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Exchange rate depreciations and local business cycles: The role of bank loan supply

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Non-technical summary

Research Question

With the gradual departure from quantitative easing in the United States in 2014, the euro depreciated sharply against the US dollar. The depreciation of the euro against the US dollar was just over 20% between mid-2014 and early 2015. What are the macroeconomic effects of such exchange rate fluctuations? What role does the banking system and its exposure to foreign assets play in transmitting exchange rate shocks to the real economy?

Contribution

We contribute to the literature on the relationship between exchange rate changes and the real economy. While standard open economy models assume that exchange rate depreciations increase output growth through improvements in the trade balance, a more recent strand of the literature focuses on the role of corporate and bank balance sheets in transmitting exchange rate shocks. We complement this discussion by looking at the impact of exchange rate fluctuations on the composition of credit. We pay particular attention to real economy effects. To this end, we construct an extensive dataset of bank-firm relationships based on the German credit register, which we augment with regional macro data. This allows us to link exchange rate depreciation to the real economy via the banking sector.

Results

We show that large banks with higher U.S. dollar foreign assets increase their credit supply to export-intensive firms and smaller local banks without significant foreign asset exposure but with a high share of exporting firms in their loan portfolios. The result is a significant increase in interbank market activity in Germany. We also find that economic growth is significantly higher in regions where the local banking sector is more affected by the above effects. Overall, our results suggest that exchange rate depreciation can have significant real economic effects by increasing liquidity in the interbank market.

Nichttechnische Zusammenfassung

Fragestellung

Mit der allmählichen Abkehr von der quantitativen Lockerung in den Vereinigten Staaten im Jahr 2014 verlor der Euro gegenüber dem US-Dollar stark an Wert. Der Wertverlust des Euro gegenüber dem US-Dollar betrug zwischen Mitte 2014 und Anfang 2015 etwas mehr als 20 %. Welche makroökonomischen Effekte haben solche Wechselkursschwankungen? Welche Rolle spielt das Bankensystem und sein Engagement gegenüber ausländischen Vermögenswerten bei der Übertragung von Wechselkursschocks auf die Realwirtschaft?

Beitrag

Wir leisten einen Beitrag zur Literatur über den Zusammenhang von Wechselkursänderungen und Realwirtschaft. Während Standardmodelle offener Volkswirtschaften davon ausgehen, dass Wechselkursabwertungen das Produktionswachstum durch Verbesserungen in der Handelsbilanz erhöhen, konzentriert sich ein neuerer Teil der Literatur auf die Rolle der Unternehmens- und Bankbilanzen bei der Übertragung von Wechselkursschocks. Wir ergänzen diese Diskussion, indem wir uns die Auswirkungen von Wechselkursschwankungen auf die Zusammensetzung der Kreditvergabe betrachten. Besonderes Augenmerk richten wir dabei auf realwirtschaftliche Effekte. Zu diesem Zweck erstellen wir einen umfangreichen Datensatz mit Bank-Firmen-Beziehungen auf der Grundlage des deutschen Kreditregisters, den wir um regionale Makrodaten erweitern. Das ermöglicht uns, die Wechselkursabwertung über den Bankensektor mit der Realwirtschaft zu verknüpfen.

Ergebnisse

Wir zeigen, dass große Banken mit höheren US-Dollar-Auslandsaktiva ihr Kreditangebot für exportintensive Unternehmen und kleinere lokale Banken ohne signifikantes Auslandsaktiva-Engagement, aber mit einem hohen Anteil an exportierenden Unternehmen in ihren Kreditportfolios erhöhen. Das Ergebnis ist ein deutlicher Anstieg der Interbankenmarktaktivität in Deutschland. Wir stellen ferner fest, dass das Wirtschaftswachstum in Regionen, in denen der lokale Bankensektor stärker von den oben genannten Effekten betroffen ist, deutlich höher ist. Insgesamt deuten unsere Ergebnisse darauf hin, dass eine Wechselkursabwertung durch die Erhöhung der Liquidität auf dem Interbankenmarkt beträchtliche realwirtschaftliche Auswirkungen haben kann.

DEUTSCHE BUNDESBANK DISCUSSION PAPER NO 52/2021

Exchange Rate Depreciations and Local Business Cycles: The Role of Bank Loan Supply*

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Abstract

This paper uses matched bank-firm-level data and the 2014 depreciation of the euro to show that exchange rate depreciations lead to increased bank loan supply of large banks with significant net foreign asset exposure. This increase in lending can be explained by a shift in credit towards both export-intensive firms and small banks without foreign asset exposure that have a higher share of exporting firms in their credit portfolio. We also find that German regions where these reallocation effects are stronger experience higher output growth. In economic terms, we show that such regions grow by 1.2 percentage points more than less exposed regions, cumulatively, in the two years after the depreciation relative to the two pre-depreciation years.

Keywords: Exchange Rates, Bank Lending, Interbank Markets, Real Effects, Regional Business Cycles, Germany
JEL Classification: E44, E52, G21, O40

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1 Introduction

With the onset of the gradual reversal of the quantitative easing policy in the United States, known as the Federal Reserve's tapering, the euro depreciated sharply against the US dollar. Specifically, between 2014:Q2 and 2015:Q1, the euro lost slightly more than 20% in value relative to the dollar. Similar sharp exchange rate movements happened during the Covid-19 pandemic, especially in emerging markets, where currencies lost between 6% in the case of South Korea and 25% in the case of Brazil in the first half of 2020 relative to the dollar. How do such exchange rate movements affect macroeconomic outcomes? What is the role of the banking system in the transmission of exchange rate shocks to the real economy?

In this paper, we use both bank-firm relationship data based on the German credit registry and German regional bank and output data to study these questions. Exploiting the euro depreciation of 2014, which can be seen as exogenous to bank lending in Germany as it was driven to large extents by the tapering of the Fed's QE policies,[1] and running a difference-in-differences analysis around this event, we show that large banks with higher volumes of USD foreign assets increase their loan supply to export-intensive firms and small local banks, without significant foreign asset exposure but with a high share of exporting firms in their credit portfolios. The result is a significant increase in interbank market activity in Germany. We further gauge that in regions where the local banking sector is more exposed to the aforementioned effects, GDP growth is significantly higher—an effect that seems to be driven by an increase in investment of more affected firms, as we show in the Online Appendix. In economic terms, we establish that more affected regions grow by 1.2 percentage points more than less affected ones, cumulatively, in the two years after the depreciation relative to the two pre-depreciation years. Taken together, our results imply that an exchange rate depreciation, by increasing interbank market liquidity, can have sizeable economic effects, even when local banks have low foreign asset exposure and are therefore not affected directly by the exchange rate shock.

These results are consistent with Agarwal (2019), who exploits the currency appreciation episode of 2015 in Switzerland and shows that it led to an increase in domestic credit growth

[1] The Bundesbank (2017) shows that tighter monetary policy in the US even had a slightly larger impact on the EUR/USD exchange rate in 2014 than expansionary monetary policy in the euro area.

of banks with higher volumes of foreign currency liabilities. The idea behind Agarwal (2019) and our analysis is that exchange rate shocks should affect bank loan supply when banks have foreign currency exposure on their balance sheets that is not perfectly hedged. If this is the case, and there is plenty of evidence supporting this assumption,[2] a bank with higher volumes of foreign currency assets than liabilities experiences an increase in net worth because of the USD appreciation and is, therefore, likely to expand credit supply.[3] This, in turn, should have a positive impact on macroeconomic outcomes.

In order to identify the linkages between the EUR/USD depreciation, bank lending and the real economy, we construct two unique data sets. The first combines data at the bank-firm level from the German credit registry with firm balance sheet characteristics from Amadeus and bank balance sheet data from the Bundesbank. The second matches comprehensive region-level data from INKAR with balance sheet characteristics of local savings banks. Here, we make use of a unique feature of the German banking sector because the lending activity of savings banks is geographically restricted to a particular administrative district, which is typically the same as the definition of administrative regions in the INKAR database, allowing us to relate regional economic dynamics to the exposure of local banks to the exchange rate depreciation.

Germany is an interesting laboratory for studying the impact of exchange rate movements on the real economy via the banking sector, not only because of this unique feature of the German banking system and the granularity of the available data, but also because the exchange rate shock was exogenous and largely unanticipated from the perspective of German banks and firms. This is the case because the euro depreciation (dollar appreciation) of 2014 was induced by the Federal Reserve's gradual reversal of its quantitative easing policies. In addition, the German banking sector has accumulated significant amounts of net foreign assets, especially since the launch of the monetary union. This fact combined with the pronounced cross-bank variation in foreign asset holdings allows us to identify the exchange rate effects across banks. At the same time, Germany is an export-intensive economy with one of the largest net exports to GDP ratios in the world.

[2]For instance, Gabaix and Maggiori (2015) gauge that large financial intermediaries actively seek risk in currency markets. Similarly, the results of Abbassi and Bräuning (2021) imply that banks do not fully hedge their on-balance sheet currency exposure.

[3]In Online Appendix Section B, we show that after the EUR/USD depreciation, banks with higher net foreign assets do indeed have a higher net worth.

Therefore, the shift in the composition of credit towards export-intensive firms is likely to have significant aggregate effects.

In terms of identification, we estimate difference-in-differences regressions around the depreciation episode of 2014:Q2-2015:Q1, during which the euro depreciated significantly by more than 20%. This depreciation was also very persistent with the EUR/USD exchange rate staying at its post-shock level for several quarters. Our identification strategy relies on the differential, pre-shock exposure of German banks to USD net foreign assets (scaled by total assets), with banks having higher foreign assets being more exposed. When studying the cross-firm differences in credit allocation, identification also hinges on the heterogeneity of firms' pre-depreciation balance sheet characteristics. Following the standard approach in the credit register literature, we further restrict our sample to firms with multiple bank relationships and include firm fixed effects to thus control for loan demand and isolate supply effects (Khwaja and Mian, 2008). In other words, we examine whether a firm borrowing from several banks experiences the highest credit growth from those banks with the most significant volumes of USD foreign assets on their balance sheets. We also include bank fixed effects in our analysis to control for time-varying heterogeneity at the bank level, such as bank size (see, e.g., Jiménez et al., 2014).

Our analysis provides three main results. First, we show that the euro depreciation encourages larger banks with significant net foreign asset exposure to expand their credit supply. This effect is statistically significant and economically meaningful: depending on the bank size definition, we find a large bank that has a 1-percentage point higher net foreign asset share than the median large bank to have a 4.5-5.5 percentage point higher credit growth from the pre- to the post-depreciation episode. Second, we establish that this increase can be explained by growth in loan supply to export-intensive firms, not to riskier firms, and, even more important, by an increase in interbank market activity. In particular, large banks with significant net foreign assets raise their interbank lending to small banks without significant foreign asset exposure, but with a higher share of exporting firms in their credit portfolio, which in turn also allows small banks to expand their credit supply. This is evidence that the exchange rate depreciation, by increasing the liquidity of distinct tiers of the domestic banking sector, can have sizeable economic effects, even when local banks have low foreign asset exposure and are therefore not affected directly by the exchange rate shock.

In fact, we finally gauge that regions that are more exposed to these effects experience significantly higher GDP growth than less exposed regions and that this increase in economic growth is likely to be driven by a rise in investment by more affected firms. In economic terms, we show that more exposed regions grow by 1.2 percentage points more than less exposed regions, cumulatively, in the two years after the depreciation relative to the two pre-depreciation years. Therefore, exchange rate movements, by shifting the composition of bank loan supply and increasing interbank liquidity, can have sizeable aggregate implications.

Related Literature. Our paper relates to the literature along multiple dimensions. First and foremost, we contribute to the literature on the impact of exchange rate changes on the real economy. Standard open economy macro models imply that exchange rate depreciations raise output growth via higher net exports. Recent studies, however, question the effectiveness of the classical trade channel and identify possible reasons for this ineffectiveness. These explanations include the presence of global value chains and imported intermediate inputs (Amiti et al., 2014; Rodnyansky, 2019), the dominant currency paradigm, i.e., a situation where producers set export prices in a dominant currency (typically the dollar) and leave them relatively stable (Gopinath et al., 2010; Gopinath et al., 2020), local currency pricing, i.e., prices that are set in the local currency of consumers (Devereux and Engel, 2003), and pricing-to-market, i.e., firms choosing markups that differ across markets with varying exchange rates (Fitzgerald and Haller, 2014). Other studies relate exchange rates to the real economy via a firm and bank balance sheet channel. While there is plenty of evidence showing that exchange rate depreciations can harm firm investment and economic growth when firms have foreign currency debt (e.g., Aguiar, 2005; Kearns and Patel, 2016; Du and Schreger, 2016; Kalemli-Ozcan et al., 2021), only one study, at least to the best of our knowledge, looks at how the growth effects of exchange rate movements are affected by banks' foreign currency exposure. Specifically, Agarwal (2019) shows that exchange rate depreciations (appreciations) can lead to an increase (decrease) in domestic credit and higher (lower) aggregate growth when the domestic banking sector has high net foreign asset exposure. We complement this research by employing more dis-aggregate bank-firm relationship data that do not only cover listed firms as is the case in Agarwal (2019), and by showing that (i) an increase in interbank market lending can explain most of the increase in bank loan supply following the exchange rate depreciation; (ii) banks use the increase in interbank liquidity to raise their bank loan supply, especially to export-intensive firms; and (iii) regions that are more exposed to this loop exhibit significantly higher GDP growth.

Second, our paper speaks to the literature relating macroeconomic developments, especially changes in the stance of monetary policy, to interbank markets. Fiordelisi et al. (2014) examine the impact of conventional and unconventional monetary policy on interbank credit markets and identify a more important role for the former. Abbassi et al. (2014) show that the European Central Bank's non-conventional long-term refinancing operations increased the supply of wholesale funding liquidity, consistent with Allen et al. (2014) and Freixas et al. (2011), who argue that monetary policy can have a *direct* impact on interbank market conditions. We show that similar effects can also be generated *indirectly* when changes in the stance of monetary policy affect the exchange rate and large domestic banks have significant foreign currency exposure.

Finally, we contribute to the literature investigating potential implications of the taper tantrum on the financial sector. Several studies show that the taper tantrum reduced cross-border capital flows, especially to emerging market economies, and as a consequence led to lower credit growth in these countries (e.g., Avdjiev and Takáts, 2014; Avdjiev and Takáts, 2019). Bruno and Shin (2019) gauge that Mexican firms that are more reliant on banks with higher dollar funding suffer a decline in credit and lower exports following the taper tantrum (through its effect on the dollar). In contrast, we establish that the taper tantrum can have a positive impact on credit dynamics by appreciating the USD and thus increasing the value of USD assets in countries where the domestic banking sector has significant foreign currency exposure.

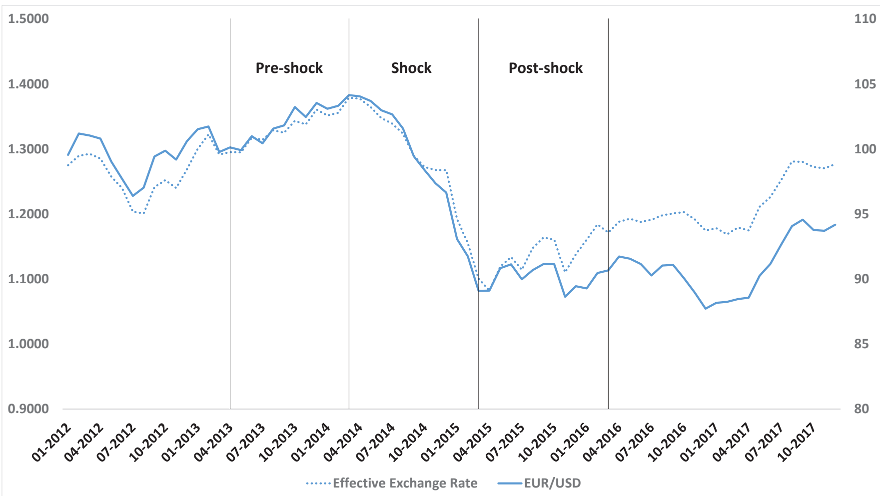
Overview. The remainder of the paper is structured as follows. In Section 2, we describe our data and the background of the EUR/USD depreciation episode that we are studying. Section 3 describes the empirical strategy. The results for the linear relation between banks' net foreign assets and loan supply are presented in Section 4. Section 5 investigates the cross-firm differences in loan supply. In Section 6, we study the real effects of the exchange rate depreciation using German region-level data. Section 7 concludes. All technical details and additional results can be found in an Online Appendix at the end of the paper.

2 Data and Institutional Background

2.1 The 2014/15 Exchange Rate Depreciation

Following ECB president Mario Draghi's "whatever it takes" speech in July 2012, the euro appreciated gradually relative to other currencies, as can be seen from Figure 1. However, from April 2014, a very sharp, unexpected and persistent depreciation of the euro began to occur. Specifically, within a relatively short time period, spanning only four quarters between 2014:Q2 and 2015:Q1, the euro lost slightly more than 20% in value relative to the US dollar. The decline relative to other currencies, as proxied by the trade weighted nominal effective exchange rate, was slightly less pronounced and less persistent.

Figure 1 THE EUR/USD EXCHANGE RATE OVER TIME



NOTE. This figure shows the dynamics of the EUR/USD exchange rate and of the trade weighted nominal effective exchange rate (1999:Q1=100) around the depreciation episode of 2014:Q2-2015:Q1.

What drove this sharp decline in the value of the euro? While it is impossible to attribute this exchange rate movement to just one single factor, many currency dealers interpret the decline in the euro as a rise in the dollar, driven at least to large extents by the gradual reversal of the quantitative easing policy in the United States, known as the Federal Reserve's tapering.[4] Yet, as shown by the Bundesbank (2017), a more expansionary monetary policy in the euro area also had a non-negligible impact on the EUR/USD exchange rate around the year 2014, with an estimated impact of the ECB's monetary policy being slightly smaller, however, than that of the Fed's policies. Overall, it therefore seems that the divergent monetary policy strategies in the US and the euro area, with the ECB continuing its purchases of financial assets, significantly weakened the euro relative to the dollar by raising the interest rate differentials between both regions.

We note that both policies are exogenous to lending at the bank-firm-relationship level. While German bank lending behavior is highly unlikely to affect the stance of monetary policy in the US for obvious reasons, it is also implausible to drive the ECB's decision to expand its lax monetary policies. This is because the ECB calibrates its monetary policy for the euro area as a whole and, especially during the episode considered in this paper, it was directed by the weak macroeconomic fundamentals in Southern Europe.

Germany is an interesting laboratory for studying the impact of this exchange rate movement on the real economy via the banking sector because the German banking sector has accumulated significant amounts of net foreign assets, especially since the launch of the monetary union, as we show in the summary statistics below. This fact combined with the pronounced cross-bank variation in foreign asset holdings allows us to identify the exchange rate effects across banks.[5] At the same time, Germany is an export-intensive economy with one of the largest net exports to GDP ratios in the world. Therefore, exchange rate changes are likely to have significant aggregate effects.

[4] See, for instance: https://www.theguardian.com/business/2015/mar/11/euro-12-year-low-gainst-the-dollar. In fact, in its FOMC meeting in December 2013, the Fed announced plans to begin tapering its purchases in January 2014. Purchases were halted altogether on 29 October 2014 after accumulating 4.5 trillion USD in assets.

[5] Note that, since 2018, financial institutions in Germany have had to report liquidity coverage ratios separately for each "significant" currency according to Article 415(2) of the Capital Requirements Regulation (CRR), where significance is defined as having liabilities in a foreign currency that are larger than 5% of total liabilities. This regulation, in turn, could bias German banks' holding of foreign liabilities towards values of slightly smaller than 5%. Yet, such a regulation, or any other regulation (or cap) on foreign currency lending or borrowing, was not in place prior to 2018 during our sample period, so this concern in our analysis is unwarranted.

2.2 Data

For the analysis carried out in this paper, we construct two unique data sets, one at the bank-firm level and one at the region-level, which we describe in turn. More details about the construction and sources of the variables can be found in the Data Appendix. The construction of the bank-firm level data set is also outlined in greater detail in Bednarek et al. (2021).

2.2.1 Bank-Firm-Level Data

The bank-firm-level data set is at quarterly frequency. The main source of this data set is the Deutsche Bundesbank's credit register, which includes traditional loans, bonds, off-balance sheet positions and exposures from derivatives positions. Financial institutions in Germany have to report any credit exposures to the Deutsche Bundesbank that exceed a threshold of 1 million euro.[6] In total, the German credit register captures about two thirds of German bank loans, including a sizable number of loans to small and medium-sized enterprises (Bednarek et al., 2021).

We match the credit registry data with bank balance sheet information. Specifically, we augment the data with the bank-level share of USD net foreign assets over total assets, bank size (log of total assets), returns on equity and assets, the capital-to-risk weighted asset ratios and non-performing loans over total loans. We also match firm-level accounting variables to our data set, sourced from Bureau van Dijk's Amadeus database. This match is complicated by the fact that the German credit register and the Amadeus database do not share a common identifier. To overcome this issue, we first match by the unique commercial register number, which is available for a sub-set of firms. Where this identifier is unavailable, we rely on Stata's reclink command, which probabilistically matches records.[7] Here, we match firms either by their name and zip code or by their name and city with a minimum matching reliability of 0.99. Finally, we also hand-match some of the hitherto unmatched firms.[8] After this matching process, we calculate firms' export intensity as the share of export turnover over total turnover. One issue here is that export turnover data are only reported by a minority of firms in Amadeus. In order to obtain a larger and more

[6] This threshold stood at 1.5 million euro before 2014.
[7] See Blasnik (2010).
[8] We match 4,143 firms by the commercial register number, 23,010 firms by Stata's reclink command and 1,038 firms by hand.

representative sample, we hence average export intensities by one-letter industry code. Other major firm covariates include the Altman Z-Score (Altman, 1968), leverage, size (log of total assets), labor productivity, defined as total sales over the number of employees, capital intensity, defined as total fixed assets over employees, and total factor productivity (TFP), all of which are also averaged by industry. The latter is constructed by estimating a production function based on our firm-level data aggregated at the industry level at the second digit of the NAICS code, following Wooldridge (2009). Specifically, TFP is the residual of a regression of firm-level log real value added on log labor input (the log of the real wage bill) and log capital input (the log of the real book value of total fixed assets). To obtain real values, value added and the wage bill are deflated with the two-digit industry price deflators from the OECD STAN database and the capital stock is deflated by the price of investment goods. For the calculation of TFP growth, we winsorize all variables at the 1% level before applying the log transformation. Finally, note that we employ additional firm variables in the specifications reported in the Online Appendix. The specifics of these variables are explained in detail there.

From our matched sample, we exclude borrowing firms in the utility or public sector. We finally end up with a sample of more than 300,000 bank-firm observations.[9]

2.2.2 Region-Level Data

Our region-level data mostly come from the INKAR database. It comprises data on 401 administrative regions in Germany and covers the period 2000-2017 at annual frequency. The main outcome variable for the region-level analysis is the change in the log of nominal GDP per capita from the pre- to the post-depreciation episode. INKAR only provides data on nominal per capita GDP. As region-level CPI indexes are not available, we do not deflate this variable. Note, however, that Germany is a diversified large economy and inflation was low and stable during the period we consider. Hence, using nominal rather than real GDP is unlikely to bias our estimation results.

In order to relate real economic activity at the region level to changes in regional bank lending behavior, we make use of a unique feature of the German banking sector, which comprises three pillars–private credit banks, savings banks and cooperative banks. Private credit banks are not geo-

[9]The regressions report a smaller number of observations due to missing data for some of the regressors.

graphically constrained in their business activities and data on the cross-regional variation of their operations are also unavailable. We hence do not consider them for the regional analysis in this paper. In contrast, what makes the German banking sector unique is that both savings and cooperative banks are confined geographically and their business model is focused on lending within their respective administrative district only. While this institutional feature implies that savings and cooperative banks have no economically meaningful foreign asset exposure (see Table 1 that reports mostly zeros for banks' USD net foreign asset exposure) and they are, therefore, not affected *directly* by the exchange rate depreciation, this paper shows that large banks with significant foreign asset exposure raise their interbank lending to small and regional banks. Thus, savings and cooperative banks are affected *indirectly* by the depreciation via an increase in interbank funding and the geographical constraints on their lending activity then allow us to relate regional economic dynamics to the (indirect) exposure of local banks to the EUR/USD depreciation.

Whereas savings banks' area of activity typically matches the 401 administrative regions in Germany,[10] the area of activity of cooperative banks is smaller than an administrative region. In addition, Dinger et al. (2020) argue that the regional market shares of savings banks are larger than those of cooperative banks, with savings banks being the largest bank in a lot of districts. This, in turn, suggests that exchange rate shocks, by affecting the balance sheet of savings banks, can have a sizeable impact on the local real economy.[11] For these reasons, in our regional analysis, we focus on savings banks rather than cooperative banks. Specifically, we use the match between savings banks and the 401 administrative regions of Dinger et al. (2020), which is based on a list of savings banks and the administrative regions in which they operate, as provided by the German Savings Banks and Giro Association, and allows us to aggregate the savings bank balance sheet variables described in Section 2.2.1 at the region level.[12]

[10] Deviations from this principle can occur for two reasons, as discussed in Dinger et al. (2020). First, there are a few cases where multiple individual municipalities within an administrative region each operate a savings bank, so that more than one savings bank can operate in a particular region. Second, mergers among savings banks can imply that one savings bank is active in more than one administrative region.

[11] See also Hakenes et al. (2015), who argue that regional banks are more effective than large private banks in promoting local economic growth.

[12] In some cases, the territorial boundaries of administrative regions have changed over time. For instance, the district Osterode was merged with an enlarged district Goettingen in 2016. Whereas Dinger et al. (2020) use an older territorial status of administrative regions, which, for instance, still includes the old (smaller) district Goettingen that had another district identifier than the new (enlarged) one, we use the 2019 territorial status of districts, which implies that we had to adjust their matching to be consistent with the 2019 status. Note as well that the list of Dinger et al. (2020) matches

Lastly, note that our omission of both cooperative and private credit banks from the regional analysis implies that our estimates are likely to be downward-biased and that the ”true” effect of the depreciation on GDP growth, working through the mechanisms highlighted in this paper, can be expected to be even larger.

2.3 Summary Statistics

Table 1 presents the summary statistics of all of the variables used in this paper. We provide the exact variable definitions and data sources in the Data Appendix, Table A.1.

The main dependent variable in our analysis, credit growth from the pre-depreciation episode (2013:Q2-2014:Q1) to the post-depreciation episode (2015:Q2-2016:Q1), has a median value of -7.12%. Considering the three-year period used to calculate this variable, this corresponds to an annualized decrease in credit volumes of approximately -2.5% – a value that is in line with the literature using German credit registry data (e.g., Bednarek et al., 2021; Behn et al., 2016a). Note that this negative value also implies that, in this paper, we examine whether the depreciation of the euro reduces this negative credit growth rate and, potentially, makes it turn positive for certain banks and firms.

Table 1 also shows that for many banks USD net foreign assets as a share of total assets are relatively low, as can be seen from the 75th percentile of 0%. However, several banks also have significant foreign asset exposure, with a 99th percentile of the distribution equal to 13.3% and six banks even having ratios larger than 25%. As we show in Section 4, these banks drive our results. On average, the fraction of USD net foreign assets in total net foreign assets is equal to 65%, making the dollar by far the most important foreign currency for German banks. Banks in our sample further have median values of liquidity equal to 14.6%, of non-performing loans equal to 2.7% and an average return on equity of 14.8%.

From the firm-level covariates, it is striking to see that firms have a median share of turnover

one bank to one district. However, there are a few cases where one savings bank operates in multiple administrative districts. For instance, after the merger between the savings bank Cologne and the savings bank Bonn to the new savings bank Cologne and Bonn, the latter operates in both districts. Therefore, whenever any of the 401 administrative districts considered in our paper were not matched to a savings bank in the list of Dinger et al. (2020), we verified whether this could be because one savings bank operates in multiple districts and matched such cases by hand, thus allowing one bank to be present in multiple districts.

Table 1 SUMMARY STATISTICS

Variable	Obs.	Median	25th	75th
$\Delta LOANS_{f,b}$	344,777	-7.12	-33.51	6.02
USD Net Foreign Assets	1,544	0.00	0.00	0.00
Total Net Foreign Assets	1,544	0.01	0.00	0.01
USD Gross Foreign Assets	1,544	0.06	0.01	0.20
USD Gross Foreign Liabilities	1,544	0.05	0.00	0.18
Size	1,544	20.20	19.26	21.23
Liquidity	1,544	14.59	10.70	20.46
ROE	1,479	14.75	10.21	19.68
NPL	1,477	2.65	1.62	4.09
Loans	1,542	60.47	50.62	68.62
Capital	1,486	18.61	15.81	22.53
$Exportshare_b$	953	17.84	21.57	47.38
EXPORTS	239,079	24.58	22.05	52.28
SIZE	239,079	2.14	1.23	2.56
TFP	239,079	3.68	3.24	4.78
Labor Prod.	239,079	0.23	0.14	0.49
Capital Intensity	239,079	0.04	0.03	1.84
Leverage	239,079	69.87	69.75	70.72
Z-Score	239,079	5.91	5.91	6.21
ΔGDP	401	11.88	9.51	14.51
$Exportshare_r$	395	26.16	0.15	40.04
Pop. Dens.	401	199.40	115.70	661.30
Share of People Above 65	401	20.60	19.30	22.20

NOTE. The table reports summary statistics for all variables. The variable definitions and data sources are in Table A.1.

generated abroad that is equal to 24.6%, strengthening our argument that Germany is an export-intensive economy, where exchange rate depreciations can be expected to have particularly strong real economic effects. Firms' median leverage, defined as total liabilities divided by total assets, comes to 69.9% and firms' average Z-Score stands at 5.9, indicating that German firms, on average, are relatively safe. Note here as well that the correlation between these firm characteristics and banks' USD net foreign assets in our matched bank-firm sample is very low (coefficients not reported in Table 1), ranging from -4% (for firm leverage), over -0.5% (for export turnover shares) to 7% (for firm size). These coefficients are similar when we confine the matched sample to large banks with significant foreign asset exposure. Therefore, selection between firms and banks is unlikely to drive our results.

Finally, concerning the region-level variables, Table 1 shows that average nominal GDP growth from 2012-13 to 2016-17 comes to 11.9% (or about 3% per year), average population density is 199 inhabitants per square kilometer of land and regions have a median share of people aged 65 or above of 20.6%.

3 Identification Strategy and Testable Hypotheses

We identify the impact of the 2014/15 exchange rate depreciation on bank lending in two steps. First, we explore the direct effect of the depreciation on overall bank loan supply, with a sensitivity that depends on banks' net foreign assets. The idea is that the depreciation should especially increase the net worth of banks with higher USD foreign assets, thus boosting their lending capacity.[13] Therefore, identification relies on the differential, ex-ante exposure of German banks to the depreciation, with banks having a higher share of foreign assets being more exposed. Second, we study the cross-firm differences in credit allocation. Identification here also hinges on the heterogeneity of firms' pre-depreciation balance sheet characteristics, as discussed in Section 3.2.

After identifying the impact of the depreciation on bank lending behavior in Sections 4 and 5, we also study its real economic effects using our comprehensive region-level data set. We present the econometric approach for this part of the analysis in Section 6.

3.1 Linear Model

In the first step of our empirical analysis, we investigate the linear effect of bank-level USD net foreign assets on bank lending, specified in a regression of the following form:

$$\Delta LOANS_{f,b,post-pre} = \alpha_f + \theta * Foreignassets_{b,pre} + \gamma X_{b,pre} + \varepsilon_{fb}, \tag{1}$$

where the dependent variable is the log change in the credit exposure of bank b to firm f from the pre-shock period average (the four quarters before the depreciation, i.e., 2013:Q2-2014:Q1) to the post-shock period average (the four quarters afterwards, i.e., 2015:Q2-2016:Q1). This calculation, consistent with a recent study by Bottero et al. (2020), minimizes problems that arise due to the standard errors' serial correlation (Bertrand et al., 2004) and averages out potential seasonality effects (Duchin et al., 2010). The main regressor is the bank-level, pre-shock share of USD net foreign assets over total assets. The regressions also include the following bank controls, subsumed in the vector X: log of total assets, loan-to-asset ratio, liquid over total assets, non-performing over

[13] See the Online Appendix Section B, where we show that after the EUR/USD depreciation, banks with higher volumes of net foreign assets do indeed have a higher net worth.

total loans, regulatory capital over risk-weighted capital and return on equity. The granularity of the credit registry data further allows us to restrict the sample to firms borrowing from at least two banks and to include firm fixed effects, α_f. Thus, we examine whether a firm which borrows from several banks experiences differential credit growth from banks with different amounts of USD foreign assets on their balance sheets. Because of this, firm-specific demand shocks are absorbed by the firm fixed effects and we are able to identify credit supply side effects (Khwaja and Mian, 2008).

All regressions in the paper that are based on German credit registry data are weighted by the volume of bank-firm credit exposures in order to prevent an oversampling of small bank-firm pairs that are unlikely to affect aggregate economic dynamics. After estimating this regression for the full sample of lenders and borrowers, we also partition the sample into borrowers in the real vs financial sector, and we furthermore distinguish between large and small lenders. To this end, we use two distinct size definitions. First, we differentiate between systemically important and non-systemically important banks.[14] Second, we define all banks in the top 2% of the total asset distribution as large, and the lowest 98% as small lenders, a threshold consistent with Kashyap and Stein (2000). In unreported specifications, we also define banks in the top 1% of the total asset distribution as large and the results are robust. Finally, the standard errors are either clustered at the bank level or, when the number of clusters is smaller than 40 because we focus on the sub-sample of large banks, we employ heteroskedasticity-robust standard errors.[15]

3.2 Interaction Model

In order to examine the effect of the exchange rate depreciation on the composition of bank loan supply across firms, in a second step, we expand Regression 1 by including the interaction between bank-level net foreign assets and different firm-level balance sheet characteristics. Identification, therefore, not only hinges on German banks' differential pre-depreciation USD exposure, but also

[14] Since 2014, according to the Deutsche Bundesbank, the following 15 banks have been classified as systemically important in Germany: Commerzbank, Deutsche Bank, DZ Bank, UniCredit Bank, Landesbank Baden-Wuerttemberg, Bayerische Landesbank, Landesbank Hessen-Thueringen, Norddeutsche Landesbank, ING DiBa, DekaBank Deutsche Girozentrale, Landwirtschaftliche Rentenbank, NRW.Bank, Hamburg Commercial Bank, Volkswagen Bank and TARGOBANK.

[15] See Angrist and Pischke (2008), who recommend that clusters should number at least 40.

on the differential, pre-depreciation characteristics of firms. This part of the analysis is specified as follows:

$$\Delta LOANS_{f,b,post-pre} = \alpha_f + \alpha_b + \beta * (FIRMVAR_{f,pre} * Foreignassets_{b,pre}) + \varepsilon_{fb}, \quad (2)$$

where the vector FIRMVAR contains different firm-level, pre-depreciation balance sheet characteristics discussed below. In addition to firm fixed effects, these regressions also include bank fixed effects, α_b, to control for (unobservable) heterogeneity across banks. Note that the sets of fixed effects absorb the main coefficients of the firm-level characteristics and bank-level net foreign assets, which therefore cannot be added separately. The same is true for the bank-level controls of Regression 1.

Which balance sheet characteristics determine firms' access to the increased credit supply following the depreciation? The existing body of literature identifies mainly two competing hypotheses. The first strand of the literature argues that export-intensive firms experience disproportionate improvements in their cash flows following a depreciation (e.g., Dao et al., 2021), which increases their credit worthiness. As a consequence, banks should expand the credit supply to such firms in particular. The first hypothesis thus suggests the following:

H1: The 2014/15 depreciation disproportionately increases banks' credit supply to firms with higher ex-ante export intensity.

To verify this hypothesis, we employ the share of firm-level export sales relative to total sales in the pre-shock period, averaged by one-letter industry code because data on export sales are missing for the majority of firms.[16] We also present specifications in which we replace the share of export sales with other firm variables, averaged at the industry level, that are shown to correlate tightly with the export intensity of firms.[17] These variables comprise firm size, capital intensity, labor productivity and total factor productivity.

A competing hypothesis suggests that mainly risky firms should experience a disproportionate

[16] We use the median to calculate average export intensities by industry in order to reduce the impact of outliers that are present in the firm-level data. Note, however, that using the mean yields similar coefficient estimates, but slightly lower statistical significance.

[17] See Wagner (2011) for a survey on this topic.

increase in credit volumes following a depreciation, since it makes banks' capital requirements less binding, thus allowing them to absorb losses and take on more risk. This channel is theoretically modelled by Martynova et al. (2020), who assume that banks typically have a stable core business and choose the size and riskiness of the riskier side investments. The model predicts that higher profitability of banks' core business loosens capital constraints, thus enabling banks to borrow more and to engage more in risky side activities. This theoretical mechanism is consistent with empirical evidence found by Calem and Rob (1999) and Perotti et al. (2011), among others.[18] Based on this channel, the second (competing) hypothesis is as follows:

H2: The 2014/15 depreciation disproportionately increases banks' loan supply to ex-ante riskier firms.

In order to examine the empirical validity of this competing hypothesis in our setting, we enrich the vector FIRMVAR (see Regression 2) by firms' Z-Score in line with Altman (1968) and firms' leverage (debt over total assets). The choice of the Altman Z-Score as one of our firm risk measures is driven by the fact that it measures firms' distance to default and encompasses several risk dimensions (working capital, retained earnings, profitability, capitalization).[19] In addition, leverage is an appropriate firm risk proxy because more levered firms are known to be more prone to asset substitution and to undertake more projects with a higher of failure. They are also more likely to default because of their worse loss-absorbing capacity (e.g., Jensen and Meckling, 1976; Carling et al., 2007). Again, to maximize the number of observations, we average these variables at the industry level.

Finally, note that we estimate Regression 2 for the full sample of firms, as well as for financial firms (banks) only, since the results from estimating Regression 1 suggest that an important role is played by interbank market lending. In order to investigate the bank-to-bank lending market, we aggregate the previously introduced firm balance sheet characteristics at the bank level. Specifically, we compute weighted bank-level averages of the firm characteristics, with weights equal to

[18] Note that the recent empirical evidence contradicts traditional corporate finance models that predict instead that more profitable firms take less risk (e.g., Keeley, 1990). For instance, around the global financial crisis, as highlighted in Martynova et al. (2020), profitable financial institutions took disproportionately high risks.

[19] In particular, we calculate the Z-Score as 3.25+6.56*working capital/total assets+3.26*retained earnings/total assets+6.72*EBIT/total assets+1.05*equity/total liabilities, in line with Altman et al. (2017).

the pre-depreciation bank-firm credit exposure. Using these averages, we examine whether lenders with a higher share of USD net foreign assets increase their interbank lending disproportionately to borrowing banks whose credit portfolio is made up of a higher share of firms with particular balance sheet characteristics.

4 The Linear Impact of Net Foreign Assets on Loan Supply

4.1 Main Results

In this section, we present the results for the linear relationship between banks' net foreign assets and credit supply. Table 2 contains the attendant estimates. As can be seen from column (1), banks with higher USD net foreign assets (NFA) increase their lending relatively more than banks with lower net foreign assets after the EUR/USD depreciation. The coefficient estimate, however, has a statistical significance slightly below the 10% level.

In columns (2)-(5), we thus continue differentiating between small and large lender banks, using two distinct size definitions. First, we distinguish between systemically important banks (SIBs) and non-systemically important banks, with the former being significantly larger than the latter.[20] Second, we define all banks in the top 2% of the total asset distribution as large, and all other banks as small. The coefficient estimates suggest that net foreign assets do not play an important role in the sensitivity of small banks' lending behavior to the exchange rate shock. In contrast, the previous results become both economically and statistically more significant for large lenders, which is evidence that only large banks with higher USD net foreign assets raise their lending in response to the exchange rate depreciation. In economic terms and given the overall decline in credit volumes in Germany throughout our sample period equal to about -7%, within the sub-group of systemically important banks, a bank that has an one-percentage point higher net foreign asset share than the median bank has a 5.65 percentage point lower credit growth contraction from the pre- to the post-depreciation episode. For banks with a 1.24 percentage point higher net foreign asset share than the median SIB, the overall credit growth rate, on average, then

[20]While total assets of SIBs in our sample average 276,179 million euro, those of non-SIBs average only 2,268 million euro.

also turns positive.[21]

Finally, we drop all borrowers that belong to the financial sector from our sample (column (6)). As becomes apparent, the NFA coefficient estimate turns negative (but statistically insignificant), suggesting that the positive coefficient of column (1) is driven by an increase in interbank market activity. This result is corroborated in column (7), where we focus on borrowers in the financial sector only and where net foreign assets again have a positive impact on lending that is statistically significant at the 10% level. In columns (8)-(9), we also investigate lending to financial vs non-financial borrowers for systemically important banks only. The attendant coefficient estimates show that, relative to the specification for all lender banks in column (7), especially these banks allocate disproportionately more credit to financial borrowers (column (9)). In contrast, SIBs rather reduce their lending to non-financials (column (8)). In unreported specifications, we also find that net foreign asset differences do not determine the lending of small (non-SIB) lenders to financial or non-financial borrowers in a statistically significant manner. Therefore, our results are mainly driven by large banks and their lending to financial sector borrowers.

Across the specifications of columns (1)-(9), it is mainly three bank-level controls that turn out to be statistically significant: banks' loan-to-asset ratio, liquidity ratio and profitability. Specifically, more liquid banks and banks with higher loan-to-asset ratios tend to lend less, which is consistent with other studies employing German credit register data (e.g., Behn et al., 2016a; Behn et al., 2016b; Bednarek et al., 2021) and can be interpreted as a convergence effect in bank lending. We also find that higher profitability reduces the lending by large banks, and increases the lending by small banks. For large banks, we also find a negative relation between non-performing loans and lending, especially when it comes to lending to financial borrowers.

Taken together, these results imply that only large banks with higher net foreign assets raise their lending in response to the exchange rate depreciation and that only an increase in interbank lending, not in lending to non-financial borrowers, can explain this effect. After presenting several robustness checks in Section 4.2, Section 4.3 studies why the effects of the depreciation are stronger for large relative to small banks with higher NFAs. Afterwards, Section 5 focuses on the potential drivers of the increase in interbank lending activity by establishing that large banks

[21] To get this number, we divide 7 by 5.65.

serve as a central intermediary that reallocates liquidity towards small banks with a higher portfolio share of export-intensive firms that experience higher demand on account of the exchange rate depreciation and are thus in need of external funds. In all of these specifications, we only use the systemically important bank definition to distinguish between small and large banks, mainly because it makes our analysis less prone to criticism regarding the exact cutoff used to define whether a bank is large or small. The results, however, are similar if we distinguish between the largest 2% of banks by total assets and the smallest 98%. These results are not reported for reasons of space, but they are readily available upon request.

Table 2 Exchange Rate Depreciations and Bank Lending: Main Results

	Full Sample	SIBs	Non-SIBs	Top 2% Bank	No Top 2% Bank	Non-Fin. Borrowers	Fin. Borrowers	Non-Fin. Borrowers, SIBs	Fin. Borrowers, SIBs
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	ΔLOANS	ΔLOANS	ΔLOANS	ΔLOANS	ΔLOANS	ΔLOANS	ΔLOANS	ΔLOANS	ΔLOANS
Foreignassets$_{b,pre}$	1.109	5.651**	-0.462	4.690*	-0.250	-0.485	1.947*	-2.497*	10.915**
	(0.73)	(2.74)	(0.74)	(2.57)	(0.48)	(0.99)	(1.02)	(1.39)	(2.99)
Size$_{b,pre}$	-2.727	-56.422**	-1.688	-2.776	2.504	1.059	-3.692	7.865	-116.221***
	(2.81)	(26.04)	(3.22)	(9.77)	(2.97)	(5.70)	(3.12)	(24.35)	(31.40)
Loans$_{b,pre}$	-0.615***	-0.193	-0.193	-1.017**	-0.128	-0.042	-0.741***	0.110	-3.402***
	(0.23)	(0.46)	(0.19)	(0.48)	(0.21)	(0.23)	(0.27)	(0.42)	(0.45)
Liquidity$_{b,pre}$	-0.642*	1.522	-0.324	-1.581**	-0.511	0.026	-0.955**	-0.550	4.461**
	(0.33)	(1.33)	(0.40)	(0.62)	(0.42)	(0.27)	(0.47)	(1.40)	(1.57)
Capital$_{b,pre}$	-0.001	1.040	0.018	0.166	0.106	-0.032	0.051	0.981	1.120
	(0.11)	(0.67)	(0.09)	(0.15)	(0.12)	(0.09)	(0.27)	(0.76)	(0.87)
NPL$_{b,pre}$	-0.820	-7.113*	-1.585	-5.819*	0.511	0.434	-1.170	3.676	-14.836***
	(1.37)	(3.59)	(1.91)	(2.90	(0.77)	(1.23)	(1.71)	(2.47)	(4.26)
ROE$_{b,pre}$	0.518	-2.074**	1.024***	0.038	0.707***	0.431	0.537	1.073	-4.486***
	(0.40)	(0.92)	(0.29)	(0.60)	(0.25)	(0.29)	(0.46)	(1.02)	(1.04)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	131,742	25,090	79,888	51,498	52,743	78,331	53,411	17,192	7,898
R^2	0.392	0.527	0.334	0.457	0.278	0.516	0.357	0.619	0.498

The regressions are based on quarterly bank-firm-relationship level data. The dependent variable is the log-difference in loan volume of bank b to firm f from the pre-depreciation period (2013:Q2-2014:Q1) to the post-depreciation period (2015:Q2-2016:Q1). The key independent variable is the bank-level share of USD net foreign assets over total assets. Columns (1)-(5) use all borrowers in the sample, columns (6) and (8) only borrowers in the non-financial sector and columns (7) and (9) only borrowers in the financial sector. While Column (1) uses all lender banks, columns (2), (8) and (9) focuses on systemically important banks, column (3) on non-systemically important banks, column (4) on the 2% of largest banks according to total assets and column (5) on banks in the lowest 98% of the total asset distribution. The regressions include firm fixed effects, as well as the following bank controls: log of total assets, loan-to-asset ratio, liquid over total assets, non-performing over total loans, regulatory capital over risk-weighted capital, return on equity. The regressions are weighted by the volume of bank-firm credit exposures and the standard errors are shown in parentheses, using bank clustered errors (columns 1, 3, 5, 6 and 7) or heteroskedasticity-robust errors (columns 2, 4, 8 and 9). *, ** and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Lastly, note that these within-firm specifications do not allow us to assess the overall impact of the depreciation on firms' credit access. That is because they only capture the intensive margin of lending and, therefore, do not take into account credit flows from new lending relationships or from those that were terminated between the pre- and post-depreciation period. Appendix D thus presents the results of between-firm regressions, in which we aggregate the bank-firm data at the firm level and control for credit demand by following the methodology proposed by Abowd et al. (1999), and recently applied by di Patti and Sette (2016), Cingano et al. (2016) and Beck et al. (2021). That is, we include in the regression the vector of firm-level fixed effects estimated from the previous bank-firm level regressions. The attendant results show that the within-firm results also feed into higher overall credit supply for more exposed firms.

4.2 Main Results: Robustness Checks

In this sub-section, we report the results of several robustness checks in which we adjust the main regression corresponding to column (2) of Table 2 in several aspects. First, while previous regressions report the coefficient estimates for USD net foreign assets, we now calculate a similar variable using not only banks' assets and liabilities denominated in USD, but also in Swiss franc, British pound and Japanese yen. In particular, the main regressor in column (1) of Table 3 is the bank-level, pre-depreciation share of net foreign assets denominated in one of these four currencies.[22] As becomes apparent, our main estimate remains positive and statistically significant at the 5% level once we apply this broader definition of net foreign assets.

Second, we disaggregate USD net foreign assets into USD gross foreign assets (column (2)) and liabilities (column (3)). As becomes apparent and consistent with our main result, the euro depreciation induces banks with higher gross foreign assets to raise their credit supply. The gross foreign liability estimate, however, is also positive and statistically significant at the 10% level, which is counter-intuitive because a weaker home currency increases the value of foreign currency liabilities. Given the substantial correlation between gross foreign assets and liabilities, which is equal to 89% in our sample, one potential reason for this result might be that gross for-

[22] Note that Bundesbank only provides banks' net foreign assets for these four currencies, which prevents us from including other currencies for this robustness check.

eign liabilities serve as a proxy for foreign assets. In fact, when we include both variables in a single regression (not reported), the gross foreign asset coefficient remains positive and the foreign liability coefficient turns negative. However, the estimates are very imprecisely estimated, presumably because of the high correlation between both variables.

Third, we include an additional bank-level control on the right-hand side of the regression—banks' interest rate exposure defined as the change in the present value (in % of own funds) of banking book positions exposed to interest rate risk due to an abrupt increase in interest rates by 200 basis points across all maturities. Adding this control might be important because because our sample period saw not only the depreciation of the EUR/USD exchange rate but also a dramtic fall in interest rates. To the extent that banks' interest rate exposure correlates with their USD net foreign assets, this would bias our results. As column (4) shows, this concern, however, is unwarranted. Specifically, even after controlling for banks' interest rate exposure, we find that banks with higher net foreign assets raise their loan supply after the depreciation. If anything, adding this control increases the size of the estimated net foreign asset coefficient.

Fourth, we adjust the calculation of the dependent variable. Specifically, instead of calculating it as the log change in the credit exposure of bank b to firm f from the four-quarter pre-depreciation average to the four-quarter post-depreciation average, we now use eight-quarter pre and post averages. As can be seen from column (5), our main estimate only decreases slightly relative to the baseline estimate of Table 2 and remains statistically significant at the 5% level.

Finally, we run a placebo analysis, calculating the credit growth rates around the year 2002, when the EUR/USD exchange rate remained relatively constant and, if anything, appreciated slightly from an average of 0.90 in 2001 to 0.95 in 2002. Specifically, we assume that the placebo event happened between 2002:Q2-2003:Q1, following our baseline analysis where the actual depreciation also started in the second quarter and continued for another three quarters (making four quarters altogether). We then calculate the dependent variable as the log change in credit volumes from the 2001:Q2-2002:Q1 average to the 2003:Q2-2004:Q1 average. As shown in column (6), in the absence of a significant exchange rate depreciation, banks with higher USD net foreign assets do not increase their lending disproportionately compared to banks with lower net foreign assets, confirming the parallel trend assumption underlying our difference-in-differences analysis. Note that we also observe insignificant effects for alternative placebo episodes (results not reported to conserve space). Specifically, we also run this placebo analysis for all other quarters between 2001 and 2014 and the coefficient estimate corresponding to banks' USD net foreign assets is never positive and statistically significant at the 5% level or higher. This result confirms our main results because there was not a single episode between 2001 and 2014 where the EUR/USD exchange rate depreciated both *significantly* and *persistently*.

In sum, Section 4.2 shows the robustness of our baseline results. Most importantly, we establish that the parallel trend assumption is likely satisfied in our analysis. That is, the credit growth rates of banks with high and low net foreign asset exposure do not differ in the absence of a significant and persistent depreciation of the EUR/USD exchange rate.

Table 3 Exchange Rate Depreciations and Bank Lending: Robustness

	(1)	(2)	(3)	(4)	(5)	(6)
	ΔLOANS	ΔLOANS	ΔLOANS	ΔLOANS	ΔLOANS	ΔLOANS
Total Foreignassets$_{b,pre}$	5.850**					
	(2.59)					
USD Gross Foreignassets$_{b,pre}$		3.829**				
		(1.58)				
USD Gross Foreignliabilities$_{b,pre}$			4.369*			
			(2.27)			
USD Foreignassets$_{b,pre}$				6.847**	4.996**	-6.622
				(2.74)	(2.26)	(7.91)
Interest Rate Exposure$_{b,pre}$				-5.700**		
				(2.55)		
Bank Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Obs	25,090	25,090	25,090	25,090	25,495	5,626
R^2	0.527	0.528	0.527	0.528	0.563	0.394

These robustness exercises are based on quarterly bank-firm-relationship level data. In column (1), we calculate net foreign assets as the sum of net foreign assets in USD, Swiss franc, Japanese yen and British pounds. In columns (2)-(3), we dis-aggregate USD net foreign assets into gross USD assets and liabilities. In column (4), we add banks' interest rate exposure as an additional covariate, defined as the change in present value (in % of own funds) of banking book positions exposed to interest rate risk due to an abrupt increase in interest rates by 200 basis points across all maturities. In column (5), the dependent variable is the log-difference in loan volume of bank b to firm f from the 8-quarter, pre-depreciation period (2012:Q2-2014:Q1) to the 8-quarter, post-depreciation period (2015:Q2-2017:Q1). In column (6), we run a placebo analysis around the year 2002, assuming that the placebo event happened during 2002:Q2-2003:Q1. In this specification, we calculate the dependent variable as the log change in credit volumes from the 2001:Q2-2002:Q1 average to the 2003:Q2-2004:Q1 average. All of the regressions include firm fixed effects, as well as the following bank controls that are not reported to conserve space: log of total assets, loan-to-asset ratio, liquid over total assets, non-performing over total loans, regulatory capital over risk-weighted assets, return on equity. The regressions are weighted by the volume of bank-firm credit exposures and the heteroskedasticity-robust standard errors are shown in parentheses. *, ** and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

4.3 Why are the Sensitivities of Large vs Small Banks Different?

Having shown that only large banks, not small ones, with higher net foreign assets are directly affected in their lending behavior by the exchange rate depreciation, this section explains that this is because only the largest banks have economically significant USD net foreign asset exposure. For instance, whereas the average share of USD net foreign over total assets is equal to 4.6% for systemically-important banks, other banks only have a share of 0.3% on average, indicating that there might be non-linearities in the effect of net foreign assets on bank lending around the depreciation episode. If this hypothesis is indeed true, we should find that the significant coefficient on large banks' net foreign assets in column (2) of Table 2 disappears once we drop banks with high net foreign asset exposure. Based on this idea, while column (1) of Table 4 reports the baseline estimate of Section 4.1 for reference containing all 15 of the systemically important banks in Germany, column (2) drops the bank with the highest share of USD net foreign assets in total assets, column (3) drops the five largest NFA-banks and column (4) drops the ten largest NFA-banks.

Table 4 The Effect on Large Banks with Lower NFAs

	All SIBs	Drop Largest NFA-Bank	Drop 5 Largest NFA-Banks	Drop 10 Largest NFA-Banks
	(1)	(2)	(3)	(4)
	ΔLOANS	ΔLOANS	ΔLOANS	ΔLOANS
$\text{Foreignassets}_{b,pre}$	5.651^{**}	5.383^{**}	4.899	-3.257
	(2.74)	(2.66)	(3.70)	(284.49)
Bank Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Obs	25,090	23,552	8,786	516
R^2	0.527	0.536	0.584	0.453

The regressions are based on quarterly bank-firm-relationship level data. The dependent variable is the log-difference in loan volume of bank b to firm f from the pre-depreciation period (2013:Q2-2014:Q1) to the post-depreciation period (2015:Q2-2016:Q1). The key independent variable is the bank-level share of USD net foreign assets over total assets. The regressions include systemically important lender banks only. While column (1) includes all of these lender banks, column (2) drops one bank with the highest share of USD net foreign assets, column (3) drops the five largest net foreign asset banks and column (4) the ten largest ones. The regressions include firm fixed effects, as well as the following bank controls that are not reported to conserve space: log of total assets, loan-to-asset ratio, liquid over total assets, non-performing over total loans, regulatory capital over risk-weighted capital, return on equity. The regressions are weighted by the volume of bank-firm credit exposures and the heteroskedasticity-robust standard errors are shown in parentheses. *, ** and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

The attendant results indicate that, once we drop only one bank, the coefficient estimate gets smaller in size, but remains statistically significant. Once we drop the five banks with the highest NFA shares, the corresponding estimate turns statistically insignificant and, once we drop the ten largest NFA-banks, the coefficient estimate even turns negative, but is estimated very imprecisely. Taken together, this is evidence that large banks do not per se have a higher sensitivity to the exchange rate depreciation, but that their more substantial shares of net foreign assets, on average, can explain their differential response to the depreciation. In other words, net foreign assets do not determine the sensitivity of large banks to the 2014/15 EUR/USD depreciation when their shares of net foreign assets are lower, like in the case of small banks.

5 The Composition of Bank Loan Supply

5.1 Cross-Firm Credit Allocation

The previous results show that large banks with a large net foreign asset position increase lending after the euro depreciation, primarily on the interbank market, while corporate lending, on average, is not affected. In the following, we explore the cross-firm allocation of credit as depicted in Regression 2. As we detail in Section 3.2, from a theoretical perspective, there are two competing hypotheses. The first suggests that export-intensive firms should obtain a disproportionately large share of the additional credit because the depreciation boosts their cash flows and increases their creditworthiness. As export-intensive firms are known to be more productive on average, an increase in lending to these firms would imply significant real economic effects. The other hypothesis suggests that banks should shift their credit allocation towards riskier firms, as the depreciation raises banks' net worth and risk-taking capacity.

As can be seen from column (1) of Table 5, large banks reallocate credit towards more export-intensive firms, as approximated by the industry average of export turnover over total turnover. The effect is statistically significant and economically meaningful. In particular, the credit growth differential around the depreciation episode of a firm at the 75th percentile of export intensity and one at the 25th percentile is equal to 2.8 percentage points for each percentage point higher USD net foreign asset share of large banks.[23]

As export turnover is only reported by a minority of firms in our sample, we next approximate

[23] We obtain this effect by multiplying the coefficient estimate (0.092) by the interquartile range of the firm-level export variable (52.28-22.05).

Table 5 Exchange Rate Depreciations and the Composition of Large Banks' Lending

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ΔLOANS	ΔLOANS	ΔLOANS	ΔLOANS	ΔLOANS	ΔLOANS	ΔLOANS	ΔLOANS
Foreignassets$_{b,pre}$ × EXPORTS$_{f,pre}$	0.092*					0.110*		
	(0.05)					(0.06)		
Foreignassets$_{b,pre}$ × SIZE$_{f,pre}$		6.374**						
		(2.78)						
Foreignassets$_{b,pre}$ × TFP$_{f,pre}$			2.141*					
			(1.15)					
Foreignassets$_{b,pre}$ × Labor Prod.$_{f,pre}$				10.756*				
				(6.00)				
Foreignassets$_{b,pre}$ × Capital Intensity$_{f,pre}$					2.841**			
					(1.22)			
Foreignassets$_{b,pre}$ × Z-Score$_{f,pre}$							-0.759	
							(1.92)	
Foreignassets$_{b,pre}$ × Leverage$_{f,pre}$								0.141
								(0.16)
Foreignassets$_{b,pre}$ × Residual SIZE$_{f,pre}$						1.318		
						(2.18)		
Foreignassets$_{b,pre}$ × Residual TFP$_{f,pre}$						0.599		
						(1.81)		
Foreignassets$_{b,pre}$ × REsidual Labor Prod.$_{f,pre}$						-3.017		
						(10.10)		
Foreignassets$_{b,pre}$ × Residual Capital Intensity$_{f,pre}$						4.231**		
						(1.80)		
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	25,090	25,090	25,090	25,090	25,090	25,090	25,090	25,090
R^2	0.531	0.531	0.531	0.531	0.531	0.531	0.530	0.530

The regressions are based on quarterly bank-firm-relationship level data for systemically important lender banks only. The dependent variable is the log-difference in loan volume of bank b to firm f from the pre-depreciation period (2013:Q2-2014:Q1) to the post-depreciation period (2015:Q2-2016:Q1). The key independent variable is the bank-level share of USD net foreign assets over total assets, interacted with the following industry medians of firm characteristics: export turnover over total turnover, log of total assets, total factor productivity, labor productivity defined as sales per employee, fixed assets over the number of employees as a measure of capital intensity, Altman's Z-Score and leverage. In column (6), we also add several residual components of some of these firm characteristics, stemming from regressions of these variables on export turnover over total turnover. The regressions include firm and bank fixed effects. The regressions are weighted by the volume of bank-firm credit exposures and the heteroskedasticity-robust standard errors are shown in parentheses. *, ** and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

export intensity using the industry average of other firm characteristics that are shown to correlate closely with export turnover, as surveyed in Wagner (2011), and are available for a larger number of firms. These proxies include size (log of total assets), total factor productivity, labor productivity, defined as sales over the number of employees, and capital intensity, defined as total fixed assets relative to the number of employees. In all of these regressions, shown in columns (2)-(5), the coefficient estimate on the interaction between bank-level net foreign assets and the respective firm-level characteristic is positive and statistically significant, showing a very robust relation between the exchange rate depreciation and a shift in large banks' credit allocation towards firms that are likely to have higher export intensities.[24]

In a next step, we horserace all of the previous double interactions with each other. The idea is to see whether export intensities dominate all other firm characteristics. In other words, to the extent that the other firm interactions lose their statistical significance once we also add the export turnover interaction, this would be evidence that the other firm characteristics of columns (2)-(5) only affect the sensitivity of bank lending to the exchange rate shock via their correlation with export intensities. In order to circumvent multicollinearity issues that arise because of the substantial correlation between export turnover and the other firm-level variables, in this additional specification, we replace the firm characteristics of columns (2)-(5) by their residuals stemming from a regression of these characteristics on firm-level export intensity. As column (6) indicates, the interaction between bank-level NFA and firm-level export intensity remains positive and statistically significant at the 10% level. The coefficient estimate is even higher than in column (1). All other interactions, apart from the one between bank-level NFA and firms' capital intensity, turn statistically insignificant. Thus, our empirical results clearly confirm the first hypothesis of Section 3.2: the euro depreciation disproportionately increased banks' credit supply to firms with higher ex-ante export intensity.

In order to verify the empirical relevance of the second hypothesis, we next interact banks' net foreign assets with the industry averages of important firm risk measures—the Altman Z-Score

[24] Note that the bank fixed effects absorb the linear (main) effect of bank-level USD net foreign assets. We therefore also run specifications without bank fixed effects (the attendant results are not reported). In these specifications, the main effect of NFA turns out to be statistically insignificant in most specifications, whereas the interaction coefficient between NFA and the previous firm characteristics remains positive and statistically significant.

and leverage ratio, respectively. As is apparent from columns (6)-(7), both firm risk interaction coefficients are statistically insignificant. Therefore, our empirical specifications cannot confirm the second hypothesis of an increased bank loan supply to riskier firms in response to the EUR/USD depreciation.

Overall, this section thus shows that large banks reallocate credit mainly towards export-intensive firms, which are more productive on average, so that the 2014 EUR/USD depreciation, at least through the channel identified in this paper, is likely to have a positive impact on German output growth. In contrast, we do not find evidence for increased bank risk-taking. After taking a closer look at how the exchange rate shock affects interbank market lending, Section 6 focuses on identifying the real effects associated with the euro depreciation.

5.2 Interbank Market Lending

Section 5.1 identifies a shift in credit towards export-intensive firms. At the same time, Section 4.1 shows that the exchange rate depreciation leads to a particularly strong increase in interbank lending activity of banks with higher net foreign assets. As the next step of our bank-firm level analysis, we ask whether the increase in interbank lending of large banks can be explained by an increase in the interbank credit supply to small banks that have a higher portfolio share of export-intensive firms. The idea is that, if small banks do not have significant net foreign asset exposure but a large share of exporting firms that experience higher demand on account of the exchange rate depreciation and are thus in need of external funds, large banks might reallocate funds towards small banks.

To identify this mechanism, following the strategy introduced in Section 3.2, we restrict the sample to large lender banks, as well as borrowers in the financial sector, and regress the credit growth rate for each lender-borrower pair on the interaction between lender-level USD net foreign assets and the borrower-level weighted average share of export sales over total sales of all firms in the borrowing bank's credit portfolio, where the weights are equal to the respective lender-borrower credit exposure in the pre-depreciation period.

As is apparent from column (1) of Table 6, large banks with higher net foreign assets do indeed

Table 6 Exchange Rate Depreciations and Large Banks' Interbank Lending

	All borrowers	Small borrowers	Large borrowers
	(1)	(2)	(3)
	ΔLOANS	ΔLOANS	ΔLOANS
$\text{Foreignassets}_{b,pre} \times \text{Exportshare}_{f,pre}$	0.268*	0.359*	0.046
	(0.16)	(0.20)	(0.17)
Lender FE	Yes	Yes	Yes
Borrower FE	Yes	Yes	Yes
Obs	1,837	1,643	161
R^2	0.439	0.455	0.548

The regressions are based on quarterly bank-firm-relationship level data for systemically important lenders only. The dependent variable is the log-difference in loan volume of lender bank b to borrower bank f from the pre-depreciation period (2013:Q2-2014:Q1) to the post-depreciation period (2015:Q2-2016:Q1). The key independent variable is the lender-level share of USD net foreign assets over total assets, interacted with the borrower-level average share of export sales over total sales of all firms in a borrowing bank's credit portfolio, weighted by the respective credit exposures. While column (1) uses the full sample of borrowers, column (2) only includes non-systemically important banks and column (3) only includes systemically important banks. The regressions include lender and borrower fixed effects. The regressions are weighted by the volume of lender-borrower credit exposures and the heteroskedasticity-robust standard errors are shown in parentheses. *, ** and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

increase their interbank lending to banks with a higher portfolio share of firms with significant export turnover. This effect is both statistically and economically significant: the credit growth differential around the depreciation episode of a borrowing bank at the 75th percentile of export shares and one at the 25th percentile is equal to 6.9 percentage points for each percentage point higher USD net foreign asset share of large banks.[25] As can be seen from columns (2)-(3), this effect is driven by small borrowing banks, not by larger ones. We thus show that the largest lender banks, following the appreciation of their foreign assets, serve as a central intermediary that reallocates liquidity towards small borrowing banks that have a higher portfolio share of export-intensive firms, suggesting that the impact of the EUR/USD depreciation on bank lending behavior is not restricted to banks that themselves have significant foreign asset exposure, but that exchange rate changes can instead affect distinct tiers of the banking system through an increase in interbank market activity.

[25] To see this, multiply the coefficient estimate (0.268) by the interquartile range of the firm-level export variable (47.38-21.57).

5.3 Do Small Banks Pass on the Additional Liquidity to (Exporting) Firms?

Previous regressions indicate that the 2014/15 EUR/USD depreciation induces large banks with higher net foreign assets to increase their interbank lending to small banks that have a higher share of exporting firms in their credit portfolios. In this sub-section, we examine whether this, in turn, allows small banks to raise their credit supply. To do so, we restrict the sample to small banks and model their lending to all firms around the depreciation as a function of the share of exporting firms in their credit portfolio, as in Section 5.2 weighted by the respective credit exposures. As can be seen from column (1) of Table Table 7, small banks with a higher share of exporting firms, which, as we have shown in Section 5.2, obtain a disproportionately large share of the increase in interbank liquidity, do indeed raise their credit supply. The attendant coefficient estimate is positive and statistically significant at the 10% level.

This significance, however, does not necessarily have to be driven by the improved access to interbank market liquidity of banks with higher shares of export-intensive firms in their portfolios. Rather, it could also be driven by alternative channels. For instance, it could be that such banks have excess liquidity anyway and the exchange rate depreciation induces them to shift some of that liquidity towards exporting firms that experience higher demand for their goods due to the depreciation and which, therefore, see improvements in their income statements. To show that the improved access to interbank markets can indeed explain the result of column (1), we next split the sample into banks with high vs low interbank dependence, using the median of the in-sample distribution of domestic interbank deposits to total assets as the threshold. To the extent that the higher interbank liquidity drives the previous result, we should obtain a significant coefficient for the high-dependence sub-sample and an insignificant coefficient for the low-dependence sub-sample.

In fact, as can be seen from columns (2)-(3), only for the sub-sample of small banks with high interbank dependence do we obtain a positive and statistically significant coefficient, which even increases in size and statistical significance relative to the full sample estimate of column (1). In contrast, for less interbank dependent banks, the estimate is smaller and not statistically different from zero. As a next step, we interact banks' portfolio export shares with firm-level

Table 7 Exchange Rate Depreciations and Small Banks' Lending

	Full Sample of Small Banks	Low Interbank Dependence	High Interbank Dependence	
	(1)	(2)	(3)	(4)
	ΔLOANS	ΔLOANS	ΔLOANS	ΔLOANS
$\text{Exportshare}_{b,pre}$	0.452*	0.141	0.609**	-0.560
	(0.26)	(0.22)	(0.29)	(0.48)
$\text{Exportshare}_{b,pre} \times \text{EXPORTS}_{f,pre}$				0.025*
				(0.01)
Bank Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Obs	41,212	9,292	23,854	23,854
R^2	0.356	0.434	0.334	0.335

The regressions are based on quarterly bank-firm-relationship level data for small (i.e., non-systemically important) lender banks only. The dependent variable is the log-difference in loan volume of lender bank b to firm f from the pre-depreciation period (2013:Q2-2014:Q1) to the post-depreciation period (2015:Q2-2016:Q1). The main independent variable is the bank-level average share of export sales over total sales of all firms in a bank's credit portfolio, weighted by the respective credit exposures. While column (1) uses the full sample, columns (2) and (3) split the sample into banks with high vs low interbank dependence, using the median of the in-sample distribution of domestic interbank deposits to total assets as the threshold. Column (4) includes the double interaction between bank-level export shares and firm-level export intensities for the sub-sample of small banks with high interbank dependence. The regressions include firm fixed effects, as well as the following bank controls that are not reported to conserve space: log of total assets, loan-to-asset ratio, liquid over total assets, non-performing over total loans, regulatory capital over risk-weighted capital, return on equity. The regressions are weighted by the volume of bank-firm credit exposures and the standard errors are clustered at the bank level and shown in parentheses. *, ** and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

export intensity, as in Section 5.1, in order to determine whether small banks use the additional interbank liquidity to raise their lending to export-intensive firms to a relatively greater extent. As becomes apparent from column (4), this is indeed the case with a coefficient estimate on the double interaction term that is positive and weakly statistically significant.[26]

Therefore, Section 5.3 shows that the additional interbank liquidity that small banks with a higher portfolio share of exporting firms obtain from large banks with higher net foreign asset exposure ultimately feeds into an increase in the credit supply of small banks, especially so to export-intensive firms. This result implies that an exchange rate depreciation, by increasing the liquidity of distinct tiers of the domestic banking sector, can have sizeable economic effects, even when local banks have low foreign asset exposure and are therefore not directly affected by the exchange rate shock. We continue identifying the real effects of exchange rate depreciations, working through the mechanism highlighted in this paper, in the next section.

[26]In unreported regressions, we saturate this regression with bank fixed effects. The results are similar, but estimated with slightly less precision.

6 Real Effects at the Regional Level

6.1 Econometric Specification

In the final step of our empirical analysis, we study the real effects of the 2014/15 euro depreciation, working through the mechanism highlighted in Sections 4 and 5. While our Online Appendix focuses on firm-level outcomes and provides evidence that more affected firms raise their investment (not their employment) after the depreciation, this section focus on a key regional outcome, output growth.

We exploit of a unique feature of the German banking system, which is that savings banks are only allowed to operate within a specific geographical area that typically matches one of the 401 administrative regions in Germany. This feature allows us to relate output growth in these 401 regions to how exposed the local banking sector is to the mechanism identified in this paper. Note that both private credit banks and cooperative banks are excluded from the following analysis. Private banks are excluded because they are not subject to geographical constraints, cooperative banks mainly because, although these are likewise geographically constrained in their activities, their area of activity typically does not match the definition of administrative regions in the national accounts for which we have GDP data. Our exclusion of these two types of banks in the following analysis implies that our estimates are likely to be downward-biased and the ”true” effect of the depreciation on GDP growth, working through the mechanisms highlighted in this paper, can be expected to be even larger.

Focusing on savings banks and following the evidence of Section 5.2 that large banks with higher net foreign assets increase their interbank lending to small banks with a higher share of exporting firms in their credit portfolios, we examine whether administrative regions where the local savings bank has a higher share of exporting firms in their portfolio have disproportionately higher GDP growth rates after the 2014 exchange rate shock. Note that such banks/regions are not affected directly by the depreciation because they typically have low shares of net foreign assets; they are, however, affected indirectly via an increase in interbank market liquidity. The region-level regressions are specified as follows:

$$\Delta Y_{r,post-pre} = \alpha_s + \nu * Exportshare_{r,pre} + \eta * X_{r,pre} + \varepsilon_r, \tag{3}$$

where ΔY is the region-level log difference in nominal GDP per capita from the two-year, pre-shock average (2012-2013) to the two-year, post-shock average (2016-2017).[27]

The main regressor is the region-level average of savings banks' share of export turnover over total turnover (as described in Section 3.2), where the regional average is weighted by banks' total assets if more than one savings bank operates in a specific administrative region. Consistent with previous steps of the analysis, we expect ν to be positive, indicating that the previous results ultimately spill over to an improvement in macroeconomic outcomes. Additional region-level controls, subsumed in the vector X, include population density and the share of people aged at least 65, as a proxy for the demography in a region. Our specifications also add fixed effects for the 16 German federal states, α_s.

6.2 Results

Column (1) of Table 8 shows that, for the full sample of regions, there is no positive relation between output growth and the share of exporting firms in local banks' credit portfolios around the 2014/15 depreciation episode. However, this non-significance can be driven by the fact that some of the savings banks with a lot of exporting firms in their portfolios have a low interbank dependence, i.e., they do not benefit from the increase in interbank lending of large banks after the depreciation. We thus split the sample into regions where the local bank has a share of domestic interbank deposits over total assets that is below and above, respectively, the median of the in-sample distribution. As can be seen from columns (2)-(3), while the impact of a higher share of exporting firms is even negative for regions with a low interbank dependence after the depreciation, the impact in regions where the local bank has a high share of interbank deposits is positive and statistically significant at the 10% level. Column (4) gauges that this result is

[27] 2014 and 2015 are excluded because the EUR/USD exchange rate depreciated from 2014:Q2-2015:Q1. The results, however, are robust to including 2015 in the post-shock average. Note as well that we get similar, albeit economically and statistically slightly weaker effects, if we compare GDP *one* year after the depreciation to the value *one* year before the depreciation.

economically and statistically even more significant when we include additional region-level variables, i.e., population density and the share of people aged at least 65, all set to their pre-sample values in 2008. In economic terms, the estimates of 0.030 (column 3) and 0.031 (column 4) imply that interbank dependent regions at the 75th percentile of the export share distribution grow by 1.2 percentage points more than regions at the 25th percentile, cumulatively, in the two years after the depreciation relative to the two pre-depreciation years.

Note here as well that, in unreported specifications, instead of splitting the sample, we obtain very similar results when we interact the share of exporting firms with the region-level interbank dependence of local banks, in which case the interaction coefficient is positive and statistically significant at the 1% level.

Table 8 The Exchange Rate Depreciation and Regional GDP Growth

	All regions	Low interbank dependence	High interbank dependence		
	(1)	(2)	(3)	(4)	(5)
	ΔGDP	ΔGDP	ΔGDP	ΔGDP	ΔGDP
$\text{Exportshare}_{r,pre}$	-0.007	-0.038***	0.030*	0.031**	-0.007
	(0.011)	(0.014)	(0.016)	(0.016)	(0.014)
$\text{Pop. Dens.}_{r,2008}$	-	-	-	-0.003***	-
				(0.000)	
Share of People Above $65_{r,2008}$	-	-	-	-0.367**	-
				(0.165)	
State FE	Yes	Yes	Yes	Yes	Yes
Obs	394	196	195	195	195
R^2	0.165	0.208	0.149	0.290	0.138

The regressions are based on annual region-level data. The dependent variable is the difference in the log of nominal GDP per capita from the pre-depreciation period (2012-2013) to the post-depreciation period (2016-2017). The key independent variable is the region-level, pre-depreciation average of savings banks' share of export turnover over total turnover as in Section 5.2, where the average is weighted by banks' total assets. Additional region-level controls include population density and the share of people aged 65 or above. We also add state fixed effects. While column (1) includes all regions, column (2) restricts the sample to regions with a below-median average of savings banks' share of interbank deposits over total assets, weighted as before. Columns (3)-(5) restrict the sample to regions with above-median interbank dependence. Column (5) runs a placebo regression using 2000-2001 as the pre-shock and 2003-2004 as the post-shock period. The heteroskedasticity-robust standard errors are shown in parentheses. *, ** and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Finally, in column (5), we run a placebo analysis, calculating the growth in GDP around the year 2002, where the EUR/USD exchange rate remained relatively constant (if anything, the euro appreciated). Specifically, we calculate the dependent variable as the log change in nominal GDP per capita from the 2000/01 average to the 2003/04 average. As becomes apparent, in the absence of a significant exchange rate depreciation, regions with local banks that have both high interbank dependence and a high share of exporting firms do not grow disproportionately more.

In summary, Section 6 establishes that the mechanism identified in this paper spills over to significantly higher output growth in more exposed regions. That is, the result that the exchange rate depreciation induces large banks with higher net foreign assets to raise their interbank lending to small banks with a higher share of exporting firms ultimately has significant macroeconomic effects. Economically, our estimates imply that regions more exposed to this loop grow by 1.2 percentage points more than less exposed regions, cumulatively, in the two years after the depreciation relative to the two pre-depreciation years.

7 Conclusions

In this paper, we use matched bank-firm-level data based on the German credit registry and exploit the exogenous and unanticipated EUR/USD depreciation of 2014/15 to show, in a difference-in-differences setting, that exchange rate depreciations lead to an increase in bank loan supply of large banks with higher net foreign assets, consistent with the evidence of Agarwal (2019) in the case of Switzerland. We further gauge that this increase is driven by a rise in interbank lending. Specifically, large banks, following an appreciation of their foreign assets, serve as a central intermediary that reallocates liquidity towards small banks that have a higher portfolio share of export-intensive firms experiencing stronger demand due to the exchange rate depreciation and are thus in need of external funds. Employing comprehensive region-level data, we further establish that regions that are more exposed to this mechanism experience significantly higher GDP growth—an effect that is likely to be driven by an increase in investment by more affected firms, as we show in the Online Appendix. In economic terms, we show that more exposed regions grow by 1.2 percentage points more than less exposed ones, cumulatively, in the two years after the depreciation relative to the two pre-depreciation years. Therefore, the documented shift in bank loan supply also has important aggregate implications.

While Agarwal (2019) studies the real and financial effects of an exchange rate appreciation episode, we look at how depreciations affect lending behavior and real outcomes. For future research, it would be interesting to study potential asymmetric responses of bank lending and real outcomes to exchange rate depreciations and appreciations in a uniform empirical setting. It would further be interesting to examine whether exchange rate movements, induced by changes in the *domestic* monetary policy stance, have a different impact than those induced by *foreign* monetary policy or economic fundamentals. We leave these interesting questions for future research.

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A Data Details

Table A.1 DEFINITIONS AND SOURCES OF ALL VARIABLES

Variable	Definition	Unit	Source
$\Delta LOANS_{f,b}$	Log-difference in the post-depreciation to pre-depreciation credit volume average of bank b to firm f	%	Credit Register
USD Foreign Assets	Bank b's USD net foreign assets over total assets	%	Bundesbank
Total Foreign Assets	Bank b's USD, yen, pounds and franc net foreign assets over total assets	%	Bundesbank
USD Gross Foreign Assets	Bank b's USD gross foreign assets over total assets	%	Bundesbank
USD Gross Foreign Liabilities	Bank b's USD gross foreign liabilities over total assets	%	Bundesbank
Size	Bank b's logarithm of total assets	ln(Euro)	Bundesbank
Liquidity	Bank b's liquid assets over total assets	%	Bundesbank
ROE	Bank b's return on equity	%	Bundesbank
NPL	Bank b's non-performing over total loans	%	Bundesbank
Loans	Bank b's loans over total assets	%	Bundesbank
Capital	Bank b's regulatory capital-to-asset ratio	%	Bundesbank
$Exportshare_b$	Average export over total sales of all firms in a bank's credit portfolio, weighted by credit exposures	%	Bundesbank, Amadeus
EXPORTS	Industry median of firms' export over total sales	%	Amadeus
SIZE	Industry median of the log of firms' assets	ln(Euro)	Amadeus
TFP	Industry median of firms' TFP, computed as in Wooldridge (2009)	%	Amadeus
Labor Prod.	Industry median of firms' sales over employees	%	Amadeus
Capital Intensity	Industry median of firms' fixed assets over employees	%	Amadeus
Leverage	Industry median of firms' total liabilities over total assets	%	Amadeus
Z-Score	Industry median of firms' Altman's Z-Score	-	Amadeus, own calculation
ΔGDP	Region r's log-difference in the post- (2016-2017) to pre-depreciation (2012-2013) average in nominal GDP per capita	%	Own calculation, BBSR Bonn (INKAR)[a]
$Exportshare_r$	Region r's asset-weighted average of savings banks' share of export over total sales in their credit portfolio	%	Amadeus, Credit Register
Pop. Dens.	Region r's number of inhabitants per square kilometer in 2008	-	BBSR Bonn (INKAR)
Share of People Above 65	Region r's share of people aged 65 or more in total population in 2008	%	BBSR Bonn (INKAR)

[a] All data from BBSR Bonn are subject to Data licence Germany – BBSR Bonn – Version 2.0

B The Depreciation and Banks' Net Worth

The underlying channel through which an exchange rate depreciation has a significant effect on bank loan supply is as follows: if a bank's foreign currency exposure is not perfectly hedged, a bank with higher foreign currency assets than liabilities will experience an increase in its net worth, which raises its lending capacity. In this section, we test this channel empirically. Specifically, we examine whether the EUR/USD depreciation increases the capital positions of banks with higher USD net foreign assets to a disproportionately greater extent. To this end, we replace the dependent variable in Regression 1 with the change in the logarithm of banks' liable capital around the depreciation.[28] The right-hand side of the regression is left unchanged.[29]

Table B.1 The Effect of the Depreciation on Banks' Net Worth

	Full Sample	SIBs	Non-SIBs
	(1)	(2)	(3)
	ΔEQUITY	ΔEQUITY	ΔEQUITY
Foreignassets$_{b,pre}$	0.451	4.571***	-0.036
	(0.32)	(0.25)	(0.19)
Bank Controls	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Obs	128,745	25,090	77,021
R^2	0.634	0.820	0.488

The regressions are based on quarterly bank-firm-relationship level data. The dependent variable is the log-difference in liable capital of bank b from the pre-depreciation period (2013:Q2-2014:Q1) to the post-depreciation period (2015:Q2-2016:Q1). The key independent variable is the bank-level share of USD net foreign assets over total assets. Column (1) includes all banks in the sample, column (2) only systemically important ones, and column (3) only non-systemically important ones. The regressions include firm fixed effects, as well as the following bank controls that are not reported to conserve space: log of total assets, loan-to-asset ratio, liquid over total assets, non-performing over total loans, regulatory capital over risk-weighted capital, return on equity. The regressions are weighted by the volume of bank-firm credit exposures. Columns 1 and 3 employ bank clustered standard errors; column 2 uses heteroskedasticity-robust standard errors, all of which are shown in parentheses. *, ** and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

As Table B.1 shows, the depreciation does indeed raise the net worth of banks with higher net foreign assets to a disproportionately greater extent; however, the statistical significance of the attendant coefficient estimate for all banks in column (1) is slightly below the 10% level. Once we

[28]The results are similar if we use banks' total capital.

[29]We run this analysis at the bank-firm level, not at the bank level, in order to be consistent with our main regressions in the paper. In addition, if we ran that analysis at the bank level, we would have just 15 observations for the regression that is restricted to systemically important banks. This is why the attendant coefficients in this bank-level regression are estimated very imprecisely (results not reported).

restrict the sample to systemically important banks only, the effect turns statistically significant at the 1% level. This means that for those banks that drive our main results, higher pre-depreciation net foreign assets are associated with increased equity positions after the depreciation. This is evidence consistent with the underlying theoretical mechanism that the significant effects of the depreciation on more exposed banks' lending can be explained by an increase in their net worth.

C Real Effects at the Firm Level

Our paper contains two main results. One is that after the depreciation large, systemically important banks with higher net foreign assets raise their loan supply, especially in the form of interbank credit provided to small financial institutions, which pass on the additional liquidity to exporting firms. The other indicates that the depreciation also has significant real effects in terms of higher GDP growth in more exposed regions. In this section, we explore whether these real effects are likely to be driven by an increase in firms' investment and/or employment. In particular, following the previous evidence that exporting firms experience a disproportionately stronger increase in lending from small, non-systemically important banks after the exchange rate depreciation, we restrict the sample to firms whose main credit relationship is with a non-systemically important bank and test whether the employment and investment response of firms with a higher export share is stronger than that of non-exporting firms. As in Section 5.1, we define export shares as the industry average of export turnover over total turnover to maximize the number of observations. These regressions can be summarized as follows:

$$\Delta Y_{f,post-pre} = \nu * Exportshare_{f,pre} + \eta * X_{f,pre} + \varepsilon_f, \tag{A1}$$

where ΔY is the firm-level log difference in the number of employees (as our proxy for employment) and total fixed assets (as our proxy for the capital stock) from the pre-event year 2012 to the post-event year 2014.[30] X includes the following two firm-level covariates, measured in 2012: size (log of total assets) and the Altman Z-Score, which encompasses capital and profitability, both of which therefore do not have to be added as separate controls. Note that the number of observations in these firm-level regressions is quite small and our firm sample only covers a very small sub-set of all firms in Germany. We therefore interpret the following results, at most, of being indicative of real effects at the regional level that are generated by an increase in firm

[30] Our firm-level data end in 2014 and we, therefore, cannot be consistent with the regional analysis, in which we compare the years 2016-2017 with 2012-2013. Yet, as the bulk of the depreciation took place in the course of 2014, and most firms report their balance sheet numbers at the end of the respective year, comparing 2014 with 2012 allows us, to a large extent, to compare the post-depreciation period with the pre-depreciation one.

employment and/or investment.

Table C.1 indicates that, for the full sample of firms, firms with a higher export turnover do not raise their investment or employment. Yet, this non-significance can be driven by the fact that some of the firms, despite their high export shares, have credit relationships with banks less affected by our channel/the depreciation, i.e., banks with low interbank dependence. Hence, we continue splitting the sample into firms where the relationship banks have a ratio of domestic interbank deposits to total assets that is smaller (columns (3) and (4)) and larger (columns (5) and (6)) than the median of the distribution, where the interbank ratio is weighted by the credit exposures if a firm borrows from multiple banks. These specifications show that firms that are most likely to be affected by the channel proposed in our paper, and as opposed to less affected firms, raise their investment in a weakly statistically significant manner (column (6)). In contrast, the employment dynamics seem to be statistically insignificant for all firms throughout.

Table C.1 The Exchange Rate Depreciation and Firms' Real Outcomes

	All Firms		Low interbank dependence		High interbank dependence	
	(1)	(2)	(3)	(4)	(5)	(6)
	ΔEMPL	ΔK	ΔEMPL	ΔK	ΔEMPL	ΔK
$\text{EXPORTS}_{f,pre}$	-0.014	0.080	-0.028	-0.007	-0.017	0.146*
	(0.11)	(0.09)	(0.14)	(0.26)	(0.13)	(0.007)
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes
Obs	1,385	1,555	520	566	865	989
R^2	0.003	0.008	0.015	0.027	0.002	0.020

The regressions are based on annual firm-level data and include all firms in our sample that have their main credit relationship with a non-systemically important bank. The dependent variables are the differences in the log of the number of employees and fixed assets from the pre-depreciation period (2012) to the post-depreciation period (2014). The key independent variable is the industry average of firms' pre-depreciation export turnover relative to the total turnover. While columns (1) and (2) use the full sample of firms, columns (3)-(4) splits the sample into firms where the relationship banks have a ratio of domestic interbank deposits to total assets that is smaller than the median of the in-sample distribution, where the interbank ratio is weighted by the credit exposures if a firm borrows from multiple banks. Columns (5)-(6) focus on the sample of firms with above-median interbank ratios. Additional firm-level controls include size (log of total assets), the return on total assets and the capital-to-asset ratio. The regressions are weighted by firms' total credit registry exposure and the heteroskedasticity-robust standard errors, clustered at the one-digit industry level, are shown in parentheses. *, ** and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

D Cross-Sectional Analysis

The regressions throughout this paper gauge that firms having a credit relationship with a (large) bank that has higher net foreign asset exposure obtain disproportionately more credit during the post-depreciation episode, even after controlling for firm fixed effects. These within-firm specifications, however, do not allow an assessment of the overall impact of the depreciation on firms' credit access, both because they do not take into account credit flows from new lending relationships and because they ignore bank-firm relationships that were terminated between the pre- and post-depreciation period. In order to examine whether more affected firms also experience improvements in overall credit supply, we estimate a regression of the following form:

$$\Delta LOANS_{f,post-pre} = \widehat{\alpha_f} + \theta * \overline{Foreignassets}_{f,pre} + \gamma * \bar{X}_{f,pre} + \varepsilon_f, \tag{A1}$$

where the dependent variable is the log change in total credit between the pre- and post-depreciation episode from all banks to firm f. $\overline{Foreignassets}$ is the exposure of each firm to the depreciation, computed as the weighted average of banks' USD net foreign asset shares across all banks lending to a firm, using as weights the pre-depreciation share of total credit of each bank. Bank controls, subsumed in the matrix X, include the same variables as in Regression 1, but are averaged at the firm level according to the share of bank-firm credit exposure prior to the depreciation.

Finally, given that we are not able to include firm fixed effects in Regression A1, we control for credit demand by following the methodology proposed by Abowd et al. (1999), and recently applied by di Patti and Sette (2016), Cingano et al. (2016) and Beck et al. (2021). That is, we include in the regression the vector of firm-level fixed effects estimated from Regression 1, $\widehat{\alpha_f}$. Finally, standard errors are clustered at the main bank level.

As can be seen from Table D.1, our within-firm results also feed into higher overall credit supply for more exposed firms. In particular, firms where the relationship banks have higher USD exposure experience a stronger increase in overall credit supply than less exposed firms. In column (2), we allow the firm exposure to the depreciation to interact with firms' export intensity, using the industry median of export turnover relative to total turnover as a proxy of export intensity. While the main effect of firm exposure remains positive and statistically significant at the 5% level, the interaction coefficient turns out to be statistically insignificant. This is evidence that all exposed firms benefit from the 2014/15 depreciation, and there is no amplified impact for export-intensive firms.

Table D.1 Between-Firm Analysis

	(1) ΔTOTAL CREDIT	(2) ΔTOTAL CREDIT
$\overline{Foreignassets}_{f,pre}$	0.868**	2.005**
	(0.39)	(0.85)
$\overline{Foreignassets}_{f,pre} \times \text{EXPORTS}_{f,pre}$		-0.030
		(0.03)
Bank Controls	Yes	Yes
Credit Demand	Yes	Yes
Obs	36,430	17,197
R^2	0.440	0.430

The regressions are based on quarterly bank-firm-relationship level data. The dependent variable is the log change in total credit between the pre- and post-depreciation episode from all banks to firm f. The key independent variable is the exposure of each firm to the depreciation, computed as the weighted average of banks' USD net foreign asset shares across all banks lending to a firm, using as weights the pre-depreciation share of total credit of each bank. In column (2), we interact this variable with the industry median of export turnover relative to total turnover. Bank controls, subsumed in the matrix X, include the same variables as in Regression 1, but are averaged at the firm level according to the share of bank-firm credit exposure prior to the depreciation. The attendant coefficients are not shown in order to conserve space. We also control for credit demand by adding the vector of firm-level fixed effects estimated from Regression 1. The standard errors are clustered at the main bank level and are shown in parentheses. *, ** and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.