Bank Lending Margins and The Exchange Rate Uncertainty Channel

Sneha Agrawal *
New York University†

November 2, 2020

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Abstract

Uncertainty in the foreign value of the US dollar affects the US banking sector and therefore, the US real economy. In this paper, I propose a novel *'Exchange Rate (ER) Uncertainty Channel'* to show the effects of increased volatility in the trade-weighted US dollar index for the US banking sector. Higher volatility in the exchange rate, leads to *retrenchment* by foreign banks from the US syndicated loans market (SLM). This entails a *loanable funds supply bottleneck* for US banks trying to finance their loans through syndicates. US banks respond with tighter credit standards in an attempt to re-allocate scarce funds. In response to a 1 standard deviation increase in ER volatility, US banks' net interest margin increase by 10 bps annualized, whereas balance sheets contract by 2-3 pp annualized. This is consistent with banks exerting market power in the loan market while simultaneously shrinking their balance sheets. Both, the price and volume effect is stronger for US banks with *greater exposure to the SLM as measured by their loans-to-interest-earning-assets ratio.* Thus, volatility in the US dollar is a *'global risk indicator'* that significantly affects the US bank lending activity.

Keywords— Exchange Rate Uncertainty, US Dollar, Syndicated Loans Market, Foreign Banks, Loanable Funds Supply Bottleneck, US Bank Lending Margin, Global Risk Indicator, Market Power

*I am very grateful to Simon Gilchrist and Ricardo Lagos for their advice and support throughout this project. I would also like to thank Virgiliu Midrigan, Mark Gertler, Egon Zakrajšec, Sydney Ludvigson, Diego Perez, Abhishek Gaurav, Venky Venkateswaran, and Jaroslav Borovička for helpful discussions, as well as seminar participants at NYU and YES conferences.

†Email: sneha.agrawal@nyu.edu

1 Introduction

The US dollar is a *global currency* that acts as a "barometer of the risk taking capacity in the global capital markets" [Avdjiev et al., 2019]. It is also the *dominant currency* for both financial and commodity transactions globally [Gopinath et al., 2020]. As a result, fluctuations in the foreign value of the USD – whether changes in its *level or volatility* – affects global financial markets. Previous research emphasizes that changes in the value of the US dollar adversely affect foreign bank balance sheets and cause a spillover to the US banking activities. The mechanism is driven by a reduction in the demand for loans by foreign banks in the secondary markets. As documented by [Niepmann and Schmidt-Eisenlohr, 2019], a one-standard deviation rise in the trade weighted broad USD index leads to a 10 percent reduction in new loan origination by the US banks.

In this paper, I propose a novel *'Exchange-Rate (ER) Uncertainty Channel'* to estimate the effect of increased uncertainty in the foreign value of the US dollar (USD) on the US banking sector. I study the extent to which US bank lending activities are exposed to volatility in the USD exchange rate through global capital markets. I show that *second moment changes* in the foreign value of the USD - measured using changes in the *volatility of the major currencies USD Index* - cause reduction in US bank lending, increase in net interest margins and a shift towards internal funding as measured by their loans-to-deposit ratio.

US banks rely on the *syndicated loans market (SLM)* to finance a majority of their commercial and industrial loans. This supply of loanable funds is obtained from foreign banks and institutional investors. Notably, foreign banks have persistently financed 30-40% of all loans issued in the SLM, over the last two decades. Since all transactions in the SLM are primarily denominated in the USD, this creates a currency mismatch in foreign banks' balance sheet and exposes them to fluctuations in the volatility of the exchange rate[1]. As a result, when ER volatility goes up, both foreign banks and institutional investors (especially the non USD denominated entities), perceive USD fluctuations as a *SLM-portfolio return risk* and cut back on their exposure to the SLM. I provide direct evidence for such a *retrenchment* by foreign banks from the SLM, in times with higher ER uncertainty using the DealScan data on loan transactions in the SLM. As foreign banks retrench, US banks are compelled to take up the slack.

One might conjecture that with a drop in competition from the foreign banks as they retrench, US banks will step in and seize more profits on the resulting excess demand for loanable funds. On the contrary, US banks have greater exposure to the SLM, and they seek to cut back owing to their increased risk exposure. Notably, I find evidence for an overall time-series contraction in the loan volumes and an increase in spreads in the US market for syndicated loans, again using the DealScan data. This indicates a spillover to the US banks in terms of higher spreads and pipeline burden. Consistent with this notion, I use the DealScan data to document that the required return on lending as measured by the AllInSpreads rise for both the US and foreign banks. These findings suggest a *supply side channel* driven by risk mitigation from the US banks.

Non financial US corporations approach US banks to borrow through credit lines or term loans. US banks issue new loans to such borrowers, with the help of funds drawn from other participants in the SLM. However, during times with higher ER uncertainty, when foreign banks are retrenching, US banks face a *loanable funds supply bottleneck.* I call this 'pipeline risk', with an emphasis on the *pipeline* due to scarcity of loanable funds. Depending on the sequential or simultaneous nature of US banks' commitment of funds to the ultimate borrowers, versus their interaction with syndicates; these bottlenecks

[1]For example, a European bank supplying loanable funds to a US syndicated loan, earns the spread over LIBOR in USD, but at the same time its' balance sheet accounts the *euro value of the return* on its funds.

represent a *risk or burden* for the US bank respectively. In the former case, the US banks have promised to issue a certain amount of loans to their borrowers, albeit now they have no funding support from foreign banks in the SLM. In the latter case, US banks seek to maintain their banking relationships à la [Chodorow-Reich, 2014], but they have difficulty arranging syndicated deals.

Such effects of ER uncertainty on the US banks through the SLM have broad spill over to the US bank lending as indicated by the Senior Loan Officers' Opinion Survey (SLOOS) data conducted by the Federal Reserve. This data provides evidence consistent with the notion that increasing number of US banks tighten their credit standards during times with higher ER volatility. Senior loan officers at US banks, more so at larger banks, increase their spread over the cost of loans to appropriately funnel their limited resources towards increased loan demand, in the absence of financial support from the foreign banks. US banks especially increase their premium on riskier loans, as measured in the SLOOS data, in an attempt to minimize their exposure to the pipeline risk. This evidence is consistent with the idea that the consequences of ER uncertainty ripple from a deficiency in the supply of loanable funds in the secondary markets, to a contraction in the supply of loanable funds by the US banks to their ultimate borrowers.

Both the evidence from DealScan and SLOOS provide *suggestive evidence* that is consistent with a mechanism by which ER uncertainty leads to a contraction in lending activity by the US banks, and an increase in spreads as measured by SLOOS or DealScan respectively. However, both the datasets have limitations in providing a measure of *identified variation* based on differential exposure of the US banks to fluctuations in the USD exchange rate volatility. Because SLOOS is a pure time series, one cannot draw causal conclusions. At the same time, DealScan data lacks relevant bank level information to specifically tie this mechanism to individual bank behavior. As a result, for my *primary empirical exercise*, I obtain the panel data on US commercial banks' balance sheets and income statements from the US Call-Reports, to identify my ER uncertainty channel working through the US banks' balance sheet.

US banks are exposed to the USD exchange rate uncertainty through their participation in the SLM. One natural way to measure US banks' exposure to the retrenchment by foreign banks is to measure the exposure of US bank lending to a contraction in loanable funds activity in the SLM. I therefore identify the ER uncertainty mechanism working through the US bank balance sheets using *heterogeneity in the US banks' exposure to the SLM*. I define exposure as US banks' loans-to-interest-earning-assets ratio as greater loans in US banks' portfolio entail higher loanable funds supply bottleneck for the US banks through the SLM[2].

In response to the USD ER uncertainty and foreign bank retrenchment, US banks minimize their pipeline risk in three distinct ways: (1) they shrink their balance sheet and contract their lending activity, (2) they rely more on internal funding as measured by core-deposits to finance the existing loans, and (3) consistent with the exercise of market power, they raise net interest margins to improve profitability to partially make up for the loss.

I estimate that a one standard-deviation increase in the USD ER volatility, leads to a 2-3% points annualized contraction in balance sheet, for a US bank with average exposure. This is accompanied by a 3-5% points annualized drop in the growth of the loans-to-deposit ratio. At the same time, I document an increase in the net interest margins of 9-13

[2] I have also conducted a full estimation analysis using an arguably closer proxy for exposure to the SLM defined as the loans-held-for-sale to interest earning assets ratio. The price and quantity effects of ER uncertainty interacted through this alternate exposure variable, on the US banks are quite similar. Since there is missing data and more measurement error in this exposure variable, I choose loans-to-interest-earning-assets ratio as my baseline specification.

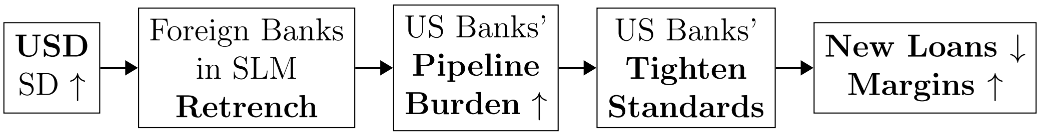
basis points annualized, for an average exposure US commercial bank. This represents on the order of a one-standard deviation increase in the net interest margin, hence an economically significant effect. In addition, the effect on US banks' net interest margin is mainly driven by an increase in the interest income on assets with negligible effect due to interest expenses. Accompanied with the evidence on falling loan volumes, this implies an increase in US *bank lending margins* during periods of high ER uncertainty. This aligns well with the observed increase in aggregate spreads from the SLOOS and DealScan datasets.

The price and quantity effects are much stronger for the US banks with greater exposure to the SLM. US Banks in the 95$^{\text{th}}$ percentile of exposure exhibit 5 basis points higher increase in net interest margins, and 1% point greater contraction in their balance sheet, relative to banks at the 5$^{\text{th}}$ percentile in the bank exposure distribution. This identification of the dynamic response of US bank lending activities to changes in the ER volatility, based on heterogeneity in the US banks' exposure to the SLM, provides causal inference.

Existing literature recognizes that market segmentation and clientele effects in the SLM ([Chodorow-Reich, 2014]) imply that US banks have market power in their lending activities. Therefore, a natural hedge for pipeline risk due to increased volatility is to increase markups in bank lending. The above findings are therefore consistent with contraction in back lending and a simultaneous rise in US bank lending margins. As the US banks shrink, they exploit clientele relationships to exert market power and net interest margins rise accordingly.

Each step of the 'ER Uncertainty Channel' discussed above, can be neatly summarized in the following figure 1. As illustrated in the figure - greater volatility in the foreign value of the USD leads to retrenchment of foreign banks from the syndicated market for loans. This creates pipeline burden for the US banks with a dearth of loanable fund suppliers in the SLM. As a result, US banks respond with tightening of credit standards, contraction in balance sheets through lesser loan volumes, and an increase in bank lending margins. Thus USD exchange rate uncertainty significantly affects the US bank lending activity.

Figure 1: The ER Uncertainty Channel



An important caveat to these conclusions is the possibility that increased ER uncertainty is itself a mere artifact of some alternate underlying mechanism that confounds this interpretation. To alleviate such concerns, I provide two robustness checks. First, ER uncertainty is correlated with general financial volatility which then may be responsible for the observed retrenchment of the foreign banks. In contrast to the evidence I provide for the USD ER uncertainty, I document that US stock market volatility as measured by the volatility in S&P 500, does not affect US bank lending activity through greater exposure to lending markets. A second concern is that ER volatility is correlated with generalized risk premiums in the financial markets. To examine this possibility, I allow for fluctuations in the excess bond premium (EBP) à la [Gilchrist et al., 2016] interacted with loan exposure, in my estimation exercise. Again, I find no evidence of interaction effects between bank exposure and the EBP. Thus controlling for either of these measures does not alter my basic findings. These results reinforce the conclusion that the ER uncertainty channel is a *distinct channel* working through the US dollar uncertainty as a 'global risk indicator' that uniquely impairs US bank lending activity.

Finally, in order to shed light on the nuances of the channel and understand the mechanism in detail, I corroborate my empirical findings with a simple static banking model.

I construct a 3 period model, with foreign banks and US banks, across 3 stages - loan origination, syndication and settlements, in a given time period. In the model, I show that an increase in ER uncertainty affects the return on USD denominated investments by the foreign banks. In line with the previous discussion, the foreign banks' managers respond to this uncertainty by retrenching from the secondary loans market, as they face higher likelihood of realizing losses. This leads to a loanable funds supply bottleneck for the US banks trying to finance their loans through syndication. Finally, I show that US banks originate fewer loans in response to higher ER uncertainty, consistent with my evidence based on the Call-Reports data. This loan contraction leads to greater spreads on loans in my model, because the large US bank has market power in choosing its' optimal origination of new loans on a downward sloping demand curve. The assumption that the US bank has market power closely aligns with the market segmentation observed in the data among large US banks with client networks. As discussed above, accordingly a clear model implication is that the effect is stronger for banks with greater loans in their books. Thus, the empirical evidence documented above can be well understood within the context of a bank lending model where domestic banks have access to a secondary loan market and can exercise market power in loan origination.

In the rest of the paper, I begin with highlighting the main contributions to the literature in the next section (section 2). This is followed by an empirical investigation of the ER uncertainty channel. First, I use the data from DealScan (section 3.2) and SLOOS (section 3.3) to provide qualitative descriptive evidence for the mechanism. I then quantify the effects of ER uncertainty for the US banking sector using panel data regressions, based on Call-Reports data in section 4. In the final section on empirics, I establish the uniqueness of the channel, and show how the USD is special in being a 'global risk indicator' (section 5). Section 6 presents a model in which I corroborate the empirical mechanism using a simple 3 period banking model. I establish four main propositions from my simple model. Finally, in section 7, I conclude with ideas to further strengthen my results.

2 Contribution to the Literature

This paper broadly contributes to 5 different strands of literature. First, there has been substantial work in the literature on the *evolving nature of the syndicated loans market and various mechanism through which it affects the US economy.* With a fairly global perspective, [Gadanecz, 2004] highlights the importance of SLM in allowing a more efficient geographical and institutional sharing of risk. He examines how SLM provides an important source of lending for foreign banks outside their respective areas. [Ivashina, 2005] explains the importance of bargaining and syndicate structure for the loan pricing outcomes. [Ivashina and Sun, 2011] also show that variation in the supply of funds is a key explanatory factor for loan spreads. [Lee et al., 2017] examine the increasing share of non bank participants in the SLM and how the lead banks screen borrowers and look for participants in the syndicates to make the supply of funds available. The paper that is most closely related to my paper in this theme, is [Niepmann and Schmidt-Eisenlohr, 2019]. They show the effects of dollar appreciation for the US banking sector through the 'secondary market channel'. While they find that dollar appreciation is driving the contraction in US banking, I instead propose that it is the second moment that affects US banking outcomes. Once I account for the changes in volatility, I find that US banks respond to increased ER uncertainty despite controlling for the USD appreciation. In fact the coefficients on level changes are rendered insignificant once uncertainty is added to the estimations. At the same time, I use the major currencies index[3] instead of the broad index used in their paper, since it is more representative of the financial interactions between US and the rest of the world. Finally, the paper by [Chodorow-Reich, 2014] is an important paper studying the employment effects of credit market disruptions using identification from the secondary market for loans in the US.

Second, I contribute to the *literature on various bank margin channels* which have been based on US bank balance sheets (deposits in particular), interest rate movements, and secondary markets so far. [Drechsler et al., 2017] propose a deposit channel for monetary policy. They show that when the fed funds rate rises, banks widen the spreads they charge on deposits, and deposits flow out of the banking system. They explain that this is due to market power in deposit markets. [Niepmann and Schmidt-Eisenlohr, 2019] explain increasing US bank margins due to USD appreciation. [Hanweck and Ryu, 2005] study the sensitivity of bank net interest margins and profitability to credit, interest rate, and term structure shocks across bank product specializations. In this paper, I propose a novel ER uncertainty channel to explain half of the standard deviation for changes in US bank lending margins. I find that bank margin is primarily increased due to higher interest income from loans and assets and respond more for banks with greater exposure to the SLM.

Third, this paper *highlights an important source of exogenous variation* that has proven important for many economic outcomes and worthy of greater research. Second moment changes or uncertainty measures have important first order effects especially in the financial sector with often fast moving variables. [Ludvigson et al., 2015] is an important paper which deals with this idea very rigorously. Their findings suggest that macroeconomic uncertainty plays an important role in recessions, by substantially amplifying downturns caused by other output and financial shocks. Another relevant paper that shows how financial market shocks are quite deeply intertwined with financial or macroeconomic uncertainty is the paper by [Caldara et al., 2016]. They account for the contemporaneous feedback between uncertainty and financial shocks and show that the Great Recession was likely an acute manifestation of their toxic interaction.

Next, the 'retrenchment' of foreign banks behind the ER uncertainty channel, is the result of limits to supply of funds from foreign banks. Such *funding constraints* are an important source for the first order response by financial institutions (or firms even), in times when they face exogenous variation due to increased volatility. The main idea is that decision makers can decide (at best) based on some expectation of the outcomes, while the ex-post realizations (especially in times with greater uncertainty) might entail worse outcomes leading to higher than expected losses. The non-linear cost of worse outcomes - motivated using debt covenants, equity issuance cost, funds holding cost etc. are an important driver for hedging with higher prices/ margins/ markups by the decision makers ex-ante. In this spirit, [Gilchrist et al., 2017] develop a model in which equity issuance costs create an incentive for firms to raise prices in response to adverse financial or demand shocks in order to avoid accessing external finance in times with higher uncertainty. On the banking side, [Heuvel, 2006] introduces regulatory capital constraints in a banking model to study the non-linear cost structure of funding for US Banks. I rely on the insights from his paper when designing my model for this paper.

Finally, an important concern in studying the uncertainty effects for any underlying variable is the *role of hedging* in mitigating its' effects on the parties that face it. Banking is special in this regard, particularly large regulated US commercial banks, as they often tend to be the counter-party to more risk averse / more impatient agents. Consequently, more often than not, they end up taking more risk in times of greater uncertainty instead

[3]FRED data has replaced this index with the Trade Weighted USD Index for Advanced Foreign Economics from 2019 onwards. All the results for 2020 need to be re-estimated with this new index.

of hedging it. [Begenau et al., 2015] find little evidence that bank's interest rate derivatives positions are used to hedge other position such as loans. They show that banks typically use derivatives which work like pay-floating instruments and have non financial corporations as their counter party. Hence, for a given notional value of derivative trading by banks of different sizes, very little share is for non-trading and top 4 bank holding companies do almost all the derivatives trading. [Di Tella and Kurlat, 2017] show that bank's deposit taking business is a natural hedge, so high interest states of the world are relatively better for the bankers than for households. Banks have a relative hedging motive, while households are willing to pay the premium to partially insure themselves against high interest rates. Likewise, I draw from the fact that banks are not actively engaging in hedging to avoid the ER uncertainty. Since the results shown in this paper are mainly substantiated using majority of US banking assets owned by large banks; the assumption is that large banks enable ER conversions in general. Consequently, they are the counter-party to more risk averse non financial corporations who want to hedge against ER uncertainty while US banks facilitate them. Also it is not possible for the US banks to perfectly hedge against the size of retrenchment, from foreign banks in times with higher ER uncertainty. Finally, even if the US banks hedge against some of the ER uncertainty, it is not enough to counteract the observed effect on US bank margins. Thus, this paper only ends up providing a lower bound to the estimated effects through the proposed channel.

3 Empirics 1: Qualitative Evidence

The empirical results are best understood in two parts: (1) a broad overview of the main mechanism with some qualitative evidence; and (2) quantitative identification of the Effects of ER uncertainty for the US banking sector. In this section 3, I will begin with the primitives of the SLM and provide some suggestive evidence for the 'ER-Uncertainty-Channel' using 2 data sources - DealScan and SLOOS. In the next section 4, I will use data from US call reports to show a more rigorous identification and estimation of the first order effects of second moment changes in the foreign value of the US dollar.

To begin with, I discuss my measure of ER uncertainty. I define level versus volatility (first and second moments) for the value of USD in section 3.1. Then, I study 2 main data sources, to understand the nuances of the deals happening in the SLM, and opinions of the senior loan officers at large US banks in times with high ER uncertainty. The first dataset I use - Thomson-Reuters-DealScan data is the primary source of data to study loan transactions in the syndicated market for loans. DealScan helps to highlight the key mechanism through which ER uncertainty might matter (section 3.2). It shows the importance of foreign banks' participation in the syndicate(s) and therefore, provides suggestive evidence for the resulting pipeline risk that may affect US bank lending. Then in section 3.3, I use qualitative survey data from the Senior-Loan-Officers-Opinion-Survey (SLOOS) data to understand the broader implications of ER uncertainty for the US loans market.

3.1 Exchange Rate Uncertainty

Exchange rate is measured using daily data on the "Trade Weighted U.S. Dollar Index for Major Currencies" from FRED[4]. This index is a good measure to capture movements in the U.S. dollar and serves as a 'Global Risk Indicator' due to the dominance of USD as a global currency.

[4]It is a weighted average of the foreign exchange value of the U.S. dollar against a subset of the broad index currencies that circulate widely outside the country of issue. Major currencies index includes the Euro Area, Canada, Japan, United Kingdom, Switzerland, Australia, and Sweden.

I measure the *level change* in exchange rate using change in the quarterly mean of this index. Let d denote days and t denote quarters, then I define level change in the ER Index as follows:

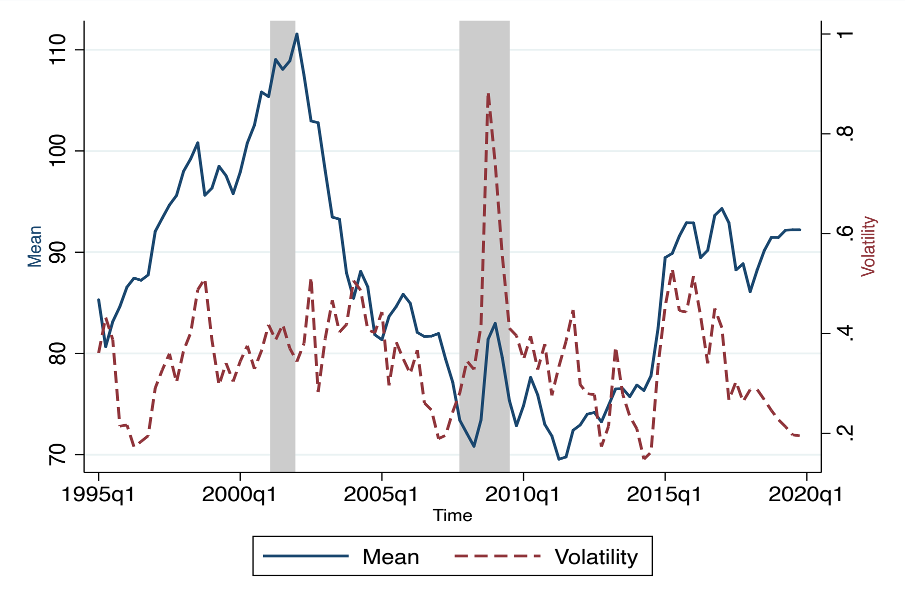
$$\Delta_1 ER_t = ER_t - ER_{t-1}, \quad \text{where} \quad ER_t = \text{Mean}(ER_d | d \in t) \tag{1}$$

The *volatility* is measured using standard deviation of the daily return of this index within each quarter. Hence it is the realized volatility within quarter t.

$$Vol(ER_t) = SD(ER_d - ER_{d-1} | d \in t) \tag{2}$$

Time series plot for the quarterly mean and volatility is shown in figure 2[5]. ER un-

Figure 2: Trade Weighted U.S. Dollar Index for Major Currencies



certainty is then, defined as changes in the second moment/ volatility measure. The level change and volatility have a weak and non significant correlation of 0.15. This warrants that *second moment changes are duly accounted for* in our analysis.

Having defined the main source of exogenous variation; in the next 2 sub-sections, let us understand how this affects the US banks through the syndicated loans market channel.

3.2 DealScan: "Syndicated Loans Market"

I start with the "WRDS Thomson Reuters loan pricing corporation DealScan database" which contains comprehensive historical information on loan pricing and contracts' details in the syndicated loans market. The dataset provides facility (loan) level observations from 1990-2018 with details on the amount of loan, type of loan, members of the syndicate, lender and borrower characteristics, currency of loan and the purpose of loan. [Carey and Hrycray, 1999] have estimated that the DealScan loans covered between 1/2 - 3/4 of outstanding commercial and industrial loans in the US and [Chava and Roberts, 2008] reported that majority of this data comes from SEC fillings. Thus, DealScan data provides a *good average of the US loans market.*

[5]One can also use log of the ER Index in all these definitions. The resulting effects are similar for either specifications.

DealScan provides suggestive evidence for 4 main insights. First, foreign banks have a strong presence in the SLM which is primarily dominated by USD denominated transactions. *Thus, foreign banks are heavily exposed to ER fluctuations while participating in the US market for syndicated loans.* Second, I find preliminary evidence that in the time series aggregate, higher ER uncertainty is associated with a *decline in the total loan volume and an increase in the average AllInSpreads* for the syndicated loans. Third, investigation of lender stakes reveals *'retrenchment' from foreign banks* and an increase in the *pipeline of loans financed* by the the US banks. Fourth, I find the best possible identification of the effects of ER uncertainty on AllInSpreads by exploiting heterogeneity in the lender stake of US and foreign banks. I assume that each bank primarily engages in one loan at any given time. I find that *higher lending stake of any bank in a deal, is associated with greater increase in AllInSpreads* in response to ER uncertainty; controlling for time, bank and loan type fixed effects.

The evidence is robust to whatever controls are available in DealScan regarding loan, lender and borrower characteristics. However, there are limits to this analysis as I can not account for some of the relevant bank and borrower characteristics from call reports or compustat data respectively, without losing substantial data in the merging process.

3.2.1 DealScan Insight 1: USD Exposure

The DealScan sample in this paper,[6] consists of only the loans with country of syndication being USA ($\approx$ 50% observations). Predominantly all the loans (99%) in this sample are denominated in the US dollar. Hence, all bank and institutional investors having stake in such syndicates would naturally be exposed to changes in the value or volatility of the USD.

Substantial Stake of Foreign Banks as Lenders

While one might conjecture that for the US banks (with their operations denominated in USD anyway), this does not pose any challenge; the lenders in this market are not merely US banks. In fact, 30% of the loans are held by foreign banks and another 10% belongs to institutional investors[7] as shown in figure 3. These foreign banks (with their operations primarily denominated in their local currencies) are therefore, exposed to exchange rate movements and uncertainty through their stake in the SLM. Hence, DealScan data provides suggestive evidence that *foreign banks have a strong presence in the secondary loans market, and that they deal in syndicated loans not denominated in their local currency.*

DealScan Data

Next, I consider the aggregate time series relationship of ER uncertainty with some of the relevant variables like loan volume and spreads in the DealScan data. But before that, I summarize some of the important characteristics of the loan transactions that can be controlled for while analyzing the correlations. In particular, I explain the important loan types, spreads, borrower types and primary purpose for the loans in the following section. This also provides us with a better understanding of the kind of transactions that happen in the syndicated loans market.

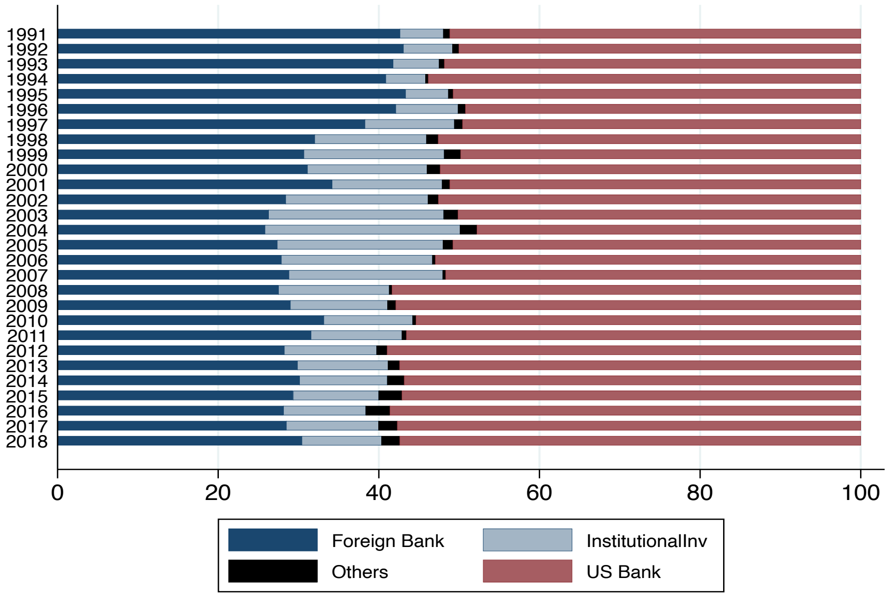
Loan Characteristics: Type of Loans

There are 2 broad types of loans that are circulated in the SLM. 'Revolving Loans/ Credit

[6]In the full sample, 90% of the loans have their distribution method as 'Syndication'. I only include such observations or the ones with sole lenders. I consider senior loans with completed deal status and remove outliers for AllInDrawn spreads and loan volume.

[7]Foreign banks include African Bank, Asia-Pacific Bank, Foreign Bank, Middle Easter Bank, Western European Bank as the institution types of lenders. Institutional investors are Corporation, Finance Company, Inst.Invest.Other, Insurance Co, Investment Bank, Mutual Fund, Pension Fund, Thrift / S&L, and Trust Co

Figure 3: DealScan: Distribution of Lender Types (%)



Lines'[8] and 'Term Loans'[9]. The composition of loan types is shown in figure 4. Revolving

Figure 4: DealScan: Distribution of Loan Types (%)

loans allow the borrowers to use the money up to a certain limit whenever they need it. Once they repay the amount owed, credit becomes available to draw again. On the contrary, term loans are to be repaid in installments over the loan period. They also have a higher average AllInDrawn spread. AllInDrawn describes the amount the borrower pays in basis points over LIBOR for each dollar drawn down. It adds the spread of the loan with any annual (or facility) fee paid to the bank group. Majority of the loan types in my sample are 'Credit Lines' ($\approx$ 60%) while the remaining are 'Term Loans'. I control for the loan type (by their subcategories) in the all my empirical results.

[8] I include the '364 - Day Facility', 'Revolver/Line $<$ 1 Year' and 'Revolver/Line $\geq$ 1 Year' in this category

[9] I include both Type A and Type B - K alon with Delay Draw Term Loans in this category.

Loan Characteristics: Primary Purpose

The DealScan data also contains information regarding the primary purpose for each loan. I restrict my analysis to include the cases which are most important for real effects (as suggested by [Chodorow-Reich, 2014]) such as loans for corporate purposes (50% of the sample), debt repayment, working capital needs, takeover, LBO's or recapitalizations.

Borrower Characteristics

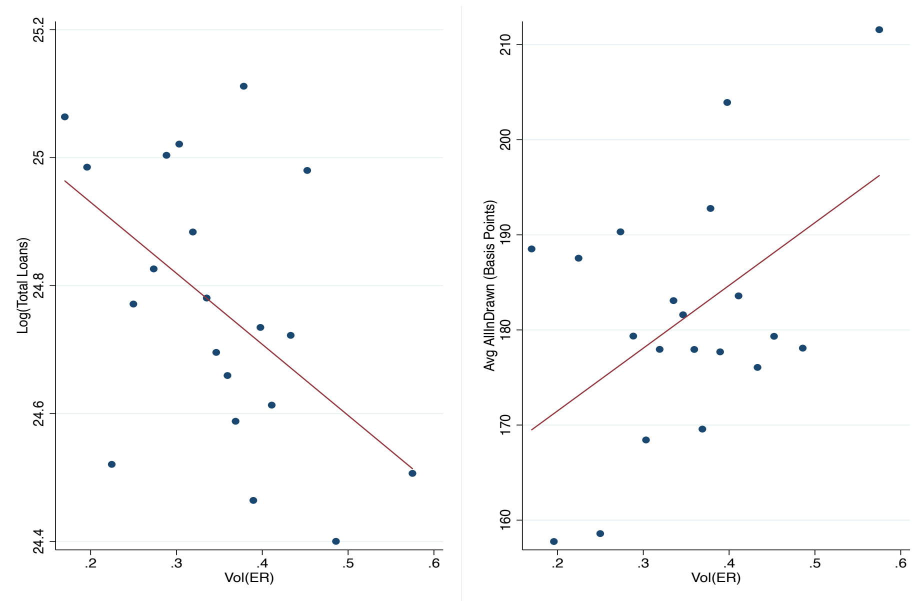
Borrower characteristics are important attributes to understand the secondary market mechanisms. 98% of the borrowers are US based. 88% of the borrower types are corporations; and the other 12% include finance companies, insurance companies or other banks. I also get the information on the industries (NAICS 6 digit classification) for a subset of the borrowers by merging the DealScan data with Compustat. I check for robustness by controlling for borrower type and industry of borrower in my empirical results. However, the merged data is a much smaller subset of the DealScan sample, so I only use these controls for robustness checks.

Thus far, I have all the the relevant transactions data to be used as controls in my analyses and the source of exogenous variation i.e. the ER uncertainty. I can now use this data to find evidence for the correlations between key outcomes in the secondary market during times with high ER volatility. This leads to the second piece of evidence using DealScan, i.e. aggregate summary of price and quantity effects in times with higher ER uncertainty.

3.2.2 DealScan Insight 2: Effect on Loan Volumes and Spreads

With the first piece of evidence on high exposure to USD, it is clear that ER uncertainty and level changes are important sources of exogenous variation in the SLM. I consider the aggregate time series effect of ER uncertainty on volume of loans and the AllInDrawn spread using bin scatter plots as shown in figure 5. I find that there is a negative corre-

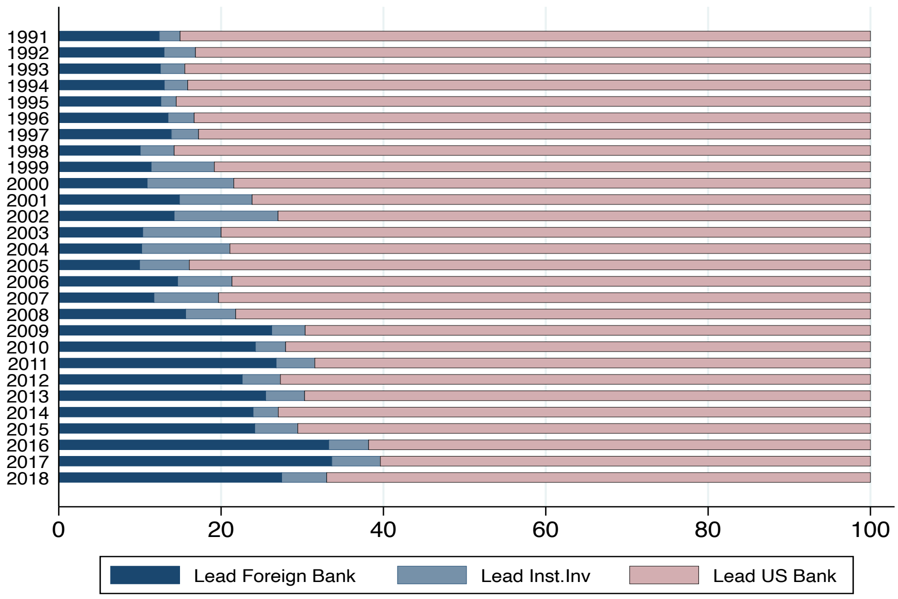
Figure 5: DealScan: Quantity and Price effect of Higher ER Uncertainty



lation between higher ER uncertainty and the log level of total loans in the SLM. At the same time, higher ER uncertainty is associated with higher AllInDrawn spreads. This is after controlling for level changes in the exchange rate (i.e. dollar appreciation) and also absorbing loan type[10]. This seems to suggest a supply side mechanism for loanable funds in the secondary market. To dig deeper into this proposed mechanism, I next analyze the details of how a syndicate works and if there is a change in the composition of lender stake within this aggregate loan volume associated with changes in ER uncertainty.

A syndicate mainly comprises of (1) *lead arranger(s)*-typically the party with highest stake in the deal (2) some *agents* that help with the managing and documentation and (3)*participants*. I follow [Bharath et al., 2011] to define the lead arranger[11] for a given facility (syndicated loan). While the lead arranger(s) have an average bank allocation of 30% in a loan, non-lead participants or other agents have an average of 7% stake. The lead arrangers are primarily US banks, but foreign banks are increasingly becoming lead arrangers over time. Conditional on being a lead arranger, the composition of lender types is shown in figure 6. Since most of the terms and conditions for a deal are decided by the lead arrangers, these results suggest that foreign banks have a persistently significant role in the supply of loanable funds and their decisions in times with higher ER uncertainty can have consequences for the secondary market equilibrium.

Figure 6: DealScan: Lender Types' Composition for Lead Arrangers (%)



3.2.3 DealScan Insight 3: Foreign Banks 'Retrench'

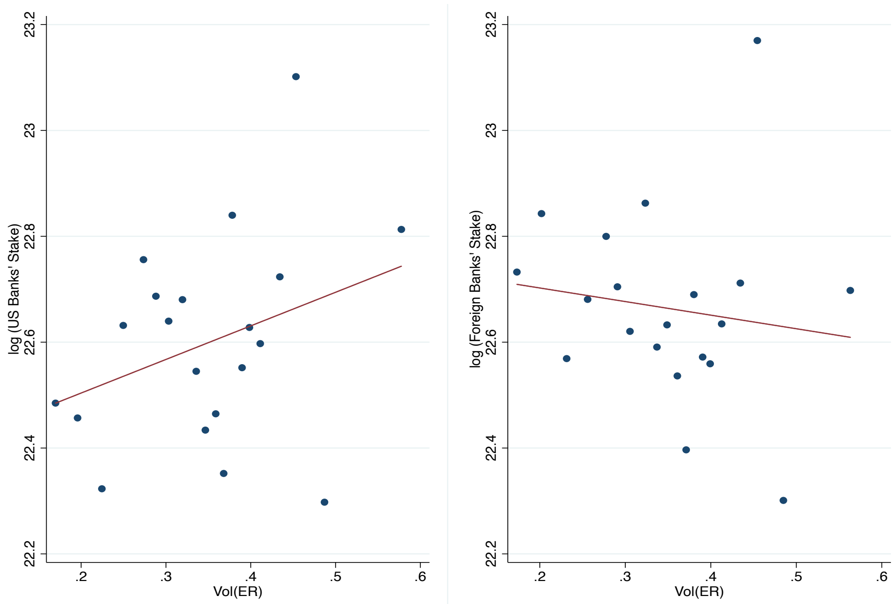
In order to understand the effect of ER uncertainty on spreads and loan shares, I calculate the stake of each lender in any loan using 'Loan Amount × Bank Allocation'. Bank allocation gives the percentage of loan, a particular lender has committed to the given deal. In particular, I find the total stake of US banks and foreign banks in each facility (loan) and plot the log values for them against ER uncertainty in figure 7. Note that time periods with higher ER uncertainty are associated with greater stake for US banks as foreign banks 'retrench' from the syndicates.[12]

[10] I also check for controls like primary purpose and borrower industry and type. The results stay the same.

[11] If the lender has Lead Arranger Credit, or if it is a 'Sole Lender', or if the lender role is one of Admin agent, Arranger, Agent, or Collateral agent. These roles have the highest allocations in the loan shares.

[12] I control for the level changes in ER (i.e. dollar appreciation) and absorb any effects due to different loan types in these figures.

Figure 7: DealScan: US v/s Foreign Banks' Stake during high ER uncertainty



3.2.4 DealScan Insight 4: Effect on AllInDrawn Spreads

Finally, I look at the effect of ER uncertainty on AllInDrawn - identified using heterogeneity in the exposure of lead arrangers. This exercise is only used to draw some suggestive conclusions since it is limited by lack of enough data on borrowers and banks. I derive the exposure using lender stakes as defined above, for (1) lead US banks and (2) lead foreign banks for each loan. I then interact these measures of exposure E_{it} (log(lender stake)) for a loan-bank pair i with the ER uncertainty and level changes. I estimate the regression with AllInDrawn regressed on my key interaction terms, level of exposure, time fixed effects, and loan type fixed effects[13] as follows.

$$\begin{aligned} \text{AllInDrawn}_{it} &= \alpha_t + \delta_k + \beta\,(E_{it} \times Vol(ER)_t) + \gamma\,(E_{it} \times \Delta_1(ER)_t) + E_{it} + \epsilon_{it}, \qquad (3)\\ E_{it} &= \log(\text{Loan Amount}_{it} \times \text{Total Bank Allocation}_{bt}),\\ b &\in \{\text{Lead US Bank}, \text{Lead Foreign Bank}\} \end{aligned}$$

Note that each loan i of type k at time t is issued by the lead arranging bank of type b. I exploit the heterogeneity in the exposure of lead banks of a specific type (US or foreign) across different loans, and estimate the effect of ER uncertainty on AllInDrawn spread for high versus low stakes of the lead banks. This is the closest proxy variable to estimate the ER uncertainty channel via banks' exposure to the deals in the SLM. The results from these regressions are summarized in table 1.

A one standard deviation increase in ER volatility is associated with a 52-79 basis points increase in the AllInDrawn spreads for an average level of lender stake among US lead banks, and foreign lead banks respectively. The response of spreads to ER uncertainty increase with higher stake of the lead arrangers, and more strongly when the syndicate is led by foreign banks. Nevertheless, I only use this as suggestive evidence for higher spreads on loans in times with ER uncertainty, estimated using heterogenous exposure of banks in the syndicated deals.

To summarize, using the DealScan data on loan transactions for over 2 decades, I establish the significant participation by foreign banks in the syndicated loans market.

[13] The results are similar once I also absorb the effects due to Borrower characteristics and Primary Purpose of the loans

Table 1: DealScan: Effect of ER Uncertainty on AllInDrawn

Lender_Type	Lead_USBank	Lead_ForBank
$\text{Expo}_{it} \times \text{Vol(ER)}_t$	24.42***	36.60**
Quarterly Effect(bps)	**52bps******	**79bps******
	(7.510)	(15.23)
$\text{Expo}_{it} \times \Delta(ER)_t$	-0.495*	-0.0921
	(0.285)	(0.597)
Expo_{it}	-48.43***	-43.63***
	(2.675)	(5.553)
# Obs	16128	3407
Adj R^2	0.361	0.334

Source: DealScan (1990Q1-2018Q4)

Robust SE in parentheses: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

These foreign banks face ER uncertainty as the volatility in the foreign currency value of their USD returns increases. Times with higher ER uncertainty, lead to retrenchment by these foreign banks from the SLM. This entails greater pipeline of loan demand to be borne by the US banks. I find evidence for loan supply deficit in the SLM - as seen through an overall drop in the volume of loans and an increase in the AllInDrawn spreads.

While the evidence from DealScan data sheds light on the dynamics in the SLM, it is important to understand how this mechanism affects the US banking sector. A first step in this direction is to analyze the perception of senior loan officers at large US banks in times with high ER uncertainty. It would enable us to estimate the broader implications of ER uncertainty on US banking sector and therefore the US economy. In order to find important qualitative responses of the US banks' to the pipeline risk, I next analyze the SLOOS data in the second part of this qualitative investigation.

3.3 SLOOS : Qualitative Response to ER Uncertainty

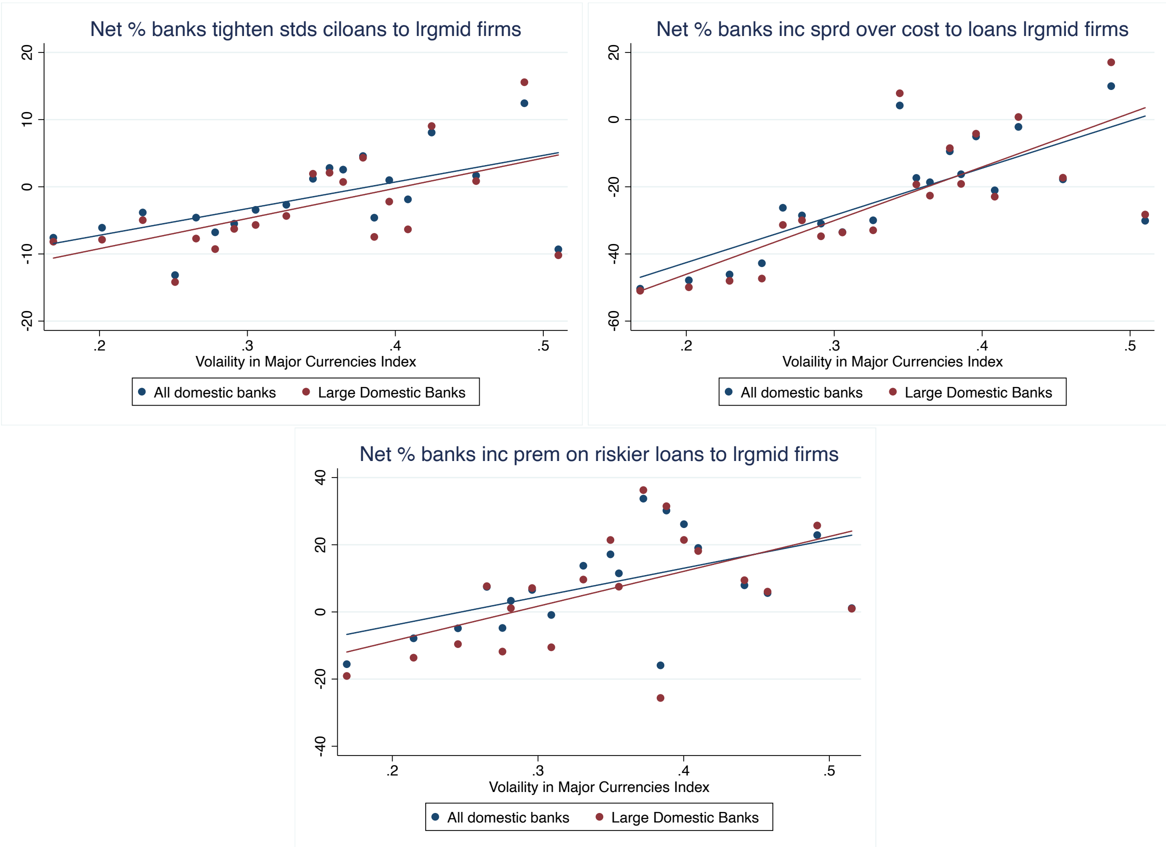
Senior Loan Officers Opinion Survey (SLOOS) [14] is a quarterly survey conducted by the Federal bank with the intent to elicit useful information without imposing undue reporting burden. As a result, the time series information obtained from the survey provides valuable insights on banking developments and is helpful in understanding the *qualitative implications of ER uncertainty*, albeit controlling for any confounding variables.

Three questions are particularly relevant to my analysis: (1) The net percentage of banks that report tightening of credit standards for commercial and industrial (CI) loans to large and middle-market firms; (2) Net percentage of banks increasing spreads of loan rates over banks' cost of funds to large and middle-market firms; and (3) Net percentage of banks increasing premiums charged on riskier loans for large and middle-market firms. The correlation of answers to these questions with ER volatility provides suggestive evidence for

[14] Senior Loan Officers Opinion Survey on bank lending practices is a survey conducted since 1992Q1 of up to 80 large domestic US Banks with assets > \$2bn and ciloans/assets > 5%. One or more senior loan officers at each respondent bank complete this survey through an electronic submission, up to six times a year. The purpose of the survey is to provide qualitative and limited quantitative information on bank credit availability and loan demand, as well as on evolving developments and lending practices in the U.S. loan markets. The presence of the largest banks in the survey is critical, as they play an important role in developing and practicing new banking techniques. However, the panel also includes a fair number of large and medium-size regional banks, which allows for a greater diversity of responses and provides a broader view of the banking system.

how the senior officers at large US banks (which account for majority of the banking sector assets) perceive the secondary market channel in times with high ER uncertainty. The main results are shown using bin scatter plots in figure 8, controlling for the level changes in the index i.e. dollar appreciation and after ruling out any effects due to recessions. I use the time series data from 1992Q1 - 2018Q4.

Figure 8: SLOOS survey responses to ER Uncertainty



As shown in figure 8, higher volatility in the ER Index is correlated with increase in the net percentage of banks that (1) report tightening in credit standards, (2) increase spreads and that (2) charge a higher premium on riskier loans. However, these graphs merely indicate correlations, and by itself, this does not rule out the possibility that some other macroeconomic fundamentals or financial sentiments are driving these correlations.

In order to further understand these nuances and quantify the effects, I estimate the following quarterly time series regression with each of the above survey responses as dependent variables.

$$X_t = \alpha + \beta Vol(ER)_t + \gamma \Delta_1 ER_t + \delta X_{t-1} + \epsilon_t \tag{4}$$

X_t denotes tally of the answers to each of the survey questions - net % of banks reporting tighter credit standards (Tight$_t$), net % of banks charging higher spreads (Sprd$_t$) and net % of banks charging a higher premium for riskier loans (Prem$_t$). $\Delta_1 ER_t$ and $Vol(ER)_t$ are as defined in section 3.1. I also control for lagged dependent variable since each of these survey results are quite persistent.

Nevertheless, this regression does not rule out other possible confounding variables like changes in market uncertainty, or the interest rates which could plausibly be correlated with the ER uncertainty and also imply the observed changes in the survey response.

Hence, I account for a number of such plausible confounding channels by adding more control variables (one at a time) to the above regression as follows.

$$X_t = \alpha + \beta Vol(ER)_t + \gamma \Delta_1 ER_t + \delta X_{t-1} + \\ \theta_1 \Delta_1 VIX_t + \theta_2 \Delta_1 EBP + \theta_3 \Delta_1 FFR + \theta_4 \Delta_1 TS + \theta_5 \Delta_1 UO + \epsilon_t \tag{5}$$

"Riskiness and market sentiments" are accounted for using changes in the CBOE volatility index (VIX) and the excess bond premium (EBP). Monetary policy changes are controlled for using changes in the [Wu and Xia, 2016] shadow fed funds rate (FFR) since our time period includes the zero lower bound. Survey of economic forecasters' measures for changes in the term spread (TS), and unemployment outlook (UO) are included to purge off any confounding due to macroeconomic effects. I estimate the regressions for all the domestic banks (A) and a subsample of only large banks (L) as documented by SLOOS. The results for each of the above regressions (4) and (5), for levels and volatility effects of ER are summarized in the following tables 2 - 3.

Table 2: SLOOS: Effect on Net % of banks reporting tightening in credit standards

	Large Banks				All Domestic Banks			
$Vol(ER)_t$	22.84*	27.28*	23.57	21.37	16.67	20.76**	18.92	18.33
	(12.94)	(13.74)	(16.83)	(15.78)	(10.08)	(9.744)	(11.25)	(10.95)
$\Delta_1(ER)_t$	-0.212	-0.246	-0.274	-0.384	-0.143	-0.178	-0.193	-0.240
	(0.408)	(0.400)	(0.397)	(0.366)	(0.321)	(0.324)	(0.317)	(0.332)
X_{t-1}	0.672***	0.620***	0.618***	0.669***	0.665***	0.604***	0.601***	0.626***
	(0.118)	(0.113)	(0.120)	(0.109)	(0.111)	(0.0968)	(0.100)	(0.0984)
$\Delta_1 l(VIX)_t$		-12.67**	-12.66**	-13.11**		-13.03***	-13.03***	-13.20**
		(5.306)	(5.110)	(5.440)		(4.478)	(4.395)	(4.941)
$\Delta_1 EBP_t$		1.604	0.835	4.836		1.156	0.741	2.537
		(5.486)	(5.549)	(5.526)		(4.743)	(4.717)	(5.223)
$\Delta_1 FFR_t$			2.435	-0.0871			1.241	0.0101
			(4.257)	(4.861)			(3.245)	(4.209)
$\Delta_1 TS_t$				-6.934				-3.270
				(4.319)				(3.381)
$\Delta_1 UO_t$				-0.675				-1.811
				(20.79)				(16.26)
_cons	-9.717*	-11.67**	-10.83*	-9.879*	-7.596**	-9.430***	-9.032**	-8.709**
	(4.790)	(5.001)	(5.742)	(5.403)	(3.607)	(3.294)	(3.687)	(3.535)
N	39	39	39	39	39	39	39	39
Adj. R^2	0.585	0.622	0.614	0.623	0.536	0.623	0.613	0.600

Source: SLOOS (2005Q1 - 2018Q4, excludes gfc), Robust SE in parentheses: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

From table 2, I estimate that a one standard deviation increase in ER volatility (=0.1) is associated with a quarterly increase in the net percentage of banks reporting tighter credit standards by 2 % points. Moreover, large banks respond more to ER uncertainty suggesting greater pipeline risk faced by them, perhaps due to greater participation in the SLM. Note that senior loan officers at US banks are not reacting the same way in times with higher 'US market volatility' versus higher 'ER uncertainty'. If anything, periods with higher stock market volatility are associated with a reduction in the percentage of banks tightening their credit standards. Other sources of macroeconomic and financial variations are not significantly correlated with changes in credit standards.

The tightening in credit standards can be imposed using a number of tools. In particular, there are 2 important survey questions in SLOOS that shed light on this. In table 3, I estimate the effect of ER uncertainty on the Net % of banks that report an increase in their spreads over cost of funds. I estimate that a one unit increase in ER uncertainty is

Table 3: SLOOS: Effect on Net % of banks increasing Spreads over cost of loans

	Large Banks				All Domestic Banks			
$Vol(ER)_t$	48.19**	52.90**	42.65*	41.14*	30.79*	32.23*	25.25	24.02
	(22.39)	(23.24)	(23.06)	(22.87)	(17.78)	(17.73)	(18.05)	(17.97)
$\Delta_1(ER)_t$	0.0713	0.193	0.0615	-0.0839	0.0258	0.202	0.121	0.0665
	(1.062)	(0.981)	(1.061)	(1.044)	(0.852)	(0.740)	(0.777)	(0.771)
X_{t-1}	0.706***	0.674***	0.653***	0.675***	0.805***	0.792***	0.780***	0.793***
	(0.0891)	(0.0920)	(0.0970)	(0.102)	(0.0748)	(0.0803)	(0.0840)	(0.0880)
$\Delta_1 l(VIX)_t$		-5.436	-5.615	-6.173		1.107	1.084	0.250
		(11.49)	(10.95)	(12.63)		(9.187)	(8.902)	(10.50)
$\Delta_1 EBP_t$		-9.671	-12.31	-7.431		-11.11	-12.70	-10.86
		(11.38)	(11.95)	(13.26)		(9.546)	(9.755)	(11.01)
$\Delta_1 FFR_t$			7.890	3.902			5.017	3.496
			(7.137)	(9.194)			(6.075)	(7.406)
$\Delta_1 TS_t$				-10.29				-4.133
				(7.687)				(6.745)
$\Delta_1 UO_t$				-4.901				5.818
				(42.10)				(31.82)
_cons	-27.32***	-30.13***	-28.78***	-27.57***	-17.23**	-18.17**	-17.09**	-16.46**
	(8.543)	(9.478)	(9.029)	(9.050)	(7.140)	(7.562)	(7.267)	(7.274)
N	39	39	39	39	39	39	39	39
Adj. R^2	0.633	0.629	0.629	0.624	0.708	0.707	0.704	0.691

Source: SLOOS (2005Q1 - 2018Q4, excludes gfc), Robust SE in parentheses: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

associated with a quarterly increase in the net % of banks charging a higher spread over their cost of loans by 3-5% points. Note that the estimated correlations do not change despite controlling for all the possible macroeconomic, monetary and market sentiment variables. Also, in harmony with the previous results, large banks tend to have higher spreads' response than all the banks in the SLOOS sample.

Zooming in on the increase in spreads, banks particularly want to get rid of the riskier loans in their books. In table 4, I estimate the effect of ER uncertainty for the net % of banks increasing premium charged on their riskier loans. It has been documented in the literature (by [Niepmann and Schmidt-Eisenlohr, 2019]), that US banks sell most of their commercial and industrial loans in the syndicated loans market within 30 days of origination, *especially the riskier ones*. Hence, secondary market channel as explained in section 3.2, suggests that US banks charge a higher premium for their riskier loans in times with greater pipeline risk (due to higher ER uncertainty). Indeed, using table 4, I estimate that a one standard deviation increase in the ER volatility is associated with a quarterly increase in the net % of banks reporting higher premiums on risky loans by 3-4.5% points. The results are robust to addition of all the possible confounding variables and are much stronger for large banks. Again, the higher premiums are not in response to market volatility, interest rate changes or worse economic outlook.

The SLOOS data helps us to understand the qualitative effects of ER Uncertainty in so far as times of higher uncertainty are positively correlated with survey variables that entail issuance of new loans at stricter terms and hence a 'negative supply of loanable funds effect' from the US banks. Also, the results show that the effects are mainly driven by ER "uncertainty" and not level changes (appreciation in the USD). Neither are the results due to worse market stability or macroeconomic outlook. Hence, the SLOOS survey provides

Table 4: SLOOS: Effect on Net % of banks increasing premiums on riskier loans

	Large Banks				All Domestic Banks			
$Vol(ER)_t$	41.97**	44.00**	48.15*	45.31*	27.16**	26.86*	29.97*	28.00*
	(19.34)	(21.01)	(25.28)	(23.40)	(13.12)	(14.52)	(16.60)	(16.00)
$\Delta_1(ER)_t$	0.0345	-0.0356	-0.00419	-0.200	0.0820	0.0207	0.0383	-0.0540
	(0.749)	(0.821)	(0.853)	(0.833)	(0.573)	(0.583)	(0.602)	(0.583)
X_{t-1}	0.611***	0.592***	0.593***	0.635***	0.619***	0.650***	0.647***	0.686***
	(0.108)	(0.127)	(0.129)	(0.131)	(0.147)	(0.151)	(0.153)	(0.146)
$\Delta_1 l(VIX)_t$		-7.526	-7.530	-8.949		-6.271	-6.306	-7.310
		(8.361)	(8.468)	(9.028)		(5.601)	(5.559)	(5.120)
$\Delta_1 EBP_t$		3.357	4.196	10.32		6.886	7.418	11.03
		(11.57)	(11.69)	(12.75)		(7.144)	(7.029)	(7.795)
$\Delta_1 FFR_t$			-2.707	-7.096			-1.929	-4.327
			(7.048)	(7.837)			(3.961)	(4.209)
$\Delta_1 TS_t$				-12.51*				-7.075
				(6.976)				(4.227)
$\Delta_1 UO_t$				8.409				5.721
				(27.86)				(16.52)
_cons	-17.37***	-18.24***	-19.19**	-18.54**	-10.88**	-10.68**	-11.42**	-11.00**
	(5.809)	(6.431)	(7.417)	(6.950)	(4.103)	(4.559)	(4.979)	(4.856)
N	39	39	39	39	39	39	39	39
Adj. R^2	0.479	0.459	0.445	0.485	0.493	0.493	0.480	0.508

Source: SLOOS (2005Q1 - 2018Q4, excludes gfc), Robust SE in parentheses: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

suggestive insights that, higher volatility in the major currencies index is perceived as a cause of concern by the senior loan officers at US banks who seem to impose tighter lending standards in such times.

4 Empirics 2: Quantitative Effects

In the first part of empirics, I have found substantial suggestive evidence (using DealScan data), that US banking is significantly integrated with foreign banks and institutional investors in the syndicated market for loans. This exposes US banks to exogenous changes in the secondary market to the extent that they rely on syndicates to gather supply of loanable funds for their borrowers. Thus, higher the volume of loans that US banks try financing through syndicates, more sensitive they would be to anything happening in the SLM. Next, USD being a global currency, any fluctuations in its' second moment indicates 'global risk' in the foreign value of the USD. This incites a response from foreign banks which has implications for supply of loanable funds in the SLM. In particular, foreign banks retrench and US banks face greater burden to finance the borrowers with their limited funds. Thus, US banks tighten their credit standards in times with high ER uncertainty (as shown using SLOOS data) to optimally funnel their limited supply of loanable funds.

Thus far, the analysis of this mechanism has been mainly qualitative and suggestive at best. To identify the quantitative implications of ER uncertainty for the US banking sector, I need a more rigorous identification exercise. The main aim is to find the price and quantity effect of ER uncertainty for the US banking sector. This is important because any changes in US banks' balance sheets or bank margins have important real effects for US market sentiments, macroeconomic outcomes and hence the US GDP.

I use the call reports data on US bank balance sheets to investigate the quantitative effect of ER uncertainty for US Banks' in the second part of empirics.

Call Reports: Response of US Banks

Quarterly data on commercial banks' balance sheet and income statements is taken from U.S. call reports data[15] for more than two decades -1995Q1-2019Q3. I consider a sample of largest US commercial banks with average assets greater than 10 billion and at least 7 years of data. It is an unbalanced panel of top 40-70 banks with at least 20% loan to asset ratio. Since bank asset distribution is highly skewed, this sample accounts for majority (60%) of the US commercial banking asset base[16]. A typical bank balance sheet for the banks in my sample is shown in table 5. Majority of the assets comprise of loans and securities, while liabilities are a sum of domestic deposits and equity. Core deposits[17] are 70% of the total liabilities, and earning assets[18] are 90% of the assets. I use earning assets (EA) to normalize the variables whenever required.

Table 5: Typical Bank Balance Sheet

Assets	**Liabilities**
Loans (60%) Securities (20%)	Deposits (80%) Equity (10%)
Cash (5%) Earning Assets (90%)	Core Deposits (70%)

4.1 Identification Mechanism

US commercial banks are exposed to ER uncertainty through their participation in the SLM. The US banks issue new loans, and sell a large portion of the loans they originate, to participants in the SLM. Most of the loans are off-loaded (sold) within 30 days of origination. I identify the ER uncertainty channel using *differential exposure* of such US commercial banks to ER uncertainty through *heterogeneity in their reliance* on the SLM.

The Call-Reports data provides a measure of 'Loans Available for Sale', however since it is not well populated for all the observations, I instead use data on lagged value of 'Loans-to-Interest-Earning-Assets' to measure the heterogenous exposure of the banks in my sample to ER uncertainty. Note that banks with higher loans are also the ones with higher loans-held-for-sale[19]. I then interact this exposure measure with level and volatility changes in the major currencies exchange rate index to measure the impact of exchange rate uncertainty on a number of dependent variables, controlling for level changes in the index. This is a *Bartik instrument* identification a lá [Goldsmith-Pinkham et al., 2018] using lagged values of the heterogenous 'exposure/ share' measure. The lag helps to ensure exogeneity in the shares which is key to the identification. By construction, the lagged values of loans to earning assets are from the time period before the exchange rate changes. As a result, this does not allow for quantity adjustments of exposure at time $t-1$ in response to ER level and volatility changes at time t[20].

[15] Compiled using codes from [Drechsler et al., 2018]

[16] Since I do not want to get bias due to mergers and acquisitions, or outliers - the sample does not include observations with very high asset growth rates.

[17] Defined as the sum of total transaction accounts, money market deposit accounts, other non transaction saving accounts, insured range of time deposits and brokered deposits.

[18] Defined as the sum of interest earning balance, fed funds loans, trading assets and securities.

[19] Loans and Loans held for sale have a significant and strong positive correlation of 0.7 using observations with data on both.

[20] I allow for different variations in my exposure variable to include 4 quarter lags, average of previous 4 quarters, 2 years lag - and they all yield similar results.

The main aim is to get a clear estimation for the *price and quantity effects of ER uncertainty* for the US banking sector. I measure the price effects using changes in *bank margins* and quantity effects using quarterly growth rates of balance sheet components over 4-6 quarter horizon. This also helps to dis-entangle the key mechanism of ER uncertainty channel as a supply side (not a demand side) effect.

A prerequisite for correct identification is to rule out any confounding effects coming from reasons other than the channel proposed in this paper. I include both bank and time fixed effects in my regressions. Time fixed effects help to rule out any other 'macroeconomic channels' driven by business cycles or monetary policies. They also help to ensure robustness to recession effects[21]. Bank fixed effects control for any bank specific idiosyncrasies that might confound the key channel. The channel I propose in this paper, is a fairly general mechanism for a typical large US bank and bank fixed effects help to make sure that things like managerial differences, bank location, scale of the banks or any other bank specific attributes not related to the secondary market channel are duly purged off. All my regressions are size-weighted. Finally, towards the end of this section, I rule out alternate explanations, which could impair my channel. I find that for the US banks' response to ER uncertainty (measuring global risk) is quite distinct from their response to stock market volatility (local risk) or fluctuations in market pessimism.

In the next two sections, let us understand the estimated price and quantity effects of ER uncertainty for my sample of US banks. From the qualitative analysis, it is quite evident that we expect an increase in bank margins (best proxy for bank spreads) in times with higher ER uncertainty. Quantity effects on bank assets, loans or deposits are not so obvious, but the estimation will shed light on them and therefore help us understand if the mechanism affecting the US primary loans market is mainly driven by decreased supply or increased demand.

4.2 Effect of ER Uncertainty on US Bank Margins

In this section, I estimate the price effect of ER uncertainty using bank margins. Bank margin captures the difference between interest income on assets and interest expenses for the banks. First, I define bank margins formally. Next, I set up the main regression based on the identification mechanism explained above and estimate the annualized effect of ER uncertainty on bank margins controlling for any level changes (i.e. USD appreciation). Finally, I decompose the estimated effect into income and expense components of the bank margins to determine which component is driving the estimated effects on margins.

Bank margin or *net interest margin* (NIM) is measured as the ratio of banks' net interest income to interest-earning-assets (IEA). Net interest income is the difference between interest income on assets (IIA) and interest expenses (IE). The quarterly average IIA is 1.5% of earning asset, and the quarterly average IE is 0.5% of earning asset in my sample. This leads to an average annualized NIM of 3.6 % with standard deviation equal to 0.35%. I consider 'h' quarter changes in each of net interest income (NII), IIA and IE normalized by interest-earning-assets, as the dependent variables (Y_{it}) to understand the h-quarter price effects of ER uncertainty in quarter t for bank i.

$$\Delta_h Y_{it} = \frac{Y_{i,t+h} - Y_{i,t-1}}{IEA_{i,t-1}} * 100, \qquad \forall Y \in \{NII, IIA, IE\} \tag{6}$$

The exposure for bank i at time t is defined as the ratio of their loans (L) to interest earning assets. Lagged values of exposure will be used. Results are robust to using 1 quarter or 4 quarter moving average lags in this exposure variable. The results for 4 lag

[21] I separately check robustness to recessions by running the same regressions with and without recessions and my results still go through.

moving average are summarized in the appendix A. Here I shall present the results for one quarter lagged exposure defined as follows,

$$E_{i,t-1} = \frac{L_{i,t-1}}{IEA_{i,t-1}}$$

I control for 4 one period lagged differences in the dependent variable to remove the effects due to any events prior to quarter t's exchange rate uncertainty. This is possible primarily because I have a long enough time series. The main regression for estimating price effects is as follows,

$$\begin{aligned} \Delta_h Y_{it} = &\alpha_i + \delta_t + \beta(E_{i,t-1} * Vol(ER)_t) + \gamma(E_{i,t-1} * \Delta_1 ER_t) + \\ &\theta E_{i,t-1} + \sum_{l=0}^{l=3} \psi^l \Delta_0 Y_{i,t-l} + \epsilon_{it}, \quad \forall Y \in \{NII, IIA, IE\} \end{aligned} \tag{7}$$

where $Vol(ER)_t$ is the standard deviation of daily returns for major currencies ER index during quarter t, and $\Delta_1(ER_t)$ is the difference in the mean value of the ER index for quarter t and $t-1$. The main coefficient of interest is β which helps to identify the differential effect of a standard deviation increase in $Vol(ER)_t$ for a low versus high exposure bank for each of the dependent variable. Clustered standard errors by banks are used to evaluate significance of the coefficients. The summary statistics for Exposure, Volatility and Level changes are shown in Table 6.

Table 6: Summary Statistics for Explanatory Variables

Variable	N	Mean	SD	Min	Max
E_{it} (Loans/IEA)	4217	.72	.12	.20	.99
$\Delta_1(ER)$	4371	-.0015	2.61	-5.31	7.96
$Vol(ER)$	4371	.36	.11	.15	.89

The results for regression (7) for each of the dependent variables are summarized in the following Tables 7, 8, 9 respectively for 1-4 quarter effects. The 'Annualized Effect' row summarizes the annualized effect of one standard deviation increase in the volatility in ER for the bank with average level of exposure (units in percentage points).

Table 7: Call Reports: Effect on Bank Margins

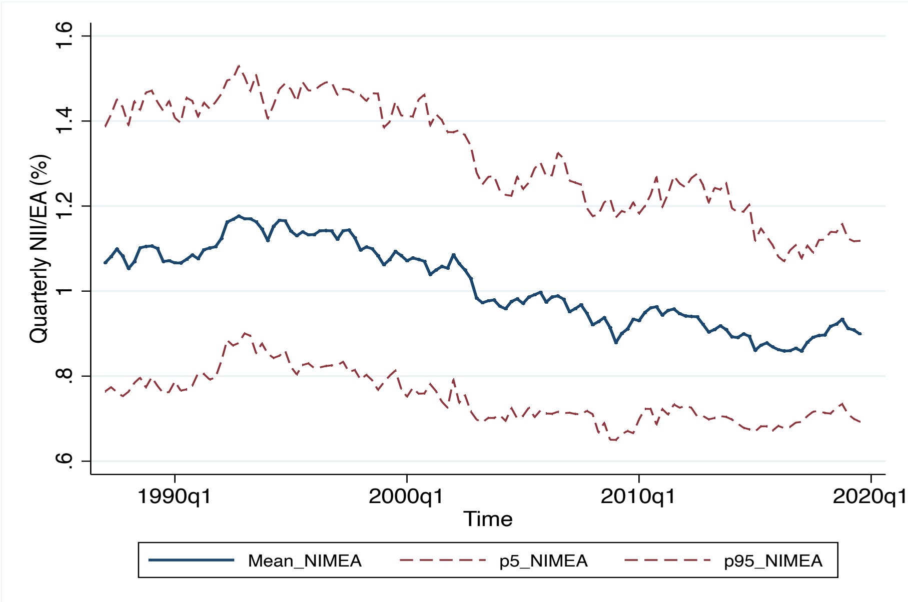
	Δ_1NII	Δ_2NII	Δ_3NII	Δ_4NII
$E_{i,t-1} \times Vol(ER)_t$	0.329	1.163***	1.075***	1.247**
Annualized Effect (bps)	**5.2**	**12*****	**8.5*****	**7.9****
	(0.240)	(0.353)	(0.402)	(0.527)
$E_{i,t-1} \times \Delta_1 ER_t$	0.02*	-0.007	-0.014	-0.013
	(0.01)	(0.02)	(0.03)	(0.02)
$E_{i,t-1}$	-0.08	-0.41***	-0.36***	-0.39*
	(0.08)	(0.11)	(0.12)	(0.22)
# Obs	3354	3304	3272	3228
Adj R-squared	0.43	0.36	0.31	0.31
Time FE	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y

Clustered SE in parentheses (*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$)

Note that a one standard deviation increase in ER uncertainty leads to an annualized increase of $\approx$ 10 bps in the bank margin for a bank with average exposure of 0.72. Dividing this by the standard deviation in the dependent variable, I find that the effect of ER uncertainty equals half of the standard deviation for the dependent variable. Moreover, a bank at 95th percentile of exposure responds with 5 bps higher annualized NIM than a bank at the 5th percentile in response to one standard deviation increase in ER uncertainty.

To put these estimates in perspective, I highlight the *slow moving aspect of bank margins* using the following figure 9. The figure summarizes the mean, 5th percentile and

Figure 9: Net Interest Income to Interest Earning Assets Ratio



95th percentile for the quarterly net interest income to interest earning asset ratio for my sample of large US commercial banks. The results for my channel, are based on a regular ongoing phenomena (not a one time shock) since volatility in exchange rates deviates from its' mean by one standard deviation roughly 1/3rd of the time periods. Also, the banks are responding to *second moment changes in ER* and the increase in bank margins is not due to mere level changes i.e. dollar appreciation. This is evident from non-significant coefficients for the interaction term with exposure times level changes in ER. This fortifies the qualitative evidence from SLOOS, that banks increase spreads in times with higher ER uncertainty, controlling for the level effects. Note that net interest margin is the closest proxy variable for 'spreads' in the Call-Reports data[22].

To further understand what is driving the increase in the net interest income, I separately summarize the effects on IIA and IE components of NII. While income side is coming from bank assets, expenses are mainly due to debt and deposits. The estimated regressions are summarized in table 8 and 9. I find that the key driver for increase in banks' NIM is the interest income from loans and securities. Interest expenses do not respond much over long horizons to higher volatility in ER.

From Table 8, it is clear that a one standard deviation increase in the ER uncertainty increases the annualized interest income on assets by $\approx$ 15 bps for a large US bank with average level of exposure. The difference between the response of 95th and 5th percentile exposure bank is 6 bps in this case. Thus, banks with greater exposure tend to have higher

[22] In principle, it comprises of both bank markups and default premiums, so these results cannot decompose the effect on each of these components.

Table 8: Call Reports: Effect on Interest Income on Assets

	Δ_1IIA	Δ_2IIA	Δ_3IIA	Δ_4IIA
$E_{i,t-1} \times Vol(ER)_t$	0.526^{*}	1.400^{***}	1.372^{**}	1.446^{**}
Annualized Effect (bps)	**8.3***	**14.8*****	**10.9****	**9.2****
	(0.30)	(0.44)	(0.58)	(0.68)
$E_{i,t-1} \times \Delta_1 ER_t$	0.022	-0.008	-0.023	-0.024
	(0.015)	(0.028)	(0.039)	(0.029)
$E_{i,t-1}$	-0.16	-0.56^{***}	-0.56^{**}	-0.61^{*}
	(0.10)	(0.16)	(0.22)	(0.33)
# Obs	3354	3304	3272	3228
Adj R-squared	0.54	0.5	0.5	0.54
Time FE	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y

Clustered SE in parentheses ($^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$)

interest income from loans in response to higher ER uncertainty. Again, level changes in the ER index have no significant effect once second moment effects are accounted for.

Table 9: Call Reports: Effect on Interest Expenses

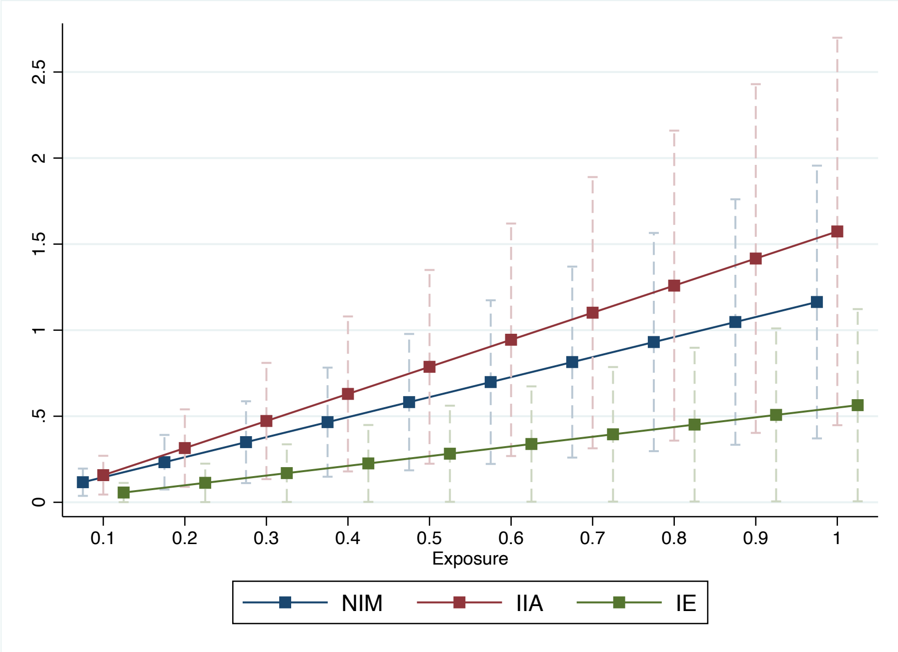
	Δ_1IE	Δ_2IE	Δ_3IE	Δ_4IE
$E_{i,t-1} \times Vol(ER)_t$	0.23^{*}	0.36^{*}	0.47	0.38
Annualized Effect (bps)	**3.6***	**3.8***	**3.7**	**2.4**
	(0.119)	(0.181)	(0.303)	(0.293)
$E_{i,t-1} \times \Delta_1 ER_t$	0.0005	-0.002	-0.011	-0.013
	(0.005)	(0.009)	(0.015)	(0.01)
$E_{i,t-1}$	-0.11^{**}	-0.21^{***}	-0.31^{**}	-0.33^{**}
	(0.04)	(0.08)	(0.12)	(0.15)
# Obs	3354	3304	3272	3228
Adj R-squared	0.71	0.70	0.73	0.78
Time FE	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y

Clustered SE in parentheses ($^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$)

As for expenses, Table 9 shows no significant effect of ER uncertainty after 2 quarters. There is a preliminary effect of 3 bps annualized increase in interest expenses on debt and deposits in response to second moment changes and no effect from level changes for any horizon.

To summarize, higher ER uncertainty leads to higher net interest margins driven mainly by higher interest income on loans/ assets as shown in figure 10. The effect is higher for a more exposed bank vis-á-vis banks with lower loans to earning assets ratio. Increased exposure entails greater 'pipeline burden' for the US bank to off-load their loans in the secondary market where higher ER uncertainty is causing all the foreign banks and institutional investors to retrench from supplying funds. Faced with limited resources at their disposal, US banks may tighten their lending standards via increased 'spreads'. The mechanism would not be well understood unless 'quantity effects' are estimated. It is

Figure 10: Call Reports: Marginal Effect of Vol(ER) on NII, IIA and IE by Exposure



not obvious if the increased interest income is due to higher spreads or greater quantity of loans. To dis-entangle the forces behind the mechanism, it is imperative to find the response of US banks' balance sheet variables, which I show in the next section.

4.3 Effect of ER Uncertainty on US Bank Balance Sheet

The main components of a typical large US banks' balance sheet were explained in table 5 above. In this section, I consider each of the major components on *assets and liabilities* side and use my identification strategy to quantify the effect of ER uncertainty on the growth rates of each of the balance sheet variables over 1-6 quarter horizon. The dependent variable for 'quantity effects' regressions (Z_{it}) is given as follows:

$$\Delta_h \log Z_{it} = \log(Z_{i,t+h}) - \log(Z_{i,t-1}) \quad \forall Z \in \{A, L, S, CD, E\} \tag{8}$$

where Z is taken to be loans(L), securities(S), or assets(A) on the assets side and core deposits (CD) and equity (E) on the liability side. The exposure variable is same as the one use for spreads regression (7) above. Again, the results for 4 quarter moving average exposure are quite similar and summarized in the appendix A. The main panel data regression for understanding quantity effects is as follows,

$$\begin{aligned}\Delta_h \log Z_{it} = \alpha_i + \delta_t + \beta(E_{i,t-1} * Vol(ER)_t) + \gamma(E_{i,t-1} * \Delta_1 ER_t) + \theta E_{i,t-1} + \\ \sum_{l=0}^{l=3} \psi^l \Delta_0 \log Z_{i,t-l} + \epsilon_{it}, \qquad \forall Z \in \{A, L, S, CD, E\}\end{aligned} \tag{9}$$

These regressions are also size weighted, and include bank and time fixed effects. The standard errors are clustered at bank level and the summary statistics used for interpretation of the coefficients are same as those in table 6. I remove any outliers in the dependent variables before running the regressions. Again, the second row summarizes the 'annualized effect' of one standard deviation increase in volatility in ER for the bank with average level of exposure (in percentage).

Asset Side Results

Overall assets in US banks contract during times with higher ER uncertainty as summarized in table 10. The effect is persistent 6 quarters out, and not driven by level changes.

Table 10: Call Reports: Effect on Asset Growth for US Banks

	Δ_1A	Δ_2A	Δ_3A	Δ_4A	Δ_5A	Δ_6A
$E_{i,t-1} \times Vol(ER)_t$	-0.084**	-0.116*	-0.222*	-0.259*	-0.591***	-0.572**
Annualized Effect (%)	**-1.33****	**-1.22***	**-1.76***	**-1.64***	**-3.12*****	**-2.56****
	(0.038)	(0.067)	(0.112)	(0.136)	(0.217)	(0.267)
$E_{i,t-1} \times \Delta ER_t$	0.002	0.001	0.007**	0.008	0.007	0.003
	(0.003)	(0.003)	(0.004)	(0.006)	(0.008)	(0.012)
$E_{i,t-1}$	0.052***	0.063*	0.110**	0.109*	0.217***	0.252***
	(0.019)	(0.034)	(0.051)	(0.061)	(0.071)	(0.085)
# Obs	3051	2996	2968	2923	2886	2852
Adj R-squared	0.42	0.37	0.31	0.21	0.14	0.12
Time FE	Y	Y	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y	Y	Y

Clustered SE in parentheses ($^*p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$)

A one standard deviation increase in ER volatility leads to an annualized decline in asset growth ranging from 1.5-3% for the average exposure US Bank in my sample. The bank at 95th percentile of loans to earning assets ratio responds with 0.7-1.5% greater decline in asset growth than the 5th percentile exposure bank. Note that the explanatory variables in the assets regression have lower explanatory power for asset growth as the horizon increases since the adjusted R^2 declines with h.

Next, let us decompose the effect of ER uncertainty on growth in loans and securities. Table 11 summarizes the results for growth in loans. The growth in loan declines over 6

Table 11: Call Reports: Effect on Loans Growth for US Banks

	Δ_1L	Δ_2L	Δ_3L	Δ_4L	Δ_5L	Δ_6L
$E_{i,t-1} \times Vol(ER)_t$	0.03	-0.23	-0.33*	-0.44**	-0.81***	-1.15***
Annualized Effect(%)	**0.42**	**-2.4**	**-2.6***	**-2.8****	**-4.3*****	**-5.2*****
	(0.0487)	(0.149)	(0.195)	(0.216)	(0.237)	(0.352)
$E_{i,t-1} \times \Delta ER_t$	0.001	0.005	0.009	0.002	0.003	-0.006
	(0.003)	(0.007)	(0.009)	(0.013)	(0.012)	(0.020)
$E_{i,t-1}$	-0.11**	-0.22**	-0.39**	-0.41**	-0.60**	-0.86**
	(0.048)	(0.092)	(0.152)	(0.174)	(0.293)	(0.410)
# Obs	2905	2864	2840	2813	2790	2761
Adj R-squared	0.514	0.412	0.284	0.199	0.165	0.138
Time FE	Y	Y	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y	Y	Y

Clustered SE in parentheses ($^*p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$)

quarters, in response to ER uncertainty, albeit with a lag of 1-2 quarters. The retrenchment from the foreign banks creates greater 'pipeline burden' for US banks as they are compelled to delay their off-loading to the secondary market. As a result there is a temporary insignificant rise in the loans held in US banks' balance sheets. However, as time passes and banks are able to make adjustments, the growth in loans declines suggesting a drop in new issuances of loans. At the same time, a drop in the growth in loans with a rise in the interest income on assets (as shown in table 8) means that 'spreads/ premium', on loans increases during periods with higher ER uncertainty. This aligns with the evidence from SLOOS where banks tighten their credit standards, increase spreads and charge a higher risk premium during high ER uncertainty. Quantitatively, a one standard deviation increase in the exchange rate volatility leads to an annualized drop of 3-5% in the growth of loans over 6 quarters. The effects is greater for more exposed banks. In particular, banks with greater loans in their books to begin with, will be more constrained by the bottlenecks due to lack of loanable funds supply, in times with higher ER uncertainty. Consequently, the banks at 95th percentile of loans to earning asset ratio respond with a 1.5-2.5 % greater drop in the growth of loans vis-á-vis the banks at 5th percentile of exposure.

Securities are more flexible to shrink (compared to loans) in times when US banks are trying to reduce the size of their books, in response to uncertainty coming to them through the SLM. Hence, securities see an annualized drop of 9-11 % for an average exposure bank

Table 12: Call Reports: Effect on Securities Growth for US Banks

	Δ_1S	Δ_2S	Δ_3S	Δ_4S	Δ_5S	Δ_6S
$E_{i,t-1} \times Vol(ER)_t$	-0.59**	-1.01**	-1.76**	-1.70***	-1.84***	-2.03***
Annualized Effect (%)	**-9.2****	**-10.6****	**-13.9****	**-10.8*****	**-9.7*****	**-9.2*****
	(0.26)	(0.40)	(0.67)	(0.37)	(0.35)	(0.47)
$E_{i,t-1} \times \Delta ER_t$	0.010	0.001	-0.001	-0.018	-0.028	0.003
	(0.014)	(0.015)	(0.013)	(0.019)	(0.024)	(0.026)
$E_{i,t-1}$	0.161	0.280	0.396	0.325	0.310	0.237
	(0.145)	(0.199)	(0.368)	(0.287)	(0.279)	(0.373)
# Obs	3291	3232	3196	3151	3115	3074
Adj R-squared	0.42	0.24	0.23	0.24	0.19	0.22
Time FE	Y	Y	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y	Y	Y

Clustered SE in parentheses ($^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$)

in response to one standard deviation higher ER volatility. To summarize, assets side of the bank balance sheet contract, indicating increased 'spreads' to explain higher interest income on assets. This also suggests that the ER uncertainty acts more like a supply side deterrent, in so far as higher prices and lower quantity is observed for the US banks. However, this conclusion is not yet full proof unless we also understand the implication for bank liabilities. In particular, it is important to see what happens to banks' domestic and core deposits in times with higher ER uncertainty. In the next section, I analyze the effect of ER uncertainty for the components on the liability side of banks' balance sheet.

Liability Side Results

Core Deposits do not change significantly in response to changes in levels or volatility of ER Index. This is shown in table 13. This is quite intuitive as both the parties in a deposits' transaction (be it depositors or US banks) are mostly operating in US dollars. Hence there is not much of an effect coming from the core deposits side of the US bank balance sheet.

As a result, decline in equity balances out the contraction on the assets side of the US bank balance sheet as summarized in table 14. The annualized growth in equity declines

Table 13: Call Reports: Effect on Core Deposits Growth for US Banks

	Δ_1CDep	Δ_2CDep	Δ_3CDep	Δ_4CDep	Δ_5CDep	Δ_6CDep
$E_{i,t-1} \times Vol(ER)_t$	-0.035	0.073	0.282	0.240	0.543	0.838
	(0.055)	(0.179)	(0.229)	(0.254)	(0.695)	(0.992)
$E_{i,t-1} \times \Delta ER_t$	0.0007	0.0002	0.001	0.0145*	0.01	-0.014
	(0.004)	(0.011)	(0.010)	(0.008)	(0.014)	(0.026)
$E_{i,t-1}$	0.013	0.031	-0.028	-0.019	-0.177	-0.082
	(0.024)	(0.061)	(0.115)	(0.175)	(0.312)	(0.407)
# Obs	3298	3235	3198	3157	3119	3079
Adj R-squared	0.44	0.24	0.10	0.13	0.08	0.10
Time FE	Y	Y	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y	Y	Y

Clustered SE in parentheses ($^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$)

Table 14: Call Reports: Effect on Equity Growth for US Banks

	Δ_1E	Δ_2E	Δ_3E	Δ_4E	Δ_5E	Δ_6E
$E_{i,t-1} \times Vol(ER)_t$	-0.11*	-0.28***	-0.25*	-0.35**	-0.78***	-0.56**
Annualized Effect(%)	**-1.8***	**-2.9*****	**-1.96***	**-2.24****	**-4.09*****	**-2.51****
	(0.062)	(0.084)	(0.147)	(0.160)	(0.261)	(0.267)
$E_{i,t-1} \times \Delta ER_t$	0.002	-0.002	-0.008	0.001	0.016	0.011
	(0.003)	(0.005)	(0.006)	(0.008)	(0.012)	(0.012)
$E_{i,t-1}$	0.074***	0.157***	0.179**	0.182	0.298**	0.297**
	(0.021)	(0.04)	(0.08)	(0.114)	(0.119)	(0.133)
# Obs	2949	2858	2797	2721	2655	2592
Adj R-squared	0.49	0.37	0.33	0.27	0.24	0.23
Time FE	Y	Y	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y	Y	Y

Clustered SE in parentheses ($^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$)

by 2-3% over 6 quarters in response to one standard deviation increase in ER volatility for a US bank with average exposure. The decline for 95th percentile exposure is 1% more than that for the 5th percentile of exposure bank.

There does not seem much of an effect coming from through the bank liabilities. This is quite logical considering that the SLM effect spillover via loans and retrenchment of foreign banks. The USD uncertainty has no direct bearing for the transactions dominated by domestic players mainly dealing in USD anyway. At the same time, US Banks face repercussions on their book equity. This has substantial spillover effects for the entire banking sector as the largest banks with majority of the assets get affected by the ER uncertainty. Banking sectors' assets distribution is typically skewed, and any channel operating through large banks has consequences for the entire banking sector and therefore entails significant financial and real economic consequences.

Ex-ante it was not obvious how the US banks' would respond to ER uncertainty in terms of each of the variables in the balance sheet. But the above analysis helps us to conclude that an average exposure banks' 'loans to deposits' ratio falls by 4-5% (annualized) in response to one standard deviation higher volatility in major currencies ER index. The regressions with growth in loans to deposit ratio as the dependent variable are summarized in table 15. Banks either shrink or rely less on secondary market fund-

Table 15: Call Reports: Effect on Loans/ Deposits ratio for US Banks

	Δ_1L/D	Δ_2L/D	Δ_3L/D	Δ_4L/D	Δ_5L/D	Δ_6L/D
$E_{i,t-1} \times Vol(ER)_t$	-0.34***	-0.44**	-0.62***	-0.54**	-0.63***	-0.87***
Annualized Effect(%)	**-5.3*****	**-4.6****	**-4.9*****	**-3.4****	**-3.3*****	**-3.9*****
	(0.121)	(0.179)	(0.212)	(0.221)	(0.226)	(0.230)
$E_{i,t-1} \times \Delta ER_t$	0.002	-0.004	0.001	-0.012	-0.008	-0.009
	(0.003)	(0.009)	(0.012)	(0.013)	(0.011)	(0.01)
$E_{i,t-1}$	0.009	-0.037	-0.045	-0.112	-0.183	-0.156
	(0.045)	(0.087)	(0.109)	(0.126)	(0.163)	(0.170)
# Obs	2905	2864	2840	2813	2790	2761
Adj R-squared	0.43	0.35	0.26	0.25	0.19	0.22
Time FE	Y	Y	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y	Y	Y

Clustered SE in parentheses ($^*p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$)

ing to maintain lending. The effect is quite persistent, and higher for banks with greater exposure. The bank with 95th percentile of exposure has a 2% points greater decline in response to one standard deviation increase in ER uncertainty than the bank with 5th percentile of exposure.

Finally, all the results suggest that once we account for the second moment changes in the ER, the bank responses are not driven as much by level changes in the ER (i.e. appreciation of the USD), as they are by the *significant first order effects of second moment changes*. Thus, the results in this paper shed new light on the interpretation of the 'Secondary Market Channel' proposed by [Niepmann and Schmidt-Eisenlohr, 2019] who study the effects of USD appreciation on US banking through the secondary market responses by foreign banks and institutional investors. This paper shows that it is important to consider the effects of ER uncertainty as much as dollar appreciation.

5 Empirics 3: USD as the "Global Risk Indicator"

So far I haven't considered whether the foreign banks are retrenching specifically in response to *exchange rate uncertainty*, or the underlying reason is something else entirely. An alternative explanation could be that ER uncertainty is plausibly correlated with 'general uncertainty in the US stocks/ bonds markets' and that is the underlying cause for the observed behavior of the foreign and US banks.

While I already rule out alternate macro-economic effects using time fixed effects in the above analysis, a more careful robustness check is essential. In this section, I show that indeed there is something special about the ER. USD is an important "Global Risk Indicator" and ER movements are crucial to the proposed syndicated loans channel. I do so, by allowing for additional variables like level and volatility changes in S&P 500, and changes in the excess bond premium á la [Gilchrist et al., 2016] in my interaction terms for the regressions.

5.1 Robustness to "US Stock Market Uncertainty"

If ER uncertainty were merely an outcome of the US stock market uncertainty, I should get the coefficients for volatility in exchange rate rendered insignificant once I account for the volatility in S&P 500. The main results can be summarized using three of the above variables (NIM, assets growth and loans to deposit ratio) as dependent variables.

I find the quantitative effect of ER uncertainty on NIM does not change with the addition of US stock market volatility in the regression. In fact, the volatility and level

Table 16: Call Reports: NIM (not driven by US Stock Market Volatility)

	Δ_1NII	Δ_2NII	Δ_3NII	Δ_4NII
$E_{i,t-1} \times Vol(ER)_t$	0.33	1.11***	0.84***	1.42***
Annualized Effect (bps)	**5**	**12*****	**7*****	**9****
	(0.22)	(0.39)	(0.29)	(0.41)
$E_{i,t-1} \times Vol(SP500)_t$	0.008	0.001	0.008	0.015
	(0.008)	(0.008)	(0.011)	(0.013)
$E_{i,t-1} \times \Delta_1 SP500_t$	0.001**	0.0003	0.0003	0.002*
	(0.0005)	(0.0002)	(0.0006)	(0.001)
$E_{i,t-1} \times \Delta_1 ER_t$	0.027**	-0.004	-0.017	-0.015
	(0.013)	(0.023)	(0.013)	(0.022)
$E_{i,t-1}$	-0.24	-0.42***	-0.36**	-0.69*
	(0.21)	(0.11)	(0.16)	(0.37)
# Obs	3330	3279	3243	3200
Adj R-squared	0.33	0.30	0.31	0.29
Time FE+Bank FE	Y	Y	Y	Y

Clustered SE in parentheses: (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$)

changes in S&P 500 do not have significant effect on bank margins. The results are summarized in table 16 and comparing it with table 7 fortifies the idea that indeed, USD uncertainty is an indicator for "global risk" and that it has repercussions for the US banks' margins through the secondary market channel.

On the quantity side, using tables 17 and 18, I find that the effects of ER uncertainty on balance sheet components is immune to the addition of US stock market volatility. If anything, the quantitative effects of volatility in S&P 500 are in the opposite direction of volatility in the "global risk indicator". Level changes in both market volatility and global risk have no bearing on banks' responses, once I account for the *second moment effects*. A one standard deviation increase in the ER uncertainty still leads to 3-4% higher growth in assets for an average exposure banks as summarized in table 17, which is similar to the results I got in table 10. The effect is driven by a drop in a growth for both

Table 17: Call Reports: Assets (US Stock Market Volatility is expansionary)

	$\Delta_1 A$	$\Delta_2 A$	$\Delta_3 A$	$\Delta_4 A$	$\Delta_5 A$	$\Delta_6 A$
$E_{i,t-1} \times Vol(ER)_t$	-0.16***	-0.26**	-0.42***	-0.52**	-0.88***	-0.84**
Annualized Effect (%)	**-2.6***	**-2.74**	**-3.32***	**-3.31**	**-4.64***	**-3.78**
	(0.058)	(0.107)	(0.155)	(0.226)	(0.287)	(0.317)
$E_{i,t-1} \times V(SP500)_t$	0.004***	0.006***	0.008***	0.019***	0.025***	0.029***
Annualized Effect (%)	3.76***	3.68***	3.78***	6.87***	7.64***	7.62***
	(0.001)	(0.001)	(0.002)	(0.004)	(0.006)	(0.008)
$E_{i,t-1} \times \Delta_1 SP500_t$	≈ 0	-0.0001	-0.0002	0.001***	0.001**	0.001***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0003)	(0.0004)
$E_{i,t-1} \times \Delta_1 ER_t$	0.0001	-0.002	0.0003	0.008	-0.001	-0.004
	(0.003)	(0.004)	(0.004)	(0.008)	(0.008)	(0.012)
$E_{i,t-1}$	0.03	0.045	0.093	-0.067	-0.019	-0.064
	(0.0299)	(0.0492)	(0.0646)	(0.069)	(0.08)	(0.118)
# Obs	3050	2997	2971	2929	2893	2858
Adj R-squared	0.42	0.39	0.32	0.23	0.18	0.14
Time FE +Bank FE	Y	Y	Y	Y	Y	Y

Clustered SE in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

loans and securities in the amount of 3-5% and 15% respectively. Thus, bank balance sheets still shrink despite controlling for the stock market volatility in response to the secondary market channel effects of ER uncertainty. Finally, I also check the robustness of the effects on loan to deposit ratio. ER uncertainty still leads to greater contraction for higher exposure banks, while S&P volatility is accompanied with an expansion in the loans to deposit ratio as shown in table 18.

To summarize, S&P volatility is an indicator of general market volatility in the US which has direct implications for US denominated borrowers, and savers. Its effects on US Bank balance sheets suggest a different channel which is important on its own and definitely worth understanding fully. But, it is beyond the scope of this paper and does not in any way change the inferences or the mechanism proposed in this paper.

5.2 Robustness to "Changes in Excess Bond Premium"

Financial market strains can be best measured using the excess bond premium (EBP) á la [Gilchrist et al., 2016]. In particular, EBP is an indicator of the 'risk bearing capacity' of the financial intermediary sector. In effect, the EBP tries to capture the variation in the average price of bearing U.S. corporate credit risk above and beyond the compensation that investors in the corporate bond market require for expected defaults.

Perhaps, it is this underlying variation in the credit market sentiment that drives the response from foreign banks and the US banking sector and not the ER uncertainty per se. On could argue that foreign banks' aforementioned response in the syndicated loans market is due to worse credit market sentiments which is perhaps correlated with higher

Table 18: Call Reports: Loans/ Deposit Ratio (US Stock Market Volatility is expansionary)

	Δ_1L/D	Δ_2L/D	Δ_3L/D	Δ_4L/D	Δ_5L/D	Δ_6L/D
$E_{i,t-1} \times Vol(ER)_t$	-0.430***	-0.611***	-0.889***	-0.873***	-0.953***	-1.142***
Annualized Effect (%)	**-6.8***	**-6.45***	**-7.04***	**-5.53***	**-5.03***	**-5.17***
	(0.149)	(0.222)	(0.299)	(0.285)	(0.289)	(0.320)
$E_{i,t-1} \times V(SP500)_t$	0.003**	0.009***	0.014***	0.018***	0.020***	0.0214***
Annualized Effect (%)	2.42**	5.57***	6.53***	6.57***	6.18***	5.58***
	(0.0011)	(0.0017)	(0.0024)	(0.0042)	(0.0048)	(0.0051)
$E_{i,t-1} \times \Delta_1 SP500_t$	-0.0003	≈ 0	≈ 0	0.0002	0.0003	0.0004
	(0.0002)	(0.0003)	(0.0003)	(0.0003)	(0.0004)	(0.0004)
$E_{i,t-1} \times \Delta_1 ER_t$	0.0001	-0.005	0.001	-0.014	-0.012	-0.014
	(0.003)	(0.007)	(0.009)	(0.011)	(0.010)	(0.009)
$E_{i,t-1}$	0.018	-0.097	-0.156	-0.265**	-0.358**	-0.359*
	(0.063)	(0.1)	(0.132)	(0.132)	(0.174)	(0.186)
# Obs	2903	2865	2847	2825	2801	2763
Adj R-squared	0.43	0.35	0.27	0.27	0.21	0.23
Time FE + Banks FE	Y	Y	Y	Y	Y	Y

Clustered SE in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

ER uncertainty. While, it is true that financial market sentiments and ER uncertainty are inter-twined as shown in [Caldara et al., 2016]; it would only be a cause of concern if the response of US banking sector to EBP changes were precisely the same as those resulting from our proposed channel.

In this section, I first estimate a vector auto-regression (VAR) to analyze the relationship between EBP and ER uncertainty along the lines of [Caldara et al., 2016][23]. This results in contemporaneous correlation between higher EBP and higher ER uncertainty. Moreover, the VAR specification consolidates the fact that ER uncertainty has important implications for the US economy through its impact on GDP growth for up to a year. Then, in the second part I re-estimate my call-reports regressions with the addition of an interaction term for exposure with changes in the EBP. If the proposed mechanism is driven by changes in EBP instead, the effects due to ER uncertainty should change dramatically or nullify with the addition of this interaction term.

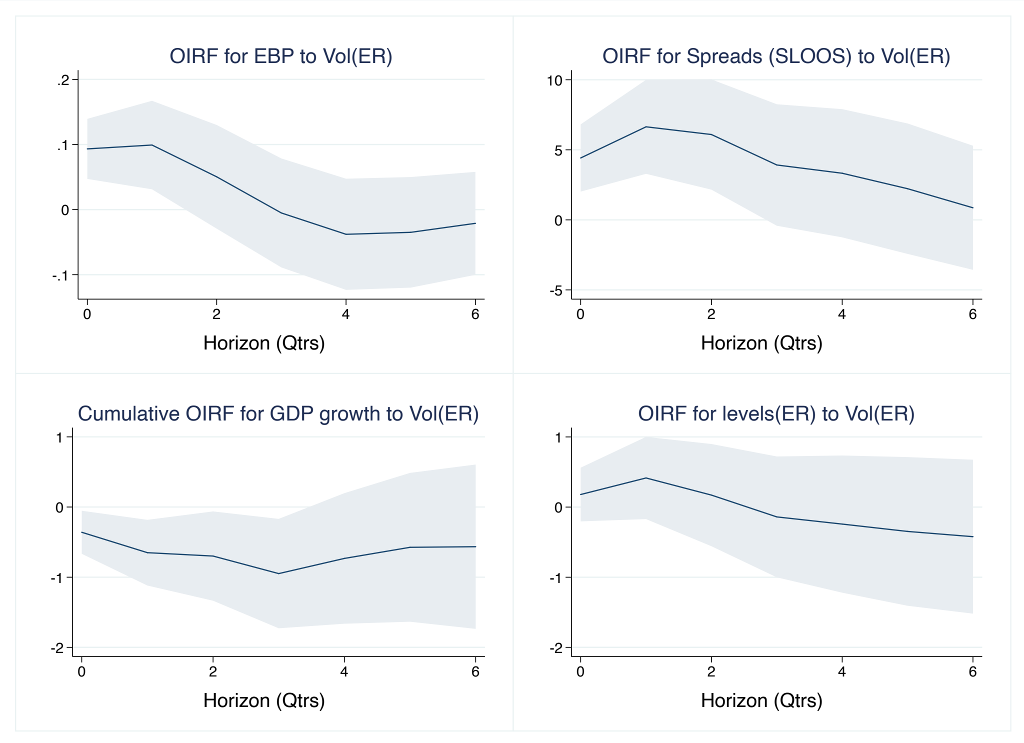
5.2.1 VAR: Financial and Uncertainty Shocks are Inter-twined

For the VAR specification, the main idea is to understand the impulse responses for some relevant variables like EBP, GDP growth and US bank spreads in response to higher ER uncertainty. In particular, I estimate the impulse responses of (1) EBP (2) SLOOS net % of banks that report higher spreads and (3) Cumulative impulse response for quarterly GDP growth rate - to volatility in ER using VAR. I add 1 year and 10 year treasury bill rates, and level changes in the major currencies exchange rate index to the VAR. I follow the recommendation of [Caldara et al., 2016] in setting up my VAR specification whereby volatility in ER is ordered before the EBP. Since uncertainty shocks and spreads are both *fast-moving* variables, [Caldara et al., 2016] suggests that it is difficult to impose plausible zero contemporaneous restrictions to identify these two types of disturbances. The 6 quarter orthogonalized impulse responses (OIRF) from the VAR with 4 lags based

[23] with 7 variables ($Vol(ER)_t$, EBP, SLOOS Spreads Survey Question, GDP growth, 1 and 10 year T-bill rates and $\Delta_1 ER_t$) in that order.

on data from 1990Q4-2018Q4 are shown in Figure 11.

Figure 11: VAR Impulse Responses



A one standard deviation shock to the volatility in major currencies index leads to 10 basis points increase in the EBP over 2 quarters, a 5 pp increase in the net % of banks reporting higher spreads in SLOOS, and a significantly negative drop in quarterly GDP growth rate for 3 quarters by 0.5-1 %. Higher EBP captures the shift in the risk attitude and willingness to intermediate credit during times with higher ER Uncertainty. These results are not driven by level changes in the ER as the OIRF for level changes is not significantly different from 0.

Hence, financial conditions and ER uncertainty are inter-twined. This further fortifies the importance of the ER uncertainty for the US economy through its' effects on some of the important variables that entail real economic outcomes. The importance of EBP as one of the most precise indicators for US recessionary tendencies is well documented in the literature. Also, [Chodorow-Reich, 2014] show that increased lending frictions in the syndicated loans market (SLM) have significant effect on employment and hence the real economy. The direct effects on GDP growth are also evident from the VAR. Thus, ER uncertainty is an important source of exogenous variation that is associated with substantial effects on the US economy. To rule out the fact that, all the results we saw above are instead driven by EBP, I shall check the robustness of my results to changes in EBP in the next section.

5.2.2 Uniqueness of the ER uncertainty channel

The regression results with the addition of the interaction term of exposure with quarterly changes in EBP are summarized in the following bank margins regression (Table 19) and in the appendix B.1. For the sake of brevity, I only summarize the key results here (details are in the appendix).

First, I find that unlike ER uncertainty, increase in EBP does not lead to an increase in bank margins. Nor does it change the magnitude of the quantitative effects due to ER

Table 19: Call Reports: NIM (not driven by Changes in EBP)

	Δ_1NII	Δ_2NII	Δ_3NII	Δ_4NII
$E_{i,t-1} \times Vol(ER)_t$	0.33	1.17***	1.08**	1.26**
Annualized Effect (bps)	**5**	**12***	**9**	**8**
	(0.235)	(0.357)	(0.413)	(0.523)
$E_{i,t-1} \times \Delta_1 ER_t$	0.035**	0.001	-0.007	0.001
	(0.014)	(0.021)	(0.028)	(0.020)
$E_{i,t-1} \times \Delta_1 EBP_t$	-0.251***	-0.159*	-0.137	-0.260
	(0.082)	(0.085)	(0.130)	(0.165)
$E_{i,t-1}$	-0.086	-0.415***	-0.363***	-0.404*
	(0.078)	(0.107)	(0.125)	(0.218)
# Obs	3354	3304	3272	3228
Adj R-squared	0.44	0.36	0.31	0.32
Time FE+Bank FE	Y	Y	Y	Y

Clustered SE in paranthesis * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

uncertainty. If anything, times with higher EBP are associated with lower or similar net interest income. This makes sense as higher EBP suggests worsening of local financial market conditions in the US. It would affect bank profits negatively as they are hit with a negative financial shock.

Second, I find that the quantity effects of EBP are in the opposite direction of ER uncertainty. US banks face an expansion of their balance sheets and an increase in their loans to deposit ratio whenever there is a significant effect of EBP, if at all there is any.

The effects of ER uncertainty are not at all affected by the addition of the interaction term with EBP. If anything they get more precise and significant in the regressions (in appendix B.1). This suggests that, while changes in EBP have interesting implications for the US banking sector, it does not confound the proposed channel for ER uncertainty. Since EBP is a good proxy for risk premiums in the loans market, this suggests that the ER channel proposed in this paper, is driven by *large US banks using market power to drive up margins in response to the loanable funds supply bottlenecks*, and not coming from risk premium in the presence of some correlated financial market uncertainty.

To conclude the empirical section, I have shown a novel source of exogenous variation – ER uncertainty – that significantly affects the US banking sector and hence the US real economy through SLM channel. In the aggregate, higher volatility is associated with higher premium on riskier loans and contraction of loan volumes in the SLM. Consequently, I exploit the cross-sectional heterogeneity among US banks', where differential exposure to the pipeline risk matters through implications on their bank lending margins. It is imperative to understand this in light of *bank market power* which is what I will focus on in my model. Further, my proposed channel is not a one time event, but rather a persistently relevant mechanism. I summarize some of the relevant robustness checks for my mechanism (using alternate definitions of uncertainty, and alternate measures of exposure) in the appendix.

In the next section, I introduce a static model for US banking with secondary markets for loans, and draw reasons behind the observed effects in data. I allow the foreign banks to participate in secondary market for loans. Since the channel is coming through exogenous variation in the ER volatility, I follow Occam's razor in so far as it is sufficient to explain the results in partial equilibrium. That is, I model the interaction between US and foreign banks once they match in a syndicate. One does not need a complicated general equilibrium dynamic model to understand the key mechanism proposed in this paper. However, it is definitely something worth pursuing in another paper due to lack of enough extensive theoretical models in this area.

6 Model

Let us consider a static banking-model with SLM to analyze the ER uncertainty channel.

The model comprises of 3 sub-periods/ stages:

$$t = 0 \text{ (Origination)}, t = 1 \text{ (Secondary Market)}, t = 2 \text{ (Liquidation)}$$

Let there be a representative *large US bank* with a given balance sheet at the start of time 0, analogous to table 5 used in the empirical section of the paper. I simplify and only include the major components of the balance sheet, for the purpose of this model.

Table 20: Model: US Bank Balance Sheet

Assets	**Liabilities**
Loans (L_0) Securities (S_0)	Deposits and Debt (B_0) Equity (E_0)
Assets (A_0)	Liabilities (A_0)

The fact that the US bank is 'large' allows me to assume that it has market power in issuing loans, and a comparative advantage in originating new USD denominated loans. This follows from the evidence on market segmentation and clientele effects observed in the issuance of large loans using syndicates ([Chodorow-Reich, 2014]).

Let there also be a unit measure of foreign banks each with some value of loanable funds F denominated in their local currency. Each type of bank is risk neutral and tries to maximize their respective profits from the loan transactions. In this simplified model, it is equivalent to maximizing the dividend payout at the end of time (just like the model by [Heuvel, 2006]), when all the balance sheets clear and profits are paid out as dividends.

6.1 US Banks' Problem

At the start of time period 0, US bank has a given balance sheet with assets = loans+ securities and liabilities = debt and deposits + equity as shown in table 20. Let us assume that the US bank pays some benchmark interest rate r on deposits and, that it earns the same interest rate r on securities. As a result only the net value of $S - B$ matters for the US bank. Without loss of generality, we can let S=0. This is merely a simplification (not crucial to the results) and widely used in the literature for simple bank balance sheet models (e.g. [Heuvel, 2006]).

Borrowers (non-financial corporations) approach this US bank at time $t = 0$ and demand new loans. As the US bank originates new loans and finances it using SLM in period 1, they charge a commission c per dollar for the loan issued. At the same time, US bank has market power in loan origination - as it chooses a point on the downward sloping demand curve for new loans. Let the borrowers get $P_0(N_0)$ per dollar for N_0 amount of new loans issued to them by the US bank. P_0 is increasing in N_0 and I assume that $P(N_0)N_0$ is convex. Thus effective interest rate charged by the US bank per unit of loan

= $(1 - P(N_0))$, is lower when larger loans are issued. This is a standard assumption used in the literature.

Once the US bank has chosen the amount of new loans (N_0) to issue, it takes them to period 1 secondary market where it can potentially sell these loans at a price P_1 per unit. The US bank chooses an amount Q_1 (s.t. $0 \leq Q_1 \leq N_0$) of these newly issued loans, it is willing to off-load as a function of the secondary market price P_1. This gives us the supply of loans / demand for loanable funds by the US banks in the secondary market as a function of price. The US bank has an incentive to issue new loans for the commissions it gets, but also sell as much of these loans as possible in the SLM because there is a convex holding cost for loans in US bank's books $\Phi(\cdot)$. This holding cost is a simplified way to allow for regulatory capital requirements á la [Heuvel, 2006] or more generally, convex funding costs.

Finally, in period 2 all loans financed by the US Bank are repaid. There is no default risk[24]. At the same time all the deposits are returned. All the equity which is basically the profits made from loan transactions in period 0 and 1 are paid out as dividends to the bank stakeholders and the bank shuts down.

With these primitives, US Bank's problem (with some given loans L_0 and debt B_0 to begin with) can be summarized using the following equation

$$\pi^U(L_0, B_0) = \max_{N_0 \geq 0} \big\{ (c - P_0(N_0))N_0 + \max_{0 \leq Q_1 \leq N_0} [(N_0 - Q_1)1 - r(B_0 + N_0 - Q_1) - \Phi(L_0 + N_0 - Q_1) + P_1 Q_1] \big\} \tag{10}$$

I assume the convex holding cost for loans $\Phi(L) = aL^\gamma, 1 < \gamma < 2$. Then, the first term in the above equation is time 0 profits for US Bank from loan origination. The second term in brackets is the remaining profits. The US bank is earning the repayment of 1 on the loans which stay in its' books, it pays interest on all the debt raised to finance these loans and also pays the holding cost. Lastly, it earns $P_1 Q_1$ for the loans that it is able to sell in the SLM and finance using foreign banks' money. I solve the model using backward induction where I first solve for the equilibrium in the secondary market and with that information, the US bank backtracks to decide the amount of new loans N_0 to issue at time 0. For now, let us solve the period 1 problem for US bank and then come back to the period 0 optimization later, once I have solved the secondary market equilibrium.

The first order condition w.r.t Q_1 in the second term of equation (10) gives the demand for loanable funds/ supply of loans by the US bank with a given stock of new loans N_0 at price P_1.

$$\left.\frac{\partial \pi^U}{\partial Q_1}\right|_{N_0, L_0} = -1 + r + \gamma a (L_0 + N_0 - Q_1)^{\gamma - 1} + P_1 = 0$$

$$\implies Q_1(P_1, N_0, L_0) = (L_0 + N_0) - \left(\frac{1 - P_1 - r}{\gamma a} \right)^{\frac{1}{\gamma - 1}} \tag{11}$$

Throughout the model, the risk free interest rate r, and the parameters of convex cost function a and γ are taken as given and known by all the agents. The supply of loans is shown in figure 13 along with the demand for loans from foreign banks which I shall derive in the next section.

[24]Again for simplicity, I get similar results if I allow for default.

6.2 Foreign Banks' Problem

There is a unit measure of foreign banks $f \in [0,1]$. All foreign Banks start with an endowment of F in their local currency and they face a portfolio choice problem. On one hand, they can always earn some benchmark interest rate r^* domestically. On the other, they can choose to supply loanable funds to the USD denominated SLM for a price after accounting for the exchange rate gain/ loss.

Each of the foreign bank assigns a manager to manage this portfolio, who is subject to an idiosyncratic penalty Λ^f, in case the portfolio cannot guarantee a minimum return of r^*F for the foreign bank. This penalty can be thought of as additional financing burden faced by the bank in case it makes losses, equity issuance cost, debt covenants or merely managers' utility cost. The penalty distribution across foreign lenders is $\Lambda \sim H(\Lambda)$. Depending on the heterogenous managerial expertise or size of the foreign bank, foreign banks can be subject to different penalty for the same amount of loss. The managers know their Λ^f, and incorporate that when deciding the amount of funds to supply in the secondary market.

To summarize, foreign banks choose an amount $0 \leq Q_1^f \leq F$ of their funds in local currency to supply in this secondary market for loans as a function of the offered price P_1, penalty Λ^f, and the return on the exchange rate between USD and their local currency r_E. Let us define the exchange rate and return on ER as follows:

$$E = \frac{\text{local currency}}{\text{USD}}, r_E = \frac{E_{t+1} - E_t}{E_t}, t = 1 \tag{12}$$

Let the return on exchange rate follow the distribution $G(r_E)$ with mean $\bar{r}_E$ and variance $\sigma(r_E)$. For the analysis of this simple model, I shall be considering a mean preserving spread for this distribution G. The manager at the foreign bank knows this distribution of currency return but does not know the exact realization of the return at the time of investing in period 1. Thus, the manager takes an expectation over this return.

Foreign banks' optimization problem can be summarized as follows

$$\begin{aligned}\Pi^f(F,\Lambda^f) = \max_{0\leq Q_1^f \leq F} \mathbb{E}_E\left[\pi^f(r_E, Q_1^f) - \Lambda^f \max\{0, r^*F - \pi^f(r_E, Q_1^f)\}\right], \qquad f \in [0,1] \\ \pi^f(r_E, Q_1^f) = (r_E + 1 - P_1)Q_1^f + r^*(F - Q_1^f)\end{aligned} \tag{13}$$

where $r_E \sim G(r_E)$. Note that the max term ensures that the manager needs to ensure a minimum return of r^*F on the available funds in order to avoid penalty. Let $r_E^\dagger$ be the threshold value of return on exchange rate such that the foreign banks' per period profits hit the minimum value of r^*F i.e.

$$r_E^\dagger: \quad \pi^f(r_E^\dagger, Q_1^f) = r^*F \implies r_E^\dagger = r^* - (1 - P_1) \tag{14}$$

This is the return on the currency exchange that just off-sets any loss in interest return between the two countries. For any lower return on exchange rate, the foreign bank manager is compelled to pay the penalty. Thus, I can simplify the foreign banks' problem as follows

$$\begin{aligned}\Pi(F,\Lambda^f) &= \max_{0\leq Q_1^f \leq F} \left[\pi^f(\bar{r_E}, Q_1^f) - \Lambda \int_0^{r_E^\dagger} r^*F - \pi^f(r_E, Q_1^f) dG(r_E)\right] \\ &= \max_{0\leq Q_1^f \leq F} \left((\bar{r}_E + 1 - P_1 - r^*)Q_1^f + \Lambda \int_0^{r_E^\dagger} (r_E + 1 - P_1 - r^*)Q_1^f \, dG(r_E)\right]\end{aligned} \tag{15}$$

If there were no penalty to pay, the second term would vanish and the distribution of exchange rate return would not affect the manager's portfolio choice problem. Only the first moment of r_E would matter. Thus the optimal decision for the foreign bank with $\Lambda = 0$ is as follows

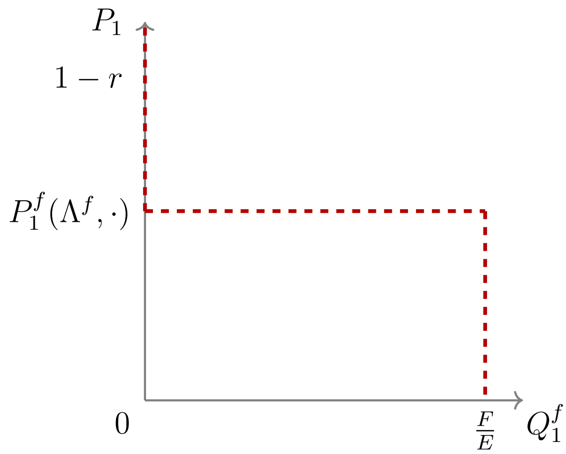
$$Q_1^f\Big|_{\Lambda^f=0} = \begin{cases} F & \text{if} \quad \bar{r}_E \geq r^* - (1 - P_1) \\ 0 & \text{otherwise} \end{cases} \tag{16}$$

For the case when Λ^f is non zero, i.e. there is a positive penalty for losses, the foreign banks' optimal decision would be modified to account for the penalty as follows

$$Q_1^f\Big|_{\Lambda^f>0} = \begin{cases} F & \text{if} \quad \underbrace{\left((\bar{r}_E + 1 - P_1 - r^*) + \Lambda^f \int_0^{r_E^\dagger} (r_E + 1 - P_1 - r^*)\, dG(r_E)\right]}_{P_1^f(\Lambda^f)\text{:value of this expression }=0} \geq 0 \\ 0 & \text{otherwise} \end{cases} \tag{17}$$

This is shown in the following figure 12 where $P_1^f(\Lambda^f, r^*, \bar{r}_E, G(r_E))$ be the price for a given Λ^f and other parameters, such that, the bank is indifferent between investing all the funds versus nothing in the secondary market.

Figure 12: Demand for loans by 'a' Foreign Bank f in SLM

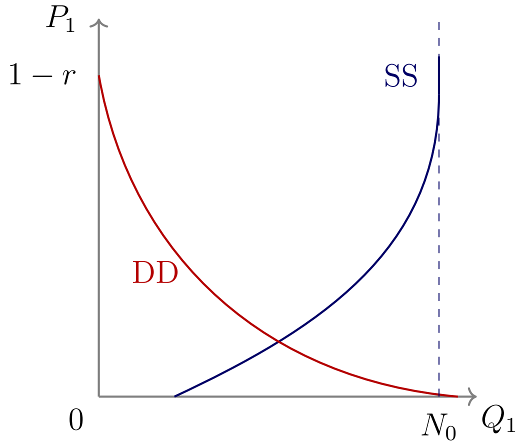


Note that higher the value of Λ^f, lower the corresponding P_1^f. In other words, higher the penalty from negative profits; greater the caution of the manager and hence she is only willing to invest all the funds F in secondary market if the price of loans (or return on loans) is sufficiently low (high). Since Λ^f follows a distribution $H(\Lambda)$ across different foreign banks, the aggregate supply of loanable funds/ demand for loans in secondary market from foreign banks can be summarized as follows:

$$\begin{aligned} Q_1^F(\underbrace{P_1}_{-}, \underbrace{r^*}_{-}, \underbrace{\bar{r}_E}_{+}, \underbrace{\sigma/G(r_E)}_{-}) &= F * Pr(P_1^f(\Lambda^f, \cdot) \geq P_1) \\ &= F * Pr\left(\Lambda^f \leq (P_1^f)^{-1}(P_1)\big|r^*, G(r_E)\right) \\ &= F * H\left((P_1^f)^{-1}(P_1)\big|r^*, G(r_E)\right) \end{aligned} \tag{18}$$

This gives us a smooth downward sloping demand for loans by foreign banks in the SLM and combining that with the above demand (equation 10) from US bank, we get

Figure 13: Aggregate demand and supply of loans in the Secondary Market



the following secondary market equilibrium shown in figure 13. Note that the demand depends on foreign interest rates r^*, and the distribution of return on exchange rate $G(r_E)$. In particular, an increase in foreign interest rate, means that foreign banks would likely invest more in their local financial markets. This would reduce their demand in the secondary market for US loans as their outside option gets more lucrative. As for $G(r_E)$, there are 2 important component in it: mean level of exchange rate $\bar{r}_E$ and the second moment of exchange rate as well $\sigma(r_E)$ that matter for the equilibrium "volume of loans" and "spread on loans" traded in the SLM.

Proposition 1. *Whether or not the penalty exists i.e. $\Lambda^f = 0$ or $\Lambda^f > 0$, all foreign banks would tend towards investing more in the US syndicates when $\bar{r}_E$ is higher.*

$$\uparrow \bar{r}_E \implies \uparrow Q_1^f \forall f \implies \uparrow Q_1^F \tag{19}$$

Foreign banks would allocate more to secondary market loans as the average foreign value of USD return they get on those loans increases. This is evident from the 'if' conditions in equations (16) and (17) respectively. However, for the case with second moments, the effect depends on whether the penalty exists or not. If there is no penalty on negative profits i.e. we are in the traditional framework for bank balance sheet models, only the first moment matters and rest of the $G(r_E)$ does not affect the portfolio decisions for the foreign banks at the margin. But, if we appropriately account for the more realistic approach where managers face a penalty for negative profits, and account for the uncertainty in the realization of exchange rates ex post; it results in the second moment affecting the bank's portfolio decisions. This is summarized in the following proposition.

Proposition 2. *If $\Lambda^f > 0$, all foreign banks would tend towards investing less in the US syndicates when they face a mean preserving spread of $G(r_E)$*[25] *i.e. when uncertainty in r_E increases.*

$$\uparrow \sigma(r_E),\ \textit{given}\ \bar{r}_E \implies \downarrow Q_1^f \forall f \implies \downarrow Q_1^F \tag{20}$$

Also, this entails an increase in spreads as the equilibrium P_1 falls in the secondary market.

To see this, consider the 'if' condition for the value of $P_1^F(\cdot)$ in equation (17). The term inside the integration is negative by the definition of $r_E^\dagger$. So, a mean preserving

[25]the only caveat is that the mean preserving spread must increase the measure for the area between $r_E^\dagger$ and $\bar{r}_E$. This is guaranteed when I consider mechanically increasing the variance while keeping the mean fixed which is what we mainly need for the proposed mechanism.

spread would increase the measure of this negative term (by increasing $dG(r_E)$) which would result in a drop in demand for loans/ supply of loanable funds by each foreign bank. Hence, an increase in $\sigma(r_E)$ associated with a mean preserving spread would lead to a downward shift in the demand curve in figure 13 and hence in the total volume of loans transacted in the secondary loans market. This goes in line with the observed negative correlation of loan volumes with exchange rate uncertainty in the DealScan data. At the same time, the spreads ($= 1 - P_1$) increase in equilibrium fortifying the DealScan result of higher AllInSpreads in times with greater volatility in foreign value of USD.

6.3 Secondary Market Equilibrium @ t=1

Finally I characterize the secondary market equilibrium at $t = 1$ by equating the aggregate supply of loanable funds and the demand for loanable funds from US bank by equating the quantities from equations (18) and (11) respectively.

$$\begin{aligned} Q_1^* \left(P_1^* \left(L_0, N_0, \alpha, \gamma, r, r^*, G(r_E) \right) \right) &= Q_1^{US} = Q_1^F \\ P_1^*(\cdot) : (L_0 + N_0) - \left(\frac{1 - P_1^* - r}{\gamma a} \right)^{\frac{1}{\gamma - 1}} &= F * H \left((P_1^f)^{-1}(P_1^*) \middle| r^*, G(r_E) \right) \end{aligned} \tag{21}$$

I have therefore solved for period 1 equilibrium best response of the US bank for a given value of new and existing loans, and the equilibrium price in the secondary market. The next step is to use backward induction with this equilibrium value and ascertain the optimal amount of new loans issued by the US bank at time period 0.

6.4 Equilibrium Loan Origination N_0 @ t=0

Using the secondary market equilibrium equation (21), I get the value of equilibrium $Q_1^*(N_0, \cdot)$ as follows

$$Q_1^*(N_0, \cdot) = (L_0 + N_0) - \left(\frac{1 - P_1^*(N_0, \cdot) - r}{\gamma a} \right)^{\frac{1}{\gamma - 1}} \tag{22}$$

With this, I can re-state the period 0 problem from equation (10) using backward induction as follows

$$\begin{aligned} \pi^U(L_0, B_0) = \max_{N_0 \geq 0} \{ & (c - P_0(N_0))N_0 + [(N_0 - Q_1^*(N_0, \cdot))1 - \\ & r(B_0 + N_0 - Q_1^*(N_0, \cdot)) - \Phi(L_0 + N_0 - Q_1^*(N_0, \cdot)) + P_1^*(N_0, \cdot) Q_1^*(N_0, \cdot)] \} \end{aligned} \tag{23}$$

Optimizing w.r.t. N_0 and using equation (22), I get the following first order condition,

$$\begin{aligned} & c - \frac{\partial (P_0(N_0) N_0)}{\partial N_0} + \\ & \left\{ \left(1 - r - \alpha\gamma(L_0 + N_0 - Q_1^*(N_0))^{\gamma - 1} \right) \left(1 - \frac{\partial Q_1^*(N_0)}{\partial N_0} \right) + \frac{\partial P_1^*(N_0, \cdot) Q_1^*(N_0)}{\partial (N_0)} \right\} = 0 \\ \implies & \frac{\partial (P_0(N_0) N_0)}{\partial N_0} = c + \left\{ P_1^*(N_0, \cdot) + Q_1^*(N_0, \cdot) \frac{\partial P_1^*(N_0, \cdot)}{\partial N_0} \right\} \end{aligned} \tag{24}$$

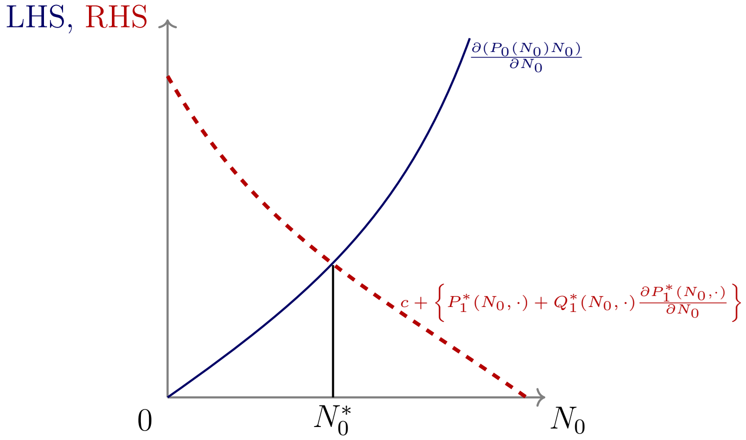
Note that the left hand side is upward sloping in N_0 since $P(N_0)N_0$ is convex, and the right hand side is downward sloping w.r.t. N_0[26] using the response of the secondary market

[26] An increase in N_0 shifts the demand curve in period 1 towards right which lowers P_1 and increases Q_1. Assuming P_1 decreases at a decreasing rate i.e. P_1 is concave in N_0 or that the supply curve from foreign banks is concave, we get that the RHS declines with an increase in N_0

equilibrium. The intersection of the 2 curves therefore yields the equilibrium amount of new loans issued by the US bank at the beginning of period 0. This is shown in the following figure 14.

Then, in period 2 all the loans are repaid and all the profits accounted for in equity for the US bank are given out as dividends. This characterizes the complete partial equilibrium for the model. Next, I use this framework to understand the impact of higher ER volatility on issuance of new loans by the US bank and their bank margins to understand the results we got using the Call-Reports data.

Figure 14: LHS and RHS for FOC w.r.t N_0 in period 0



6.5 Model Implication

Proposition 3. *A mean preserving spread in $G(r_E)$ due to an increase in the second moment of r_E, leads to a drop in the equilibrium amount of new loans issued by the US Bank and an increase in the loan spread.*

$$\uparrow \sigma(r_E) \implies \downarrow RHS \implies \downarrow N_0^* \implies \downarrow P_0(N_0^*) \implies \uparrow (1 - P_0(N_0^*)) \tag{25}$$

Consider a mean preserving spread in $G(r_E)$ due to an increase in the volatility of the return on exchange rate. This leads to a downward shift in the demand for loans by foreign banks in period 1 secondary market equilibrium. As a result, the P_1 and Q_1 in the RHS of the above figure decrease causing a downward shift in the RHS line. The idea is that an increase in ER uncertainty leads to retrenchment from the foreign banks in the secondary market. As a result the return from issuing new loans in order to sell them to foreign banks declines. Consequently the US bank reduces equilibrium loan origination ($\downarrow N_0^*$). At the same time, since the US bank is a large bank with market power in loan issuance, they charge a higher spread for lower loan volumes. Thus, US bank responds with fewer new loans and higher spreads therefore leading to higher bank margins assuming that the price effect is stronger.

Proposition 4. *The contractionary effect of ER uncertainty on loan origination is higher for the US bank with greater existing loans in its balance sheets.*

$$\uparrow L_0 \implies \downarrow RHS \implies \downarrow N_0^* \implies \downarrow P_0(N_0^*) \implies \uparrow (1 - P_0(N_0^*)) \tag{26}$$

US bank with greater loans to begin with, is at the steeper portion of the holding cost function. Consequently, any more burden due to holding cost from loan originations that cannot be off-loaded in the secondary market - leads to worse outcomes for the US banks with more pre-existing loans. This can be seen as a drop in the potential price at which the US bank is willing to off-load the loans in the secondary market - and hence a drop in the benefits from new loan origination. Thus the equilibrium P_1^* is lower, when US bank has higher existing loans, and the RHS in the first order condition for N_0 shifts downward causing lesser equilibrium origination of new loans. This closely explains the identification based on US banks' loans-to-interest-earning-assets ratio used in the empirical estimations.

Using the model, we see how greater volatility in the foreign value of USD leads to a drop in supply of funds by foreign banks in the secondary market. This in turn affects the secondary market equilibrium with lower loan transaction volumes and higher spreads, in line with the DealScan evidence from section 3.2. The secondary market effect ripples to loan origination problem for US banks which face increased pipeline burden, through backward induction in the model. Finally, the ER uncertainty channel works its way, in the decisions of the large US bank which chooses to issue fewer loans with higher spreads for a given downward sloping demand curve. The effects are differential based on heterogeneity on the pre-existing loans in the US bank balance sheet. This is in line with the evidence from SLOOS in section 3.3 and from the Call Reports regressions in section 4.

The idea of the model is simple, the US Bank would like to issue as many new loans as possible because it gets a commission from the borrowers. At the same time it would like to off-load as many loans as possible to the secondary market since it saves on its' holding costs motivated using capital regulatory costs or debt servicing costs. But, higher ER uncertainty works against its' incentives and results in reducing the amount of loans the US banks could finance with the help of syndicates. As a result, the US bank is compelled to issue less new loans to avoid huge amount of holding cost in the even of higher pipeline burden. The effect is amplified when the US bank has greater loans since the convex holding cost become much steeper. There is no need for a more complex general equilibrium model to understand the ER uncertainty channel as this simple model already depicts the entire mechanism clearly and succinctly.

7 Conclusion

In this paper, I have established a novel channel for the passthrough of uncertainty in the foreign value of the USD to the US banking sector. I have estimated that the US banks increase their bank margins and shrink the size of their balance sheets in response to higher ER uncertainty. I have shown that the effects for US banking sector are large and persistent. The effects are primarily driven by exogenous variation in *second moments*, controlling for any changes in the levels. Moreover, the channel works through the secondary loans market which has meaningful implications for the real US economy. In particular, ER uncertainty intertwines with financial uncertainty and they culminate into a significant drop in US GDP over 3 quarters. I have relied on heterogeneity in US banks' exposure to the SLM in my identification, and the presence of market power while issuing loans among large US banks to explain the observed data responses.

The fact that second moment changes have important first order effects is worth investigating more in the future. For example, I have found that US stock market uncertainty and changes in EBP have important effects on the US banking sector too, except analyzing its' implications has been beyond the scope of this paper. Also, syndicated loans market channel for global uncertainty affecting the US economy through other sources is an interesting area for potential future research. For this paper, I am working towards establishing robustness of my results to implied volatility measures, and collecting more evidence on bank-clientele effects and its implications in my data. This paper has opened avenues for a lot of interesting questions that I shall investigate in my future work.

Appendix A

A.1 Regression Estimates for 4 Quarter MA Exposure

I summarize the quantitative estimates for the effects on net interest income, balance sheet size and loan to deposit ratio in the following section. Everything is the same as in section 4, except the exposure variable is now defined using 4 quarter lagged moving average of loans-to-interest-earning-asset ratio as follows:

$$E_{it^-} = \frac{1}{4}\sum_{l=1}^{4} \frac{\text{Loans}_{i,t-l}}{\text{Interest Earning Asset}_{i,t-l}}$$

Note that my baseline results in the main paper, are robust to this alternative measure of exposure. The net interest margin still responds with 10 bps increase for an average exposure bank. The results for IIA and IE are also same as before.

Table 21: Effect on bank margins with moving average exposure

	Δ_1NII	Δ_2NII	Δ_3NII	Δ_4NII
$E_{i,t^-} \times Vol(ER)_t$	0.30	1.21***	1.16***	1.40**
Annual (bp) Effect	**05**	**13*** **	**10*** **	**09** **
	(0.25)	(0.37)	(0.40)	(0.53)
$E_{i,t^-} \times \Delta_1 ER_t$	0.02**	-0.01	-0.01	-0.01
	(0.01)	(0.02)	(0.03)	(0.02)
E_{i,t^-}	-0.09	-0.36***	-0.31***	-0.40**
	(0.08)	(0.10)	(0.11)	(0.20)
#Obs	3294	3252	3216	3172
Time FE	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y

Clustered SE in parentheses (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$)

US bank balance sheet shrinks in times with high ER uncertainty. The effect is driven

Table 22: Effect on assets with moving average exposure

	Δ_1A	Δ_2A	Δ_3A	Δ_4A	Δ_5A	Δ_6A
$E_{i,t^-} \times Vol(ER)_t$	-0.09**	-0.10	-0.25*	-0.28*	-0.61***	-0.60**
Annual (%) Effect	**-1.43** **	**-1.02**	**-1.96** *	**-1.75** *	**-3.2*** **	**-2.72** **
	(0.04)	(0.07)	(0.13)	(0.15)	(0.21)	(0.28)
$E_{i,t^-} \times \Delta ER_t$	0.003	0.002	0.008**	0.008	0.006	0.005
	(0.003)	(0.004)	(0.004)	(0.006)	(0.009)	(0.013)
E_{i,t^-}	0.05**	0.06*	0.12**	0.13**	0.28***	0.32***
	(0.02)	(0.03)	(0.06)	(0.06)	(0.08)	(0.09)
# Obs	3001	2951	2924	2881	2847	2813
Time FE	Y	Y	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y	Y	Y

Clustered SE in parentheses (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$)

by a decline in the growth rate of both securities and loans. While securities decline instantaneously since they are more flexible, their effect is only for 20% of the assets. Loans decline with a lag as US banks face the pipeline burden in the beginning which only adjusts after 3 quarters with drop in loan originations and tighter credit standards. Nevertheless, loans are 60% of the assets and they are responsible for a large portion of the overall contraction in the US bank balance sheet.

Finally, the loans to deposit ratio have a significant and persistent decline as banks rely less on secondary market risky sources of funding and look more towards internal funding sources while simultaneously lowering their supply of loanable funds.

Table 23: Effect on loan/deposit ratio with moving average exposure

	Δ_1L/D	Δ_2L/D	Δ_3L/D	Δ_4L/D	Δ_5L/D	Δ_6L/D
$E_{i,t^-} \times Vol(ER)_t$	-0.36***	-0.45***	-0.62***	-0.51**	-0.58***	-0.85***
Annual(%) Effect	**-5.7***	**-4.8**	**-4.9***	**-3.2**	**-3.1***	**-3.8***
	(0.123)	(0.163)	(0.202)	(0.212)	(0.209)	(0.206)
$E_{i,t^-} \times \Delta ER_t$	0.001	-0.005	-0.0	-0.013	-0.010	-0.009
	(0.003)	(0.009)	(0.013)	(0.014)	(0.013)	(0.012)
E_{i,t^-}	0.027	-0.009	-0.015	-0.081	-0.146	-0.091
	(0.047)	(0.085)	(0.116)	(0.138)	(0.168)	(0.173)
# Obs	2855	2821	2796	2771	2751	2726
Time FE	Y	Y	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y	Y	Y

Clustered SE in parentheses (*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$)

Appendix B

B.1 Regression Results for Robustness to Changes in EBP

Table 24: Call Reports: Assets (Change in EBP is expansionary)

	$\Delta_1 A$	$\Delta_2 A$	$\Delta_3 A$	$\Delta_4 A$	$\Delta_5 A$	$\Delta_6 A$
$E_{i,t-1} \times Vol(ER)_t$	-0.0813**	-0.122*	-0.228**	-0.264*	-0.599***	-0.587**
Annualized Effect (%)	**-1.28**	**-1.29***	**-1.81**	**-1.67***	**-3.16***	**-2.66**
	(0.037)	(0.0652)	(0.111)	(0.136)	(0.218)	(0.269)
$E_{i,t-1} \times \Delta_1 ER_t$	0.001	-0.001	0.005	0.004	0.002	-0.001
	(0.003)	(0.003)	(0.003)	(0.005)	(0.009)	(0.012)
$E_{i,t-1} \times \Delta_1 EBP_t$	0.012	0.053***	0.049**	0.062**	0.095**	0.0913*
	(0.022)	(0.019)	(0.023)	(0.031)	(0.039)	(0.048)
$E_{i,t-1}$	0.052***	0.067**	0.114**	0.113*	0.224***	0.260***
	(0.019)	(0.033)	(0.05)	(0.061)	(0.070)	(0.084)
# Obs	3051	2996	2968	2923	2886	2852
Adj R^2	0.42	0.37	0.31	0.21	0.14	0.12
Time FE + Banks FE	Y	Y	Y	Y	Y	Y

Clustered SE in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 25: Call Reports: Loans/ Deposit Ratio (Change in EBP is not significant)

	Δ_1L/D	Δ_2L/D	Δ_3L/D	Δ_4L/D	Δ_5L/D	Δ_6L/D
$E_{i,t-1} \times Vol(ER)_t$	-0.33***	-0.44**	-0.61***	-0.52**	-0.62***	-0.88***
Annualized Effect (%)	**-5.15***	**-4.67**	**-4.8***	**-3.29**	**-3.27***	**-3.98***
	(0.109)	(0.181)	(0.207)	(0.213)	(0.214)	(0.237)
$E_{i,t-1} \times \Delta_1 ER_t$	0.0002	-0.005	-0.002	-0.015	-0.009	-0.011
	(0.002)	(0.007)	(0.011)	(0.012)	(0.01)	(0.009)
$E_{i,t-1} \times \Delta_1 EBP_t$	0.055	0.03	0.085*	0.083*	0.041	0.093
	(0.045)	(0.047)	(0.047)	(0.047)	(0.086)	(0.094)
$E_{i,t-1}$	0.008	-0.035	-0.046	-0.116	-0.186	-0.152
	(0.042)	(0.089)	(0.108)	(0.123)	(0.158)	(0.174)
# Obs	2905	2864	2840	2813	2790	2761
Adj- R^2	0.44	0.35	0.26	0.25	0.19	0.22
Time FE + Banks FE	Y	Y	Y	Y	Y	Y

Clustered SE in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix C

C.1 Robustness to Alternate Measures of ER Uncertainty

In this appendix, I show robustness of my empirical estimates for an alternate measure of uncertainty based on [Jurado et al., 2015]. This paper exploits a data rich environment to provide direct econometric estimates of time-varying macroeconomic uncertainty. ER uncertainty is measured for various horizons, 1-12 months, based on the standard deviation of the forecast errors for the major currencies index, derived from a factor analysis model with 103 macroeconomic and financial series. I replace my measure for realized volatility, with this ex-ante measure of uncertainty (denoted with U_h3) and evaluate the corresponding effects on NIM, balance sheet size and loan-to-deposit ratios for US banks. The results are summarized in the following tables for 3 month / 1 quarter forecast hori-

Table 26: NIM: Robustness to 1Q Uncertainty from [Jurado et al., 2015]

	Δ_1NII	Δ_2NII	Δ_3NII	Δ_4NII
$E_{i,t-1} \times U\_h3_t$	0.19	0.36*	0.4*	0.36
Annualized Effect (bps)	**8**	**10***	**9***	**6**
	(0.14)	(0.18)	(0.23)	(0.28)
$E_{i,t-1} \times \Delta_1 ER_t$	0.024**	≈0	-0.01	0.002
	(0.01)	(0.02)	(0.02)	(0.02)
$E_{i,t-1}$	-0.18	-0.3**	-0.33*	-0.3
	(0.13)	(0.15)	(0.19)	(0.28)
# Obs	3294	3252	3216	3172
Adj R^2	0.4	0.36	0.33	0.32
Time FE	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y

Clustered SE in parentheses ($^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$)

zon to align with our realized volatility over one quarter in the baseline results. However, the results are very similar for all the available data for uncertainty from 1-12 quarter forecast horizons. At the same time, the magnitude of results using this ex-ante measure of uncertainty yields similar effects for the US bank net interest margins for an average banks ranging from 5-10 basis points over 4 quarters. The differential effect by exposure for 95th versus 5th percentile exposure bank are also approximately 5 bps in this case. Further research shows that, this effect is still driven by interest income on assets while the effect due to interest expenses are relatively quite small. I do not show the regression summary for each component here, for the sake of brevity.

I also check robustness for the quantity effects under this alternate measure for ER uncertainty.

Table 27: Loan/Deposit Ratio: Robustness to 1Q Uncertainty from [Jurado et al., 2015]

	Δ_1L/D	Δ_2L/D	Δ_3L/D	Δ_4L/D	Δ_5L/D	Δ_6L/D
$E_{i,t^-} \times U\_h3_t$	-0.12**	-0.2***	-0.21**	-0.16*	-0.15	-0.18
Annual(%) Effect	**-5.23****	**-5.4*****	**-4.28****	**-2.26***	**-1.82**	**-1.89**
	(0.05)	(0.076)	(0.08)	(0.089)	(0.092)	(0.129)
$E_{i,t^-} \times \Delta ER_t$	-0.001	-0.009	-0.005	-0.017	-0.014	-0.014
	(0.002)	(0.009)	(0.012)	(0.014)	(0.012)	(0.012)
E_{i,t^-}	0.03	0.046	-0.012	-0.088	-0.189	-0.196
	(0.053)	(0.107)	(0.127)	(0.150)	(0.184)	(0.242)
Observations	2855	2821	2796	2771	2751	2726
Adj R^2	0.43	0.34	0.24	0.235	0.17	0.18
Time FE	Y	Y	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y	Y	Y

Clustered SE in parentheses ($^*p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$)

Table 28: Loan Growth: Robustness to 1Q Uncertainty from [Jurado et al., 2015]

	Δ_1L	Δ_2L	Δ_3L	Δ_4L	Δ_5L	Δ_6L
$E_{i,t-1} \times U\_h3_t$	0.02	-0.12	-0.13	-0.18*	-0.39***	-0.52**
Annualized Effect(%)	**0.36**	**-1.28**	**-1***	**-1.16***	**-2.03*****	**-2.36*****
	(0.021)	(0.075)	(0.086)	(0.109)	(0.138)	(0.220)
$E_{i,t-1} \times \Delta ER_t$	0.002	0.002	0.006	-0.004	-0.006	-0.012
	(0.003)	(0.006)	(0.009)	(0.014)	(0.012)	(0.021)
$E_{i,t-1}$	-0.017	0.108	-0.025	0.0416	0.324*	0.425*
	(0.044)	(0.099)	(0.108)	(0.146)	(0.182)	(0.219)
Observations	2855	2821	2796	2771	2751	2726
Adjusted R^2	0.51	0.41	0.27	0.19	0.15	0.11
Time FE	Y	Y	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y	Y	Y

Clustered SE in parentheses ($^*p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$)

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