affine model of exchange rates.

other economic sources of risk such as risk aversion, liquidity, and, marginally, real activity reveal that the HML carry factor contains a broad array of economic shocks including but not limited to intermediary capital risk. Further work must be done to uncover other economic sources of risk embedded within the HML carry factor which I have shown plays a dominant role in the pricing of risk embedded within the cross-sections of foreign exchange.

Fluctuations in intermediary capital also appear to be related to the global dollar factor, although this relationship significantly arises in the past two decades. Liquidity and real activity risk are embedded within this factor in line with intuition, but note that the significance of my proxy of real US activity is counterintuitive, given that the global factor should be purged of US-specific risk. This leads me to posit that US real activity may serve as a proxy for broader real activity risk that is captured by fluctuations in the global dollar factor, but may also suggest that individual currencies differentially load onto US-specific risk. One can rationalize the latter point through the lens of heterogeneity in financial and trade linkages of countries with the US.

1.6 Conclusion

Does intermediary capital matter for the pricing of exchange rates? I find that the answer is yes as the risk-bearing capacity of financial intermediaries helps explain the carry trade and pattern of excess returns of the joint cross-section of a wide number of currency portfolios. Intermediary capital shocks carry a significant risk price for both, improving upon the Fama French global market return as well as durable and non-durable consumption growth, thus pointing towards the central relevance of financial intermediaries for the pricing of exchange rates and identifying a fundamental economic source of risk that drives the cross-section of foreign exchange returns. The central role of financial intermediaries and their risk-bearing capacity rationalizes the existence of the forward premium puzzle as the differential exposures of currencies to intermediary capital risk align with the pattern of carry trade returns, a result that extends to the joint cross-section of currency portfolios. My findings of a positive and significant risk price of intermediary capital shocks for the joint cross-section show that they serve as a systematic source of global risk with a meaningful economic interpretation that underlies a wide variety of exchange rate risk premia.

My comparison of the intermediary capital shocks to the HML carry factor reveals the latter as the most dominant pricing factor in the carry and joint cross-sections of exchange rates and that its presence in the asset pricing tests removes or dampens the significance of the price of intermediary capital risk. Combining this result with my previous findings suggests that intermediary capital risk must be a component of the global risk embedded within the portfolio generated HML carry factor as it is significantly priced in all other specifications without this larger factor that subsumes it. I verify this claim by showing that intermediary capital shocks positively and significantly correlate with the HML carry factor. In addition, I explore other potential economic determinants and show that changes in the VIX and Libor-OIS spread, proxies for market volatility and risk aversion, and liquidity, respectively, are negatively correlated with carry trade returns, in line with empirical findings by previous researchers and the theoretical predictions of the macro-finance literature. I also show evidence for the relevance of real activity for the HML carry factor.

Analogously, I also explore the interaction of intermediary capital shocks with the dollar and global dollar factors identified by Verdelhan (2018) to assess their relative performance against these foreign exchange risk factors that are systematically responsible for an outsize portion of exchange rate movements. I find that intermediary capital risk is significantly priced in relation to these factors, displaying the importance of the risks emanating from fluctuations in the risk-bearing capacity of financial intermediaries for exchange rate risk premia. Intermediary capital shocks robustly price both the carry trade and joint cross-section of currency portfolios and I uncover the relevance of the global dollar factor purged of US-specific risk for the pricing of the wider cross-section. In contrast, the dollar factor itself which still contains US-specific risk fails to be significantly priced, showing that the risk premia in the cross-section of exchange rates stems from exposure to global shocks as inclusion of US-specific risk appears to dilute the relevant information contained in dollar factor.

Focusing on the global dollar factor, I find that intermediary capital shocks positively correlate with this global factor only after controlling for a variety of other potential shocks. This finding however is primarily due to the linkage between the two arising in the past two decades. Furthermore, I uncover the significance of liquidity and, surprisingly, US real activity for the global dollar factor, despite the fact that it should be purged of US-specific information. I interpret the latter finding as either US real activity serving as a proxy for global real activity and/or heterogeneous exposure to US risk that prevents it from being fully removed.

My findings thus validate open economy models with financial intermediaries, providing empirical support for this theoretically successful class of models. I show that financial intermediaries help us better understand existing exchange rate factors as fluctuations in their risk-bearing capacity serve as a fundamental economic source of risk that generates the carry trade and broader joint cross-sections of exchange rate excess returns. Future work may be done in terms of finding more complete measures of intermediary capital shocks and risk-bearing capacity, perhaps constructing shocks for other participants in foreign exchange markets such as large buy-side investors, e.g. hedge funds, asset managers, and other institutional investors. It may very well be the case that we are missing a key piece of the intermediary-based asset pricing by not utilizing their pricing kernels as an additional risk factor. Furthermore, given my findings on the central relevance of financial intermediaries, it would be of interest to fully derive an open economy intermediary-based asset pricing model to clearly outline and interpret my findings in general equilibrium. I leave these exercises open to future research.

Chapter 2

The Role of Dollar Funding and US Monetary Policy in International Bank Lending

2.1 Introduction

Motivated by theory, the growth of financial integration in the international banking sector could yield important diversification benefits. Global banks can provide an additional source of funding for local businesses that may substitute for local lending during domestic downturns and expand growth prospects in normal times due to access to funding that is unconstrained by the level of domestic savings. The introduction of foreign banks can also help import improved institutional and regulatory standards (Cetorelli and Goldberg 2011), potentially accelerating the pace of financial development in emerging economies. Furthermore, with increased global financial integration, capital can be more easily allocated to where it provides the best marginal product, which may subsequently improve real global

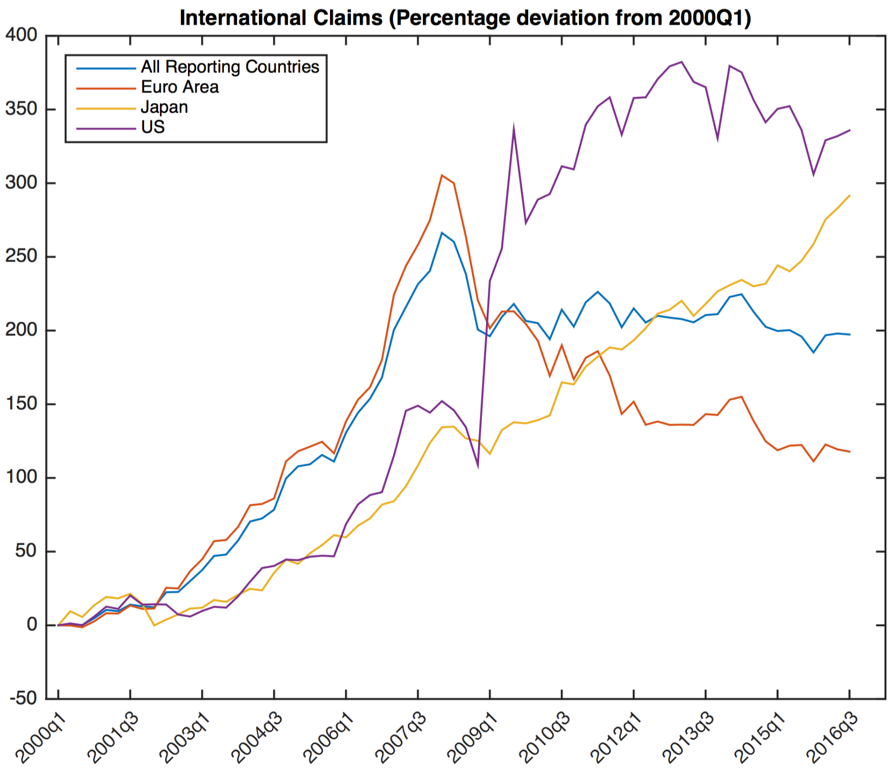


Figure 2.1: Total International Claims

Notes: The variables are obtained from the BIS Consolidated Banking Statistics looking at international claims from all reporting countries, the Euro Area, Japan, and the US vis-à-vis all nonresidents. There may be breaks in the series due to the inclusion of banks in certain countries, a prime example being the huge spike in US claims around 2009 Q1 which is attributed to more reporting banks.

growth.

Unfortunately there are two sides to every coin and global financial integration is no different. In contrast to the many potential benefits, global banks' cross-border activities can also serve as a destabilizing mechanism, transmitting financial conditions across borders that lead to declines in real variables in economies that would have otherwise been insulated. One example is the Global Financial Crisis in which we observed a sharp contraction of bank capital flows to emerging economies, falling from approximately \$500 to \$100 billion between 2007 and 2008 (Cetorelli and Goldberg 2011). The general notion is that when banks are hit with a negative shock, they curtail lending throughout their entire balance sheet, including but not limited to cross-border claims. If domestic entities fail to replace this gap in lending, domestic businesses presumably experience tighter borrowing conditions that may lead to worse real outcomes.

The previous discussion however has abstracted from the fact that different countries have different currencies. Banks may engage in international lending with counterparties in countries with different currencies, providing the additional margin of currency denomination when granting cross-border credit. One might expect banks to prefer to lend in their own currency in order to utilize their domestic currency deposits, generally their primary source of funding, and avoid tight funding conditions or currency mismatches on their balance sheet that leave them vulnerable to fluctuations in exchange rates. However Figure 2.2 paints a different picture, displaying the dominant role of the dollar. Dollar-denominated lending encapsulates nearly two-thirds of all international lending, twice the amount of euro-denominated lending, the next most common currency choice. In other words, global banks tend to lend a significant amount in dollars despite not necessarily having stable dollar deposit base.

Thus far I have painted the picture of a world with significant cross-border activities of global banks that are primarily lending and borrowing in dollars, invariant to their own domestic currency. Unable to obtain dollars for lending from insured deposits, these banks must then obtain dollar financing from uninsured sources such as US money market funds and other banks, or engage in swap markets, exchanging domestic currency for dollars (Ivashina, Scharfstein, and Stein 2015). Under the assumption that there exist some limits to arbitrage in swap markets[1], an increase in the cost of dollar funding from US money markets or other banks decreases the spread on lending in dollars, which should lead to a

[1] If there exist no limits to arbitrage, banks could simply swap their domestic deposits for US dollars at exactly the same cost as borrowing dollars directly from insured sources, preventing a need to utilize costlier uninsured funding.

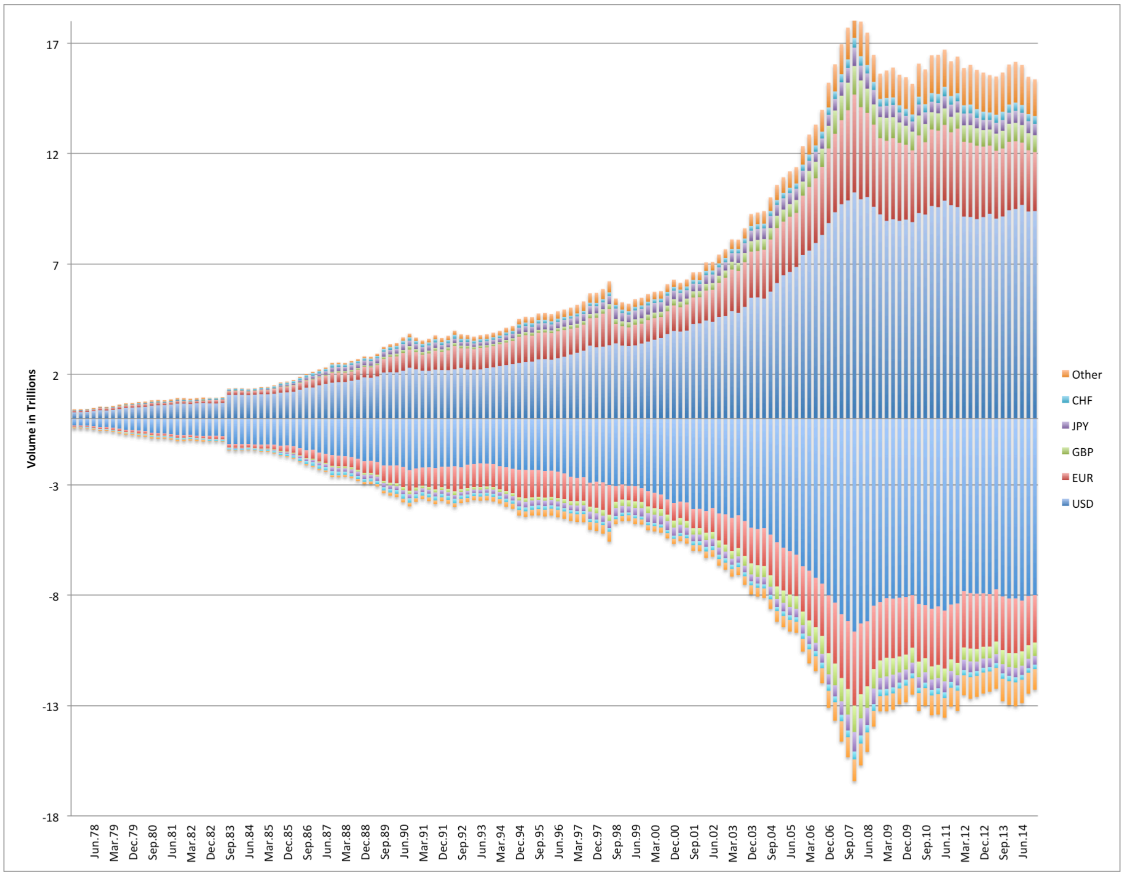


Figure 2.2: International Claims and Liabilities by Currency Denomination

Notes: This graph displays the total volume of international claims and liabilities in the positive and negative axes respectively for all BIS reporting banks. The data is sourced from Table 5A of the BIS Locational Banking Statistics.

decline in dollar-denominated loans. This manifests into an overall decline in cross-border lending activity if the substitution towards lending in other currencies is not sizeable enough to offset the reduction in dollar-denominated loans.

This paper aims to examine this hypothesis by attempting to answer the following questions. First, do funding conditions in the US affect the amount of cross-border lending abroad? If so, through which channel(s) does this spillover operate? How do global banks adjust their balance sheets in response to these shocks?

I approach this question by focusing on the relationship between monetary policy in the United States and the activities of global banks as proxied by aggregate data from the

BIS, searching for evidence of an international bank lending channel of monetary policy. The original bank lending channel posits that contractionary monetary policy leads to a decrease in reserves and thus a decline in the size of deposits. Banks then have to substitute the decline in deposits with an alternative source of funding which can be more costly under the existence of financial frictions.[2] Given the higher cost of funding, banks will then cut back on supply, completing the transmission of monetary policy to lending.

The mechanism that I look to identify is quite similar as it relies on the existence of a friction for global banks in obtaining dollar financing. The idea is that US monetary policy shocks pass through to the borrowing rates of global banks for dollar funding, namely contractionary shocks should make it costlier to obtain dollars in US money or interbank Eurodollar markets. As previously described, higher costs in dollar funding lead banks to decrease international dollar lending, and potentially total international lending if substitution effects are not large enough. It follows then that banks with larger dollar funding exposure should experience larger declines in international claims as it should be more difficult to compensate for the decline in dollar funding.

I first show that contractionary monetary policy shocks as borrowed from the high frequency identification literature indeed passes through to higher borrowing rates in dollar money and interbank markets. For a variety of interest rates and horizons, I find an almost one-for-one pass-through of the shocks to LIBOR and Eurodollar deposit rates by the end of the days of US monetary policy announcements, an effect that does not significantly reverse in the following weeks. This is consistent with persistent pass-through of US monetary policy to offshore dollar borrowing rates.

Moving to international lending, I find that lender country banking systems with a

[2] If the world is frictionless as in Modigliani-Miller, banks would be able to costlessly substitute the decline in deposits with other funding, thus leaving the asset side of their balance sheet unchanged.

higher fraction of dollar to total liabilities have larger declines in lending growth following contractionary monetary policy shocks, consistent with the proposed mechanism. This result is robust to controlling for leverage and dollar swap pressure, sector fixed effects, and removing the US as either lenders or borrowers. After dividing my sample into counterparty sectors, I show that these results are primarily driven by contractions in lending to the non-bank private and banking sectors, suggestive of real international effects associated with US monetary policy. I then explore whether global banks differentially alter their lending at short and long maturities, as well as local lending in local currency, another form of cross-border credit. I show that long-term lending is slightly more affected by monetary policy shocks and that local currency lending is not affected.

The paper proceeds as follows. Section 2.2 discusses the related literature. Section 2.3 describes the data sources and provides summary statistics. Section 2.4 outlines the econometric methodology and identification strategy. Section 2.5 presents results. Section 2.6 provides alternative explanations and issues with and potential confounders of the results. Section 2.7 concludes.

2.2 Literature Review

This paper is primarily related to the empirical literature on global banks and their role in transmitting shocks across borders. The seminal contributions by Peek and Rosengren (1997, 2000) document the decline in lending by US branches of Japanese banks following the collapse of the Nikkei in the early 1990s, a shock to the capital of a subset of global banks. Khwaja and Mian (2008) develop a novel identification strategy involving borrower fixed effects to estimate the effects of the liquidity shock caused by the nuclear tests in Pakistan in 1998 on bank lending, finding a decline after controlling for contemporaneous demand shocks. Schnabl (2012) follows their identification strategy and examines the effect of the 1998 Russian default on the lending of international and domestic banks in Peru, finding that reductions in lending were greatest for banks that were more reliant on international funding and did not have alternate funding sources. Other papers that look at the effects of liquidity shocks through global banks include Acharya and Schnabl (2010), Chava and Purnanandum (2011), Correa, Sapriza, and Zlate (2012), and Acharya, Afonso, and Kovner (2017).

Most similar to this paper is Cetorelli and Goldberg (2011) who employ the Khwaja and Mian (2008) methodology to aggregate international bank lending data to examine the change in loan growth extended from advanced to emerging economies before and after the 2007-2009 crisis. Exploiting the heterogeneity of dollar exposure of advanced economy lenders, they find that lenders that were more exposed to dollar funding ex-ante had lower ex-post lending growth to emerging markets. I differ from their paper by making use of the time dimension in my analysis as opposed to only examining the difference between the pre- and post crisis periods. Furthermore, I focus on the relationship between US monetary policy shocks, dollar funding exposure as proxied by fraction of dollar-denominated liabilities, and international lending growth to advanced and emerging economies alike.

My mechanism draws upon the international bank lending channel that has been posited and explored by a number of researchers. The story most closely related to my own comes from Ivashina, Scharfstein, and Stein (2015). They construct a theoretical model that illustrates how a global bank with local currency deposits and lending in dollars and local currency will choose to substitute away from dollar lending if the cost of dollar funding increases in both direct funding and swap markets. The authors proceed to verify this mechanism by focusing on the period between May 2011 and June 2012, namely the peak of the European sovereign debt crisis that affected the creditworthiness of Eurozone banks and decreased access to wholesale dollar funding from US money market funds. Using syndicated loan data, they show that there is a decline in the participation of Eurozone lenders in international loan syndicates during this crisis period which they attribute to a loss in dollar funding from US money market funds.

I depart from Ivashina, Scharfstein, and Stein (2015) by focusing on the increased cost of dollar funding coming from US monetary policy rather than a decrease in the supply. A few other papers have looked at a similar relationship. Cetorelli and Goldberg (2012) look at the response of global banks to US monetary policy, finding an internal transmission of funds from foreign affiliates and decrease in foreign loans following contractionary US monetary policy. Brauning and Ivashina (2017) examine the response of global banks to changes in the interest rate on excess reserves finding that global banks shift funds towards holding reserves in higher interest rate countries, a capital flow that places pressure on swap markets, increasing the cost of funding and thus causing a decrease in loans denominated in the higher interest rate currency.

Most related to this paper in this strand of literature is Morais, Peydro, and Ruiz (2015) who use Mexican banking micro-data to examine the effects of interest rate changes and quantitative easing (QE) from the Federal Reserve, European Central Bank (ECB), and Bank of England (BoE) on international bank lending to Mexico. The authors find that monetary policy changes only affect banks of the same nationality, for example ECB policy only curtails the lending of European banks, but not necessarily US banks. Similarly, a recent paper by Ongena, Schindele, and Vonnak (2017) examine the differential responses following changes to domestic and foreign monetary policy using a Hungarian supervisory dataset. Both papers have better identified empirical specifications attributed to their usage of micro-data, but my paper serves to provide supporting evidence that looks at a wider range of countries to further encourage the study of the international bank lending channel.

Lastly, this paper is broadly related to the literature on determinants of global banking capital flows. Most papers have focused on the role of the VIX, which proxies for global risk aversion or uncertainty, as a major push factor in capital flows as in Forbes and Warnock (2012), Rey (2015), Broner et al. (2013), Bruno and Shin (2015a), Avdjiev et al. (2017). Rey (2015) and Bruno and Shin (2015b) take this one step further and posit a global financial cycle driven by US monetary policy through a risk-taking channel, suggesting that expansionary US monetary policy increases risk-taking which lowers the VIX, leading to a loosening of global bank balance sheets and allowing an increase in cross-border lending. Although my paper also looks at the relationship between US monetary policy and global bank lending, I emphasize the different mechanism of the international bank lending channel involving dollar funding costs and remain agnostic about the effects on and of risk-taking.

2.3 Data

Data Construction

My dataset comes from four sources: the Bank for International Settlements' International Banking Statistics, the International Monetary Fund's Balance of Payments and Financial Indicators, the World Bank's World Development Indicators, and Bloomberg.

The international bank lending data come from the Bank for International Settlements Consolidated and Locational Banking Statistics. The Consolidated Banking Statistics contain the aggregated bilateral claims of all banks with main headquarters in the reporting country vis-à-vis counterparty countries on immediate counterparty and ultimate risk bases. Importantly, this measure of lending includes activities of foreign subsidiaries and branches, but attribute them to the home country of the parent bank. The data is generally not granular as claims cannot be subdivided into instrument type, counterparty sector, or currency denomination for immediate counterparty basis. Additional granularity with respect to counterparty sectors is available for the ultimate risk basis, but the variable definition confounds exactly to whom the loan is granted as it measures who ultimately collateralizes the loan. This data is available semi-annually from 1983 Q2 – 1999 Q4, and quarterly from 2000 Q1 – 2016 Q3. I utilize the quarterly data from 2000 Q1 – 2016 Q3 which contains 31 reporting countries and 219 counterparty countries.

The locational banking statistics provide the aggregate bilateral claims and liabilities on all banks in reporting countries. The distinction between the locational and consolidated statistics is that the former reports on a residential basis, namely claims are attributed to the country in which they are booked as opposed to the country in which the parent bank resides as in the consolidated statistics. I utilize the ability of the locational banking statistics to divide claims and liabilities vis-à-vis all non-residents into currency denomination, using the fraction of dollar to total liabilities as my proxy for exposure to dollar funding. I take the amount of dollar-denominated liabilities for all banks with headquarters in a given country as the amount of dollar-denominated liabilities in a given country instead of the location where the liability was booked to remain consistent with the consolidated basis of my bilateral claims. This data is only available for 12 reporting countries quarterly from 2000 Q1 - 2016 Q3. Given my interest in dollar funding exposure, the locational banking statistics limit my sample to the bilateral data available for these 12 reporting country lenders.

Data on country banking characteristics comes from the World Bank's World Development Indicators. I obtain the ratio of country banking sector capital to assets available annually from 2000 Q1 – 2016 Q4, with a break for some countries between 2004-2005. Given the quarterly frequency of my lending data, in order to exploit this higher frequency with annual data, I left-piecewise interpolate the annual leverage data to construct quarterly data. For example I set leverage in all quarters of 2000 equal to the annual leverage in 2000, all quarters of 2001 equal to the annual leverage in 2001, and so forth.

My monetary policy shocks are the policy news shocks from Nakamura and Steinsson (2018), available online on either of the authors' websites. The measure is constructed via high frequency identification, namely they measure unanticipated changes in realized and expected federal (Fed) funds rates, and expected Eurodollar futures rates at 2-, 3-, and 4-quarters ahead horizons over the 30-minute window enclosing Federal Open Market Committee (FOMC) announcements. The idea is if no other relevant information is revealed during this 30-minute window, the measures capture the pure surprises in monetary policy stemming from the FOMC announcement. Nakamura and Steinsson then construct the policy news shock as the first principle component of the unanticipated changes in the five aforementioned interest rates. It is important to note that this measure captures the effect of the monetary policy shock across a larger portion of the yield curve as short movements are captured by the Fed funds rate changes, while movements further out in the term structure are captured by the Eurodollar futures rates changes. This serves as an improvement over only the change in the Fed funds rate as up until December 2015, the Fed funds rate was stagnant at the zero lower bound and US monetary policy primarily comprised of forward guidance.

In an ideal setting, I would have more high frequency data on banking claims to isolate the effects of these monetary policy shocks on lending. However given the quarterly periodicity of the BIS data, I am unable to exploit the daily frequency of the monetary policy shocks. Instead, I aggregate all of the monetary policy shocks in a given quarter and use that as my quarterly monetary policy shock measure.

Lastly, the interest rate data comes from the money market monitor in Bloomberg. I obtain daily, end-of-day rates for a variety of Eurodollar and US LIBOR rates from 2000 to present. I match these with the dates of scheduled and unscheduled FOMC announcements from the Nakamura and Steinsson data in order to study the pass-through of US monetary policy shocks to dollar interest rates relevant for global banks.

Summary Statistics

Table 2.1 displays summary statistics of my sample. The 12 available lender countries are Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, Spain, Sweden, Switzerland, the United Kingdom, and the United States with 216 potential counterparty countries from 2000Q1 to 2016Q3, yielding an upper bound sample size of 61,497 after accounting for missing values. International lending growth, computed as the difference in log international claims to a particular counterparty, ranges from mean and median declines of 1.8% in Belgium and Canada, respectively, to mean and median growth in the United States of 2.4% and 1.7% as measured across all counterparties and quarters. The mean and median over all lenders, counterparties, and quarters are 0.8% and approximately 0%, respectively.

I construct dollar funding exposure as the fraction of dollar-denominated liabilities to total liabilities for a given lender country as obtained from the BIS Locational Banking Statistics. I obtain this measure for all 12 lender countries in my sample in each of the 67 quarters from 2000Q1 to 2016Q3 for a total of 804 observations. The mean and median over all lender countries and quarters are 43.6% and 39.6%, respectively, with a minimum of 9% as observed in Belgium and a maximum of 84.8% in the United States. Aside from Canada and the United States, all means and medians lie between 19% and 56%, confirming the role of the dollar in international financing.

The remaining variables are monetary policy shocks as drawn from Nakamura and Steinsson (2018), leverage as measured by the World Bank's bank capital-to-assets ratio, and my measure of dollar swap pressure. The monetary shocks have a mean of approximately 0 and median of .007, ranging from -.187 to .082, with a positive value corresponding to a hawkish announcement reflecting potential monetary tightening by the FOMC. Dollar swap pressure is computed as the difference between dollar-denominated claims and liabilities over total claims as obtained from the BIS Locational Banking Statistics. As with the fraction of dollar liabilities, this is available for all 12 countries for the 67 quarters between 2000Q1 and 2016Q3. The mean is -.003 and median is -.013, reflecting an overall lack of pressure when averaging across all lenders and quarters as a more positive value denotes a larger currency mismatch in the balance sheet. Lastly leverage as measured annually has a mean of 5.714 and median of 5.294, ranging from 2.7 to 12.7.

2.4 Econometric Methodology

Establishing the existence of an international bank lending channel requires the disentanglement of loan demand and loan supply, a common identification problem in the literature. I am interested in the effects on loan supply that result from monetary policy shocks and thus must account for concurrent shocks to loan demand, otherwise estimates for the supply effects will be biased and confounded.

Table 2.1: Summary Statistics

International Lending Growth						
Country	Mean	Median	SD	Min	Max	N
Belgium	-0.018	0.000	0.494	-5.714	4.736	9150
Canada	-0.014	-0.018	0.302	-2.112	2.211	394
France	0.013	0.000	0.428	-4.564	4.585	11981
Germany	0.004	0.005	0.134	-1.124	1.010	719
Italy	0.009	-0.005	0.338	-3.121	3.218	1117
Japan	0.017	0.008	0.319	-4.248	5.953	6725
Netherlands	0.009	0.015	0.163	-0.933	0.896	1056
Spain	0.013	0.000	0.436	-6.019	5.863	9638
Sweden	-0.002	-0.004	0.634	-6.396	7.711	2893
Switzerland	0.017	-0.001	0.574	-7.649	7.312	3075
United Kingdom	0.011	0.000	0.440	-5.056	5.602	11185
United States	0.024	0.017	0.229	-2.176	1.494	3564
Total	0.008	0.000	0.436	-7.649	7.711	61497
Fraction of Dollar Liabilities						
Country	Mean	Median	SD	Min	Max	N
Belgium	0.202	0.225	0.066	0.090	0.331	67
Canada	0.703	0.696	0.045	0.512	0.787	67
France	0.370	0.366	0.042	0.299	0.474	67
Germany	0.389	0.388	0.029	0.323	0.467	67
Italy	0.209	0.192	0.066	0.105	0.362	67
Japan	0.543	0.530	0.075	0.386	0.659	67
Netherlands	0.325	0.311	0.053	0.245	0.463	67
Spain	0.359	0.369	0.046	0.247	0.427	67
Sweden	0.390	0.364	0.090	0.269	0.615	67
Switzerland	0.552	0.549	0.043	0.461	0.640	67
United Kingdom	0.414	0.414	0.036	0.307	0.481	67
United States	0.782	0.794	0.037	0.703	0.848	67
Total	0.436	0.396	0.179	0.090	0.848	804
Independent Variables						
	Mean	Median	SD	Min	Max	N
Monetary Policy Shocks	-0.000	0.007	0.047	-0.187	0.082	53
Dollar Swap Pressure	-0.003	-0.013	0.112	-0.280	0.309	804
Leverage	5.714	5.294	1.972	2.700	12.739	704

The general approach to parsing out loan supply from demand shocks follows the identification strategy of Khwaja and Mian (2008). With bilateral data, the researcher has the identity of the borrower and lender, allowing them to control for borrower fixed effects that soak up demand shocks that would otherwise have been in the residual and bias coefficient estimates. Under the requirement that borrowers obtain loans from multiple lenders, the borrower fixed effects remove the average of loans granted across all lenders, effectively controlling for the borrower's average loan demand and yielding the within borrower estimate of the lending supply shock. The researcher is then estimating the effect on loan supply offered to a given borrower conditional on a lender's exposure to the shock. More specifically suppose the lending supply schedule is given by the following:

$$\Delta L_{i,j} = \alpha_j + \beta D_i + \epsilon_{i,j} \tag{2.1}$$

where $\Delta L_{i,j}$ is the change in loans from bank i to borrower j, D_i is bank i's exposure to the shock, and α_j contains unobservable characteristics or shocks to borrower j.

Without including borrower fixed effects, if the unobserved shock to borrower j, α_j, is correlated with the monetary policy shock, the estimate of β will be biased. However once borrower fixed effects are accounted for, demand shocks should be controlled for thus isolating the effect on loan supply. Note that the identifying assumption is then that borrowers demand the same type of loans from all lenders, namely there are not borrower-lender specific interactions.

The previous discussion focuses on a differences-in-differences methodology, looking at the change in loan supply before and after a single shock event. I depart from this methodology and exploit the variation in the time series data on bank lending and monetary shocks. The immediate benefit is an increase in sample size attributed to the time dimension. Monetary policy shocks occur following every FOMC announcement, so with eight announcements per year, we have at least one shock per quarter. Furthermore, if effects occur with lag, we may trace out the dynamics over time. Abstracting from the latter notion I estimate the following:

$$\Delta L_{i,j,t} = \alpha_i + \alpha_{j,t} + \beta_0 D_{i,t-1} + \beta_1 D_{i,t-1} \times USMP_{t-1} + \epsilon_{i,j,t} \quad (2.2)$$

where $\Delta L_{i,j,t}$ is the change in log loans from the banking sector in country i to all borrowers in country j between quarter t and $t-1$. $USMP_{t-1}$ is the sum of the previous quarter's monetary shocks and $D_{i,t-1}$ is a proxy for dollar funding exposure in country i. My fixed effects or unobservables are now α_i and $\alpha_{j,t}$, the lender time-invariant and borrower-time fixed effects, respectively.

Some important differences arise here. First given my aggregate data, the borrowers and lenders are all sectors in a given country receiving a loan from all banks in a lender country, respectively. Thus one may think of the fixed effects as country-borrower or country-banking sector specific. My results will only be suggestive as I cannot identify whether the monetary policy shock is affecting country- or bank-specific supply, or both. Second, we have another margin for shocks, namely the magnitude of the monetary policy shock in addition to the ex-ante exposure of the lender country as opposed to only exposure in the previous specification. Third and most importantly, because we are no longer looking at a single shock, country-borrower fixed effects alone cannot entirely control for demand shocks as they are time-invariant, namely they only capture unobserved characteristics that remain static over the entire sample. Some examples of this include countries that rely primarily on external financing or very financially integrated countries that on average have a higher amount of international loan demand than other countries.

In order to control for demand shocks, I include country-borrower-time fixed effects, captured by $\alpha_{j,t}$. Analogous to the borrower fixed effects in the differences-in-differences regression, these fixed effects control for the average of loan demand for a given country in a given quarter across all lenders. Without including these time-varying fixed effects and if loan demand in country j in quarter t covaried with either the monetary policy shock, the level of exposure in country i, or both, the estimate of the sensitivity of lending to monetary shocks conditional on the level of dollar funding exposure will be biased.

The idea then is if country j experiences a demand shock in a given quarter, averaging out its demand across lenders for that quarter should control for the shock, leaving only the potential lending supply shock. This requires the country to borrow from multiple lenders which allows me to measure the within-country effect, namely the effect of monetary shocks on loan supply to a given country contingent on a lender country's dollar exposure.

Given the country-borrower-time fixed effects, collinearity prevents me from including time-varying regressors that are not lender-specific. The identification strategy limits the regressors to time-varying lender-specific variables and interactions. Alternatively if we were interested in time-varying country borrower characteristics, I could include time fixed effects. However, this would assume that demand shocks are homogeneous across all borrowers, a much stronger assumption than that required by the country-borrower-time fixed effects.

My specification thus controls for confounding demand shocks by exploiting the bilateral nature of the BIS data that allows me to control for the average country-borrower loan demand across all lenders in a given quarter and identify the effect on loan supply. The coefficient of interest, β_1, measures the sensitivity of the effect of monetary shocks on loan supply conditional on a lender's exposure to dollar funding. This is completely analogous to

Cetorelli and Goldberg (2011) with the main difference being the additional time dimension, building upon their differences-in-differences approach that focused only on the Lehman crisis.

2.5 Results

Pass-Through

Before examining the impacts on international bank lending, it is important to document the pass-through of US monetary policy shocks as my mechanism operates through an increase in the cost of dollar funding. The policy shock measures changes in the actual and expected current and future path of dollar interest rates following FOMC announcements. Given no arbitrage in money and interbank markets, changes in the market expectation of interest rates of one source of dollar funding should thus lead to changes in dollar borrowing rates in related markets.

I confirm this by regressing changes in Eurodollar and US LIBOR rates at a variety of maturities on the policy indicator. To measure the extent of pass-through, I calculate the announcement effect by regressing the change of a particular interest rate between the end of the announcement day and the end of the previous day. A positive and significant coefficient on the indicator suggests initial pass-through of the policy shock to relevant borrowing rates for global banks. This result would support the notion that a surprise contraction in US monetary policy leads to a realized increase in dollar borrowing rates both on- and offshore.

It is important to note that an announcement effect may not necessarily translate to persistent pass-through as the rates may initially adjust to match the monetary policy shock, but markets may be overreacting and not actually adjust borrowing rates over the medium and long term. Global banks presumably utilize dollar funding markets multiple times in a quarter, not only on FOMC announcement days, so the mechanism crucially depends on persistent pass-through as this would imply altered dollar borrowing rates long after the announcement.

To measure the extent of persistent pass-through, I follow the finance literature and measure the extent to which there is a reversal of the announcement effect. If the pass-through is persistent, we should observe little to no reversal of the effect of the shock on interest rates at future horizons. Specifically, I regress the change between the relevant interest rate on the day after the announcement and one, two, four, and twelve weeks following the announcement on the policy shock. If there is a reversal, we should see a negative and significant coefficient on the indicator as this implies that after the initial announcement effect the market moves rates in the opposite direction, nullifying the announcement effect and implying only a transitory pass-through.

My regression specification is thus:

$$\Delta R_t = \alpha + \beta USMP_t + \epsilon_t \tag{2.3}$$

where ΔR_t is the change in the relevant interest rate for the window of interest, namely the announcement or future reversals.

Table 2.2 shows evidence consistent with initial pass-through. In column (1), we see that the US monetary policy shock has a positive and significant effect on offshore dollar rates as measured by the Eurodollar deposits rates and interbank dollar borrowing rates as measured by the LIBOR at all horizons. With the exception of the 1-month LIBOR rate, the coefficient is quite large, ranging from .725 for the 3-month LIBOR, to 1.178 for the

Table 2.2: US Monetary Pass-through to Dollar Borrowing Rates

	1-month LIBOR Rate				
	(1)	(2)	(3)	(4)	(5)
VARIABLES	Announcement	1 Week	2 Week	1 Month	1 Quarter
Monetary Shock	0.0544**	0.0226	0.243*	1.239	0.694
	(0.0254)	(0.0958)	(0.127)	(1.019)	(1.387)
Observations	100	103	101	47	101
R-squared	0.045	0.001	0.036	0.032	0.003
	3-month LIBOR Rate				
	(1)	(2)	(3)	(4)	(5)
VARIABLES	Announcement	1 Week	2 Week	1 Month	1 Quarter
Monetary Shock	0.725***	-0.817	-0.566	0.824	2.187
	(0.0926)	(1.881)	(0.604)	(3.358)	(1.637)
Observations	106	106	106	49	106
R-squared	0.371	0.002	0.008	0.001	0.017
	3-month Eurodollar Deposit Rate				
	(1)	(2)	(3)	(4)	(5)
VARIABLES	Announcement	1 Week	2 Week	1 Month	1 Quarter
Monetary Shock	1.178***	-0.0603	-0.0539	1.166	-0.0642
	(0.144)	(0.0820)	(0.201)	(1.039)	(1.427)
Observations	106	103	102	48	103
R-squared	0.391	0.005	0.001	0.027	0.000
	6-month Eurodollar Deposit Rate				
	(1)	(2)	(3)	(4)	(5)
VARIABLES	Announcement	1 Week	2 Week	1 Month	1 Quarter
Monetary Shock	1.024***	-0.191	-0.326	0.717	-0.282
	(0.147)	(0.133)	(0.235)	(1.030)	(1.433)
Observations	106	103	101	48	103
R-squared	0.317	0.020	0.019	0.010	0.000
	1-year Eurodollar Deposit Rate				
	(1)	(2)	(3)	(4)	(5)
VARIABLES	Announcement	1 Week	2 Week	1 Month	1 Quarter
Monetary Shock	1.046***	-0.413**	-0.898***	-0.245	-0.833
	(0.156)	(0.191)	(0.304)	(1.078)	(1.463)
Observations	106	103	102	48	103
R-squared	0.303	0.044	0.080	0.001	0.003

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

3-month Eurodollar rate, suggesting almost complete pass-through.

Columns (2) to (5) examine the extent of potential reversals of this announcement effect at the 1-, 2-, 4-, and 12- week horizons. With the exception of the 1-year Eurodollar rate, there is no evidence of reversal as nearly all coefficients are insignificant. Although we do observe some negative coefficients, the magnitudes are quite small relative to the initial announcement effect, suggesting that while there may be a reversal, it is quite mild and rates still persistently respond to US monetary policy shocks.

The results thus show that there is an announcement effect of US monetary policy shocks on a variety of dollar funding rates that is persistent for at least up to one quarter in the future. This supports the notion that US monetary policy can indeed influence the cost of obtaining dollars both at home and abroad in the expected direction, a cost that will presumably be passed on to those that borrow and lend in dollars. I now proceed to examine the effect on international lending in the following section.

Baseline

I begin my empirical investigation with the baseline specification of the change in log international loans on the fraction of dollar liabilities and its interaction with the aggregated policy shock. If my mechanism is indeed at play, I expect a negative and significant coefficient on the interaction term, suggesting that monetary policy shocks decrease international lending growth with increasing magnitude contingent on the fraction of dollar-denominated liabilities to total liabilities for a given lender country's banking system.

The results are displayed in Table 2.3. Column (1) is the OLS regression with no fixed effects, our potentially most problematic regression. A lack of fixed effects will fail to account for country-specific characteristics, time-varying shocks, simultaneous demand

Table 2.3: Baseline Regression

Dependent Variables	(1) $\Delta log(L_{i,j,t})$	(2) $\Delta log(L_{i,j,t})$	(3) $\Delta log(L_{i,j,t})$	(4) $\Delta log(L_{i,j,t})$
$D_{i,t-1}$	0.0754***	0.186***	0.111***	0.138***
	(0.00897)	(0.0329)	(0.0351)	(0.0334)
$D_{i,t-1} \times MP_{t-1}$	0.437***	0.463***	-0.428	-0.706**
	(0.0886)	(0.0891)	(0.277)	(0.280)
Observations	46,077	46,077	46,077	46,077
R-squared	0.001	0.006	0.017	0.319
Country FE	No	Yes	Yes	Yes
Time FE	No	No	Yes	No
Borrower-Time FE	No	No	No	Yes
Adjusted R2	0.00105	0.00109	0.0106	0.118

*** p<0.01, ** p<0.05, * p<0.1

Notes: The dependent variable in this regression is the change in log cross-border claims of country banking sector i on all borrowers in all sectors in country j. The independent variables are the fraction of dollar-denominated liabilities to total liabilities of the lender country in the previous quarter. Country fixed effects denotes time-invariant borrower and lender country fixed effects. Time fixed effects denote quarterly fixed effects. The regression in column (4) includes only time-invariant lender fixed effects and borrower-quarter fixed effects. Standard errors are clustered at the lender-borrower pair level.

shocks, and other omitted variables that may confound the estimates and bias results. As we can see, this specification yields a positive and significant coefficient on the interaction between monetary policy shocks and fraction of dollar liabilities, contrary to the proposed mechanism. Column (2) holds similar results after controlling for time-invariant country-borrower specific fixed effects, but note that this regression is still subject to bias coming from unobserved time-varying demand shocks. Both regressions yield incredibly low R^2's, on the order of 0.1% to 0.6% of variation explained, suggesting that not much is being picked up by these specifications and omitted variables bias may be rampant.

Column (3) provides a slightly better specification, accounting now for global time-varying shocks as captured by time fixed effects. I obtain a negative, albeit insignificant coefficient on the interaction term, and although still small, we do see a substantial improvement in the R^2 to 1.7% of variation explained. Column (4) provides the most illuminating results as I am now controlling for time-varying borrower-country fixed effects. This specification more convincingly and cleanly absorbs unobserved credit demand, and, as hypothesized, we observe a negative and significant coefficient on the interaction between monetary policy shocks and fraction of dollar-denominated liabilities. Concerns about omitted variables may be somewhat alleviated as we observe a sharp increase in both the raw and adjusted R^2, with the former jumping to almost 32%, and the latter to 11.8%, over ten times that of the prior specification.

Controls

I now augment the baseline regression with lender country banking sector leverage and dollar swap pressure. Leverage is captured by the banking sector's ratio of capital to assets with the idea that more highly levered country banking sectors should be relatively more sensitive to funding shocks. Dollar swap pressure is captured by the difference between a given country's banking sector's dollar-denominated claims and liabilities, scaled by the country's total claims. If a banking sector has more dollar-denominated claims than liabilities, it is lending more than borrowing in dollars, and thus must be funding these claims by swapping currency for dollars. Given that global banks can choose whether to obtain dollars either directly through borrowing in money and interbank markets or swapping domestic currency for dollars, controlling for the latter controls for the notion that if the cost of direct dollar borrowing increases, banks can substitute for dollar funding by engaging in swap markets. We thus expect an opposite effect of the interaction between the monetary shock and swap pressure compared to that of the proxy for dollar exposure as access to swap markets should help alleviate the decline in lending attributed to the increase in funding costs.

My results are presented in Table 2.4. First, the inclusion of controls has confirmed

Table 2.4: Full Regression with Controls

Dependent Variables	(1) $\Delta log(L_{i,j,t})$	(2) $\Delta log(L_{i,j,t})$	(3) $\Delta log(L_{i,j,t})$	(4) $\Delta log(L_{i,j,t})$
$D_{i,t-1}$	0.101***	0.223***	0.142***	0.166***
	(0.0141)	(0.0352)	(0.0365)	(0.0345)
$D_{i,t-1} \times MP_{t-1}$	-0.143	-0.538	-1.053**	-1.668***
	(0.371)	(0.395)	(0.468)	(0.460)
$Lev_{i,t-1}$	-0.00148	-0.000438	0.000304	-0.000426
	(0.00129)	(0.00171)	(0.00188)	(0.00182)
$Lev_{i,t-1} \times MP_{t-1}$	0.0461	0.0787**	0.0906**	0.120***
	(0.0312)	(0.0335)	(0.0397)	(0.0377)
$Swap_{i,t-1}$	0.0144	0.0332	0.120**	0.0784
	(0.0155)	(0.0409)	(0.0483)	(0.0495)
$Swap_{i,t-1} \times MP_{t-1}$	0.372	0.403	0.582	0.952**
	(0.354)	(0.357)	(0.407)	(0.396)
Observations	38,719	38,719	38,719	38,719
R-squared	0.002	0.008	0.018	0.339
Country FE	No	Yes	Yes	Yes
Time FE	No	No	Yes	No
Borrower-Time FE	No	No	No	Yes
Adjusted R2	0.00143	0.00180	0.0112	0.127

*** p<0.01, ** p<0.05, * p<0.1

Notes: The dependent variable is the change in log international claims of country i on country j. The independent variables are the lagged fraction of dollar-denominated liabilities, leverage as measured by bank capital-to-asset ratio, swap pressure as measured by dollar-denominated claims less liabilities scaled by total claims, and their interactions with the sum of monetary policy shocks in the previous quarter. Fixed effects are as in the baseline regression. Standard errors are clustered at the lender-borrower pair level.

the presence of omitted variables bias in the OLS counterparts of the baseline regression as the sign of the interaction between dollar liabilities and the monetary policy shock is now robustly negative across all specifications. Significance is not obtained until I control for time fixed effects in columns (3) and (4), but it becomes even stronger than the baseline case without controls. Explained variation as measured by the R^2 marginally improves, but not by enough to warrant a higher weighting on the additional channels introduced.

Moving to the controls now, the interaction of dollar swap pressure and monetary policy enters in positive and significant, consistent with a substitution effect. As monetary policy in the US appears more contractionary, lenders perhaps find it more profitable to lend in dollars funded by swap markets instead of borrowing in dollar funding markets, thus leading them to increase their international lending. This then offsets the reduction in international lending stemming from increased cost of dollar funding, leaving the overall effect on total international lending potentially ambiguous.

We may check the overall effect on total lending by performing a back-of-the-envelope calculation. The means of the fraction of dollar funding and swap pressure are .436 and -.003, respectively, hence a one-standard deviation shock to monetary policy of .047 leads to a decrease in cross-border lending vis-à-vis one country borrower by 3.42% from dollar funding and almost no change from dollar swap pressure. The dollar funding channel dominates, namely the substitution to dollar swap markets is not enough to offset increased costs, and we thus should expect lower international lending following a contractionary shock.

A lower levered or more capitalized banking system appears to be associated with a positive effect of monetary shocks on lending growth holding the fraction of dollar funding and swap pressure constant. In magnitudes, with a mean of 5.714, a one-standard deviation shock yields an increase in cross-border lending of 3.22%. The net effect of monetary policy shocks on lending is thus still negative, namely -0.20%, but it appears that well capitalized banking sectors tend to be economies that are relatively insulated from dollar funding shocks coming from changes in US monetary policy.

Sector Fixed Effects

The previous analysis has abstracted from the specific sector of counterparties, a limitation of the banking claims data when using the immediate counterparty basis. The BIS

Consolidated Banking Statistics also include total claims on an ultimate risk basis that provides granularity in counterparty sectors. I exploit this rich feature of the data in order to examine whether the patterns documented in the previous sections remain robust to the inclusion of borrower-country-sector-time fixed effects, a specification that more precisely controls for potential demand shocks, and to analyze potential heterogeneity in the response of international claims to specific sectors.

I begin by looking at the original specification with controls, but with observations now at the lender country, borrower-country-sector, and time level. With borrower fixed effects now at the sectoral level, we should observe an improvement in controlling for borrower demand as the specification now accounts for the heterogeneity in borrower demand across sectors. As before, my regressions range from no fixed effects, time-invariant fixed effects, global time fixed effects, and borrower-sector-specific time-varying fixed effects.

The patterns identified in the previous section remain robust as displayed in Table 2.5, namely the negative interaction between the fraction of dollar funding and monetary policy shocks and the positive interactions between lender country leverage, dollar swap pressure, and monetary policy shocks are as before. The magnitudes of these coefficients have become much larger and I now obtain 1% significance across all specifications. More carefully controlling for demand shocks by accounting for the heterogeneity in the response of lending to particular sectors in a given counterparty country has in fact strengthened the results, providing additional evidence in favor of the international bank lending channel.

Subsamples Sectors and Controls

I now exploit the granularity of the ultimate risk basis data in order to study the heterogeneous response of international bank lending to monetary policy shocks across counterparty

Table 2.5: Full Regression with Sector Controls

Dependent Variable	(1) $\Delta log(L_{i,j,s,t})$	(2) $\Delta log(L_{i,j,s,t})$	(3) $\Delta log(L_{i,j,s,t})$	(4) $\Delta log(L_{i,j,s,t})$
$D_{i,t-1}$	0.249***	0.517***	0.258***	0.308***
	(0.0236)	(0.0681)	(0.0691)	(0.0710)
$D_{i,t-1} \times MP_{t-1}$	-5.567***	-6.400***	-6.882***	-8.112***
	(1.252)	(1.347)	(1.431)	(1.388)
$Lev_{i,t-1}$	-0.0129***	-0.0124***	-0.00782*	-0.00857*
	(0.00206)	(0.00317)	(0.00455)	(0.00475)
$Lev_{i,t-1} \times MP_{t-1}$	0.465***	0.528***	0.669***	0.779***
	(0.101)	(0.108)	(0.119)	(0.119)
$Swap_{i,t-1}$	-0.0658***	0.0382	0.147	0.0968
	(0.0205)	(0.0850)	(0.0894)	(0.0979)
$Swap_{i,t-1} \times MP_{t-1}$	1.233**	1.219**	2.332***	3.028***
	(0.540)	(0.542)	(0.691)	(0.761)
Observations	50,393	50,393	50,393	50,393
R-squared	0.003	0.007	0.021	0.372
Country FE	No	Yes	Yes	Yes
Sector FE	No	Yes	Yes	No
Time FE	No	No	Yes	No
Borrower-Sector-Time FE	No	No	No	Yes
Adjusted R2	0.00239	0.00231	0.0155	0.102

*** p<0.01, ** p<0.05, * p<0.1

Notes: The dependent variable is the change in log international claims of the banking sector in country i on sector s in country j. Sectors are classified by bank, non-bank financial, official, and non-bank private. Sector FE denotes time-invariant sector fixed effects, while borrower-sector-time FE denotes fixed effects at the country-sector-quarter level, namely $\alpha_{j,s,t}$ as opposed to $\alpha_{j,t}$. Standard errors are clustered at the lender-borrower country pair level.

sectors. In particular, I estimate regressions as in the previous sections on the subsamples of each counterparty sector in order to identify which are most affected or immune to the monetary shocks and provide some broader insight into how global banks adjust their international lending in response to dollar funding shocks at an aggregate level.

The BIS data disaggregates counterparty sectors into banks, non-bank financial institutions, the official sector, and the non-bank private sector, for each of which I construct subsamples and run the previous regressions. Note that for brevity I have only included the full regression specifications with time-varying borrower country fixed effects and only

Table 2.6: Counterparty Sector Specific Regressions

Counterparty	Banks		Non-Bank Financial		Official		Non-Bank Private	
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$D_{i,t-1}$	0.372***	0.300**	4.846	25.27	-0.125	0.00629	0.222***	0.268***
	(0.0900)	(0.124)	(8.279)	(17.96)	(0.106)	(0.132)	(0.0704)	(0.0870)
$D_{i,t-1} \times MP_{t-1}$	-0.0791	-0.507*	-2.377	-7.539	0.238	-0.0380	-0.631***	-1.222***
	(0.187)	(0.270)	(5.595)	(10.12)	(0.238)	(0.331)	(0.112)	(0.174)
$Lev_{i,t-1}$		-0.0111		-1.222		-0.00188		0.00139
		(0.00889)		(0.853)		(0.00951)		(0.00606)
$Lev_{i,t-1} \times MP_{t-1}$		0.249**		17.55		0.349**		0.449***
		(0.107)		(12.99)		(0.144)		(0.0820)
$Swap_{i,t-1}$		-0.0265		-14.62		0.493**		0.103
		(0.187)		(15.81)		(0.230)		(0.108)
$Swap_{i,t-1} \times MP_{t-1}$		0.165		471.9		2.985**		1.477*
		(1.307)		(374.0)		(1.353)		(0.796)
Observations	18,948	15,932	855	855	15,994	13,511	23,985	20,095
R-squared	0.351	0.365	0.267	0.273	0.348	0.377	0.354	0.398
Adjusted R2	0.0970	0.0983	-0.0414	-0.0402	0.0609	0.0811	0.115	0.151

*** p<0.01, ** p<0.05, * p<0.1

Notes: The dependent variable is the change in log international claims of the banking sector in country i on the counterparty sector in country j. This regression is estimated on four different subsamples that isolate the counterparty sectors. In the interest of space, I only display the baseline and full specification results that include lender country time-invariant and borrower country-time fixed effects. Standard errors are clustered at the lender-borrower country pair level.

compare the baseline specification to that with the two controls.

Table 2.6 displays my results for each of the subsamples and specifications. First note that the interaction between contractionary monetary policy shocks and fraction of dollar-denominated liabilities is negative for all sectors except the official sector. Furthermore we consistently see a positive interaction for leverage and swap pressure.

The strongest results reside with non-bank private sector counterparties, with coefficients of -0.631 in the baseline and -1.222 in the full specification in columns (7) and (8). This yields a 2.5% decline in lending to non-bank private sector counterparties in aggregate following a one standard deviation monetary policy shock. It appears then that the decline in international lending from global banks hits the non-bank private sector the hardest, namely firms and households. If they are unable to substitute international bank lending for an alternate source, say from domestic banks, we should expect to see real international spillovers and effects from the US monetary shock.

The next set of results in columns (1) and (2) pertain to banking sector counterparties. We observe a negative interaction between the fraction of dollar funding and monetary shocks, but significance is only marginally obtained in the full specification with controls. The magnitude is much lower than that observed in the non-bank private sector subsample at -0.507, suggesting that the monetary shocks more strongly affect lending to the non-bank private sector than banks. For reference, this yields a 1.03% decline in cross-border lending to banking sector counterparties following a one standard deviation shock.

Results for the non-bank financial sector yield no significance as displayed in columns (3) and (4), but this could be attributed to the small sample size. Note however that the sign on the interaction between fraction of dollar funding and monetary shocks is negative as expected, and that the magnitudes on coefficients are quite large. This may of course just be due to small sample bias.

Finally for the official sector in columns (5) and (6), note that there is no significance on the interaction between fraction of dollar liabilities and monetary shocks and the sign is in fact positive. More interestingly we observe a large and positive significant interaction between dollar swap pressure and monetary shocks at 2.985, above and beyond that of the non-bank private sector. This then suggests that with higher dollar rates and swap pressure, global banks will in fact increase their cross-border claims on official sectors. This is consistent with the notion of carry trade, as higher rates abroad should lead domestic agents to borrow in their own currency and lend in foreign currency to take advantage of higher interest differentials.

To summarize, I have found that lending to the non-bank private sector is most sensitive to US monetary policy shocks, followed by the banking sector. The official sector, while not significantly affected by monetary shocks through their interaction with lender's fraction of dollar-denominated liabilities, appears to be positively impacted by monetary shocks through the interaction with dollar swap pressure, suggesting an increase in cross-border claims potentially due to participation in the carry trade.

Maturity

I next examine whether global banks differentially adjust claims of different maturities following US monetary shocks. The consolidated banking statistics on an immediate counterparty basis distinguish between claims of all maturities and those up to and including one year, the latter of which I consider short-term lending. I take the difference between these two series to construct my measure of longer-term lending and run regressions on the subsamples of short, long, and all maturity lending.

My results are displayed in Table 2.7. At first glance, we see that the interactions between fraction of dollar funding and monetary shocks are negative for all maturities and significant in the full specifications, suggesting a homogeneous response to higher dollar funding costs. Note however that significance and magnitude are larger for the longer maturity claims, at -1.494 in the full specification compared to -1.343 for short maturity claims.

Short maturity claims fail to have significance in the interaction between leverage and monetary shocks, but are estimated with a positive coefficient, consistent with previous results. Long maturity claims have both a positive and significant coefficient of .149, slightly higher than that estimated for all maturities.

Short maturity claims further differentiate from longer term and all maturity claims in their positive and significant coefficients on lender country leverage and dollar swap pressure.

Table 2.7: Maturity Regressions

Maturity	Short-Term		Long-Term		All	
	(1)	(2)	(3)	(4)	(5)	(6)
$D_{i,t-1}$	0.181***	0.256***	0.150***	0.149***	0.138***	0.166***
	(0.0468)	(0.0562)	(0.0428)	(0.0501)	(0.0334)	(0.0345)
$D_{i,t-1} \times MP_{t-1}$	-0.492	-1.343*	-0.217	-1.494**	-0.706**	-1.668***
	(0.391)	(0.689)	(0.400)	(0.678)	(0.280)	(0.460)
$Lev_{i,t-1}$		0.00552**		-0.00300		-0.000426
		(0.00264)		(0.00238)		(0.00182)
$Lev_{i,t-1} \times MP_{t-1}$		0.0835		0.149***		0.120***
		(0.0549)		(0.0485)		(0.0377)
$Swap_{i,t-1}$		0.278***		-0.0791		0.0784
		(0.0788)		(0.0696)		(0.0495)
$Swap_{i,t-1} \times MP_{t-1}$		0.411		0.604		0.952**
		(0.718)		(0.468)		(0.396)
Observations	34,002	28,063	31,744	25,999	46,077	38,719
R-squared	0.393	0.401	0.414	0.434	0.319	0.339
Adjusted R2	0.147	0.141	0.169	0.184	0.118	0.127

*** p<0.01, ** p<0.05, * p<0.1

Notes: The dependent variable is the change in log international claims of the banking sector in country i on the counterparty sector in country j. This regression is estimated on three different subsamples, short-term claims with maturity less than and up to 1 year, claims of all maturities, and long-term claims obtained by subtracting short-term claims from all claims. In the interest of space, I only display the baseline and full specification results that include lender country time-invariant and borrower country-time fixed effects. Standard errors are clustered at the lender-borrower country pair level. *** p<0.01, ** p<0.05, * p<0.1

In contrast to longer maturity lending growth, short maturity lending growth appears to be higher in countries that are either more highly levered or exhibit a large amount of dollar swap pressure. Note that these effects are invariant to the interaction with the monetary policy shocks, suggesting that these differences remain even in the absence of shocks.

Local Lending

Recall that the consolidated banking statistics attribute banks' claims to their parents' locations, namely those coming from offices in their headquartered countries and those booked at their foreign affiliates located abroad are both categorized as credit from the parent country. Given that not all international lending is done cross-border as banks may choose to extend loans abroad through their affiliates located in the borrower country, it is of interest to examine whether there is a differential response of this type of lending following US monetary shocks.

Analogous to the previous sections, I regress the change in log local claims on the fraction of dollar funding, its interaction with the monetary policy shock, and the controls and their interactions. Note that the local claims in the BIS data only include those booked in local currency. For example, local claims booked vis-à-vis counterparties in Argentina will only include those denominated in Argentine Pesos. Given the limited availability of data, this exercise should serve as both a placebo as well as a check for a substitution effect. Specifically, I expect either no change in local lending as increased dollar funding costs should not affect lending denominated in domestic currency or should increase local lending as I expect that banks would replace the decline in dollar-denominated loans with loans in the domestic currency.

Consistent with my conjecture, in Table 2.8 we do not observe a statistically significant interaction between the monetary shock and fraction of dollar-denominated liabilities, successfully passing the placebo test. Furthermore the sign of the interaction depends on whether I include controls, thus providing inconclusive evidence regarding the existence of a substitution effect.

Note however that lack of conclusive evidence for a substitution effect does not invalidate its existence as my prior regressions were looking at changes in international or cross-border lending whereas this set of results pertains to local lending. If we were to observe a substitution effect, it would more likely appear in changes in international lending in foreign currency, a level of granularity not available in my dataset.[3]

[3]Ivashina, Scharfstein, and Stein (2015) use syndicated loan data to show that there is indeed a shift in lending from dollar-denominated loans to euro denominated loans at Eurozone banks in the midst of the

Table 2.8: Local Regressions

Dependent Variables	(1) $\Delta log(L_{i,j,t})$	(2) $\Delta log(L_{i,j,t})$	(3) $\Delta log(L_{i,j,t})$	(4) $\Delta log(L_{i,j,t})$
$D_{i,t-1}$	0.118***	0.535***	0.421***	0.276**
	(0.0294)	(0.0887)	(0.0935)	(0.113)
$D_{i,t-1} \times MP_{t-1}$	0.414	-0.597	-0.781	-0.778
	(0.581)	(0.634)	(0.638)	(0.811)
$Lev_{i,t-1}$	-0.00778***	-0.00424	0.00289	0.00391
	(0.00278)	(0.00351)	(0.00378)	(0.00480)
$Lev_{i,t-1} \times MP_{t-1}$	-0.0240	0.0622	0.117**	0.131**
	(0.0451)	(0.0497)	(0.0522)	(0.0660)
$Swap_{i,t-1}$	-0.0403	-0.200*	0.0899	0.0272
	(0.0324)	(0.106)	(0.114)	(0.136)
$Swap_{i,t-1} \times MP_{t-1}$	-0.162	-0.237	0.203	0.566
	(0.531)	(0.535)	(0.652)	(0.812)
Observations	17,086	17,086	17,086	17,086
R-squared	0.001	0.015	0.024	0.390
Country FE	No	Yes	Yes	Yes
Time FE	No	No	Yes	No
Borrower-Time FE	No	No	No	Yes
Adjusted R2	0.000292	0.00374	0.0102	0.0534

*** p<0.01, ** p<0.05, * p<0.1

Notes: The dependent variable is the change in log local lending of banks located in country j with headquarters in country i to borrowers in country j denominated in the local currency of country j. The independent variables, fixed effects, and regression specifications are as in previous exercises. Standard errors are clustered at the lender-borrower country pair level.

2.6 Potential Critiques

The previous empirical analysis is not immune to critiques regarding the identification strategy, proxy variables used, and usage of aggregate data. I discuss a few potential critiques in this section.

Endogeneity and Identification

This paper seeks to estimate the causal effect of US monetary policy shocks on international bank lending which relies heavily on the assumption of exogeneity of the monetary policy

Euro crisis.

shocks themselves. One might argue that the shocks used are not exogenous as it could be the case that even though Nakamura and Steinsson's measure cleanly isolates the changes in relevant interest rates through high frequency identification, because we are looking at quarterly horizons, other events could have occurred in that time period that have caused the change in monetary policy, the fraction of dollar liabilities, and cross-border lending. This would then leave my regression subject to omitted variables bias which would confound my estimates.

One counterargument to this point is that when controlling for global time fixed effects in my specifications, which would soak up variation from events occurring in each quarter that could lead to omitted variables bias, my results remain robust in the sense that I almost always obtain a negative interaction between monetary shocks that is significant once all controls are added to the specification. In this sense, concerns may be somewhat alleviated as my effect still holds despite controlling for potential shocks that otherwise would have biased results.

This of course does not completely exonerate my results as it is easy to think of a situation in which the FOMC adjusts monetary policy due to factors that also affect international lending. In this case, I am then not measuring the causal effect of US monetary policy shocks on international lending, but rather the effect of whatever factors lead the FOMC to adjust monetary policy on international lending. In this case, the only way to estimate the causal effect would be to find an instrument for US monetary policy, one example being oil price shocks. Unfortunately oil price shocks would likely violate the exclusion restriction as oil prices affect credit supply and demand outside of their effects on dollar interest rates.

Fraction of Dollar Liabilities as Proxy for Dollar Funding Exposure

The bulk of my analysis relies on the usage of the fraction of dollar-denominated liabilities as a proxy for a lender country's banking system reliance on dollar funding or dollar funding exposure. It is not necessarily the case that all of these dollar liabilities come from uninsured wholesale dollar funding sources such as US money markets or the interbank market and thus a country's sensitivity to US monetary policy shocks may be much less than that measured by the fraction of all dollar-denominated liabilities. If the fraction of dollar-denominated liabilities overstates dollar funding exposure, my estimates would in fact understate the effect of a monetary policy shock on cross-border lending, which should not be a problem as we have then established a lower bound on the effect.

However, it could also be the case that fraction of dollar liabilities understates dollar funding exposure. This scenario seems more likely as global banks use uninsured dollar funding sources only for short term dollar funding, so scaling by all liabilities rather than short-term liabilities can understate the exposure. The ideal measure would be the fraction of dollar funding from US money markets and the interbank market over all short-term dollar-denominated liabilities, a variable that to the best of my knowledge cannot be constructed.[4] In this case if dollar funding exposure is understated by my measure, my estimates would overstate the effect of monetary shocks on lending.

Another issue with using my proxy is that it may not reflect dollar funding exposure and instead other reflects differences in banking sector balance sheets, a point discussed by Cetorelli and Goldberg (2011). In this case, my empirical results would not be confirming my proposed mechanism of increased cost of dollar funding leading to a curtailing of in-

[4] Ivashina, Scharfstein, and Stein (2015) construct the sum of money market fund holdings and scale it by the sum of bank deposits and short-term debt, but note that short-term *dollar* denominated debt is unavailable.

ternational lending and would instead be providing evidence for some other balance sheet mechanism in the veil of my own.

Lack of Granularity to Pin Down Mechanism

The previous point on an inability to clearly attribute the decline in lending to the dollar funding channel extends further given that the aggregate data lacks granularity with respect the currency denomination of lending. The cross-border claims data from the BIS fails to break down the volume of lending done in individual currencies when examining bilateral lending relationships. I thus am unable to determine specifically whether the volume of dollar-denominated loans decreases following the monetary shock in line with the proposed mechanism.

With only data on total cross-border lending vis-à-vis counterparty country borrowers, I cannot verify whether the decline in lending is due to a curtailing of dollar-denominated loans due to the higher funding costs or a decline in overall loans perhaps due to US monetary policy proxying for broader economic conditions. The results from Section 2.5 do provide some reassuring evidence as we do not see a response in local currency lending following monetary shocks, but as discussed, we could better determine the channel through which US monetary policy decreases lending with access to the currency breakdown of cross-border lending, allowing us to document the change in dollar-denominated lending and explore to what extent a substitution towards lending in other currencies occurs.

Usage of aggregate country data also makes it difficult to definitively attribute the effects to banking sector specific or country-specific factors. Because I do not have individual bank lender data, my independent variables may be capturing country-specific rather than bank-specific factors that affect exposure of cross-border lending to US monetary policy, the latter of which I am interested in. The inability to disentangle bank-specific from country-specific factors makes it difficult to assert that the dollar funding exposure of individual banks leads to a decline in international lending following monetary shocks as my regressions could just be picking up variation coming from country-specific factors rather than bank-specific factors. The ideal scenario would be to have bank-specific lending data and dollar funding exposure with the nationality of each bank identified, allowing me to average out the country specific factors and isolate the bank-specific effects. To the best of my knowledge, the available data does not permit this exercise.

Results Driven by US

The final potential critique is that my results may be driven primarily by the inclusion of US borrowers and lenders. If this were the case, declines in international lending following contractionary US monetary policy shocks may perhaps not be attributable to the offshore dollar funding mechanism that I argue for, but rather the traditional bank lending channel and mechanical response of US banks facing higher domestic funding costs. Declines in observed lending could also be due to decreased borrowing demand by US counterparties due to contractionary monetary policy at home, although this effect should have already been absorbed by the borrower-time fixed effects. I alleviate this concern by running my regressions on the sample excluding US lenders and borrowers and comparing the results to the full sample to determine whether there are any significant differences.

Table 2.9 displays my results for the full and non-US subsample. In both the baseline and full specifications, my result remains robust as we observe a negative and significant interaction between fraction of dollar liabilities and the monetary policy shock. The magnitude of this interaction becomes even larger when excluding the US, increasing from -0.706

Table 2.9: Full Sample vs. Excluding US

VARIABLES	(1) $\Delta log(L_{i,j,t})$	(2) $\Delta log(L_{i,j,t})$	(3) $\Delta log(L_{i,j,t})$	(4) $\Delta log(L_{i,j,t})$
$D_{i,t-1}$	0.138***	0.161***	0.166***	0.192***
	(0.0334)	(0.0358)	(0.0345)	(0.0369)
$D_{i,t-1} \times MP_{t-1}$	-0.706**	-1.642***	-1.668***	-3.525***
	(0.280)	(0.573)	(0.460)	(0.836)
$Lev_{i,t-1}$			-0.000426	-0.00376*
			(0.00182)	(0.00215)
$Lev_{i,t-1} \times MP_{t-1}$			0.120***	0.126***
			(0.0377)	(0.0411)
$Swap_{i,t-1}$			0.0784	0.0941
			(0.0495)	(0.0585)
$Swap_{i,t-1} \times MP_{t-1}$			0.952**	1.831***
			(0.396)	(0.504)
Observations	46,077	42,736	38,719	35,670
R-squared	0.319	0.324	0.339	0.346
US in Sample	Yes	No	Yes	No
Adjusted R2	0.118	0.107	0.127	0.113

*** p<0.01, ** p<0.05, * p<0.1

Notes: The regressions in (1) and (3) are the same as in Section 2.5 including lender and borrower-time fixed effects. Columns (2) and (4) run these regressions on the sample excluding US lenders and borrowers. Standard errors are clustered at lender-borrower country pair level.

to -1.642 in the baseline and up to -3.525 from -1.668 in the full specification. The mean of dollar funding exposure is 40.4% for the sample excluding the US, so a back-of-the-envelope calculation yields a larger decline in international lending of 3.12% in comparison to 1.45% for the full sample in response to a one-standard deviation shock in the baseline regression. It follows then that my results are not being driven by the inclusion of US borrowers and lenders as my results remain robust and get larger in magnitude once I exclude them. Given that the proposed mechanism should be stronger for non-US banks, this provides further support in favor of the existence of the international bank lending channel for US monetary policy.

2.7 Conclusion

In this paper I explore the relevance of US monetary policy for international bank lending, finding evidence for the transmission of US monetary policy to cross-border credit. I document the pass-through of US monetary policy shocks to offshore and interbank dollar borrowing rates relevant for global banks. I then use bilateral international banking data to examine the effects of US monetary policy shocks on international lending by global banks, controlling for loan demand shocks by employing country borrower-time fixed effects. I find a negative interaction between a country lender's fraction of dollar liabilities and monetary policy shocks, suggesting a larger decline in cross-border lending for more dollar funding exposed country lenders in response to a contractionary monetary policy shock. This result remains robust to adding in leverage and dollar swap pressure and their interactions with monetary policy as controls, controlling for sectors, and excluding US borrowers and lenders. Furthermore I show that this effect is primarily relevant for lending to non-bank private and bank borrowers.

The results of this paper are merely suggestive as a precise empirical analysis of the international bank lending channel requires micro-data containing bank-firm-loan level information that would more tightly estimate effects, control for confounding demand effects, and separate bank- and country-specific factors affecting international lending. In addition, definitively establishing the causal link between US monetary policy and bank lending requires an exogenous instrument for monetary shocks, an exercise saved for future work.

Chapter 3

International Bank Lending and the October 2016 US Money Market Fund Reform

3.1 Introduction

One stylized fact in international finance has been the dominant role of the dollar as the currency of choice for cross-border claims and liabilities. Its omnipresence in international lending markets leads one to ask what are the relevant implications and potential for international spillovers, namely does the outsize role of the dollar cause shocks emanating from the US to propagate across borders? This paper seeks to answer one dimension of this question by focusing on the relevance of dollar funding US money market funds and their potential effects on international bank lending.

Figure 3.1 displays the total cross-border claims of all reporting Bank for International Settlements (BIS) banks decomposed into currency denomination. A large portion of cross-

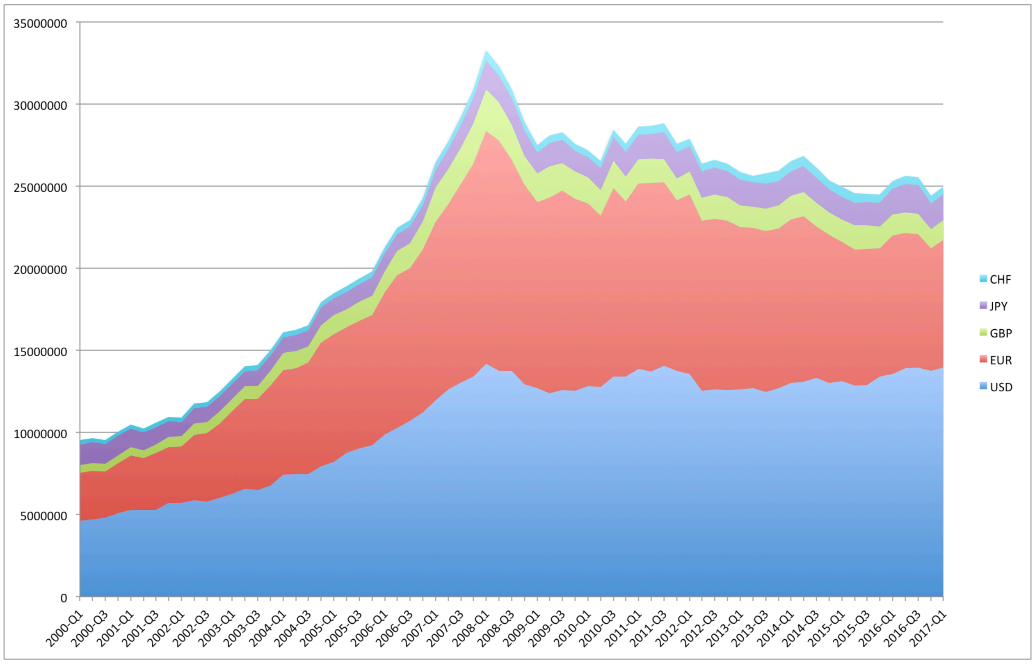


Figure 3.1: Cross-Border Claims by BIS Reporting Banks by Currency Denomination

Notes: This graph displays the total volume of international claims and liabilities in the positive and negative axes respectively for all BIS reporting banks. The data is sourced from Table 5A of the BIS Locational Banking Statistics.

border claims are denominated in dollars - approximately $14 trillion out of the $29 trillion dollars, or about 40%, in outstanding cross-border claims by global banks as of 2017 Q1. One may posit that the prevalence of the dollar may be a by-product of the size of the US economy and banking sector. However if we look further and decompose this $14 trillion of dollar-denominated cross-border claims into US and non-US banks, it is apparent from Figure 3.2 that the lion share of these claims are in fact extended by non-US banks. In other words, foreign banks, or what I call global banks, extend the majority of cross-border dollar credit in the world.

What is the relevance of this stylized fact? To start, we must consider the differences between US and global banks. At the most primitive level, banks are responsible for taking on deposits, generally from domestic households or businesses. Hence it is likely that a bank's deposit base, its primary source of funding, is mostly denominated in its domestic

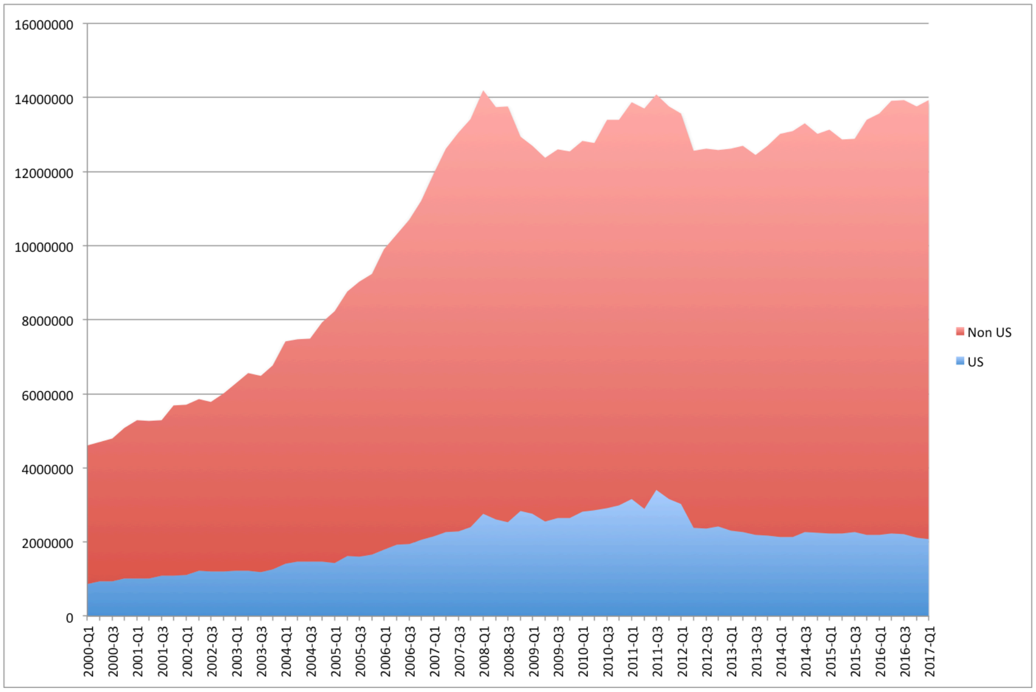


Figure 3.2: Cross-Border Claims by BIS Reporting Banks by Nationality

Notes: This graph displays the total volume of dollar-denominated international claims for all US and non-US BIS reporting banks. The data is sourced from the BIS Locational Banking Statistics.

currency - for example, German banks have euro deposits and Japanese banks have yen deposits. Foreign banks may still raise dollar deposits abroad, but note that in the US, only US banks have insured dollar deposits via the Federal Deposit Insurance Corporation (FDIC), while foreign bank dollar deposits are uninsured.[1] US banks thus have a stable source of dollar funding through deposits, whereas the dollar deposits of foreign banks may be uncertain from a stability standpoint and vulnerable to runs.[2]

Global banks need not only rely on domestic deposits for dollar funding. Some other sources include swapping foreign currency into dollars, offshore (Eurodollar) deposits, dollar-denominated bond issuance, and short-term unsecured borrowing from other banks

[1]Dollar deposits of foreign banks are secured if obtained through an established subsidiary domiciled in the United States.

[2]The intuition is that during bad times, US banks are less likely to undergo a bank run and flighty deposits a la Diamond and Dybvig (1983) because their deposits are insured. Foreign banks on the other hand appear more vulnerable and risky to depositors who likely will withdraw funds during a crisis.

or financial institutions. This paper focuses on the latter, namely short-term foreign bank borrowing from US money market funds, and examines whether a shock to this source of dollar funding affects their international lending behavior with regards to the currency composition of their loan portfolio and total volume of dollar-denominated loans.

To answer this question, I focus on the effects of the US money market fund reform enacted in October 2016. Following the Global Financial Crisis of 2008-2009, the Securities and Exchange Commission (SEC) sought to improve regulation on US money market funds given the run that occurred following the collapse of Lehman Brothers.[3] It targeted prime funds, namely those responsible for extending short-term dollar credit to domestic and foreign financial institutions, changing rules regarding the general valuation of and redemption from these funds during potential liquidity crises. As a result, these funds lost their attractiveness to investors who subsequently withdrew a large portion of their money, moving them to funds not subject to the new rules and effectively removing a substantial source of dollar funding for foreign banks.

I exploit this arguably exogenous shock to dollar funding markets and utilize the cross-sectional heterogeneity of banks' reliance on US money market funds prior to the shock to isolate the effect of a loss of dollar funding on international lending volume and composition. I find that despite the large magnitude of the loss in dollar funding, the effect on international syndicated lending is largely ambiguous, leaning more towards a lack of an effect, suggestive of banks' ability to substitute for other sources of dollar funding in line with evidence from the BIS Quarterly Review (2017).

[3]The Reserve Primary Fund held exposure to Lehman Brothers in commercial paper. Following Lehman's bankruptcy in September 2008, these assets became worthless, causing the fund to decrease its net asset value to 97 cents a share from the standard dollar per share, effectively "breaking the buck," one of the first times witnessed in history by a money market fund. Although the losses from Lehman only accounted for less than 1.5% of the fund's balance sheet, investors rapidly began withdrawing funds out of fear. This widespread fear spread to other funds, even those without exposure to Lehman and AIG, thus providing an example of one of the worst runs in money market funds in history.

My analysis entails two approaches. The first employs a Bartik instrument in which I proxy for the exposure or treatment of each bank to the decline in US money market funding with the pre-reform share of money market funding to total short-term liabilities. I use the Bartik instrument in two ways: cross-sectionally by examining the pre- and post-reform lending for each bank and dynamically by utilizing the time series variation from 2011 to 2017 in money market funding to assess whether changes in money market funding in the previous quarter lead to declines in lending in the following quarter. My results from the cross-sectional specifications do not provide evidence of a contraction in lending following the reform, while those from the dynamic specifications are unable to find robustly significant effects after accounting for global shocks as captured by time fixed effects and alternate sources of dollar funding.

The second approach also exploits cross-sectional variation, but employs the within estimator as pioneered by Khwaja and Mian (2008). This approach identifies the effect of the US money market fund reform on bank lending by controlling for borrower demand with borrower fixed effects which I employ at the individual borrower and borrower-sector levels. As with the specifications with the Bartik instrument, I do not find a consistently significant effect of the decline in dollar funding from US money market funds on lending volume. I do however find an effect on the prices of loans as I obtain a significant increase in loan spreads over LIBOR following the reform when controlling for individual borrower fixed effects. This result however does not hold in the sectoral specifications.

With regards to composition, I do not find evidence of a robustly significant change in the fraction of dollar-denominated loans relative to all loans before and after the shock period, as well as over time as identified by the quarterly time series specifications. I do obtain some significant estimates in the time series that suggest that the fraction of dollar-denominated loans *increases* in both value and quantity contrary to my prior, but these results do not survive the more well-identified specifications that isolate the loss in funding from prime funds and control for alternate sources of dollar funding coming from government funds and dollar bond issuance. Given the findings, I again conclude that the results lean towards a lack of an effect.

My results thus suggest that the US money market fund reform did not have a significant impact on foreign bank lending, a surprising result given the magnitude of the loss in dollar funding. I provide some evidence of substitute sources of dollar funding such as increased funding from US government money market funds and dollar bond issuance. Banks may have been able to smooth their dollar funding needs across other dimensions as well such as obtaining increased offshore dollar deposits, but data limitations prevent me from exploring this hypothesis. There does not appear to be a significant relationship between dollar funding from US money market funds and international bank lending, both in volume and composition, illuminating the fact that perhaps not all dollar funding sources are as important as expected.

The paper proceeds as follows. Section 3.2 discusses the relevant literature. Section 3.3 provides the institutional background behind US money market funds and the October 2016 reform. Section 3.4 describes the data and provides some summary statistics on bank lending and money market funding. Section 3.5 explains the identification strategy and empirical methodology. Section 3.6 displays the empirical results. Section 3.7 provides a discussion of the results. Section 3.8 concludes.

3.2 Literature Review

To the best of my knowledge, this is the first paper to closely examine the implications of the US money market fund reform with careful treatment of the econometrics and causal interpretation. There has been previous work examining the linkage between US money market funds and foreign bank lending, namely Ivashina, Scharfstein, and Stein (2015). They focus on the European Sovereign Debt Crisis of 2011-2012 and argue that during this period US money market funds withdrew their dollar funding to Eurozone banks, which, in combination with strained swap markets[4], lead to a dry-up in dollar funding. They find that Eurozone banks shifted their lending portfolios away from dollar-denominated loans and towards euro-denominated loans, and firms that had previously borrowed from Eurozone banks had a lower probability of obtaining a dollar-denominated loan. Similarly, Correa, Sapriza, and Zlate (2012) focus on the US subsidiaries of foreign banks, finding that during the same period foreign banks lost a large portion of time deposits, which they attribute to US money market funds, and subsequently decreased their dollar-denominated lending, controlling for sector fixed effects. This paper looks to answer similar questions through the same channel, but differentiates from the literature by focusing on a more plausibly exogenous shock[5] and carefully estimating the effects on international lending by exploiting bank-level exposure to US money market funds.

This paper in essence examines the effect of a liquidity shock on bank lending. In particular, I employ the Khwaja and Mian (2008) within-firm estimator in a few specifications to isolate the effect of the shock on credit supply by controlling for borrower demand. Re-

[4]If swap markets are frictionless, the cost of swapping foreign currency into dollars should equal the cost of borrowing directly in dollars

[5]Eurozone banks could have cut back lending due to other concerns revolving around the European Sovereign Debt Crisis.

lated papers include Peek and Rosengren (2000) and Schnabl (2012) who find that shocks from abroad may transmit across borders into lending through global banks. I focus on a similar mechanism of liquidity shocks affecting international bank lending, but with particular emphasis on the role of the dollar and its related funding markets. Acharya, Afonso, and Kovner (2017) find that foreign banks differentially lost dollar funding relative to US banks during the asset-backed commercial paper freeze of 2007, and as a result passed on higher interest rates through their dollar-denominated loans. I examine this notion, but with respect to the decline in dollar liquidity attributed to money market funds.

There also exists a literature on money market funds with regards to their role as lenders and susceptibility to runs. Most closely related is Chernenko and Sunderam (2014) who find that money market funds exposed to Eurozone banks experienced large outflows during the Euro crisis of 2011 which lead to a decline in short-term financing for borrowers heavily reliant on such funds. This paper builds upon this notion, looking at the effects of the decline in short-term financing on loans extended by these lenders. Schmidt et al. (2016) examine the money market fund run following the Lehman bankruptcy, noting that more sophisticated investors, namely institutional as opposed to retail investors, withdrew funds much faster, providing support for imposing fees and gates on redemptions from certain types of money market funds. Kaperczyk and Schnabl (2013) also look at the Lehman run, instead shedding light on the risk-taking behavior of money market funds that lead to runs in bad times. The money market fund reform was not a run as in the previous episodes studied in the literature, but bears similarities in the sense of fund outflows and a decline in short-term debt financing for banks.

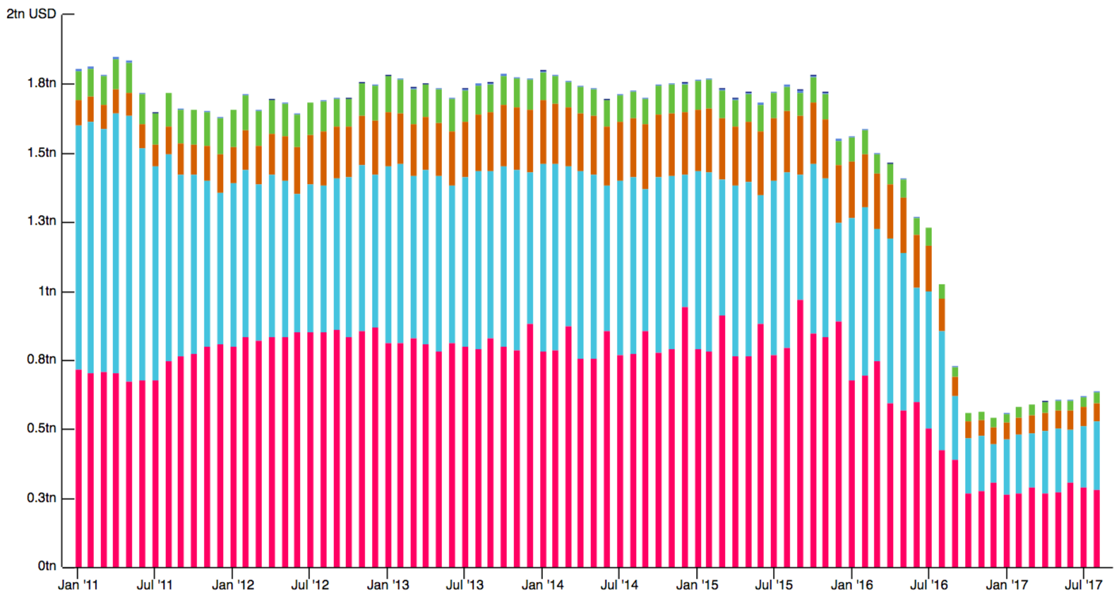
Lastly, given the alternative sources of dollar funding, this paper broadly relates to the literature on relating deviations in the covered interest parity (CIP) to dollar funding markets and lending. Traditionally, if the CIP held, banks could frictionlessly substitute for dollar funding by borrowing in domestic currency and swapping into dollars. However turbulence in dollar funding markets can spill over to swap markets, leading to deviations in CIP as was observed in the second half of 2007 (Baba, Packer, and Nagano (2008), Coffey, Hrung, and Sarkar (2009)), and more recently researchers have found a relationship among deviations in CIP, cross-border bank lending, and the strength of the US dollar (Avdjiev et al. 2017). Deviations in the CIP since the Global Financial Crisis have been identified by Du et al. (2016) and Rime et al. (2017), with authors arguing for the role of limited risk-bearing capacity of arbitrageurs to eliminate the mispricing. This paper takes the deviations in CIP as given, assuming that banks may find it more costly to finance dollar lending via swap markets, and are thus more sensitive to shocks to dollar funding markets as in the model in Ivashina, Scharfstein, and Stein (2015).

3.3 US Money Market Funds and the October 2016 Reform

Money market funds are mutual funds that invest in relatively safe, short-term debt securities. They serve as liquid investments that provide potentially higher returns than cash equivalents as they mainly hold government securities and commercial paper. This paper focuses on prime funds, namely those that invest in the commercial paper and certificates of deposits of financial institutions, and to a lesser extent, government funds which hold US treasuries, agency debt, and the related repurchase agreements (repos).

Investors purchase shares of the fund, which conventionally are priced at a net asset value (NAV) of $1 per share, and receive dividends for holding this share. Up until October 2016, money market funds maintained stable NAV's of $1, with a recent exception being the Reserve fund following the Lehman collapse in October 2008, leading the fund to "break

Figure 3.3: Total Assets of US Prime Money Market Funds



Sources: SEC Form N-MFP2, OFR Analysis

the buck" as its NAV declined to less than $1.

US prime money market funds are of particular relevance as they provide short-term liquidity to both US and foreign financial institutions. Banks may issue certificates of deposits or commercial paper, or engage in repo transactions with these money market funds, providing them short-term dollar funding to be paid back and generally rolled over maturities of less than a year. Figure 3.3 displays the total assets of all US prime money market funds. These funds held a quantitatively large amount of short-term bank liabilities at approximately $1.8 trillion from 2011 to 2015. Focusing only on foreign counter-parties in Figure 3.4, observe that prime funds provided $1.1 trillion of dollar funding to foreign banks, which presumably was used to finance dollar-denominated loans or assets.

The October 2016 money market fund reform was adopted on July 23rd, 2014 to address the risk of investor runs on money market funds. The reform re-classified prime funds into institutional and retail prime funds, distinguished by the type of investor in the funds, and

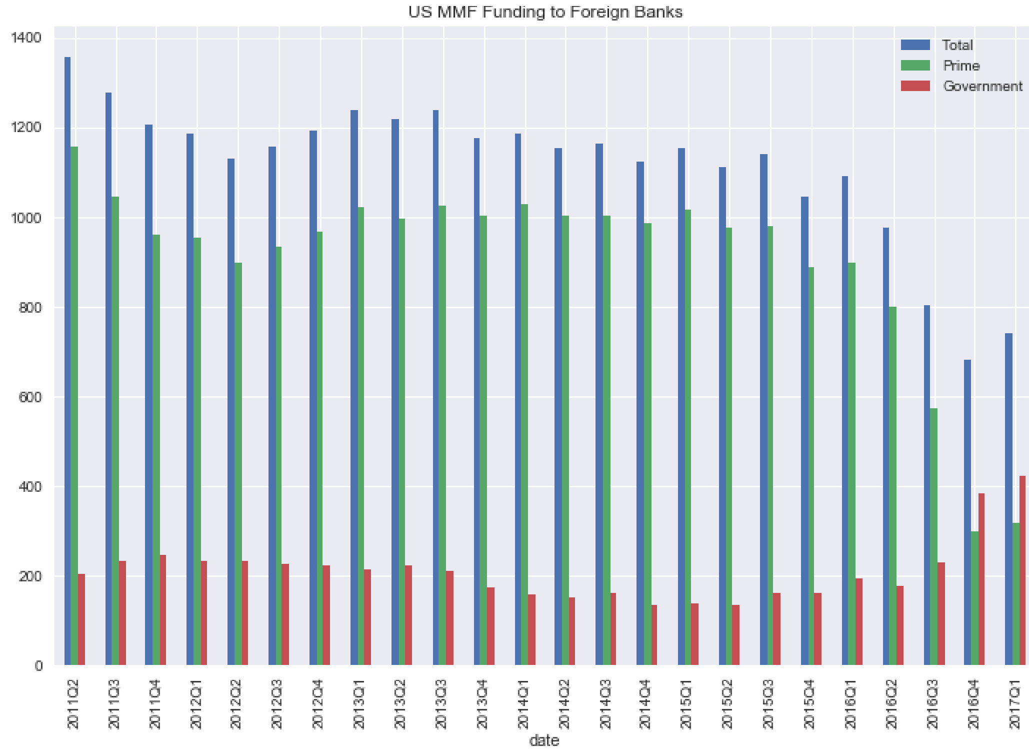


Figure 3.4: US Money Market Funding to Non-US Banks

Notes: Data come from Money Market Fund Monitor from the US Office of Financial Research.

enacted rules on the institutional prime funds in order to provide safeguarding measures in the case of a future run. In particular, institutional prime funds were required to have a daily floating NAV based on the current market value of their portfolio as opposed to the stable $1 NAV typical in money market funds prior in order to allow share prices to more accurately track the market values and dis-incentivize investors from withdrawing their money during bad times.

The reform also introduced new rules on liquidity fees and redemption gates to further discourage and prevent runs. The liquidity fees impose a fee of up to two percent on all redemptions if a money market fund's level of "weekly liquid assets" falls below 30% of total assets, and a minimum fee of one percent if weekly liquid assets fall below 10% of total assets.[6] This rule in effect allows fund managers to impose a discretionary fee during particularly bad times to dis-incentivize investors from withdrawing funds. In the case that this fails, fund managers can also impose a gate on redemptions, preventing investors from withdrawing funds for up to 10 business days if the fund's level of weekly liquid assets falls below 30%.

All in all, the reform reduced the general safety and attractiveness of institutional prime funds by potentially removing liquidity benefits during bad times. Investors responded by withdrawing an enormous amount of funds, with outflows starting in late 2015. As shown in Figure 3.3, total assets of prime funds dropped from $1.8 trillion to $700 billion by October 2016, when the reform was officially enacted. Foreign banks in particular lost approximately $500 billion in funding, which was not offset by the corresponding increase in funding of about $200 billion from government funds as displayed in Figure 3.4.

I thus use this gradual, yet precipitous drop in funding from institutional prime funds as the shock to the dollar funding of foreign banks. The decline appears quantitatively large at first glance as banks lost over 50% of their prior funding in aggregate. I provide a rough measure of how relevant this shock was for foreign banks in relation to the size of their balance sheets, but first introduce the data.

3.4 Data

The dataset comes from a few sources: the Office of Financial Research's Money Market Fund Monitor, Thomson Reuters Dealscan, Orbis BankFocus, and Datastream.

The main source of heterogeneity stems from foreign banks' exposures or prior reliance

[6] "Weekly liquid assets" refer to cash or government securities with remaining maturities of less than 60 days and securities that may be liquidated into cash within a week.

on US money market funds. The Office of Financial Research (OFR) provides the U.S. Money Market Fund Monitor which tracks the investment portfolios of all U.S. money market funds, disaggregated into specific fund, fund type, borrower, and type of instrument at the monthly frequency from January 2011. For each bank, I observe the type of instrument that each specific type of fund holds, e.g. the amount of commercial paper or certificates of deposits issued by Deutsche Bank held by all prime funds. I aggregate these instruments by summing at the bank level to obtain the bank-specific level of money market funding, split into prime and government funds.

The data from the OFR lists banks at the bank-holding company level, so I match this data with quarterly and annual bank-holding company level balance sheet data from Orbis BankFocus. I assume that balance sheet variables are constant in a given quarter and construct scaled money market fund exposures by dividing the level of money market funding from the OFR data by the total amount of short-term liabilities of a given bank.

Given the ultimate interest in effects on bank lending, I merge the bank money market fund exposures and balance sheet variables with the syndicated loan data from Thomson Reuters Dealscan. Dealscan provides origination data on international syndicated loans, namely those with multiple lenders, and one can observe the total loan amount, borrower, currency denomination, and in some cases the spread charged over LIBOR. One issue is that many of the loan observations do not include the share that each lender contributed, so I extend the sample following Chodorow-Reich's (2014) imputation method[7] in order to more accurately ascribe the amount of credit extended by each lender in a syndicate.

[7] I assume that syndicates with similar structures have similar compositions of loan amounts. For example if I observe that syndicates with 1 lead arranger and 1 participants split the loan amount by 60% and 40%, I assume that all syndicates of with this structure have the same composition. In general, I take the shares to be the mean loan amount share for either the lead arrangers or participants over all loans of the same syndicate structure. My results remain robust to utilizing the original, non-imputed data.

Furthermore, I attribute loans at the bank-holding company level, e.g. loans extended by subsidiaries of HSBC in other countries will still be attributed to HSBC.

Lastly, I obtain data on dollar bond issuance at the bank-holding company level from Datastream. For each bank-holding company I aggregate the amount of dollar bond issuance at the quarterly level to obtain the time-varying bank-specific level of dollar funding from bond markets.

My dataset manifests into two forms. First, I have a quarterly panel of banks with the aggregate amount and fraction of dollar-denominated loans matched with their scaled money market fund exposure. Second, I have a cross-section of bank-firms where I observe the last loan extended before my shock period, which I describe in the following section, and the first loan extended after, matched with the change in the bank's money market fund exposure over the same time period.

Summary Statistics

Table 3.1 provides preliminary summary statistics for the dataset. The quarterly average of total US money market funding is about \$15 billion per bank, going as high as \$145 billion. As described previously, most of this comes from prime money market funds, who provide \$12.7 billion on average to each bank, with government funds providing the remaining \$3 billion.

Taking into account now the size of the bank, I scale the money market fund exposures by the liabilities and short-term deposits of each bank to get a better sense of the relative exposures of each bank. On average, US money market funding accounts for 3.9% of liabilities, but note that this number understates the relevance as I am only interested in dollar-denominated liabilities, whereas the denominator includes all currency liabilities. As expected, the bulk of this fraction comes from prime funds at 3.5% of liabilities.

Looking at quarterly changes in funding, I observe a mean drop of $297 million per quarter overall, with a $443 million quarterly decline in prime funding. This is skewed towards zero by the more numerous quarters in which money market funding barely changed and thus seems small relative to the total amount of funding for each bank. However if we take the mean over the reform period from November 2015 to October 2016, I obtain a mean quarterly drop of $1.3 billion in funding. A more precise measure of the drop in money market funding will come shortly.

Summarizing the loan data, I observe an average loan size from a given bank of $62.6 million with a spread of 232 basis points over LIBOR and maturity of 56 months. The average dollar loan size is a bit larger at $77.8 million per loan, but with similar spread and maturity of 231 basis points and 55 months, respectively. Lastly, looking at the number of loan originations, I see that on average each bank extends 121 loans, with 56, or 45%, of those loans being dollar-denominated. Note the heterogeneity however as the standard deviation in loan amount and number are both quite large, suggesting that some banks are much larger and extend many loans relative to the average bank in the sample.

I now examine the cross-section directly around the shock period, namely the difference between the quarter before November 2015 and quarter after October 2016, in Table 3.2. The average bank lost $8.3 billion in dollar funding from US prime funds, which after accounting for an increase in funds from government funds, netted to a mean loss of $5.2 billion in funding. It is important to note however that some banks actually increased their dollar funding during this period, as I observe a maximum increase of $35.8 billion in money market funding over the period, attributed to BNP Paribas, or Deutsche Bank, which saw an increase of $20 billion. These banks are examples in which government funding

Table 3.1: Quarterly Summary Statistics

	N	Mean	SD	Min	Max	Median
Total MMF	5079	15.768	21.505	0.000	145.229	4.144
Prime MMF	5079	12.758	16.628	0.000	88.725	3.660
Gov MMF	5079	3.009	7.768	0.000	93.567	0.000
Total MMF Scaled	5079	0.039	0.049	0.000	0.377	0.020
Prime MMF Scaled	5079	0.034	0.045	0.000	0.377	0.017
Gov MMF Scaled	5079	0.005	0.012	0.000	0.215	0.000
$\Delta Total$	1719	-0.297	3.884	-43.021	23.717	0.000
$\Delta Prime$	1719	-0.443	3.391	-32.172	12.584	0.000
ΔGov	1719	0.146	1.822	-18.578	24.593	0.000
Loan Amount	218658	62.586	132.601	0.000	12500.000	31.553
Spread	104819	232.660	153.940	1.000	4645.000	195.000
Maturity	214924	56.666	40.528	0.000	725.000	60.000
Dollar Loan	95887	77.846	150.359	0.000	12500.000	41.577
Dollar Spread	70334	231.460	148.857	1.000	1450.000	187.500
Dollar Maturity	94195	54.989	30.754	0.000	721.000	60.000
Quarterly No. Loans	1799	121.549	170.632	1.000	1722.000	56.000
Quarterly No. $ Loans	1716	55.879	75.075	1.000	434.000	20.000
Fraction $ Loans	1716	0.450	0.253	0.018	1.000	0.413

increased substantially during this period, which either counteracted and even superceded the previous reliance on prime funding.

The average decline in US money market funding to liabilities is 1.5%, which is a little less than half the pre-reform average of 3.9%, while the ratio of prime funding to liabilities dropped by 2.1%. Government funding increased by .6% on average, which was not enough to cover the decline in funding for most banks, bar a few exceptions that were previously mentioned. Lastly, contrary to our priors, there was average loan *growth* rather than decline in the quarter before and after the period as the median is 5.4%.

3.5 Identification

As with most of the empirical bank lending literature, I focus on the effect of credit supply rather than credit demand shocks. In order to argue for causality, I require a plausibly

Table 3.2: Cross-Sectional Summary Statistics

	N	Mean	SD	Min	Max	Median
ΔMMF	72	-5.203	11.298	-46.045	35.853	-1.616
$\Delta Prime$	72	-8.317	11.873	-52.282	2.766	-1.650
ΔGov	72	3.113	7.545	-0.165	39.308	0.000
$\Delta MMFScaled$	72	-0.015	0.036	-0.123	0.188	-0.008
$\Delta PrimeScaled$	72	-0.021	0.028	-0.123	0.018	-0.013
$\Delta GovScaled$	72	0.006	0.023	-0.000	0.186	0.000
MMF/Liabilities	73	0.035	0.041	0.000	0.176	0.023
$\Delta Loans$	67	0.944	5.848	-1.000	47.375	0.054

exogenous shock to banks that leads to a decrease in their dollar funding that did not simultaneously cause them to contract their supply of loans for other reasons, such as current business cycle conditions or sentiment, and/or affect their borrowers' demand for loans.

I approach this by exploiting the heterogeneity across banks in exposure to US money market funds. Under the assumption that the reform was exogenous to the lending period in question in the sense that it was not motivated by contemporaneous events, a plausible notion given that it was agreed upon well in advance in 2014, examining the differences across banks contingent on their relative reliances on dollar funding from US prime funds provides a more convincing estimate of what I call the "US dollar funding channel." The general idea is that examining the cross-section of bank lending should shed light upon how international bank lending is affected by dry-ups in dollar liquidity.

I employ two approaches to identification. The first comprises of cross-sectional regressions that exploit the heterogeneity of banks' exposures to money market funds by utilizing a Bartik instrument, namely I construct an instrument using the exogenous variation in pre-reform exposure to money market funds that isolates the decline in money market dollar funding due solely to the reform itself. I use this instrument as my treatment variable and examine its effects at both the cross-sectional and time series dimensions on international bank lending around the US money market fund reform and the period from 2011 to 2017.

The second approach should be familiar to consumers of the empirical bank liquidity literature as I employ the Khwaja and Mian (2008) within firm estimator. This identification strategy is built upon the availability of bank-firm matched loan level data where one can observe borrowers who have multiple bank lenders. The idea is that with bank-firm pairs, one can control for firm-borrower fixed effects in order to control for credit demand, and effectively estimate the change in loans extended to a given firm contingent on their lenders' exposures to the shock. This exercise more clearly isolates the effects of credit supply on firm-specific lending, but the first approach serves to elucidate how the reform affected the composition of lending with regards to currency choice.

Cross-sectional Regressions with Bartik Instrument

The Bartik instrument is constructed under the assumption that the cross-sectional heterogeneity in banks' reliance on US money market funds is uncorrelated to both the reform and any other phenomena that may affect bank lending during the period in question. As is required by any instrumental variables approach, I require a strong first stage, namely that banks have heterogeneous exposures to US money market funds and thus to the reform itself contingent on their pre-exposure, banks' pre-reform exposures significantly correlate with their relative losses in prime funding, and the exclusion restriction must be satisfied. The exclusion restriction requires that the money market reform does not affect international bank lending aside from its effect on banks' dollar funding from US prime funds.

I construct my instrument as follows. I compute each bank's scaled money market fund exposure, ϕ_b, as the average fraction of total US money market funding to total deposits and short-term liabilities in 2015 between January and September. I exclude the latter months of the year as the treatment period begins in October 2015. Note that this will understate bank exposure to money market funds as the denominator contains liabilities denominated in all currencies, whereas I am interested in the fraction relative to dollar-denominated liabilities. Specifically:

$$\phi_b = \frac{MMF_{b,2015}}{Deposits_{b,2015}} \tag{3.1}$$

For the first stage, I regress each bank's change in money market funding, ΔMMF_b, between October 2015 to October 2016 on ϕ_b. Note that I do not multiply by the aggregate change in money market funding as it would be equivalent to multiplying the exposure by a constant, given that there is only cross-sectional heterogeneity in the pre-reform shares, not the aggregate shock. All this changes is the sign of coefficient as the interpretation has changed, but results are consistent in either specification.

$$\Delta MMF_b = \gamma \phi_b + \nu_b \tag{3.2}$$

For the second stage, I regress the percentage change in dollar-denominated loans extended by bank b, $\%\Delta L_b$, or other dependent variables of interest such as loans in all currencies, fraction of dollar-denominated loans, and other forms of dollar funding, in the quarter before and after the shock period, which I define as November 2015 to October 2016, on the fitted first stage, $\Delta M\hat{M}F_b$:

$$\%\Delta L_b = \beta \Delta M\hat{M}F_b + \epsilon_b \tag{3.3}$$

If the first stage is strong, namely the heterogeneity of each bank's change in money market funding is correlated with their pre-reform exposures, and we assume that the money market fund reform only affected bank lending through the change in each bank's supply of dollars from money market funds, β identifies the relevance of the "US dollar funding channel," or the effect of changes in dollar funding from US money market funds on international dollar bank lending.

The intuition behind the Bartik instrument is that in the first stage I am isolating variation in the change in money market funding for a given bank due to their exogenous exposure before the shock occurred. We are fixing the size of the treatment of the decline in money market funding for a given bank due to the reform and examining how much of the measured decline is predicted by its pre-reform exposure. Given that I am utilizing the fitted value of the change in a bank's money market funding in the second stage, I am effectively examining the effect of the change of money market funding on bank lending due solely to exposure to the aggregate shock, or treatment. If we believe the exclusion restriction, then I have identified an instrument that allows us to identify the causal relationship between a bank's US money market dollar funding and its syndicated lending.

Time Series Regressions with Bartik Instrument

The previous exercise by construction is limited by the number of banks in the sample and estimates thus may be subject to low power. I maneuver around this by exploiting the time dimension of my panel, looking instead at quarterly changes in both money market funding and lending across my entire sample from 2011-2017.

Similar to the cross-sectional regressions, I rely on the exogeneity of each bank's scaled exposure to dollar funding from US money market funds. The difference is that I construct the Bartik instrument by multiplying this exogenous share, ϕ_b, taken as the mean of scaled money market funding from 2011 to 2015, with the aggregate quarterly change in money market funding, ΔMMF_t. Formally the first stage is now:

$$\Delta MMF_{b,t} = \alpha_b + \gamma\phi_b \times \Delta MMF_t + \nu_{b,t} \tag{3.4}$$

where I have now included bank fixed effects, α_b, and my instrument now includes the aggregate change in money market funding. The Bartik instrument works to isolate the change in bank-specific money market funding attributed to the aggregate decline holding fixed the exposure.

The second stage is now:

$$\Delta L_{b,t} = \alpha_b + \beta \Delta M\hat{M}F_{b,t-1} + \epsilon_{b,t} \tag{3.5}$$

The coefficient β then measures the effect of a quarterly decline in money market funding on quarterly loan growth in the following quarter, controlling for unobservable bank characteristics via the bank fixed effects. The time series dimension in effect utilizes information both from periods in which money market funding did not change by much and treatment periods in order to estimate whether loan growth was statistically different in the latter. Finding a significant β would then suggest that loan growth is affected by changes in dollar money market funding.

However, it could also be the case that there are other shocks occurring in quarters where money market funding is falling that are unrelated to US money markets funds specifically, such as a decline in sentiments. In this case we may mistakenly attribute the effect of the sentiments on lending growth to money market funds when we in fact just have an omitted variables problem.

One specification that may alleviate this potential issue introduces time fixed effects into the first and second stages:

$$\Delta MMF_{b,t} = \alpha_b + \alpha_t + \gamma\phi_b \times \Delta MMF_t + \nu_{b,t} \tag{3.6}$$

$$\Delta L_{b,t} = \alpha_b + \alpha_t + \beta\Delta M\hat{M}F_{b,t-1} + \epsilon_{b,t} \tag{3.7}$$

We now control for unobservable shocks that occur in quarter t, thus isolating shocks to money market funding. However note that we potentially could have a collinearity issue in the sense that because the money market fund reform was an aggregate shock from 2015 Q4 to 2016 Q3, any variation induced by the reform could be absorbed or dampened by the time fixed effects. Formally this is not an issue because the Bartik instrument is bank-quarter specific, but because the bank-specific part of the instrument is unchanging over time, the only source of variation is the aggregate change in money market funding, which could remove some statistical significance by “splitting” the effect between the fixed effects and coefficient of interest.

In addition to the inclusion of time fixed effects, for robustness I also construct the Bartik instrument and the first stage using changes in *prime* money market funding rather than total US money market funding. Because prime funds were specifically affected by the reform, these specifications should more cleanly identify the effect of the reform, as well as capture any potential relationship between foreign bank lending and dollar money market funding. Furthermore in these specifications I can control for alternate sources of dollar funding such as US government money market funds and dollar bond issuance without concern for collinearity due to the decomposition of money market funding, allowing for a more careful treatment of omitted variable bias.

Within-Firm Estimator

The within-firm estimator looks to control for credit demand shocks and isolate the effect of credit supply shocks on bank lending. It accomplishes this by controlling for borrower fixed effects, which removes the average in loan demand for a given borrower across all lenders. The remaining regressor is then the lender exposure to the shock, which yields the within-firm estimator, or the effect of the shock on the outcome variable in question contingent on a lender's exposure to the shock.

I examine the following specification:

$$\Delta L_{b,f} = \alpha_f + \beta \Delta MMF_b + \epsilon_{b,f} \tag{3.8}$$

where $\Delta L_{b,f}$ is the change in loans extended by bank b to firm f, α_f is a firm fixed effect, and ΔMMF_b is the lender's change in money market funding. Differences are taken as the first loan extended by bank b to firm f after October 2016 and the last loan extended before November 2015.

The main identifying assumption is that firms demand the same types of loans from all banks, namely there are not bank-firm specific interactions that would otherwise not be captured in the regression. If this were the case, we may still have an unobserved variable in the residual that could be correlated with the change in lender money market funding that would confound our estimates.

I also explore a specification that looks at bank-industry pairs, similar to Correa, Sapriza, and Zlate (2012), in order to exploit a larger portion of my loan data. I apply this approach because it may be unlikely that a firm will have obtained a new loan after October 2016 if it obtained one between 2012-2016 given the average loan maturity of 5 years. Without a pre- and post bank-firm loan observation, I cannot employ the within-firm estimator, which significantly reduces my sample. However under the assumption that firms in the same industry demand the same types of loans across banks and their loan demand responds homogeneously to shocks, examining the difference between loans extended by a bank to an industry before and after the shock may also identify the effect of a decline in money market funding on bank lending.

Specifically I take the difference between the mean of loans extended by bank b to a given industry s before and after the shock, $\Delta L_{b,s}$, and again regress it on the bank-specific change in money market funding, controlling now for industry fixed effects, α_s. Formally:

$$\Delta L_{b,s} = \alpha_s + \beta \Delta MMF_b + \epsilon_{b,s} \tag{3.9}$$

The coefficient β thus informs the change in total loans extended to a given sector contingent on a bank-lender's change in money market funding.

I have presented a variety of specifications that I employ to explore the relevance of US money market funding for foreign bank lending. I approach the problem in a number of ways using a Bartik instrument and the within-firm estimator in order to thoroughly examine this relationship. I proceed now to discuss the results.

3.6 Results

This section presents the empirical results from the specifications described in the previous section. The results are split into the cross-sectional and time-series Bartik regressions, and within-firm and industry estimates.

Table 3.3: Cross-Sectional Bartik Instrument

	$\Delta MMFPrime_b$	ΔL_b	$\Delta MMFGov_b$	$\Delta BondIssuance_b$
	First Stage	Second Stage		
	(1)	(2)	(3)	(4)
$\frac{MMF_b}{Deposits_b}$	-0.656^{***}			
	(0.022)			
$\Delta MMFPrime_b$		0.877	3.346	-8.090
		(2.737)	(3.500)	(51.775)
Constant	0.001	0.132	0.000	-3.610
	(0.001)	(2.633)	(3.376)	(49.945)
Observations	72	67	72	72
R^2	0.930	0.002	0.013	0.0003
F Statistic	924.759^{***}	0.103	0.914	0.024

$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Notes: In column (1), the dependent variable is the change in average prime money market funding for bank b between in the quarter before November 2015 and quarter after October 2015, while the instrument is the average fraction of money market funding to short-term liabilities and deposits for bank b in the first 9 months of 2015. Columns (2)-(4) show the second stage estimates of change in the sum of dollar-denominated loans, average government funding, and sum of dollar-denominated bond issuance in the quarters before and after November 2015 - October 2016 on the instrumented change in prime money market funding.

Cross-Section Bartik

The first set of results pertains to the cross-sectional regressions with the Bartik instrument as discussed in Section 3.5. In column (1) of Table 3.3, I obtain a strong first stage, namely the bank's pre-reform ratio of money market funding to total deposits and short-term liabilities strongly predicts its loss in prime funding. My estimates indicate that a 10% larger ratio indicates a decline of $65.6 million in funding from prime money market funds with an F-statistic well above the rule-of-thumb threshold of 10. Intuitively this suggests that banks with larger reliance on dollar funding from US money market funds as a percentage of short-term liabilities experienced larger drops in the level of dollar funding due to the reform.

For the second stage, I regress the percentage change in loans in the quarter before and after the shock period on the fitted value of the change in prime funding from the first stage. Results are displayed in column (2), which do not yield a significant effect from the loss in prime funding on loans. I find that despite the large decline in dollar funding to foreign banks, they did not reduce their dollar lending, contrary to what one would expect if dollar funding from US money market funds mattered.

The lack of a statistically significant effect on lending leads to the question of what may have prevented the transmission of decreased dollar funding to dollar lending. One potential avenue, outlined by the BIS (2017), is that foreign banks may have accessed other sources of dollar funding to substitute for the decline in funding from US money market funds. For example, according to the BIS (2017), Canadian banks increased their dollar bond issuance, while Japanese banks saw an increase in offshore dollar deposits. If banks could easily substitute for dollar funding from these alternate sources, it becomes easier to reconcile the lack of an effect on dollar lending.

To test for this effect, I utilize the same first stage and change my outcome variable to observable potential sources of alternate dollar funding, namely US government money market funds and dollar bond issuance. The former reflects the fact that some of the dollars that left prime funds flowed into government funds, some of which engaged in repo transactions with foreign banks, providing one source of substitute short-term dollar funding. The latter draws upon the anecdotal evidence about Canadian banks, which could have also occurred at other foreign banks.

Columns (3) and (4) display the second stage of the regressions with the change in government fund funding and bond issuance in the quarter prior and following the shock period. I again obtain no significant estimates, suggesting that either there was not a uniform response to the reform, unobservable sources of dollar funding such as offshore deposits were more important for supporting lending, or another unobservable factor supported bank lending.

The previous results on loan growth only pertained to the total amount of dollar-denominated credit extended by foreign banks. I also look at how the reform may have impacted the composition of bank lending with regards to the fraction of dollar-denominated loans to all loans. Table 3.4 displays the second stage results from these analogue regressions, examining the potential effects on total loan growth and fraction of dollar-denominated loans in both number of loans and loan amounts.

As before, I do not obtain significant estimates of an effect of a decline in dollar funding from prime funds on loan growth or composition. Column (2) examines the effect on loans denominated in all currencies, including the dollar, finding a negative albeit insignificant coefficient. One could interpret this as an increase in loan supply in other currencies which may be larger than the contraction in dollar-denominated loans, thus expanding the total loan supply, but the coefficient is insignificant. Columns (4) and (5) display estimates of the effects on the change in number of dollar-denominated and total loans, finding positive coefficients that are in line with priors, but highly insignificant. Columns (3) and (6) display the effects on the change in fraction of dollar-denominated loans to all loans in both amount and number, which again yields insignificant estimates.

Time Series Bartik

Given that the cross-sectional sample has only 72 observations at most, namely the number of banks with finite loan growth, the lack of significant estimates could be attributed to low power. One way to get around this is to exploit the time series dimension of the data and

Table 3.4: Cross-Sectional Regressions on Lending Composition

	$\%\Delta Loans_{\$}$	$\%\Delta Loans_{all}$	$\Delta \frac{DollarLoans}{Loans}$	$\Delta \# Loans_{\$}$	$\Delta \# Loans_{all}$	$\Delta \frac{\# Loans_{\$}}{\# Loans_{all}}$
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta MMFPrime_b$	0.877	−0.606	0.202	4.815	1.854	0.149
	(2.737)	(0.403)	(0.132)	(8.280)	(20.973)	(0.115)
Constant	0.132	0.687*	−0.209	0.200	7.400	−0.174
	(2.633)	(0.389)	(0.127)	(7.987)	(20.232)	(0.110)
Observations	67	72	72	72	72	72
R^2	0.002	0.031	0.033	0.005	0.0001	0.024

*p<0.1; **p<0.05; ***p<0.01

Notes: This table displays the second stage regressions of the percentage change in dollar-denominated loans, all currency denominated, change in fraction of amount of dollar-denominated loans to all loans, change in number of dollar-denominated loans, change in total number of loans, and change in fraction of number of loans where the changes are taken as the percentage changes or differences of the sum of loans in the quarter before and after the treatment period.

instead look at quarterly changes in lending. Because the drop in money market funding occurred over the course of a year rather than sharply in one instance, one could argue that looking for persistent quarterly changes during the shock period provides a better estimate of any effects.

I alter the previous regression by adding the time dimension, namely in the first stage I regress the quarterly change in prime money market funding to bank b on its pre-shock ratio of money market funding times the aggregate change in money market funding in the same quarter. The second stage then regresses the quarterly change in lending for bank b on the lagged fitted value of the change in funding from prime money market funds from the first stage.

The first stage results are displayed in Table 3.5. By exploiting the time dimension, I drastically increase the sample size. By including more time periods, including quarters that were not the shock period, I can better estimate whether the changes in lending differed from normal periods, contingent on the actual changes in money market funding during

Table 3.5: First Stage of Time Series Bartik Instrument

	No Euro Crisis				All			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\phi_b \times \Delta MMF_t$	0.260***	0.229***			0.245***	0.206***		
	(0.036)	(0.037)			(0.041)	(0.041)		
$\phi_b \times \Delta MMFPrime_t$			0.076**	0.047			0.068**	0.037
			(0.030)	(0.032)			(0.027)	(0.028)
$\Delta MMFGov_{b,t+1}$			−0.329**	−0.230*			−0.226**	−0.139
			(0.134)	(0.118)			(0.108)	(0.092)
$\Delta Bond_{b,t+1}$			−0.073*	−0.052			−0.069*	−0.047
			(0.042)	(0.049)			(0.041)	(0.049)
Time FE	No	Yes	No	Yes	No	Yes	No	Yes
Observations	1,428	1,428	1,428	1,428	1,722	1,722	1,722	1,722
R^2	0.087	0.044	0.060	0.024	0.060	0.027	0.029	0.009
F Statistic	128.753***	61.262***	28.463***	10.616***	104.300***	45.160***	16.512***	4.720***

*p<0.1; **p<0.05; ***p<0.01

Notes: The dependent variable in all columns is the quarterly change in prime money market funding for bank b. The first four columns reflect the sample from January 2011 Q1 - 2017 Q1, excluding May 2011 - June 2012, while columns (5)-(8) contain the entire sample. Columns (3), (4), (7), (8) control for next quarter's change in government money market funding and bond issuance as the dependent variables in the second stage will be in the quarter ahead, e.g. regressions are on previous quarter change in money market funding. Standard errors are clustered at the bank level.

each period. I estimate on two samples, one excluding the Euro crisis between May 2011 - June 2012, and one including it, with the goal of observing whether including an additional treatment period provides similar and robust results. In the baseline first stage regressions with no controls, I observe a significant and strong first stage in both samples, robust to the inclusion of time fixed effects as displayed in columns (1), (2), (6), and (7).

Controlling now for contemporaneous sources of substitute funding, namely the change in funding from government funds and bond issuances in the current quarter, I again find a significant first stage as indicated in columns (3) and (7). Furthermore I observe the significance of government and bond funding, suggesting a negative correlation between substitute sources of funding and prime funding. Intuitively, an increase in government or bond funding is associated with a decline in prime funding in the previous quarter,

Table 3.6: Quarterly Change in Lending in Dollars

	No Euro Crisis				All			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Delta MMF_{b,t-1}$	0.101***	−0.116			0.125***	−0.143		
	(0.035)	(0.125)			(0.048)	(0.132)		
$\Delta MMFPrime_{b,t-1}$			−0.048	0.690			−0.135	0.636
			(0.089)	(0.512)			(0.132)	(0.663)
$\Delta MMFGov_{b,t}$			−0.021	0.178			−0.050	0.092
			(0.035)	(0.142)			(0.047)	(0.112)
$\Delta Bond_{b,t}$			−0.012	0.042			−0.017	0.039
			(0.012)	(0.037)			(0.017)	(0.040)
Time FE	No	Yes	No	Yes	No	Yes	No	Yes
Observations	1,428	1,428	1,428	1,428	1,722	1,722	1,722	1,722
R^2	0.0001	0.00001	0.0001	0.00000	0.0002	0.0001	0.0002	0.0001

*p<0.1; **p<0.05; ***p<0.01

Notes: The dependent variable in all columns is the quarterly change in dollar-denominated loans for bank *b* regressed on the instrumented previous quarter change in total money market funding in columns (1), (2), (5), (6), and only prime money market funding in columns (3), (4), (7), (8). The first four columns reflect the sample from January 2011 Q1 - 2017 Q1, excluding May 2011 - June 2012, while columns (5)-(8) contain the entire sample. Standard errors are clustered at the bank level.

suggestive of substitution effects. Note however that this is merely correlational and will be explicitly examined shortly. Furthermore in the full specification with time fixed effects and controls in columns (4) and (8), I lose significance of the Bartik instrument. This however could be due to collinearity as was described in Section 3.5.

Moving now to the second stage, I first examine the quarterly change in dollar-denominated lending in Table 3.6. In the baseline regressions with no controls or time fixed effects, I obtain a positive and significant effect of money market funding on dollar loan growth, namely a \$100 million decline in money market funding in the previous quarter lead to a 1% reduction in dollar-denominated loans in the current quarter. The magnitude slightly increases to 1.25% when including the Eurozone crisis as displayed in column (5).

Note however that this estimate is not robust to including time fixed effects or controls.

In the purest interpretation, the time fixed effects remove any common time series variation, attributed to common global shocks or conditions in a given quarter. It is important to keep in mind that the money market fund reform could be considered an aggregate shock in the sense that all banks lost funding for the same reason, so the fixed effects may actually be slightly collinear with the change in funding, absorbing some of the statistical significance.

On the other hand, the fact that the effects dissipate upon inclusion of other substitute sources of dollar funding as displayed in columns (3) and (7) provides further evidence against a significant effect of the reform on lending. By controlling for dollar funding from government funds and increased dollar bond issuance, the specification isolates the effect of a loss of dollar funding specifically from prime money market funds, whereas the prior specifications may have been subject to omitted variables bias. Given that including time fixed effects and/or alternate sources of dollar funding eliminates the statistical significance of the effect of dollar money market funding on loan growth, this suggests that substitute sources of dollar funding temper the effects of declines in money market funding.

Expanding our dependent variable now to lending in all currencies, I search for a differential effect contingent on currency denomination. Table 3.7 displays the second stage regressions of quarterly changes in loans of all currencies on changes in money market funding to examine whether a decline in dollar funding could have lead to contractions or expansions of lending in currencies not limited to the dollar. Surprisingly I find a significantly positive effect in the baseline regressions in columns (1) and (5), with a declines of 1.11% and 1.16% of all loans for a $100 million decline in money market funding for the sample excluding and including the Euro crisis, respectively. This is robust to the inclusion of time fixed effects as shown in columns (2) and (6), which shrinks the magnitude of the effect in half to .68% and .74% per $100 million decline, respectively.

Table 3.7: Quarterly Change in Lending in All Currencies

	No Euro Crisis				All			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Delta MMF_{b,t-1}$	0.111***	0.068*			0.116***	0.074**		
	(0.020)	(0.037)			(0.029)	(0.035)		
$\Delta MMFPrime_{b,t-1}$			0.126	0.473			0.145	0.604
			(0.153)	(0.452)			(0.218)	(0.838)
$\Delta MMFGov_{b,t}$			0.020	−0.023			−0.0004	−0.116
			(0.017)	(0.055)			(0.022)	(0.199)
$\Delta Bond_{b,t}$			0.012*	0.026			0.011*	0.026
			(0.006)	(0.023)			(0.006)	(0.034)
Time FE	No	Yes	No	Yes	No	Yes	No	Yes
Observations	1,428	1,428	1,428	1,428	1,722	1,722	1,722	1,722
R^2	0.001	0.0003	0.001	0.0001	0.001	0.001	0.001	0.0002

*p<0.1; **p<0.05; ***p<0.01

Notes: The dependent variable in all columns is the quarterly change in all loans for bank *b* regressed on the instrumented previous quarter change in total money market funding in columns (1), (2), (5), (6), and only prime money market funding in columns (3), (4), (7), (8). The first four columns reflect the sample from January 2011 Q1 - 2017 Q1, excluding May 2011 - June 2012, while columns (5)-(8) contain the entire sample. Standard errors are clustered at the bank level.

These results however are not robust to the inclusion of controls as indicated in columns (3), (4), (7), and (8), further supporting the notion that any effects on lending are mitigated by other dollar funding sources. The results here thus show that alternate sources of dollar funding can also insulate spillovers to lending in all currencies, not just dollars.

Next I examine the effect on the currency composition of each bank's loan portfolio by looking at the change in the fraction of the total amount and number of dollar-denominated loans to all loans for a given bank in each quarter. Tables 3.8 and 3.9 display my results, which suggest marginally significant negative relationships between money market funding and the currency composition banks' loan portfolios, although the magnitudes are quite small and not robust to the inclusion of controls. We obtain similar results with loan amounts and loan counts, namely an *increase* of .05% in dollar-denominated loans relative

Table 3.8: Quarterly Change in Fraction of Dollar-Denominated Loans

	No Euro Crisis				All			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Delta MMF_{b,t-1}$	-0.005^{**}	-0.015^{**}			-0.006	-0.019^{**}		
	(0.002)	(0.006)			(0.004)	(0.009)		
$\Delta MMFPrime_{b,t-1}$			-0.005	0.020			-0.005	0.033
			(0.005)	(0.016)			(0.012)	(0.031)
$\Delta MMFGov_{b,t}$			-0.003	0.003			-0.004	0.001
			(0.002)	(0.005)			(0.003)	(0.006)
$\Delta Bond_{b,t}$			-0.001	0.001			-0.001	0.001
			(0.001)	(0.002)			(0.002)	(0.002)
Time FE	No	Yes	No	Yes	No	Yes	No	Yes
Observations	1,428	1,428	1,428	1,428	1,722	1,722	1,722	1,722
R^2	0.00003	0.00000	0.0001	0.00002	0.0002	0.0001	0.0001	0.00000

*p<0.1; **p<0.05; ***p<0.01

Notes: The dependent variable in all columns is the quarterly change in the fraction of dollar-denominated loans in amount for bank b regressed on the instrumented previous quarter change in total money market funding in columns (1), (2), (5), (6), and only prime money market funding in columns (3), (4), (7), (8). The first four columns reflect the sample from January 2011 Q1 - 2017 Q1, excluding May 2011 - June 2012, while columns (5)-(8) contain the entire sample. Standard errors are clustered at the bank level.

to all loans in the baseline that increases to .15% upon inclusion of time fixed effects for a $100 million quarterly decline in money market funding.

Prior work by Ivashina, Scharfstein, and Stein (2015) shows that banks shift the currency composition away from dollar-denominated lending towards other currencies. The money market fund reform period may have been associated with an increase in fraction of dollar-denominated lending, contrary to the decline I would expect given that a decline in dollar funding should lead to a decline in lending in that same currency, as was observed in the Eurozone crisis. The results here thus mildly support Ivashina, Scharfstein, and Stein's (2015) findings as the positive effect is nullified by the negative effect observed in the Eurozone crisis period.

Lastly I examine whether lagged quarterly declines in prime money market funding lead to substitute increases in dollar funding from other sources. Table 3.10 shows that in

Table 3.9: Quarterly Change in Fraction of Number of Dollar-Denominated Loans

	No Euro Crisis				All			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Delta MMF_{b,t-1}$	−0.003	−0.016***			−0.003	−0.019**		
	(0.003)	(0.005)			(0.005)	(0.008)		
$\Delta MMFPrime_{b,t-1}$			0.002	0.028**			−0.001	0.026
			(0.004)	(0.014)			(0.008)	(0.023)
$\Delta MMFGov_{b,t}$			−0.0001	0.006			−0.001	0.002
			(0.002)	(0.006)			(0.002)	(0.005)
$\Delta Bond_{b,t}$			−0.002	0.001			−0.002	0.0004
			(0.002)	(0.002)			(0.002)	(0.002)
Time FE	No	Yes	No	Yes	No	Yes	No	Yes
Observations	1,428	1,428	1,428	1,428	1,722	1,722	1,722	1,722
R^2	0.00001	0.00005	0.00001	0.0005	0.0001	0.000	0.001	0.0002

*p<0.1; **p<0.05; ***p<0.01

Notes: The dependent variable in all columns is the quarterly change in the fraction of dollar-denominated loans by number of loans for bank b regressed on the instrumented previous quarter change in total money market funding in columns (1), (2), (5), (6), and only prime money market funding in columns (3), (4), (7), (8). The first four columns reflect the sample from January 2011 Q1 - 2017 Q1, excluding May 2011 - June 2012, while columns (5)-(8) contain the entire sample. Standard errors are clustered at the bank level.

the baseline regressions with no time fixed effects, a \$100 million decline in prime funding leads to a \$20.6 million increase in dollar funding from government money market funds in the following quarter, while dollar bond financing surprisingly decreases by \$11.6 million, with the magnitude of these effects increasing in the full sample with the Euro crisis. Note however that these effects are not robust to the inclusion of time fixed effects.

In contrast to the cross-sectional regressions, I do now find a significant effect of money market funding on foreign banks' dollar and total loan growth at the quarterly frequency in the baseline regressions with no controls or time fixed effects. The composition of banks' loan portfolios slightly change, tilting more towards dollar-denominated lending with declines in money market funding, contrary to conventional wisdom. However it is important to note that these effects largely dissipate upon the inclusion of time fixed effects, which control for contemporaneous aggregate shocks, and controls for other sources of dollar

Table 3.10: Quarterly Change in Government and Bond Funding

	No Euro Crisis				All			
	$\Delta MMFGov_{b,t}$		$\Delta Bond_{b,t}$		$\Delta MMFGov_{b,t}$		$\Delta Bond_{b,t}$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Delta MMF_{b,t-1}$	-0.206^{***}	-0.025	0.116^{**}	-0.001	-0.209^{***}	-0.028	0.121^{**}	0.0003
	(0.041)	(0.067)	(0.048)	(0.063)	(0.079)	(0.104)	(0.053)	(0.068)
Time FE	No	Yes	No	Yes	No	Yes	No	Yes
Observations	1,429	1,429	1,429	1,429	1,806	1,806	1,806	1,806
R^2	0.001	0.002	0.00002	0.001	0.002	0.013	0.00001	0.001

*p<0.1; **p<0.05; ***p<0.01

Notes: The dependent variables are the quarterly change in the sum of government fund funding in columns (1), (2), (5), (6) and quarterly change in the sum of dollar bond issuance in columns (3),(4), (7), (8). The first four columns reflect the sample from January 2011 Q1 - 2017 Q1, excluding May 2011 - June 2012, while columns (5)-(8) contain the entire sample. Standard errors are clustered at the bank level.

funding. Furthermore looking at the response of these alternate sources of dollar funding, I find significant responses of government funding and bond financing, albeit with the bond financing in the opposite direction as expected. As before, time fixed effects remove any statistical significance, leading one to question whether these responses are truly due to changes in money market funding or contemporaneous shocks perhaps unrelated to changes in funding.

Within Estimator

The final set of results pertains to the within-firm and within-sector specifications. As will be shown, I find mixed results of an effect on lending and expand my analysis to include the European sovereign debt crisis to compare to the money market fund reform. I do not find evidence of effects on loan quantity in the within-firm estimates, but do find a significant effect on loan spreads following the money market fund reform, suggestive of pricing rather than quantity changes. On the other hand the within-sector estimates suggest a significant effect on lending during the Eurozone crisis. The lack of robustly estimated effects leads me to underweight these findings and lean towards viewing money market funds as not causing significantly large contractions in lending, at least in the two episodes that I study.

Table 3.11 displays the results of the within-firm estimates for the Euro crisis sample that runs from 2009 to 2015, and the MMF sample that covers 2013 to 2017. Recall that each bank-firm observation takes the difference between the last loan extended before the shock period and the first loan extended after the shock for a given bank-firm pair, which I regress on the change in money market funding to bank b from the beginning to the end of the shock period. As shown in columns (1) and (3), I do not obtain a significant effect from the change in money market funding on lending. For a given firm, I cannot reject the null that the change in lending is the same across all lenders, regardless of their loss in money market funding. This stands in contrast to the findings of Ivashina, Scharfstein, and Stein (2015) as they find a decrease in the probability of a firm obtaining a dollar-denominated loan if it was previously reliant on credit from Eurozone banks. My findings show that in the case that a firm was able to obtain a dollar-denominated loan after either the Euro crisis or the money market reform, the change in the amount of the loan was negligible and insignificant.

Given that banks may also adjust lending through interest rates offered on loans, I examine whether the change in lender dollar funding affected the spread on dollar-denominated loans in columns (2) and (4). For the money market fund reform in column (4), I find that a $1 billion decline in funding increased spreads over LIBOR by 54.7 basis points. Intuitively this says that for a given firm, lenders that experienced larger declines in money market funding passed on higher dollar rates to borrowers. This is similar to the results found by Acharya, Afonso, and Kovner (2017) who find that foreign banks increased the interest rates on loans during the asset-backed commercial paper freeze of 2007. I surprisingly do

Table 3.11: Within Firm Estimator

	Euro Crisis		MMF Reform	
	$\Delta Loan$	$\Delta Spread$	$\Delta Loan$	$\Delta Spread$
	(1)	(2)	(3)	(4)
ΔMMF_b	-0.239	10.792	0.070	-54.731^{*}
	(0.311)	(21.405)	(0.289)	(29.642)
Observations	4,552	3,161	2,264	1,534
R^2	0.0002	0.0001	0.00002	0.002

*p<0.1; **p<0.05; ***p<0.01

Notes: The dependent variables are the change in the amount and spread over LIBOR of the last and first dollar-denominated loan extended from bank b to firm f before November 2015 and after October 2016. Standard errors are clustered at the bank level.

not find any effect for the Euro crisis despite the expectation of a larger pass-through due to both declines in money market funding and an increase in credit risk. One potential explanation is that banks simply stopped lending, while the banks that maintained credit insulated their borrowers from tighter financial conditions.

I next examine the within-sector estimates, namely for a given sector, the change in the total loans extended by its lenders, contingent on their change in money market funding. Table 3.12 displays the results. For the money market fund reform, I observe no significant change in lending to a given sector across lenders in column (3), while I estimate a significant effect from the Euro crisis in column (1). Looking now at spreads in columns (2) and (4), I observe no significant effect. My results from the within-sector estimates thus show that while there were no discernible effects on loan supply for both the amount and rate charged on loans following the October 2016 money market fund reform, there were some effects during the Euro crisis after applying sectoral aggregation.

The evidence here is thus mixed. For the within sector specifications, I find evidence of price effects and increased spreads from the US money market fund reform on syndicated

Table 3.12: Within Sector Estimator

	Euro Crisis		MMF Reform	
	$\Delta Loan$	$\Delta Spread$	$\Delta Loan$	$\Delta Spread$
	(1)	(2)	(3)	(4)
ΔMMF_b	0.830^{**}	-90.203	-0.375	26.303
	(0.408)	(68.208)	(0.425)	(64.364)
Observations	3,748	2,970	2,327	1,695
R^2	0.001	0.001	0.0003	0.0001

*p<0.1; **p<0.05; ***p<0.01

Notes: The dependent variables are the change in the average amount and spread over LIBOR over all loans extended by bank b to sector s between January 2012 - November 2015 and October 2016 - March 2017. Standard errors are clustered at the bank level.

dollar bank lending, but do not find quantity effects as there was no significant change in loan amounts. For the Euro crisis, the within firm results show no evidence of an effect at all. In contrast, looking within sector, I find evidence of an effect on loan amounts during the Euro crisis, but no effects on spreads, and no overall effect on the US money market fund reform. The lack of consistency across my results in this section makes it difficult to assert and conclusively state that US money market funds matter for international bank lending.

3.7 Discussion of Results

From the results in the previous sections, the evidence appears mixed but leans more heavily towards the lack of a significant effect of declines in US money market funding on dollar-denominated lending by foreign banks. Although I do obtain some significant estimates, namely in the time series estimates, these effects were not robust to the inclusion of time fixed effects and other sources of dollar funding. Furthermore given the lack of significance in the more carefully identified specifications, namely the within-firm and sector estimators, I lean my conclusion towards a lack of an effect.

To summarize, I obtained a strong first stage in both the cross-sectional and time-series regressions, finding that the fixed scaled exposure to money market funding correlated highly with the size of the decline in prime money market funding as banks with higher exposure observed larger declines following the aggregate drop in prime funding. Looking at the second stage effect on dollar-denominated loans however yielded mixed results that were mostly insignificant in the sense that nothing was detected in the cross-section, and in the time series, any significant effects disappeared upon controlling for other time-varying shocks via time fixed effects and other sources of contemporaneous dollar funding. I also tried controlling for lagged substitute dollar funding as one could argue that contemporaneous measures reflect contemporaneous shocks akin to time fixed effects, however my results remain robust, invariant to the timing of the control variables.

The lack of estimated effects on lending are supported by the within estimators. In the firm- and sector-specific specifications, I fail to find a significant effect of the change in money market funding on the loan supply extended to a given firm or sector for both the Eurozone crisis and the money market fund reform. I do find a marginally significant effect of the money market fund reform on the loan spreads extended to a given firm as they experience an increase in the interest rate on their post reform loans from banks that had larger declines in money market funding. This suggests that although there are not quantity effects from the reform, there may have been price effects as banks simply passed on higher dollar funding costs to their borrowers consistent with evidence found by Acharya et al. (2017) in their study on the ABCP freeze of 2007. Furthermore I find evidence of the decline in money market funding during the Eurozone crisis having a contractionary effect on lending, but given the lack of an effect in the within-firm estimates, I interpret this result with caution.

I obtain similar results for lending in all currencies, namely no significant effects after controlling for substitute sources of dollar funding. Without the controls, I do find a positive relationship between money market funding and lending in all currencies, namely a decline in money market funding leads to a quarterly decline of lending in all currencies that remains significant, although marginally, upon inclusion of time fixed effects in contrast to the results focusing solely on dollar-denominated loans. This is suggestive of the notion that the dollar is the funding currency relevant for lending in all currencies, not just the dollar, given that I find marginally significant effects for lending in all currencies as opposed to no effects when looking at only dollar-denominated lending.

This notion is extended when looking at the quarterly change in the fraction of dollar-denominated loans in response to a change in money market funding. The cross-sectional results again display a lack of an effect, both on the number and fraction of dollar-denominated loans relative to all loans, while I obtain significantly negative estimates for the effect of money market funding on the fraction of dollar-denominated loans. In other words the results without controls suggest that a decline in money market funding leads to an *increase* in the fraction of dollar-denominated, contrary to conventional wisdom. However given that this result is not robust to the inclusion of controls, the magnitude of the effect is quite small and arguably insignificant, and statistical significance appears haphazardly, I argue the evidence points towards another lack of an effect.

One explanation for the results is the existence of substitute dollar funding from other sources. Although I do not estimate a significant effect from an increase in government fund funding or bond issuance once controlling for time fixed effects, it could be the case that dollar funding substitution is widely heterogeneous across banks in the sense that a few may have issued bonds, some others may obtained repo dollar funding from the government funds, and perhaps others found offshore dollar deposits, as expressed by the BIS (2017). Thus because the responses are so heterogeneous across banks, it may be hard to detect systematic responses with respect to specific sources of dollar funding. Furthermore it could be the case that there are time-varying unobserved characteristics of banks not captured by the bank and time fixed effects that contribute to their resilience to funding shocks.

Another possible explanation stems from relationship based banking. It could be the case that although banks saw a decline in dollar funding, they do not cut back on lending to firms with which they have previously established relationships, choosing instead to either pass on the higher costs or absorb the costs themselves. In this sense, bank-firm relationships may serve as insurance mechanisms, with banks absorbing costs when negative funding shocks hit, and profiting when dollar funding costs decrease, maintaining a constant loan supply to their borrowers in either case.

This is somewhat supported if we combine the results of Ivashina, Scharfstein, and Stein (2015) with those found in this paper. They find that firms face a lower probability of obtaining a dollar-denominated loan contingent on having a Eurozone bank in their last loan syndicate. Thus while they examine the extensive margin, this paper looks at the intensive margin, namely what happens to loan terms if they are extended again. One interpretation of my lack of significant effects is that banks choose to continue lending only to firms with which they have established relationships, and thus choose to insulate the loan terms from funding shocks to preserve the relationship. On the other hand, for firms with which they do not have such a long-standing relationship, banks may choose to either increase the spreads, decrease loan amounts, or just not lend altogether. If we assume that the majority of loans extended were to firms with good relationships with their borrowers, then this notion of loan term insulation to preserve relationships may help justify some of the results.

3.8 Conclusion

This paper has examined the effects of the US money market fund reform of October 2016 in search of effects on international bank lending in both currency denomination and composition. The results were somewhat inconclusive and skew more heavily towards the lack of a significant effect. I find that despite the large drop in dollar funding from US money markets from November 2015 to October 2016, foreign banks did not significantly cut back on their dollar-denominated loans, nor fraction of dollar-denominated loans relative to other currency denominated loans once controlling for time fixed effects and substitute sources of alternate dollar funding.

Furthermore, although increased dollar funding from government money market funds provided substitute funding, it was not sufficient enough to offset the loss in funding from prime funds and cannot be solely attributed as the source of substitute funding to insulate all banks. While I do find an increase in government funding associated with a decline in prime funding, suggestive of some substitution, I find the opposite for dollar bond issuance in the sense that I observe a decrease in bond issuance following a decline in prime funding. Note however that both of these results are not robust to the inclusion of time fixed effects.

I also examine the Eurozone crisis to compare to the money market fund reform and again find mixed results depending on the specification. For specifications with borrower-firm fixed effects, I find that there was no significant effect on loan amounts, but there was an increase in spreads associated with the money market fund reform. In contrast for the specifications that look at the borrower-sector level and include the associated borrower fixed effects, I find a significant effect for the Eurozone crisis, but not the money market fund reform. The lack of consistency between the two specifications and robustness leads me to question and discount the results when assessed in context with the other exercises that did not yield significant effects overall.

The results from this paper suggest that the dollar funding mechanism is quite complex as foreign banks appear to have a multitude of options with which to substitute for dollar funding, each of which are heterogeneously utilized depending on the individual bank. As a result, this paper has shown that focusing solely on money market funding and bond issuance may be insufficient to capture alternate sources and thus I cannot definitively identify whether there is an effect on bank lending from declines in dollar funding from money markets. One important source may be off-shore dollar deposits as well as interbank loans, both of which are difficult to account for in the data. Future work may hopefully find and incorporate this data in the study of bank financing decisions and how they affect loan supply.

In addition, following upon the notion of bank-firm relationships as an insurance mechanism, one can examine whether funding costs counter-cyclically affect bank profits. This paper was one example of a dollar funding shock due to a decline in liquidity from money market funds, but we can extend this notion to other shocks to funding costs as well. I reserve this project for future work.

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Chapter 1 Appendix

A.1 Taming the FX Factor Zoo

One aspect missing from the exchange rate asset pricing literature is a consensus on the set of baseline control factors to consider when testing the existence and relevance of a new pricing factor. Papers have generally followed the equity pricing literature primarily using the market return or consumption growth as baseline factors, but there is no guarantee that the hallmark asset pricing factors are relevant or correct for exchange rates. This may be due to the difficulty of identifying risk factors for exchange rates, but the literature could nonetheless benefit from a common baseline as studies are otherwise difficult to compare.

I attempt to fill this void by applying the double selection procedure of Feng et al. (2017) in order to uncover the existence of baseline factors with which I can compare the intermediary capital shocks. I closely follow their paper, compiling a series of readily available risk factors previously identified in the literature, in search of baseline factors that survive regularization to determine the most relevant factors that we may use as benchmarks in future studies. My set of control factors are AQR's factors: Devil's HML (Asness and Frazzini 2013), Betting Against Beta (Frazzini and Pedersen 2014), Quality Minus Junk (Asness, Frazzini, and Pedersen 2017), Value, and Momentum (Asness, Moskowitz, and Pedersen 2013) and the Fama French factors: market excess return, size, value, profitability, and investment, and their global equivalents, and the S&P 500 excluding financials return.

The procedure involves the application of machine learning techniques, namely regularization through the use of the LASSO (least absolute shrinkage and selection operator), that tests a wide number of factors simultaneously and yields a parsimonious set of factors that best describe the cross-section of returns. The usage of LASSO may be substituted with other feature selection methods from the machine learning toolbox including but not limited to other regularization operators (elastic net, ridge regression), random forests, boosting, and neural networks.

Suppose we have a set of new factors to test, $\{g_t\}$, a set of factors that we want to use as controls, $\{h_t\}$, and a cross-section of returns, $R_{i,t}$. The goal is to find the parsimonious set of factors in $\{h_t\}$ such that our estimates of risk prices from the factors in $\{g_t\}$ are not or less susceptible to omitted variable bias.

The first step involves running a cross-sectional LASSO regression of average returns on the covariances between returns and factors in $\{h_t\}$, namely the following:

$$\min_{\lambda_h} \left\{ n^{-1} ||\bar{r} - \hat{Cov}(r_t, h_t)\lambda||^2 + \alpha_1 n^{-1} ||\lambda||_1 \right\}$$

This step is analogous to directly estimating the second step of the Fama MacBeth procedure as our regressors, $\hat{Cov}(r_t, h_t)$ are the β's from the first stage of Fama MacBeth and we are thus estimating the risk prices of each factor. The main difference is the inclusion of the penalty term that increases with the number of non-zero estimates of regressors, biasing estimates towards zero which isolates only the most relevant factors. The α_1 coefficient is a tuning parameter that controls the relative size of the penalty, with $\alpha_1 = 0$ reverting back to ordinary least squares, and $\alpha_1 \to \infty$ shrinking all estimates to zero. Let $\{I_1\}$ denote the set of factors selected in the first step.

The second step employs a second pass of LASSO aimed at capturing any factors in $\{h_t\}$ that may have been missed in the first step. Some factors may have been shrunken to zero because they do not hold large relative importance as priced risk factors for the cross-section of returns, but one may nonetheless need them as controls if they covary with the covariance of our set of new candidate factors in $\{g_t\}$ and returns. Omission of these factors would then leave the estimates of risk prices for the candidate factors susceptible to omitted variable bias that may confound our final estimates as the error term would contain factors that co-vary with both the β's and returns. Formally for each factor $j_t \in \{g_t\}$ I estimate the following:

$$\min_{\chi_j} \left\{ n^{-1} ||\hat{Cov}(r_t, j_t) - \hat{Cov}(r_t, h_t)\chi_j||^2 + \alpha_2 n^{-1} ||\chi_j||_1 \right\}$$

The previous specification yields a set of estimates, χ_j, for each factor $j_t \in \{g_t\}$. The α_2 parameter again controls for how stringent the penalty term is. Our final set of control factors $\mathcal{F}$ is thus the union of the selected factors in the first step, $\{I_1\}$, and those in the second step $\{I_2\}$, which includes selected factors in any of our second stage regressions. We are then equipped with a set of baseline factors $\mathcal{F}$ that we control for in any future asset pricing exercises.

Parameter Selection

One of the most important tasks for the researcher in machine learning is the selection of the algorithm's tuning parameters. Model performance and thus selection is quite dependent on the values of these parameters, so I discuss my approach to the selection of (α_1, α_2), the shrinkage parameters in each phase of the two-step procedure.

Recall that as $\alpha \to 0$, LASSO estimates tend towards OLS, whereas $\alpha \to \infty$ increasingly shrinks all estimates towards zero. I must tune the α parameter to avoid overfitting and parameter estimation instability issues with low values of α as $\alpha \to 0$, while simultaneously ensuring that α is not too high such that all estimates are shrunk towards zero and the LASSO estimates are less informative for feature selection. Furthermore given that there are a relatively low number of test assets due to the limited number of exchange rates and cross-sections in comparison to the thousands of equities, one must more carefully select the shrinkage parameters as estimates are quickly shrunk to zero as α increases.

I tune the parameters using k-fold cross validation to limit over-fitting. I first construct a grid of (α_1, α_2) values and perform the two-step procedure for each respective pair on 2 folds, fitting the model on each fold and testing it on the other. For each pair, I compute the mean-squared error on each fold and take the means to determine the respective combination's loss.

Figure A.1 displays the heat-map for parameter combinations and the mean-squared

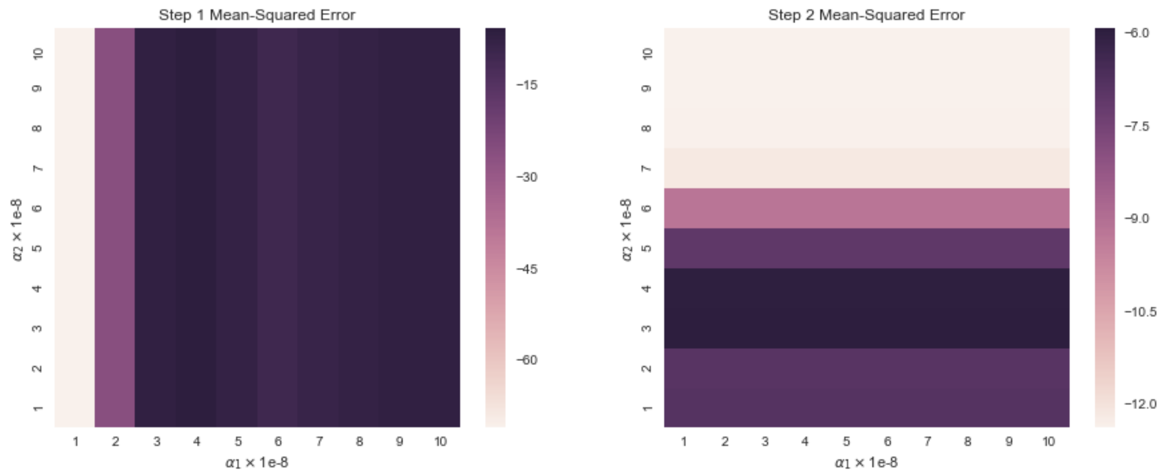

Figure A.1: Heatmap of Parameter Combinations

error in each step of the procedure. I show estimates for $\alpha_1 \in [10^{-8}, 10^{-7}]$ and $\alpha_2 \in [10^{-8}, 10^{-7}]$ as larger values of α quickly shrink all estimates to zero, whereas smaller values are subject to over-fitting and parameter estimation issues as $\alpha \to 0$. The optimal combination, $\alpha = 4 \times 10^{-8}$ and $\alpha_2 = 4 \times 10^{-8}$, yields the lowest mean-squared errors.

Upon finding the optimal parameters, I then re-estimate the model using the entire sample and find that the Fama French Global Market and S&P 500 excluding Finance returns robustly survive the procedure. The main paper contains the specifications controlling for the Fama French Global Market return and I include the specifications with the S&P 500 excluding Finance returns here in the appendix in Tables A.1 and A.2. Note that results are qualitatively the same, with weaker results for the joint cross-section in specifications including intermediary capital, dollar, and global dollar factors.

A.2 Eroded Profitability of FX Strategies

As was hinted in the cumulative return plots of Section 1.3 of the paper, nearly all of the currency strategies other than value do not appear to be profitable after 2010, as cumulative returns very marginally increase, stagnate, or fall altogether. I examine the decomposed returns of each cross-section to identify the key drivers of excess returns and how they change after 2010. I find that exchange rate strategies decline in profitability due to a combination of compressed interest rate differentials and relative dollar appreciation from

Table A.1: Risk Price of Intermediary Capital Shocks vs. S&P 500 excluding Finance Return and Consumption

	Dependent variable:					
	(1)	(2)	(3)	(4)	(5)	(6)
$\beta_{IntCapital}$	0.063**	0.042**	0.086	0.015*	0.025**	0.021*
	(0.029)	(0.018)	(0.143)	(0.009)	(0.010)	(0.013)
$\beta_{SPXexFin}$	−0.029		0.103	0.078		0.151
	(0.359)		(2.842)	(0.109)		(0.148)
$\beta_{DurableCons}$		−0.049	−0.235		0.085	0.075
		(0.241)	(1.639)		(0.107)	(0.111)
$\beta_{NonDurableCons}$		0.030	0.135		0.077*	0.078*
		(0.041)	(0.435)		(0.044)	(0.041)
Observations	1,986	2,436	1,986	11,772	11,772	11,772
R^2	0.794	0.783	0.902	0.600	0.591	0.700

*p<0.1; **p<0.05; ***p<0.01

Table A.2: Risk Price of Intermediary Capital Shocks vs. S&P 500 excluding Finance Return and FX Factors

	Dependent variable:									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$\beta_{IntCapital}$	0.016	0.055**	0.054**	−0.022	−0.012	0.003	0.015	0.014	0.007	0.004
	(0.039)	(0.024)	(0.024)	(0.061)	(0.065)	(0.009)	(0.010)	(0.009)	(0.010)	(0.009)
$\beta_{HMLCarry}$	0.079***			0.083***	0.083***	0.067***			0.061***	0.065***
	(0.019)			(0.019)	(0.019)	(0.022)			(0.022)	(0.022)
β_{Dollar}		0.015		0.018			0.011		0.012	
		(0.105)		(0.119)			(0.022)		(0.021)	
$\beta_{GlobalDollar}$			−0.010		0.073			−0.008		−0.0005
			(0.178)		(0.235)			(0.039)		(0.041)
$\beta_{SPXexFin}$	0.042	0.269	0.225	−0.382	−0.409	0.064	0.284**	0.244**	0.223*	0.178
	(0.324)	(0.398)	(0.425)	(0.699)	(0.623)	(0.120)	(0.124)	(0.124)	(0.119)	(0.118)
Observations	1,986	1,986	1,986	1,986	1,986	11,772	11,772	11,772	11,772	11,772
R^2	0.881	0.882	0.880	0.924	0.923	0.629	0.678	0.667	0.698	0.688

*p<0.1; **p<0.05; ***p<0.01

2010 onwards.

Table A.3 displays the high-minus-low returns for each of the currency strategies, decomposed into the attribution from the forward discount, or equivalently interest rate differential, and exchange rate movements. It is evident that mean excess returns are higher before 2010, with some strategies such as the dollar, momentum, and volatility providing mean losses providing dismal performance from 2010 onwards.

The intermediary capital strategy initially generates excess returns through a combination of carry at 3.6% and relative exchange rate appreciation of 1%. Note that these returns are attributed to the differences in forward discounts and exchange rate movements between the top and bottom portfolios, namely the high intermediary capital shock beta currencies on average had a 3.6% spread in the forward discount over the bottom, and on average appreciated relative to the bottom currencies, yielding a pre-2010 mean excess return of 4.6%.

In panel B, observe that both the forward discount/carry spread has declined to 1% and that the high currencies now depreciate relative to the bottom currencies, eroding returns by .5%. It is thus apparent that the intermediary capital shock strategy has experienced decreased mean excess returns due to a combination of interest rate differential compression and unfavorable spot exchange rate movements.

The carry exhibits the same decline in mean excess returns due to a compression of interest rate spreads. Before 2010, the bulk of the profitability of the carry trade stemmed from outsize interest rate differentials as indicated by a difference in average forward discounts of 15.2%. This was offset by 6.1% of exchange rate depreciation of the top carry currencies relative to the bottom, yielding a mean excess return of 9.1% per annum. As with the intermediary capital strategy, the excess return attributed to the difference in forward discounts, or equivalently the carry component, declined from 2010 onwards, decreasing by over half to 7.2% per annum. Relative spot exchange rate movements remained relatively similar, and thus it appears that the carry trade has declined primarily due to a compression of interest rate differentials, which may be attributed to broad central bank easing following the Global Financial Crisis and the corresponding low-interest rate monetary policy regimes.

Panel A: Pre-2010

	Capital	Carry	Dollar	Momentum	Volatility	Value
Δs_{t+1}						
Mean	-0.99	6.06	-3.62	-4.80	-0.29	-8.15
SD	9.54	10.16	10.80	11.16	9.91	11.40
$\Delta f_t - s_t$						
Mean	3.62	15.15	1.43	3.66	3.76	-1.78
SD	0.99	5.37	0.91	5.20	0.84	1.18
ΔRX_{t+1}						
Mean	4.61	9.09	5.05	8.46	4.05	6.37
SD	9.52	11.07	10.83	12.66	9.99	11.50
Sharpe	0.48	0.82	0.47	0.67	0.41	0.55

Panel B: 2010 - 2017

	Capital	Carry	Dollar	Momentum	Volatility	Value
Δs_{t+1}						
Mean	-0.99	6.06	-3.62	-4.80	-0.29	-8.15
SD	9.54	10.16	10.80	11.16	9.91	11.40
$\Delta f_t - s_t$						
Mean	3.62	15.15	1.43	3.66	3.76	-1.78
SD	0.99	5.37	0.91	5.20	0.84	1.18
ΔRX_{t+1}						
Mean	4.61	9.09	5.05	8.46	4.05	6.37
SD	9.52	11.07	10.83	12.66	9.99	11.50
Sharpe	0.48	0.82	0.47	0.67	0.41	0.55

Panel C: Full Sample

	Capital	Carry	Dollar	Momentum	Volatility	Value
Δs_{t+1}						
Mean	-0.60	6.13	-2.18	-3.24	0.54	-7.58
SD	9.32	9.52	10.52	10.33	9.67	11.27
$\Delta f_t - s_t$						
Mean	2.93	13.27	1.41	2.86	3.53	-1.88
SD	0.95	4.80	0.82	4.58	0.77	1.04
ΔRX_{t+1}						
Mean	3.54	7.14	3.59	6.11	2.99	5.69
SD	9.31	10.33	10.54	11.63	9.73	11.37
Sharpe	0.38	0.69	0.34	0.52	0.31	0.50

Table A.3: Portfolios Decomposed

Notes: Each column represents the decomposition of the high-minus-low for each respective cross-section of foreign exchange. Changes are computed as the mean differences in the averages of spot exchange rate depreciation, forward discounts, and excess returns of currencies between the high and low portfolios.

The dollar strategy attributes most of its excess returns to favorable exchange rate movements. The bulk of profits stem from the appreciation of high relative to low dollar beta currencies, at 3.6% before 2010, which in combination with a 1.4% carry yielded a 5.1% mean excess return. However from 2010 onwards, the high dollar beta currencies on average depreciated by more than their low equivalents, eroding returns by 1.9% rather than contributing to them, leaving a mean loss of .5%. Given the relative stability of the difference in average forward discounts, it is apparent that the dollar strategy suffered mainly due to broad based currency depreciation that affected high dollar beta currencies by more than their low counterparts.

Before 2010, the momentum strategy benefits from a combination of exchange rate movements and carry, with the former generating 4.8% and the latter adding 3.7% to yield mean excess returns of 8.5% per annum. Following 2010, both components decline as the strategy faces compressed relative interest rate differentials at .3%, and exchange rate depreciation at 1.8% as opposed to the previous appreciation that generated over half of mean excess returns, resulting in very poor post-2010 mean excess returns at -1.6% per annum. This strategy thus suffers due to a combination of lower carry and relative depreciation.

The volatility strategy erodes primarily due to relative exchange rate depreciation. While relative carry decreased from 3.8% to 2.9%, the decline in mean excess returns is mainly due to the shift of low volatility beta currencies from appreciating relative to the high beta currencies, to depreciating by 2.9%.[8] The carry and spot rate components thus nullify each other and yield a mean excess return of 0% in the post-2010 period.

Value is the only strategy that retains some semblance of profitability following 2010. The strategy mainly derives its profits from favorable exchange rate appreciation, consistent with intuition as high value currencies are precisely those that are undervalued and expected to appreciate over time. Before 2010, the high value currency portfolio on average appreciates by 8.2% relative to the low value portfolio, and while this does decline to 6.2% in the post 2010, relative appreciation remains a positive contributor to the value strategy's

[8] Recall that for the volatility strategy, the "high" currencies, namely those that outperform, are actually those with lower betas.

mean excess returns.

The carry component detracts from value strategy returns in both partitions of the sample. Consistent with previous findings relative forward discounts decreased from -1.8% to -2.1% in the pre- and post-2010 periods, both of which dampened returns. Value profitability however remained robust due to the outsize contribution of favorable exchange rate movements, yielding mean excess returns of 6.4% and 4.1% in the pre- and post- periods, respectively.

It is thus apparent that all currency strategies have declined in profitability from the recent period following the Global Financial Crisis. Strategies whose returns relied heavily on the carry component, namely the intermediary capital shock, carry, and momentum strategies, suffered due to compressed relative interest rate differentials as proxied by forward discounts, whereas all strategies faced decreased profitability due to unfavorable spot exchange rate movements. In particular, the dollar, momentum, and volatility strategies faced relative portfolio depreciation in contrast to previously beneficial mean portfolio appreciation, resulting in poor returns in the past decade. The value strategy is unique in remaining profitable in the recent period, deriving the bulk of its returns from relative currency appreciation and containing negative carry throughout.

My results suggest that global low interest rate monetary policies may have been responsible for the steep declines in systematic exchange rate strategies in combination with broad based dollar appreciation that yielded unfavorable relative currency depreciation. Given the eroded profitability of exchange rate strategies, I reiterate that the lack of identification of significant risk prices may be due to compressed returns in the recent period.

Decomposition By Portfolio

Table A.4 displays the decomposition of the excess returns of each of the carry trade portfolios as well as the high-minus-low into realized exchange rate depreciation and forward discount. The latter captures the interest rate differential, or the carry, while the former reflects exchange rate movements that generally erode the return on the carry of interest. The failure of the uncovered interest parity is the empirical fact that exchange rates do not depreciate enough to offset the gains of carry, leading to positive excess returns.

Pre-2010

	1	2	3	4	5	6	HML
Δs_{t+1}							
Mean	-1.82	-0.87	-2.41	-1.16	1.01	4.24	6.06
SD	9.04	8.41	8.21	8.82	9.63	10.64	10.16
$\Delta f_t - s_t$							
Mean	-3.88	-1.00	0.50	2.00	4.00	11.27	15.15
SD	4.78	0.55	0.54	0.54	0.60	2.54	5.37
ΔRX_{t+1}							
Mean	-2.06	-0.13	2.91	3.16	2.99	7.03	9.09
SD	10.48	8.42	8.30	8.88	9.62	10.76	11.07
Sharpe	-0.20	-0.02	0.35	0.36	0.31	0.65	0.82

Post-2010

	1	2	3	4	5	6	HML
Δs_{t+1}							
Mean	0.07	1.78	2.29	-0.10	2.72	6.43	6.37
SD	6.85	7.09	7.61	7.92	9.24	9.65	7.14
$\Delta f_t - s_t$							
Mean	-0.97	-0.20	0.56	1.56	2.66	6.21	7.18
SD	0.24	0.14	0.14	0.23	0.24	0.19	0.34
ΔRX_{t+1}							
Mean	-1.04	-1.99	-1.73	1.65	-0.06	-0.23	0.81
SD	6.84	7.08	7.60	7.91	9.25	9.68	7.18
Sharpe	-0.15	-0.28	-0.23	0.21	-0.01	-0.02	0.11

Full Sample

	1	2	3	4	5	6	HML
Δs_{t+1}							
Mean	-1.37	-0.25	-1.30	-0.91	1.41	4.76	6.13
SD	8.57	8.12	8.09	8.61	9.53	10.41	9.52
$\Delta f_t - s_t$							
Mean	-3.19	-0.82	0.52	1.90	3.69	10.08	13.27
SD	4.20	0.50	0.48	0.49	0.56	2.31	4.80
ΔRX_{t+1}							
Mean	-1.82	-0.57	1.82	2.80	2.27	5.32	7.14
SD	9.74	8.12	8.15	8.65	9.53	10.54	10.33
Sharpe	-0.19	-0.07	0.22	0.32	0.24	0.50	0.69

Table A.4: Carry

Notes: Each column represents a portfolio of the carry trade, with portfolio 1 containing the currencies with the lowest forward discounts and portfolio 6 containing the highest. HML is the difference between the two. Excess returns for each portfolio are decomposed into exchange rate depreciation, Δs_{t+1} and forward discount or interest differential, $f_t - s_t$, with RX_t representing final excess returns. Periods are split between the beginning of the sample until December 2009 and January 2010 until March 2018.

Prior to 2010, we observe a forward discount of 11.3% per annum on the top portfolio and a forward premium of 3.9% on the bottom portfolio, leading to a carry of 15.2% for the HML portfolio. This is eroded by an average of 6.1% of exchange rate depreciation, leading to a mean excess return of 9.1% for the HML carry and an impressive Sharpe ratio of .82.

In contrast, forward discounts and premiums have been compressed from 2010 onwards, as on average the top and bottom portfolios yield only 6.2% and -1% respectively, leading to a much lower HML carry of 7.2%. Currencies also appear to have broadly depreciated against the dollar, with the top portfolio depreciating 6.4% on average per month annualized, whereas the bottom portfolio has also depreciated .1% on average, leading to a high-minus-low average depreciation of 6.4%, not too dissimilar from the pre-2010 period. Thus while we do have additional depreciation, the largely compressed forward discounts appear to be responsible for the steep decline in excess returns in the post-2010 period.

It thus apparent that the carry trade became less profitable due to a combination of decreased forward discounts, or lower interest rate differentials, and increased exchange rate depreciation. The former can be attributed to central banks' zero and low interest rate policies since the Global Financial Crisis, while the latter implies an improved, although imperfect resurgence of the uncovered interest parity, the source of which is outside the scope of this paper and open to future research.

The decomposition of dollar portfolio returns in Table A.5 show that the majority of excess returns are attributed to currency movements rather than carry. The pre-2010 period displays a meager 1.4% carry per annum, whereas spot rate changes were as large as 3.6%. The HML has a mean excess return of 5.1% per annum, largely due to the appreciation of the high dollar exposure basket, with a reasonable Sharpe ratio of .47. However in the post-2010 period, while forward discounts mildly compress, the major difference is the shift from broad currency appreciation to depreciation in all portfolios. Instead of exchange rate movements serving as the primary driver of excess returns, they now erode excess returns, leading to negative mean returns of -.5% and an abysmal Sharpe ratio of -.06.

The intermediary capital portfolios display similar patterns as the carry portfolios, namely the decline in excess returns primarily due to smaller forward discounts, and thus carry, that is slightly amplified by increased currency depreciation as displayed in Table

Panel A: Pre-2010

	1	2	3	4	5	6	HML
Δs_{t+1}							
Mean	-0.48	-2.00	-1.83	-2.61	-4.94	-4.28	-3.62
SD	5.76	5.87	8.44	10.36	10.37	10.85	10.80
$\Delta f_t - s_t$							
Mean	1.00	0.66	1.83	2.19	2.06	2.40	1.43
SD	0.75	0.78	0.95	0.90	0.77	0.86	0.91
ΔRX_{t+1}							
Mean	1.48	2.66	3.67	4.80	6.99	6.67	5.05
SD	5.75	5.81	8.39	10.30	10.38	10.94	10.83
Sharpe	0.26	0.46	0.44	0.47	0.67	0.61	0.47

Panel B: Post-2010

	1	2	3	4	5	6	HML
Δs_{t+1}							
Mean	2.84	1.45	3.31	4.65	3.19	4.71	1.86
SD	3.95	5.55	7.97	8.64	9.93	11.36	9.65
$\Delta f_t - s_t$							
Mean	0.47	0.98	1.14	1.66	1.34	1.79	1.33
SD	0.40	0.45	0.53	0.63	0.43	0.64	0.47
ΔRX_{t+1}							
Mean	-2.38	-0.47	-2.17	-3.00	-1.85	-2.91	-0.54
SD	3.89	5.63	7.96	8.62	9.88	11.37	9.64
Sharpe	-0.61	-0.08	-0.27	-0.35	-0.19	-0.26	-0.06

Panel C: Full Sample

	1	2	3	4	5	6	HML
Δs_{t+1}							
Mean	0.39	-1.10	-0.49	-0.70	-2.81	-1.93	-2.18
SD	5.36	5.79	8.34	9.97	10.30	11.03	10.52
$\Delta f_t - s_t$							
Mean	0.86	0.74	1.65	2.05	1.87	2.24	1.41
SD	0.68	0.71	0.87	0.84	0.71	0.81	0.82
ΔRX_{t+1}							
Mean	0.46	1.84	2.14	2.75	4.68	4.16	3.59
SD	5.34	5.77	8.31	9.93	10.30	11.11	10.54
Sharpe	0.09	0.32	0.26	0.28	0.45	0.37	0.34

Table A.5: Dollar

Notes: Each column represents portfolios sorted by dollar betas, with portfolio 1 containing the currencies with the lowest betas and portfolio 6 containing the highest. HML is the difference between the two. Excess returns for each portfolio are decomposed into exchange rate depreciation, Δs_{t+1} and forward discount or interest differential, $f_t - s_t$, with RX_t representing final excess returns. Periods are split between the beginning of the sample until December 2009 and January 2010 until March 2018.

Panel A: Pre-2010

	1	2	3	4	5	6	HML
Δs_{t+1}							
Mean	0.97	-0.41	1.25	1.17	0.99	-0.23	-0.99
SD	8.95	9.39	8.46	8.68	8.83	8.76	9.54
$\Delta f_t - s_t$							
Mean	-0.32	0.44	1.19	2.11	2.16	3.29	3.62
SD	0.78	0.79	0.76	0.89	0.93	0.93	0.99
ΔRX_{t+1}							
Mean	-1.29	0.85	-0.06	0.94	1.17	3.52	4.61
SD	9.07	9.46	8.55	8.72	8.82	8.82	9.52
Sharpe	-0.14	0.09	-0.01	0.11	0.13	0.40	0.48

Panel B: Post-2010

	1	2	3	4	5	6	HML
Δs_{t+1}							
Mean	2.45	0.60	3.03	4.75	2.68	2.93	0.48
SD	4.72	6.04	7.75	9.25	10.08	10.38	8.74
$\Delta f_t - s_t$							
Mean	1.07	0.92	2.47	2.59	1.90	2.06	0.99
SD	0.27	0.27	0.45	0.28	0.55	0.44	0.56
ΔRX_{t+1}							
Mean	-1.38	0.31	-0.56	-2.16	-0.79	-0.87	0.51
SD	4.68	6.02	7.76	9.22	10.08	10.40	8.70
Sharpe	-0.29	0.05	-0.07	-0.23	-0.08	-0.08	0.06

Panel C: Full Sample

	1	2	3	4	5	6	HML
Δs_{t+1}							
Mean	1.36	-0.14	1.71	2.11	1.43	0.60	-0.60
SD	8.06	8.63	8.27	8.83	9.16	9.21	9.32
$\Delta f_t - s_t$							
Mean	0.05	0.56	1.52	2.24	2.09	2.97	2.93
SD	0.71	0.70	0.71	0.78	0.85	0.85	0.95
ΔRX_{t+1}							
Mean	-1.31	0.71	-0.19	0.12	0.66	2.37	3.54
SD	8.15	8.68	8.34	8.85	9.16	9.26	9.31
Sharpe	-0.16	0.08	-0.02	0.01	0.07	0.26	0.38

Table A.6: Intermediary Capital

Notes: Each column represents portfolios sorted by intermediary capital betas, with portfolio 1 containing the currencies with the lowest betas and portfolio 6 containing the highest. HML is the difference between the two. Excess returns for each portfolio are decomposed into exchange rate depreciation, Δs_{t+1} and forward discount or interest differential, $f_t - s_t$, with RX_t representing final excess returns. Periods are split between the beginning of the sample until December 2009 and January 2010 until March 2018.

A.6. While there was previously a significant spread in forward discounts between the top and bottom portfolios prior to 2010, forward discounts become relatively flat across portfolios following 2010 leading to the low excess returns for the HML. Currencies depreciate by more on average, leading to mean excess returns of .5%.

Volatility exhibits similar performance to intermediary and carry but in smaller magnitude as we observe excess returns driven by carry, and less so by exchange rate movements prior to 2010. After 2010, we see that returns are mainly eroded due to exchange rate depreciation, with the bottom portfolio depreciating the most out of all portfolios, putting a sharp dent in excess returns.

The momentum strategy prior to 2010 derives its profitability from a balance of carry and exchange rate appreciation, attributing slightly more towards the former as displayed in Table A.7. The pre-2010 mean excess return was 8.5% per annum yielding a decent Sharpe ratio of .67 that came from 3.7% of carry and 4.8% of exchange rate appreciation. After 2010, momentum performs poorly, as the highest portfolio currencies have the largest depreciations and the forward discount halves, while the lowest portfolio sees increased an improved forward discount. Thus the mean excess return of -1.6% after 2010 primarily comes from the poor performance of the top portfolio that both substantially depreciates and loses carry.

As expected, value operates primarily through exchange rate movements as high value currencies are precisely those that will appreciate over time as shown in Table A.9. Prior to 2010, the HML appreciated 8.2% while carry was actually negative, removing 1.8% of excess returns, for a final mean excess return of 6.4%. However after 2010, currencies overall appear to have depreciated against the dollar. While higher valued currencies depreciated by significantly less than low value currencies, the lack of currency appreciation for the high portfolio shed a little under 2% of excess returns compared to the pre-2010 period. The carry component has also slightly eroded as the highest portfolio now provides slightly negative carry, while the low portfolio has a larger forward discount, both of which detriment mean excess returns. However in contrast to the other strategies, value remains profitable in the post 2010 period at 4.1% per annum with a Sharpe ratio of .37.

The evidence in this section clearly points towards a decline in the profitability in

Panel A: Pre-2010

	1	2	3	4	5	6	HML
Δs_{t+1}							
Mean	3.58	0.69	0.25	-1.84	-0.44	-1.23	-4.80
SD	11.40	9.15	9.06	9.09	9.22	9.07	11.16
$\Delta f_t - s_t$							
Mean	1.23	1.21	2.12	2.19	2.85	4.89	3.66
SD	4.96	0.92	1.69	1.01	1.17	1.73	5.20
ΔRX_{t+1}							
Mean	-2.34	0.52	1.88	4.03	3.29	6.12	8.46
SD	12.70	9.13	9.10	9.15	9.24	9.19	12.66
Sharpe	-0.18	0.06	0.21	0.44	0.36	0.67	0.67

Panel B: Post-2010

	1	2	3	4	5	6	HML
Δs_{t+1}							
Mean	3.19	1.36	1.44	2.80	-0.26	5.02	1.83
SD	9.78	9.21	7.73	7.80	6.86	7.32	6.87
$\Delta f_t - s_t$							
Mean	2.10	1.51	1.54	1.59	1.64	2.38	0.28
SD	0.51	0.39	0.34	0.43	0.42	0.46	0.85
ΔRX_{t+1}							
Mean	-1.09	0.15	0.09	-1.21	1.91	-2.64	-1.55
SD	9.80	9.19	7.72	7.82	6.88	7.29	6.93
Sharpe	-0.11	0.02	0.01	-0.16	0.28	-0.36	-0.22

Panel C: Full Sample

	1	2	3	4	5	6	HML
Δs_{t+1}							
Mean	3.48	0.85	0.53	-0.75	-0.40	0.24	-3.24
SD	11.03	9.16	8.76	8.81	8.71	8.71	10.33
$\Delta f_t - s_t$							
Mean	1.44	1.28	1.98	2.05	2.57	4.30	2.86
SD	4.34	0.83	1.49	0.91	1.05	1.56	4.58
ΔRX_{t+1}							
Mean	-2.05	0.43	1.46	2.80	2.96	4.06	6.11
SD	12.07	9.14	8.79	8.87	8.73	8.84	11.63
Sharpe	-0.17	0.05	0.17	0.32	0.34	0.46	0.52

Table A.7: Momentum

Notes: Each column represents portfolios sorted by the previous month's excess returns, with portfolio 1 containing the currencies with the lowest returns and portfolio 6 containing the highest. HML is the difference between the two. Excess returns for each portfolio are decomposed into exchange rate depreciation, Δs_{t+1} and forward discount or interest differential, $f_t - s_t$, with RX_t representing final excess returns. Periods are split between the beginning of the sample until December 2009 and January 2010 until March 2018.

Panel A: Pre-2010

	1	2	3	4	5	6	HML
Δs_{t+1}							
Mean	-0.43	2.41	1.28	1.02	-0.77	-0.17	-0.29
SD	10.47	9.40	8.54	8.53	7.77	8.22	9.91
$\Delta f_t - s_t$							
Mean	3.46	2.56	2.37	1.17	0.54	-0.28	3.76
SD	0.98	0.84	0.80	0.90	1.01	0.71	0.84
ΔRX_{t+1}							
Mean	3.89	0.15	1.09	0.15	1.31	-0.11	4.05
SD	10.63	9.40	8.53	8.60	7.93	8.29	9.99
Sharpe	0.37	0.02	0.13	0.02	0.17	-0.01	0.41

Panel B: Post-2010

	1	2	3	4	5	6	HML
Δs_{t+1}							
Mean	4.70	4.22	2.06	2.83	1.08	1.82	2.88
SD	11.28	9.81	8.77	7.67	6.66	4.73	8.95
$\Delta f_t - s_t$							
Mean	3.31	2.57	1.87	1.67	1.57	0.42	2.89
SD	0.38	0.38	0.39	0.38	0.37	0.22	0.46
ΔRX_{t+1}							
Mean	-1.39	-1.65	-0.19	-1.17	0.49	-1.40	0.01
SD	11.31	9.81	8.72	7.68	6.69	4.71	8.96
Sharpe	-0.12	-0.17	-0.02	-0.15	0.07	-0.30	0.00

Panel C: Full Sample

	1	2	3	4	5	6	HML
Δs_{t+1}							
Mean	0.92	2.88	1.49	1.49	-0.29	0.35	0.54
SD	10.70	9.50	8.59	8.30	7.49	7.46	9.67
$\Delta f_t - s_t$							
Mean	3.42	2.56	2.24	1.30	0.81	-0.10	3.53
SD	0.86	0.75	0.72	0.80	0.89	0.63	0.77
ΔRX_{t+1}							
Mean	2.50	-0.32	0.75	-0.19	1.09	-0.45	2.99
SD	10.82	9.49	8.57	8.36	7.62	7.51	9.73
Sharpe	0.23	-0.03	0.09	-0.02	0.14	-0.06	0.31

Table A.8: Volatility

Notes: Each column represents portfolios sorted by volatility betas, with portfolio 1 containing the currencies with the lowest betas and portfolio 6 containing the highest. HML is the difference between the two. Excess returns for each portfolio are decomposed into exchange rate depreciation, Δs_{t+1} and forward discount or interest differential, $f_t - s_t$, with RX_t representing final excess returns. Periods are split between the beginning of the sample until December 2009 and January 2010 until March 2018.

Panel A: Pre-2010

	1	2	3	4	5	6	HML
Δs_{t+1}							
Mean	3.55	-0.47	0.62	0.25	-2.77	-5.22	-8.15
SD	12.16	10.39	10.13	10.20	11.14	8.69	11.40
$\Delta f_t - s_t$							
Mean	1.79	0.64	0.56	0.62	0.42	0.28	-1.78
SD	0.98	0.79	0.97	0.86	0.79	0.78	1.18
ΔRX_{t+1}							
Mean	-1.76	1.11	-0.06	0.36	3.19	5.50	6.37
SD	12.17	10.41	10.12	10.10	11.20	8.84	11.50
Sharpe	-0.14	0.11	-0.01	0.04	0.28	0.62	0.55

Panel B: Post-2010

	1	2	3	4	5	6	HML
Δs_{t+1}							
Mean	7.64	-0.05	0.60	3.89	-2.50	1.45	-6.19
SD	11.86	9.19	10.93	9.39	10.94	8.64	11.00
$\Delta f_t - s_t$							
Mean	2.05	0.34	0.57	0.73	0.62	-0.08	-2.13
SD	0.62	0.31	0.47	0.21	0.26	0.16	0.54
ΔRX_{t+1}							
Mean	-5.59	0.39	-0.03	-3.16	3.11	-1.53	4.06
SD	11.90	9.21	10.92	9.40	10.94	8.63	11.08
Sharpe	-0.47	0.04	-0.00	-0.34	0.28	-0.18	0.37

Panel C: Full Sample

	1	2	3	4	5	6	HML
Δs_{t+1}							
Mean	4.74	-0.35	0.62	1.27	-2.69	-3.35	-7.58
SD	12.07	10.05	10.36	9.97	11.07	8.71	11.27
$\Delta f_t - s_t$							
Mean	1.87	0.56	0.56	0.65	0.48	0.18	-1.88
SD	0.89	0.69	0.86	0.74	0.68	0.67	1.04
ΔRX_{t+1}							
Mean	-2.88	0.91	-0.05	-0.63	3.17	3.53	5.69
SD	12.08	10.08	10.34	9.91	11.10	8.82	11.37
Sharpe	-0.24	0.09	-0.01	-0.06	0.29	0.40	0.50

Table A.9: Value

Notes: Each column represents portfolios sorted by value as measured by five year changes in PPP, with portfolio 1 containing the currencies with the lowest value and portfolio 6 containing the highest. HML is the difference between the two. Excess returns for each portfolio are decomposed into exchange rate depreciation, Δs_{t+1} and forward discount or interest differential, $f_t - s_t$, with RX_t representing final excess returns. Periods are split between the beginning of the sample until December 2009 and January 2010 until March 2018.

portfolio based currency strategies in the past decade. For strategies reliant on carry, forward discounts have compressed, potentially due to ultra loose global monetary policy, removing the previously dominant source of excess returns. For the remaining strategies, currency movements were largely unfavorable as most currencies and portfolios depreciated against the dollar, commonly in the top portfolios, causing mean excess returns to go from positive to low or even negative between the two periods. The source for this broad based depreciation is reserved to future research, but anecdotally may be related to the China devaluation and EM sell-off in 2015-2016 as well as the dollar appreciation immediately following the 2016 election. I use this evidence to emphasize that the previously identified cross-sections of foreign exchange may no longer be valid given the poor performance in the past decade, and thus the asset pricing tests in the following sections will have difficulty picking up significant prices of risk given the lack of dispersion in returns.

A.3 Capital Flows and Intermediary Risk

I explore whether we can relate capital flows to various currencies' exposures to the dollar and HML carry factors in search of an economic interpretation behind these loadings. Recall that these are precisely the dollar betas from the bilateral regressions in Tables 1.4 and 1.5 for the dollar factor, and the average forward discounts that proxy for interest rate differentials for the HML carry factor. Verdelhan (2018) linked the systematic variation, or R^2, of the bilateral exchange rate movements to the R^2 of a country's capital outflows with respect to aggregate capital flows.

I explore this notion by examining whether the elasticities of capital flows elucidate the mechanism either behind the source of systematic variation or dependence on global risk and provide an economic explanation for the heterogeneity in dollar betas and interest rate differentials. The intuition is that countries with capital flows that are more sensitive to aggregate capital flows or intermediary capital shocks are precisely the ones that are the most exposed to the risk factors. When a bad intermediary capital shock hits, if aggregate capital flows retrench, we expect that countries that experience larger capital outflows to have depreciating currencies, in line with a portfolio balance approach.

I test this mechanism through a two-step process. In the first step I estimate the elasticity of a country's bilateral capital flows vis-à-vis the US to aggregate capital flows and intermediary capital shocks.[9] Formally I estimate:

$$\frac{\Delta Y_{it}}{Y_{it-1}} = \alpha_i + \beta_i Z_t + \epsilon_{it} \tag{A.10}$$

where Y_{it} is the stock of foreign holdings of US securities or US holdings of foreign securities and the regressor is either the percentage change in total capital flows from the US or the intermediary shock, $Z_t = \{\frac{\Delta Y_t}{Y_{t-1}}, CShock_t\}$. The set of β_i's capture the elasticities of capital flows between country i and the US to total US capital flows and the intermediary capital shock.

In the second stage, I examine the correlation between estimated capital flow elasticities and the average dollar betas or forward discounts of each country. If capital flows provide an economic interpretation behind the cross-sectional heterogeneity in loadings on any of the exchange rate factors, we would expect monotonic relationships between the elasticities and loadings.

Table A.10 displays the first stage results, namely the capital flow elasticities. The first two columns display the elasticities of bilateral capital flows to aggregate US capital flows and the third and fourth columns display elasticities with respect to intermediary capital shocks. The US columns (1) and (3) reflect the elasticities of foreign holdings of US securities, while columns (2) and (4) display the elasticities of US holdings of foreign securities. I do not perform significance tests for the elasticities of aggregate capital flows, as they mechanically should all be non-zero and co-move with aggregate capital flows, given that aggregate flows are the sum of all bilateral flows. However for the elasticities to intermediary capital shocks, we observe that most estimates are insignificant, contrary to our priors as we would expect the fluctuations in the capital ratio of financial intermediaries to lead to readjustments of cross-border holdings, leading to capital flow movements.

[9] I obtain capital flow data from the U.S. Department of the Treasury's Treasury International Capital monthly reports on cross-border transactions (S1) and holdings of long-term securities (SLT). I combine the two series to construct percent changes in US holdings of foreign securities and foreign holdings of US securities, from September 2011 - December 2017.

Country	Aggregate US (1)	Aggregate Foreign (2)	Intermediary US (3)	Intermediary Foreign (4)
Australia	0.561732	0.407000	0.015	8.60e-03
Austria	-0.168590	-0.111995	0.011	1.45e-02
Belgium	0.139965	-0.662080	-0.005	-1.27e-02
Canada	0.816440	1.159179	-0.006	6.92e-03
Czech Republic	0.507321	1.411286	-0.013	-2.73e-02
Denmark	-0.213865	-0.930597	-0.010	1.01e-02
Europe	0.591023	0.358775	0.000	4.90e-03
Finland	-0.411674	-0.077929	0.046*	-1.53e-02
France	5.972431	0.956297	-0.019	2.32e-02
Germany	0.222892	0.256582	0.032***	1.51e-03
Greece	-0.199668	1.685592	0.013	-3.29e-02
Hungary	-0.757481	0.007804	0.193***	-1.44e-01**
India	1.250955	0.464913	-0.074	-1.26e-02
Indonesia	1.209023	-0.451205	0.010	2.34e-02
Ireland	-0.504120	0.085577	0.005	-1.28e-02
Italy	0.092151	0.497940	-0.048***	5.33e-02*
Japan	1.164754	1.209108	0.013	3.00e-02***
Kuwait	0.058945	11.394841	0.010	-1.27e+00**
Malaysia	0.545921	3.436849	0.020	1.48e-01**
Mexico	1.116823	1.707253	0.051	-3.90e-03
Netherlands	0.098945	-0.269754	-0.003	1.53e-02
New Zealand	0.428238	-0.690802	0.004	-1.10e-01
Norway	0.170633	1.526813	-0.006	-4.69e-03
Philippines	1.914606	-1.787952	0.068**	7.99e-02
Poland	1.271581	2.448223	0.008	-8.13e-03
Singapore	0.491213	-0.929658	0.014	9.66e-03
South Africa	-0.365768	-0.218440	0.050	2.18e-02**
South Korea	0.852502	1.176868	0.042	3.28e-02
Spain	-0.140088	0.514217	-0.041**	4.45e-02
Sweden	-0.496272	0.183090	-0.001	1.47e-02
Switzerland	0.817910	-0.027211	0.001	-3.92e-03
Taiwan	-0.310020	-0.236327	0.020*	2.26e-02**
Thailand	0.736721	0.172318	0.161**	3.03e-02**
Turkey	-1.975374	-0.403001	0.112	2.80e-04
United Kingdom	3.550686	3.987050	0.005	1.32e-02

Table A.10: Capital Flow Elasticities

Notes: This tables displays the capital flow elasticities estimated via Equation A.10. Columns (1) and (2) display the elasticities of bilateral capital flows of countries with the US with respect to aggregate capital flows with the US. Columns (3) and (4) display the elasticities of capital flows with respect to the intermediary capital shock. Columns (1) and (3) contain the elasticities of foreign holdings of US securities, while Columns (2) and (4) contain the elasticities of US holdings of foreign securities.

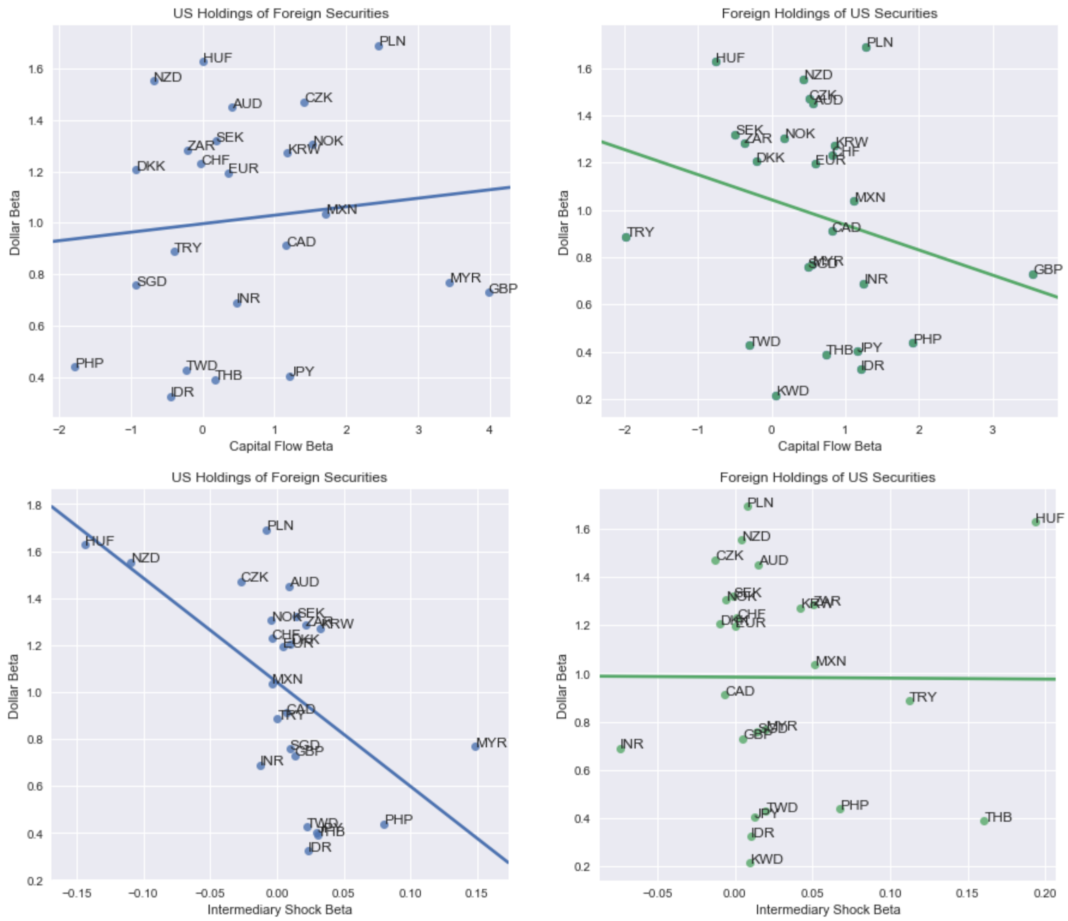

Figure A.2: Dollar Betas vs. Capital Flow Elasticities

All is not lost however, as we can still examine the correlation between these estimated, but insignificant elasticities and the dollar betas and average forward discounts, which proxy for exposure to the dollar factor and the HML carry factor, respectively. Figure A.2 displays scatter plots of the elasticities and dollar betas. Although most of the plots do not display any striking pattern, note that we do observe a distinct negative correlation between the elasticity of US holdings of foreign assets to intermediary capital shocks and dollar betas in the bottom left corner.[10] On the other hand, we do not observe any relationship between the capital flow elasticities and forward discounts as displayed in Figure A.3.

I test this with a simple regression of each country's average dollar beta or forward

[10]Note that the negative correlation is robust to excluding Hungary, New Zealand, Malaysia, and the Philippines, which look like outliers. The negative correlation remains significant and in fact increases in magnitude.

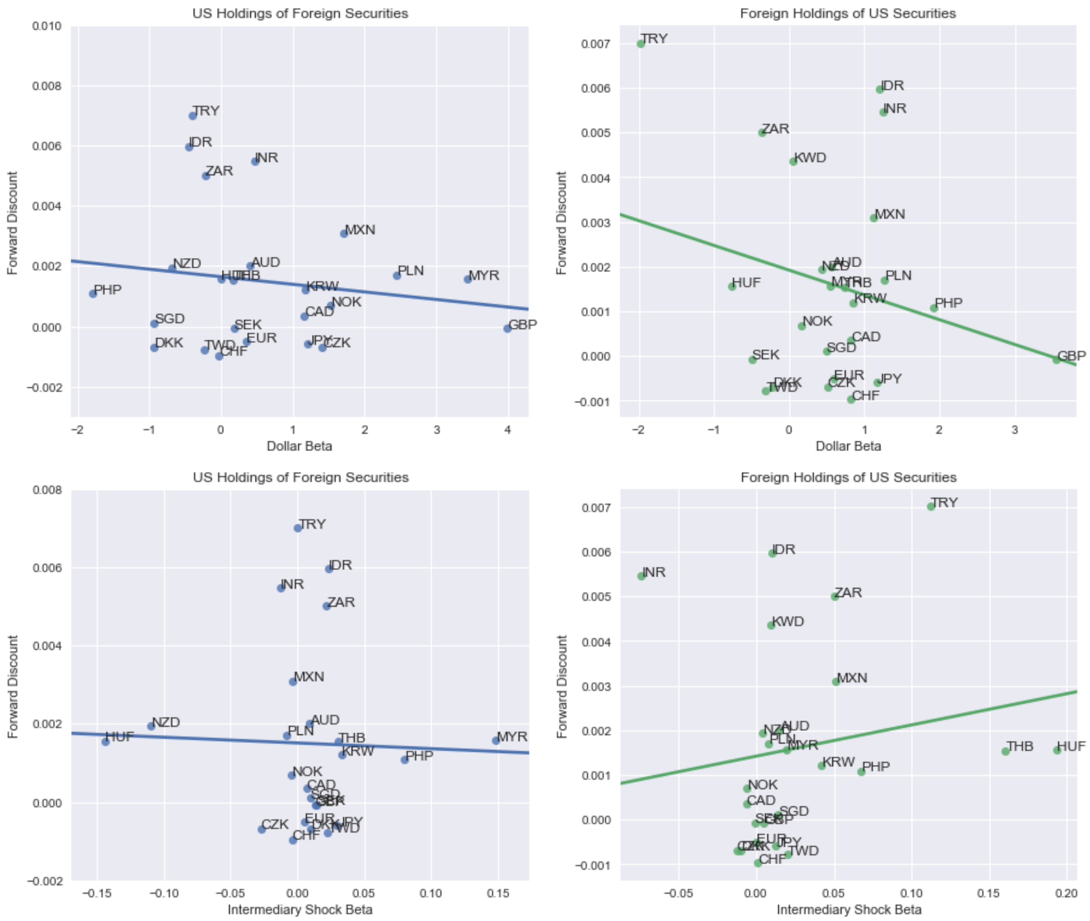

Figure A.3: Average Forward Discount vs. Capital Flow Elasticities

discount on its elasticities. Table A.11 displays my results for dollar betas, which confirms the scatter plots as we estimate a significant and negative correlation between US holdings of foreign assets and dollar betas as shown in Column (3). The interpretation is then that currencies with high dollar betas, such as the Hungarian forint and New Zealand dollar, have negative or smaller capital flow elasticities with the intermediary shock. When bad intermediary shocks hit, namely a decline in intermediaries' capital ratios, we observe an *increase* in US holdings of foreign securities in these high dollar beta countries. This may appear counterintuitive as this implies that there is an increase in demand for foreign securities during bad times, and thus presumably capital flows into foreign currencies that would cause them to appreciate, opposite our prior. One way to reconcile this finding is to remember that for every buyer there must be a seller, and thus the increase in US holdings of foreign securities symmetrically implies that there must be a decrease in foreign holdings of foreign securities, at least vis-a-vis US agents. Hence if we interpret US agents as similar to a global market maker or dealer, the increase in their holdings of foreign securities during negative intermediary capital shocks may just be the opposite end of a foreign sell-off of foreign currency assets. This of course leads to the question of whether this observed pattern is due to the portfolio decisions of foreign or US agents, and the relative importance of each with regards to currency movements, a question outside the scope of this paper due to data limitations.

The remaining columns of Table A.11 and all of Table A.12 display insignificant correlations between dollar betas and average forward discounts with capital flow elasticities. At face value, this implies that the dispersion, if we ignore the insignificance of the estimates, in these specific capital flow elasticities do not help explain the dispersion in dollar betas and average forward discounts, and by extension interest rate differentials. This of course could be due to biases in the capital flow data that may be suppressing both the actual magnitude and significance of the elasticities.[11] However, without higher quality capital flow data, I am unable to verify this claim.

[11] It is well known that the TICs data is subject to transactions and custodial bias. The transactions bias reflects the fact that the TIC S data only records the country of the first cross-border counter-party, so if for example a Chinese investor purchases a US security through a broker in the United Kingdom, this transaction is listed as a sale to the UK rather than Chinese counter-party. The custodial bias is similar in the sense that if for example a Chinese investor chooses to purchase a US security but keep it with a custodian in the UK, the liability is recorded against the UK, rather than China. Both biases thus tend to suppress actual changes in capital flows in a majority of countries that are not financial centers. See Bertaut and Judson (2014) for a more detailed discussion.

Table A.11: Correlation Between Capital Flow Elasticities and Dollar Betas

	Aggregate		Intermediary	
	Foreign	US	Foreign	US
	(1)	(2)	(3)	(4)
Intercept	0.996***	1.043***	1.042***	0.985***
	(0.097)	(0.102)	(0.075)	(0.102)
Beta	0.033	-0.106	-4.432***	-0.042
	(0.066)	(0.089)	(1.409)	(1.663)
R2	0.01	0.06	0.31	0.00
N	24	25	24	25

Table A.12: Correlation Between Capital Flow Elasticities and Average Forward Discounts

	Aggregate		Intermediary	
	Foreign	US	Foreign	US
	(1)	(2)	(3)	(4)
Intercept	0.002***	0.002***	0.002***	0.001**
	(0.001)	(0.001)	(0.000)	(0.001)
Beta	-0.000	-0.001	-0.001	0.007
	(0.000)	(0.000)	(0.009)	(0.008)
R2	0.02	0.06	0.00	0.03
N	24	25	24	25