# Macroprudential policy spillovers and international banking - Taking the gravity approach

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**Abstract**

In this paper I study how the effects of nationally implemented macroprudential policy spill across borders via international lending. For a set of 157 countries, I estimate a gravity model applied to international banking where the use of different macroprudential policy measures enter as friction variables. My findings support the existence of cross-border spillovers from macroprudential policy. Moreover, I find that the overall effect from more macroprudential regulation is highly dependent on the income group of the countries in which banks operate: The effect is of opposite sign for advanced and for emerging economies. I argue that the difference may tell of banks having more opportunities for regulatory arbitrage in emerging market economies.

**Keywords:** Macroprudential policy, International banking, Policy spillovers

**JEL Codes:** F42, G15, G21

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# 1 Introduction

The proliferation of the use of macroprudential policy measures[1] (MPMs) after the financial crisis has been rapid and widespread[2]. Even though the field has expanded rapidly, there remains substantial gaps in knowledge about the use of MPMs, their effectiveness and transmission mechanisms. To gain fuller understanding on the effectiveness of MPMs, one should not restrict considerations to the ability of MPMs to deliver the desired outcomes inside the country implementing the policies. There is evidence showing that the effects of MPMs spill across borders via international bank lending[3] and that this may reduce the effectiveness of nationally implemented MPMs[4]. My findings support the existence of spillovers[5], but in addition, I find that the spillover effects differ substantially across different country groups.

This paper sets out to add to the knowledge on cross-border spillovers from nationally implemented MPMs occurring via international bank lending. I argue that the gravity model[6] of international financial asset trade applied to cross-border banking can give insight into the spillover effects. I demonstrate this by employing a standard gravity setup with the usual gravity controls, such as distance, a shared border and a common language, included. After including measures for MPMs implemented in the origin and the destination countries to such a setup, I use the Poisson pseudo-maximum-likelihood (PPML)[7] procedure to estimate the thus specified gravity model. I find a sta-

[1] IMF has defined MPMs broadly as instruments that are either designed to or modified to target systemic risk explicitly and specifically. Thus MPMs should be distinguished from other macroeconomic instruments that might also support financial stability. The overarching objective of MPMs is to enhance financial stability by engaging in crisis prevention and crisis management. See IMF, 2013 and 2014.

[2] See e.g. Cerutti et al. 2017a, 2017b.

[3] See e.g. a meta study of Buch and Goldberg and the research cited therein, 2017, Agénor et al., 2017, and Cerutti and Zhou, 2018b.

[4] See e.g. Reinhardt and Sowerbutts, 2015.

[5] Following Buch and Goldberg, 2017, policy spillovers are defined here broadly as effects stemming from both potential regulatory arbitrage and responses to changes in supply and demand of credit.

[6] The gravity model, a workhorse model of trade literature, has been shown to emerge from many different theoretical settings considering a bilateral interaction between two countries and empirically to fit many different data. See Head and Mayer (2014) for a relatively recent survey.

[7] Proposed by Santos Silva and Tenreyro, 2006.

tistically significant effect from MPMs on cross-border lending and argue that this is an indication of the existence of cross-border spillovers from MPMs via international bank lending. Thus, my findings confirm previous results[8] on the existence of such spillovers.

In addition to what has been found in previous studies, I find that the overall effect from more macroprudential regulation implemented is highly dependent on the income group of the countries in which the banks operate. For banks operating in advanced economies (AEs), the spillover effect from more MPMs implemented is always negative. This means that banks appear to reduce foreign lending when more MPMs are implemented in either the origin or the destination country. On the contrary, for banks operating in emerging and developing market economies (EMDEs), the spillover effect is always positive. Thus it seems that these banks increase foreign lending when more MPMs are implemented in either the origin or the destination country. I argue that this difference could be related to there being more opportunities for regulatory arbitrage for banks operating in EMDEs.

Up-to-date, comprehensive and consistent data on the use of MPMs around the globe has not been available for a large set of countries until very recently. This is a natural consequence of macroprudential policy as an independent policy framework taking shape only after the global financial crisis. For its part, the lack of data has impeded research into the effects of MPMs. The International Monetary Fund (IMF) in 2013 stepped up to fill in the gap by initiating an annual survey on the use of MPMs[9]. Based on the responses, IMF published first in 2015 the Global Macroprudential Policy Index (GMPI) -data[10], which was the first attempt to stand up to the task of consistently

[8]Such as the meta study of Buch and Goldberg and the research cited therein, 2017, Agénor et al., 2017, and Cerutti and Zhou, 2018b.

[9]For more information on the survey, see https://www.elibrary-areaer.imf.org/Macroprudential/Pages/Home.aspx.

[10]This data provides the most extensive database to date on the use of MPMs by documenting the various MPMs implemented in a sample of 160 countries over the years 2000-2017. Most of this data comes from the Macroprudential Policy Instruments survey carried out by the IMF. Cerutti et al. (2017a) complement this data with different smaller sources. The data set is compiled by and described in Cerutti et al., 2017a, and updated in 2018. Available via Eugenio Cerutti's homepage: https://www.imf.org/~/media/

documenting the use of these tools across a very large set of countries[11]. I combine this data with a network of bilateral bank asset holdings, which I build using the locational banking statistics compiled by the Bank of International Settlements (BIS). To my knowledge, my paper is the first one to consider these data together[12]. In addition, as the coverage of the GMPI-data is very good compared to previously available data sets, I can provide a multi-country look at spillovers from MPMs that is substantially more extensive in terms of country coverage than that of previous work[13].

I use the gravity model to confirm the existence of cross-border spillovers from MPMs. The gravity model applied to international banking allows for controlling for the classic "gravity result", i.e. the stylized fact of distance affecting negatively in principle any bilateral relationship. This has been found to hold also in international banking[14]. I am aware of only two papers that explicitly consider the effects of regulation on international bank activity in the gravity framework. In both these papers, Houston et al. (2012) and Cerutti and Zhou (2018b), the data, set-up and estimation methods are however different from my approach.

Building a gravity-type model is relatively straightforward, but the choice of estimation method is restricted by the type of data one is dealing with. The nature of the bilateral data required by a gravity type set-up is usually characterized by an at least non-negligible, and often large share of zero observations, heteroskedasticity and clustering. The traditional approach of log-linearizing the gravity equation, considering only the positive observations and estimating the determinants of the gravity equation using an OLS method have been

Websites/IMF/imported-datasets/external/pubs/ft/wp/2015/Data/_wp1561.ashx.

[11] In March 2019, IMF published another data set based on the same survey data. The integrated Macroprudential Policy Database (iMaPP), alas not available while this paper was being written, is available at https://www.imf.org/~/media/Files/Publications/WP/2019/datasets/wp1966.ashx.

[12] In a recent paper by Cerutti and Zhou (2018b), the GMPI-data is considered parallel to international banking *flows* from the BIS *consolidated* banking statistics.

[13] E.g. the papers by Reinhardt and Sowerbutts, 2015, and by Avdjiev et al., 2017, cover 60 and 53 countries respectively. I cover 157 countries.

[14] See e.g. Buch (2005), Blank and Buch (2007), Müller and Uhde (2012), Houston et al. (2012), Sander et al. (2013), Buch et al. (2013), Brei and von Peter (2018), and Cerutti and Zhou (2018a, 2018b).

shown to lead to biased estimates (e.g. Santos Silva and Tenreyro, 2006, Brei and von Peter, 2018). In this paper I use the theory-consistent Poisson pseudo-maximum-likelihood (PPML) method proposed by Santos Silva and Tenreyro (2006), that is robust in terms of heteroskedasticity, clustering and zero observations.

The rest of the paper is organized as follows. The related literature is reviewed by strands in section 2 and data presented in section 3. The research questions, the model, the methodology and results are discussed in section 4. Section 5 concludes.

# 2 Related literature

This paper contributes to two strands of literature. First, my results add to the knowledge on the cross-border effects of macroprudential policy, i.e. regulatory spillovers and leakages associated with MPMs. Second, my results help in filling in the gaps in understanding of what affects international banking flows by providing an application of the gravity model for bilateral cross-border bank holdings and estimating the model with a theory-consistent method.

## 2.1 On the spillover effects of macroprudential policy

The history of financial crises makes it evident that financial instability has little respect for national borders (see e.g. Reinhart and Rogoff, 2009). The global financial crisis and the subsequent Euro area sovereign debt crisis showed that as the global financial markets have become ever more closely intertwined and economies ever more open, financial calamity can spread with a speed difficult to match by policy makers. In the presence of large and fast-moving capital flows and extensive cross-border activities of large international banks, the effects of MPMs may not be confined to the country that implements them. Cross-border spillovers of macroprudential policy may arise e.g. when banks exploit differences in the standards of national regulation by placing their activities in countries with the least imposing regulatory requirements. This *regulatory arbitrage* can to some extent be mitigated by mutual recognition, often referred to as reciprocity, of MPMs by the national authorities of different countries. Even though the leakages have so far been found to be rather small, they may increase as national MPMs become more widespread (Buch and Goldberg, 2017).

The effectiveness of macroprudential instruments can be compromised if banks can take their lending activities outside the scope of regulation or if domestic agents can freely borrow abroad. As Engel (2016) points out, if the domestic supervisor has different regulatory oversight on domestic banks and foreign branches or subsidiaries, macroprudential policy leakages and spillovers

arise quite naturally. This has two consequences. First, the domestic economy remains exposed to systemic risk even after regulatory tightening. Second, the domestic financial intermediaries are left at a disadvantage as a funding cost advantage is created for foreign banks outside the scope of national regulation. This provides the motivation for reciprocity, i.e. mutual recognition of MPMs by different countries. The gains from policy coordination can potentially be sizable, as shown by Agénor et al. (2017) who develop a core-periphery model of coordinated and non-coordinated MPMs.

However, reciprocity can also lead to foreign financial institutions simply shifting their activities to other countries. In a sense, this can be a desirable outcome, insofar as it may reduce the fragility of the financial system and thus the risks to the domestic economy, but it can also have undesirable consequences. First, this may lessen the options for domestic households and companies. Second, it may diminish the availability of expertise that may not be available locally and thus make also the domestic financial sector less competitive (Engel 2009). Third, and perhaps most importantly, if increased regulation encourages foreign financial institutions to relocate, the possibly adverse effects of the resulting thinner financial markets may last a lot longer than the financial cycle. This is why some economists, e.g. Korinek (2011a,b) and Jeanne (2012), favour counter-cyclical capital controls instead of more stringent prudential regulation. The problem of regulatory arbitrage would naturally disappear if regulation was completely harmonized across all countries. However, optimal macroprudential policy is highly unlikely to be identical across different economies, i.e. there is a trade-off between national customization and global harmonization of policy measures.

Because of the reasons discussed above, it is paramount to consider also the sometimes unexpected effects that nationally implemented MPMs can have on the cross-border activities of banks. A relatively early comprehensive look into how international lending might be affected by regulatory arbitrage, i.e. spillovers from regulation, is by Houston et al. (2012). They consider the effect of regulation on international bank flows in a gravity framework and

find strong evidence of banks transferring funds to markets with less imposing regulation. Early implementation of MPMs has made UK an interesting case for researchers. Aiyar et al. (2014a) and Aiyar et al. (2014b) both look at whether the effects of MPMs spill across borders and find this effect to be substantial for UK banks. Danisewicz et al. (2015) and Reinhardt and Sowerbutts (2015) look at spillovers from MPMs implemented in the UK and find that the spillovers reduce the effectiveness of macroprudential regulation. Reinhardt and Sowerbutts (2015) argue that the sign of spillover effects should depend on the nature and the scope of the regulation. Regulation that is applicable to only domestic banks and the subsidiaries of foreign banks, should lead to more cross-border lending by foreign banks. According to the reasoning of Reinhardt and Sowerbutts, this happens because of a funding advantage available to the banks outside the regulatory oversight. The authors argue that regulation directed to financial institutions typically has this types of gaps in coverage. On the other hand, if regulation can be applied to all domestic borrowers, in the way a maximum loan-to-value ratio is typically thought to be, there is no advantage for foreign banks and thus no increase in cross-border borrowing. In a multi-study initiative by the International Banking Research Network (documented in a meta-study by Buch and Goldberg, 2017) the main findings were that the effects of MPMs indeed occasionally spill across borders via bank lending, but that the effects have been of small scale and heterogeneous across banks, countries and policy instruments.

The most pressing issue for studying the effectiveness and spillovers from MPMs across a large set of countries has been the lack of consistent data. This has been recently alleviated by the data collected at the IMF. Cerutti et al. (2017a) build and describe an annual data set of MPMs for a much larger set of countries than previously available in the literature. In addition to compiling and describing the data, they use the data to conclude that usage of MPMs is generally associated with lower credit growth in the domestic economy and greater cross-border borrowing (i.e. cross-border spillover of macroprudential policy). With the help of a smaller, but quarterly data set on

MPMs described in Cerutti et al. (2017b), Avdjiev et al. (2017) find evidence that the implementation of MPMs has a significant impact on international bank lending that also results in cross-border spillovers. They find that most of the spillovers from tightening of macroprudential regulation lead to expansions in cross-border bank activity.

## 2.2 International banking and the gravity model

The gravity model has been very successful in studying the determinants of many different financial linkages: portfolio investments[15], foreign direct investments[16], M&A's[17], sovereign lending[18] and also international banking. Perhaps because of not as easily available data, papers considering gravity in international banking have not been as frequent as studies of gravity in portfolio investments. In an early example Choi et al. (1986) proposed fitting a gravity equation to data on the interconnectedness of financial centres. Cross-border bank asset holdings have been considered by Buch (2005), Blank and Buch (2007), Sander et al. (2013) and Buch et al. (2013) with an emphasis on European banks and their reactions to the introduction of the EMU, the Euro and the effects of the financial crisis. Expanding the set-up to a larger set of countries, Müller and Uhde (2012) consider the determinants of banking flows from OECD countries to emerging markets, and Houston et al. (2012) the effects of regulatory arbitrage on international banking flows. Taking an emphatically global perspective, Brei and von Peter (2018) take a long-run look at the distance puzzle in banking, Cerutti and Zhou (2018a) investigate the trend of regionalization seen after the financial crisis, and most recently Cerutti and Zhou (2018b) consider the circumvention of macroprudential and capital control measures. These papers broadly confirm that the classic gravity result applies also to international banking. Bilateral bank asset holdings or

[15]See e.g. Portes et al., 2001, Portes and Rey, 2005, Martin and Rey, 2004, Coeurdacier and Martin, 2009, Okawa and van Wincoop, 2012, <a couple of more recent papers also.

[16]See e.g. Head and Ries, 2008, Bergstrand and Egger, 2010, and de Sousa and Lochard, 2011.

[17]See e.g. di Giovanni, 2005, and Hyun and Kim, 2010.

[18]Rose and Spiegel, 2004

flows decrease as the distance between the origin and destination countries increases. As in portfolio investments, the gravity result has been shown to hold even within countries[19] and banking groups[20]. The general rationale behind bilateral banking being affected by distance is that assessing risks is less costly when borrowers are located closer to the bank (Brei and von Peter, 2018).

The theory underpinning gravity in international banking is mostly based on the micro-founded models of cross-border portfolio investments formulated by Martin and Rey (2004) and Coeurdacier and Martin (2009) or the structural gravity formulation in international trade developed by Anderson and van Wincoop (2003). Exceptions to this rule are Brüggermann et al. (2012), who model international banking as a search model, and Fillat et al. (2017) and Cerutti and Zhou (2018a, 2018b), who both develop a model of heterogeneous bank internalization in a similar vein as Helpman et al. (2008) have done for heterogeneous exporter firms.

As Head and Mayer (2014) point out, the different micro-founded models all give rise to a gravity equation that can be applied to many different bilateral interactions. The equations always include variables for "mass", economic or other, that arise from the different constraints of the micro-founded problem, and variables for bilateral and multilateral "resistance" or "friction" terms. When the gravity framework is applied to international finance in general and also international banking in particular, the relative frictions limiting the volume of transactions are thought to be made up of different transaction and information costs instead of transport costs, as the assets are not physically shipped around the globe. The gravity equation for bilateral financial transactions to be estimated is similar in its general structure to the one estimated for international trade:

$$A_{ij,t} = \alpha Y_{i,t} Y_{j,t} O_i D_j d_{ij}^{\theta} e^{\lambda' z_{ij,t}} \tag{1}$$

[19] Petersen and Rajan, 2002, for small business lending in the US, and Degryse and Ongena, 2005, in Belgium.

[20] Mian, 2006.

where $A_{ij,t}$ is the assets held by the origin country $i$ in the destination country $j$, $Y_{i,t}$ and $Y_{j,t}$ are the economic masses, usually GDPs, $O_i$ and $D_j$ the time-invariant fixed effects, $d_{ij}$ the bilateral distance, and $z_{ij,t}$ is a vector containing controls for trade or information frictions between the country pair, such as a shared language, border or currency. The coefficient $\theta$ measures the distance effect and the composite coefficient $\lambda$ arises from the theoretical microfoundations of the gravity equation.

My paper is closest to the papers by Houston et al. (2012) and Cerutti and Zhou (2018b), as they also consider an application of the gravity model for studying the spillovers from prudential regulation to cross-border lending. The differences between their approaches and mine are however notable. First, the variables measuring the implemented MPMs is different. Houston et al. (2012) include many different regulatory variables in their specification, but these are not explicitly macroprudential in nature. Cerutti and Zhou (2018b) use the total GMPI index of macroprudential regulation from Cerutti et al. (2017a). I use the same data as Cerutti and Zhou (2018b), but separate between the subindices that measure MPMs aimed at financial institutions and at borrowers. This I do because the effect of measures directed at financial institutions is likely to be different than the effect of measures directed at borrowers[21].

Second, the dependent variable I have chosen is different from the dependent variable chosen by both Houston et al. (2012) and Cerutti and Zhou (2018b). I use the BIS Locational Banking Statistics as the source for cross-border bank asset holdings, following e.g. Brei and von Peter (2018). This data is compiled according to the residence principle, which is used in e.g. the balance of payments and external debt methodology. This aspect makes the data very compatible with the geographical dimension of the gravity model. Houston et al. (2012) and Cerutti and Zhou (2018b) both use the BIS Consolidated Banking Statistics as a source for their dependent variable. This data is collected on a "ultimate risk" basis, which means that the locational dimension of the bank asset holdings is lost. In addition, Houston et al. (2012) and

[21] See the discussion in Reinhardt and Sowerbutts (2015).

Cerutti and Zhou (2018b) use cross-border banking asset *flows*, whereas I use the *holdings* of banking assets. As Brei and von Peter (2018) point out, the structural gravity framework from the international trade literature applied to international finance determines the bilateral *stocks of asset holdings*. In contrast Cerutti and Zhou (2018b) employ Cerutti and Zhou (2018a) as their theoretical base, which yields a gravity equation for flows.

Third, the estimation strategy of all three papers is completely different. Houston et al. (2012) estimate a log-linearized model using OLS, which results in omission of the zero observations and potential bias due to this. Cerutti and Zhou (2018b) employ a two-stage estimation procedure to a log-linearized model. This method allows for separating the intensive and extensive marging of cross-border lending, thus ensuring an appropriate treatment of the limited dependent variable. I use the PPML method, proposed by Santos Silva and Tenreyro (2006), on a gravity equation in its multiplicative form. In trade literature, this procedure is currently considered to be the most theory-consistent method of estimating a gravity equation, as it is able to handle appropriately all the peculiarities usually present in bilateral data: zeros, heteroskedasticity and clustering.[22]

[22]See e.g. Brei and von Peter for an application to cross-border banking and UNCTAD, WTO, 2016, for a textbook example for trade policy analysis.

# 3 Data

For the purpose of the gravity model, all data is considered in a bilateral framework with multiple origin and destination countries. Here a *country of origin* refers to the country where the bank operates as a bank with a domestic headquarter or a subsidiary of a bank with a foreign headquarter. Thus the origin country is the *lender* country. The *destination country* is the country to which the banks from the country of origin extend credit. Thus the destination country is the *borrower* country. Variables related to the origin country and the destination country are denoted by subscripts $i$ and $j$ respectively. A variable related to a country pair is denoted by subscript $ij$.

## 3.1 Data on the use of macroprudential tools

As stated before, the major limitation to studying the effectiveness of MPMs has been the lack of data. Consistent, up-to-date data with a good coverage across a large set of countries and a reasonable time span have not been available until quite recently. The IMF initiated already in 2013 an annual survey on the use of MPMs, the Macroprudential Policy survey.[23] Cerutti et al. (2017a) make use of this data and previous studies to build a database that gives rise to an annual index on the use of MPMs, the Global Macroprudential Policy Index (GMPI).[24] This data set is the most ambitious take on documenting the use of MPMs to date.[25]

The GMPI-data has a coverage that is substantially larger than any of the

[23]For more information on the survey, see https://www.elibrary-areaer.imf.org/Macroprudential/Pages/Home.aspx.

[24]First published in 2015, the index is updated and available at Eugenio Cerutti's home page: https://www.imf.org/~/media/Websites/IMF/imported-datasets/external/pubs/ft/wp/2015/Data/_wp1561.ashx.

[25]The MP survey has given rise to two other data sets also: In Cerutti et al. (2017b) the data is used to build an index for a much smaller set countries, that is quarterly and takes into account the intensity of the tool. In March 2019, IMF published yet another data set based on the same survey data. The Integrated Macroprudential Policy Database (iMaPP) covers an almost as large set of countries as the GMPI while also taking the changes in tools into account. This data alas was not available while this paper was being written. The data is available at https://www.imf.org/~/media/Files/Publications/WP/2019/datasets/wp1966.ashx.

data sets previously available: 160[26] countries have responded to the survey and reported their use of MPMs over the period 2000-2017.[27] To match the sample with the coverage of my other data sources, I drop three countries[28] from the sample and make do with 157 countries. The IMF survey covers all in all 18 macroprudential tools, but for the data set 12 instruments are included. The instruments are divided into two categories following the classifications used by e.g. the IMF and European Systemic Risk Board (ESRB), and thus two aggregate indices are formed. First index comprises ten instruments that target financial institutions, while the second index is formed of the two instruments that are aimed at borrowers' leverage. These two indices aggregated give a composite index comprising all tools and thus capturing total use of MPMs.

In this paper, I separate between the two sub-indices, denoted by $mpib$ and $mpif$, because there is a rather clear cut difference between MPMs targeting the supply of credit, i.e. financial institutions, and those targeting demand of credit, i.e. borrowers. As the two classes of MPMs target different agents, their channels of effect are potentially different. Moreover, the regulatory coverage of these different types of MPMs might differ, further differentiating between the channels of effect. (Reinhardt and Sowerbutts, 2015) The different policy instruments are listed in Table 1 and Table 2 for MPMs targeting borrowers and financial institutions respectively.[29]

**Table 1:** MPMs targeting borrowers

| **Measure** | **Abbreviation** |
|---|---|
| Debt-to-income ratio cap | DTI |
| Loan-to-value ratio cap | LTV |
| Index: DTI + LTV | *mpib* |

The indices are built in such a way that implementing any of the ten or two tools results in an increase of the index by one integer. Thus if a country at a given year implements one more MPM in addition to the one it already

[26] The only notable omissions are mostly small financial centers such as Bermuda, Cayman Islands and Macao.

[27] When first published in 2015, the index covered 119 countries and years 2000-2013. An update published in 2018 extended the coverage to 160 countries and years 2000-2017.

[28] Curacao, Kosovo, and St. Kitts and Nevis.

[29] For more detailed definitions, see Table 1 in Cerutti et al. (2017a).

**Table 2:** MPMs targeting financial institutions

| **Measure** | **Abbreviation** |
|---|---|
| Time-varying/dynamic loan-loss provisioning | DP |
| General countercyclical capital buffer/requirement | CTC |
| Leverage ratio | LEV |
| Capital surcharges on SIFIs | SIFI |
| Limits on interbank exposures | INTER |
| Concentration limits | CONC |
| Limits on foreign currency loans | FC |
| FX and/or countercyclical reserve requirements | RRREV |
| Limits on domestic currency loans | CG |
| Levy/tax on financial institutions | TAX |
| Index: DP+CTC+LEV+SIFI+INTER+CONC +FC+RRREV+CG+TAX | $mpif$ |

has, the value of the index becomes 2. The maximum value for $mpif$ is 10 and for $mpib$ 2 as there are ten different MPMs targeting financial institutions and borrowers respectively.

**Table 3:** The evolution of the use of MPMs targeting borrowers

| | 2000 ... | 2008 ... | 2017 |
|---|---|---|---|
| **Instrument** | **% of countries implementing** | | |
| DTI | 3% | 13% | 29% |
| LTV | 6% | 14% | 36% |
| **Mean value for $mpib$ for the sample countries** | | | |
| Mean $mpib$ | 0.09 | 0.26 | 0.65 |
| **% of countries implementing $n$ tools** | | | |
| 0 | 92% | 80% | 56% |
| 1 | 6% | 14% | 23% |
| 2 | 2% | 6% | 21% |

According to the GMPI-data, there has been a clear upward trend in the average number of MPMs implemented throughout the 2000's (see Figure 1). From Figure 1 the very pronounced difference in the use MPMs between the different country groups is also very evident: The major EMEs [30] have implemented substantially more MPMs than any of the other country groups. The share of countries in the 157-country sample that have implemented the different instruments has crept up steadily over the sample period and consis-

[30]Here major EMEs are defined as the 19 largest emerging market economies: Argentina, Brazil, Bulgaria, Chile, China, Colombia, Hungary, India, Indonesia, Malaysia, Mexico, Peru, Philippines, Poland, Romania, Russia, South Africa, Thailand, and Turkey. These countries are often considered separately from all EMDEs. See e.g. the World Economic Outlooks of the IMF.

**Table 4:** The evolution of the use of MPMs targeting financial institutions

| | 2000 ... | 2008 ... | 2017 |
|---|---|---|---|
| **Instrument** | **% of countries implementing** | | |
| DTI | 3% | 13% | 29% |
| LTV | 6% | 14% | 36% |
| DP | 3% | 8% | 15% |
| CTC | 0% | 1% | 5% |
| LEV | 5% | 10% | 23% |
| SIFI | 0% | 0% | 39% |
| INTER | 11% | 18% | 31% |
| CONC | 39% | 63% | 82% |
| FC | 6% | 11% | 26% |
| RRREV | 13% | 16% | 18% |
| CG | 3% | 7% | 12% |
| TAX | 4% | 8% | 23% |
| **Mean value for $mpif$ for the sample countries** | | | |
| Mean $mpif$ | 0.84 | 1.41 | 2.72 |
| **% of countries implementing $n$ tools** | | | |
| 0 | 47% | 27% | 9% |
| 1 | 33% | 34% | 14% |
| 2 | 13% | 21% | 18% |
| 3 | 4% | 12% | 34% |
| 4 | 3% | 5% | 13% |
| 5 | 0% | 1% | 8% |
| 6 | 0% | 0% | 4% |
| 7 | 0% | 1% | 0% |
| 8 | 0% | 0% | 1% |
| 9-10 | 0% | 0% | 0% |

tently across the different tools (see Tables 3 and 4). The mean value for $mpif$ for the sample countries has also more than tripled over the sample period, and for $mpib$ the increase has been even more pronounced. Still, the mean values for either type of MPMs is not very high. That is, most countries have implemented two or three, perhaps four MPMs, and very few countries have used more than five tools.

**Table 5:** Summary statistics for all observations of $mpif$ and $mpib$

| **Variable** | **Mean** | **Std.dev.** | **Min** | **Max** | **Range** | **Obs.** |
|---|---|---|---|---|---|---|
| $mpif$ | 1.63 | 1.40 | 0 | 8 | 0-10 | 2 826 |
| $mpib$ | 0.43 | 0.70 | 0 | 2 | 0-2 | 2 826 |

The most important thing to note and keep in mind about the indices is that they simply document the number of MPMs implemented by the countries during a given year. The intensity of the measures is ignored as well as

**Figure 1:** Average number of MPMs implemented across different country groups.

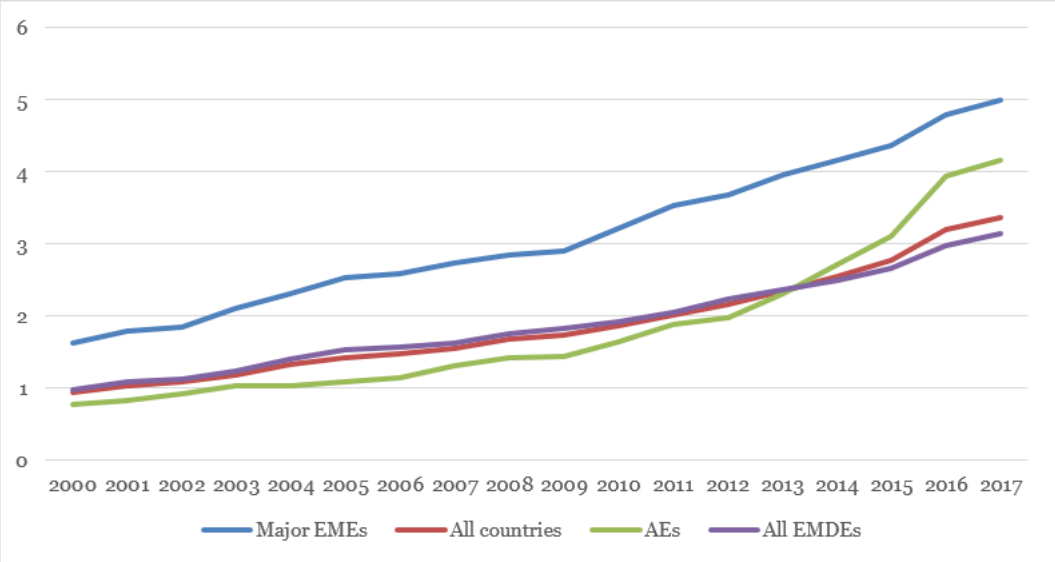



**Table 6:** Distribution of all observations of $mpif$ and $mpib$

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7-10 |
|---|---|---|---|---|---|---|---|---|
| $mpif$ | 27% | 29% | 21% | 15% | 6% | 2% | 1% | 0% |
| $mpib$ | 69% | 19% | 12% | - | - | - | - | - |

changes in the stance of the different policies. That is, the index changes by the same amount for countries that implement a 0.1 % countercyclical capital buffer and a country that implements a 5 % one. Also, the indices do not distinguish between a binding regulation and a recommendation. This allows for the broadest possible coverage of countries and instruments, but arguably gives a very simplified view of the policy field.

In other aspects also, the data is not without caveats. First of all the data is based on survey data, and thus all the usual challenges of survey data should be kept in mind. Second, the years covered coincide also with a period during which the specific macroprudential framework was non-existent or just beginning to take shape. These facts considered together with the myriad of ways the details of MPMs vary across countries means that consistency is most probably somewhat compromised. Still, it is easy to see that the data provides a valuable stepping stone for research on the effects of MPMs.

## 3.2 The dependent variable: Bilateral bank asset holdings

As the purpose of most MPMs is to address excess growth of debt and leverage, it is natural to assume that the spillovers from MPMs should affect lending also. Further, the theoretical gravity framework applied to trade in financial assets explains the determination of holdings of financial assets, as previously discussed (see section 2.2). Thus the appropriate dependent variable for the purpose of this paper is the bilateral cross-border bank asset holdings. The data comes from the BIS Locational Banking Statistics[31] database, which provides the most extensive source of bilateral cross-border positions. This data is drawn from the balance sheets of banks that operate internationally and it allows for a geographical breakdown of their counterparties, which can belong to any sector. This data is then aggregated to a country-to-country framework. In the full LBS data set there are 44 reporting countries and 216 counterpart countries with quarterly observations from 1977 onwards. For the purpose of this paper I use annual data and choose 38 of the reporting countries and 119 counterpart countries to match the countries for which I have data on the use of macroprudential tools.

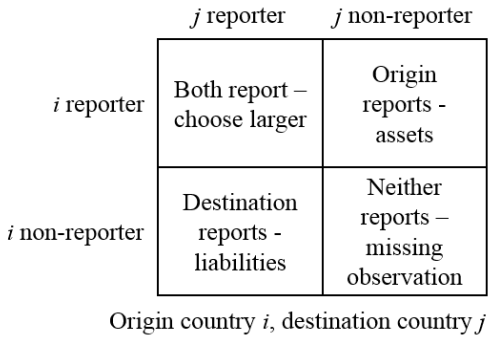
To extend the coverage of the data on bilateral asset holdings, I overlay the data on assets held by origin countries in the destination countries onto data on liabilities of origin countries held by destination countries. This procedure, following Brei and von Peter (2018)[32], leads to a network of bilateral holdings for pairs of countries where both are BIS reporting countries or where either the origin country or the destination country is a BIS reporting country. Assets give the observations for pairs where the origin country reports and the destination country does not. The vice versa cases are obtained from the liabilities. When both origin and destination country are BIS reporters, the

[31] Following Brei and von Peter (2018). See discussion in Brei and von Peter (2018) for a more detailed case for using the locational banking statistics instead of the consolidated banking statistics.

[32] A detailed description of the procedure can be found in appendix A of Brei and von Peter (2018).

bilateral positions are reported twice, once as assets and once as liabilities. Following Brei and von Peter (2018), the larger of the two is chosen to counteract under-reporting. By following this procedure it is ensured that the observations equalling zero can be considered "true" zeros, as only observations for pairs where both countries are not BIS reporting countries are missing. This is noteworthy, as it affects the choice of estimation strategy.

**Figure 2:** The matrix of bilateral bank asset holdings




The dependent variable is thus banking assets held by banks in the origin country that are the liabilities of borrowers in the destination country, denoted by $ba_{ij}$, where $i$ is the identifier of the origin country and $j$ of the destination country. In Table 7 I report summary statistics for the whole sample and for the positive observations. There are 157 countries in the sample, of which 38 are BIS reporting countries and 119 are counterpart countries in the LBS data. After dropping some observations for which the data on controls is incomplete, 10 146 country pairs and 182 035 observations enter the sample. The data are in thousands of dollars, i.e. the mean of all observations is 2.3 billion dollars and of the positive observations is 4.8 billion dollars.[33] It is also noteworthy that median is zero for the unrestricted sample and only 65 000 dollars for the non-zero part of the sample. This means that the sample is very skewed towards not only zero observations, but also observations that are extremely

[33]Note that the position of banks in origin country vis-a-vis the destination country can be negative due to short selling. In the full sample of 188 100 observations there are 23 negative observations of $ba_{ij}$. The PPML should be able to handle few minor negative values, as the only crucial assumption is that the conditional mean is always positive. Even so, I have excluded those observations, due to their insignificance and to be certain that they will not cause any peculiarities.

**Table 7:** Summary statistics of the dependent variable

| | $ba_{ij}$ | $ba_{ij} > 0$ |
|---|---|---|
| N of pairs | 10 146 | 6 847 |
| N of periods | 18 | 18 |
| N of observations | 182 035 | 87 627 |
| Mean* | 2 300 | 4 779 |
| Standard deviation* | 23 223 | 33 294 |
| Min* | 0 | 1 |
| Max* | 1 481 374 | 1 481 374 |
| Share of 0s | 52 % | - |
| Median* | 0 | 65 |

*In millions of dollars.

small compared to the maximum values.

Indeed, an important feature of the data is the share of zero observations. This share is very large: 52 % of all observed bilateral cross-border bank asset holdings are equal to zero. This is a common feature in all bilateral data, be it data on international goods trade flows, cross-border portfolio asset holdings, foreign direct investments or banking data. That is, at any given time, a country trades with or invests in or extends credit to only a handful of other countries. Because of how the data is constructed, the zero observations can be considered "true zeros" stemming from an implicit selection process, instead of missing observations due to insufficient data. That is, the zero observations contain important information about barriers to international lending and banks' decisions not to extend credit to a certain destination country. Thus the probability of a positive observation between two countries is correlated with some, perhaps unobserved, characteristics of that country pair. The non-negligible share of zero observations calls for the use of estimation methods that are suitable for limited dependent variables, such as the PPML or a selection model. Failing to do so will inevitably result in biased estimates.[34]

## 3.3 The other controls

In order to estimate a gravity type equation, two types of independent variables are required. First, one should include variables that account for the "masses" of the two countries, such as the GDP, GDP per capita or market

[34]See e.g. UNCTAD and WTO, 2016.

capitalization. In order to account for the "mass" of the gravity equation, I use annual GDP as a measure of the economic masses of both the origin country and the destination country. All GDP data is annual data from the IMF World Economic Outlook database. GDP is in logged millions of 2010 dollars, whereas GDP per capita data is logged 2010 dollars.

Second, one should include variables that account for the different bilateral and multilateral "resistance" terms. The bilateral terms measure the frictions and facilitators of the bilateral interactions. Distance is usually included as a proxy for broadly defined transaction costs and/or home bias. Besides distance, one can include myriad variables indicating outright barriers, frictions or facilitators of exchange between the two countries. Variables indicating similarities that facilitate the flow of information between the two countries are common examples of controls: shared official language, border, currency, legal origins and colonial history are just a few often used variables. Here, distance is measured as logged population-weighted distance between the largest cities of the two countries. The data for distance comes from the gravity database of CEPII, as does data for four of the most common gravity dummies: contiguity, common language, common colonial history and common currency. Distance is expected to increase the frictions of trade, but the other controls are all expected to reflect less frictions in bilateral trade. There is an almost countless number of other possible controls used in the literature, such as time zone difference or internet traffic. However, the chosen four are the most commonly used and the ones most often found to have a statistically significant effect on bilateral asset holdings (see e.g. Brei and von Peter, 2018).

When a gravity model is applied to trade in financial assets, the role of variables measuring financial sophistication become important. Many of the variables used in previous literature to account for financial sophistication, such as a measure for income group or an indicator for financial openness, are time-invariant over the relatively short sample period, so their effect is captured by the country-fixed effects. As a time-variant control for financial sophistication, I include GDP per capita. This is acknowledged to be a simplification done

in order to preserve the broadest possible coverage. The underlying reasoning here is that wealthy countries tend to have well-functioning financial markets and a well-developed banking sector.

In the gravity literature, the need to control for a so called multilateral resistance term has been emphasized since the influential papers by Anderson and van Wincoop (2003) and Redding and Venables (2004). In the context of trade in financial assets, this is meant to capture the fact that the assets of any given country must "compete" with the assets of all the other countries. The multilateral resistance can be captured by adding fixed effects for both origin and destination countries. One can use time-variant fixed effects if the interest of the research is on the coefficient of a country-pair variable, but if the interest is on the coefficient of a country-specific variable, one has to use time-invariant fixed effects. (UNCTAD and WTO, 2016) The additional benefit of including country fixed effects is that it should account for the systematic tendency of some countries with large banking sectors to import and export more banking assets relative to GDP. This is because fixed effects should account for any unobservable effects that changes the level bank asset holdings of a given country[35].

There are 36 advanced and 121 emerging or developing countries in my sample, but in the observations the share of advanced economies is much higher than a quarter: 41% of all observations have an advanced economy either as the country of origin or the destination country. Almost all advanced economies are BIS reporting countries, thus observations where at least one of the pair is an advanced economy is highly unlikely to be missing. On the other hand none of the BIS reporting countries is a developing country. Thus observations where at least one of the countries is a developing country are much more likely to be missing.

The summary statistics for the continuous independent variables are documented in Table 8 and for the dichotomous controls in Table 9.

[35]See the discussion related to trade in Head and Mayer (2014).

**Table 8:** Continuous independent variables

| Variable | Mean | Standard deviation | Observations |
|---|---|---|---|
| $log(gdp_i)$ | 4.66 | 2.40 | 182 035 |
| $log(gdp_j)$ | 4.66 | 2.40 | 182 035 |
| $log(distw_{ij})$ | 8.73 | 0.78 | 182 035 |
| $log(gdpcap_i)$ | 9.05 | 1.59 | 182 035 |
| $log(gdpcap_j)$ | 9.05 | 1.59 | 182 035 |

Log of GDP in millions of dollars, of distance in km's and of GDP per capita in dollars.

NB: The sample is symmetrical, thus statistics for $i$ and $j$ similar.

**Table 9:** Dichotomous controls: %-share of observations

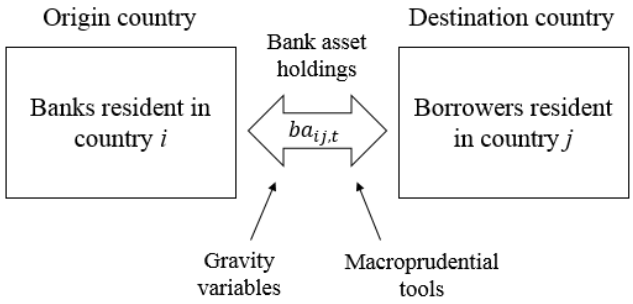
| Variable | 0 | 1 | Observations |
|---|---|---|---|
| *contig* | 98.09 % | 1.91 % | 182 035 |
| *comlangof* | 88.80 % | 11.20 % | 182 035 |
| *col*45 | 98.36 % | 1.64 % | 182 035 |
| *comcur* | 97.01 % | 2.99 % | 182 035 |

# 4 The model and estimation results

## 4.1 The model: A gravity equation for cross-border banking

The key hypothesis in my chosen set-up is that if MPMs have an effect on cross-border banking, then that is an indication of the existence of spillovers from nationally implemented MPMs. That is, if the variables measuring macroprudential regulation in the origin and the destination country have a statistically significant effect on cross-border bank asset holdings after controlling for the usual variables found to be of statistically significant in previous studies on gravity in banking, spillovers are confirmed.

**Figure 3:** The effect of MPMs on bilateral cross-border bank asset holdins




I specify a gravity equation with four independent variables controlling for the use of MPMs targeting financial institutions in the origin country and the destination country as Equation (2) below:

$$\begin{aligned} ba_{ij,t} =& \alpha_t * log(gdp_{i,t})^{\beta_1} * log(gdp_{j,t})^{\beta_2} * log(distw_{ij})^{\theta} \\ & * e^{\lambda' z_{ij}} * log(gdpcap_{i,t})^{\beta_3} * log(gdpcap_{j,t})^{\beta_4} \\ & * mpif_{i,t}^{\gamma_1} * mpif_{j,t}^{\gamma_2} * mpib_{i,t}^{\gamma_3} * mpib_{j,t}^{\gamma_4} \\ & * O_i * D_j * T_t, \qquad (2) \\ & i, j = 1, ..., 157 \text{ and } t = 1, ..., 18, \end{aligned}$$

where the origin and destination country fixed effects are included in $O_i$ and

$D_j$ respectively, and the gravity controls are included in the term $z_{ij}$. The coefficients $\gamma_1$ and $\gamma_2$ measure the effect of implemented MPMs targeting financial institutions and $\gamma_3$ and $\gamma_4$ measure the effect of implemented MPMs targeting borrowers. The coefficient $\theta$ measures the distance effect and $\lambda$ is a composite coefficient arising from the theoretical microfoundations of the gravity equation.

The dependent variable is bilateral bank asset holdings, held by banks in origin country with destination country as the counterpart. The economic masses of the origin and destination countries are represented by annual GDP in logs. The population-weighted distance between the two countries is also in logs. I include the four most common gravity controls: contiguity, common official language, common colonial history and common currency. Financial sophistication is proxied by GDP per capita in logs.

The variables measuring the use of MPMs in the origin and the destination country enter Equation (2) after the standard gravity variables. The value of the index for MPMs targeting financial institutions in the origin and destination country are given by $mpif_{i,t}$ and $mpif_{j,t}$ respectively. The value of the index for MPMs targeting borrowers in the origin and destination country are given by $mpib_{i,t}$ and $mpib_{j,t}$ respectively.

I account for multilateral resistance and time-invariant characteristics by including a full set of country fixed effects. I include time dummies to account for macroeconomic conditions. There are 157 countries that can both be origin or destination countries. After discarding missing values, i.e. the observations where neither of the countries is a BIS reporting country or where data on controls is missing, the sample consists of 10 146 country pairs and 182 035 observations. Time runs from 1 to 18, i.e. from 2000 to 2017. Note that the potentially overlapping clustering in the observations is accounted for by the chosen estimation method. Thus there is no need to control for it explicitly.

## 4.2 The results

The full model to be estimated is given by Equation (2) formulated in section 4.1. In the first specification I include only variables traditionally found in a gravity equation. To the second specification I add my variables of interest: The macroprudential policy indices for both destination and origin countries. Country fixed effects for origin and destination countries, time dummies and a constant are included in all specifications. The results of the PPML estimation for the three first specifications are given in Table 10.

**Table 10:** Results of the PPML estimation with full sample

| Specification: | (1) Standard gravity | | (2) Add *mpib* and *mpif* | | (3) No offshore centers | |
|---|---|---|---|---|---|---|
| $mpib_i$ | - | (-) | 0.117*** | (0.034) | 0.111*** | (0.033) |
| $mpib_j$ | - | (-) | 0.011 | (0.029) | 0.010 | (0.030) |
| $mpif_i$ | - | (-) | -0.056** | (0.025) | -0.088**** | (0.024) |
| $mpif_j$ | - | (-) | -0.015 | (0.026) | -0.058*** | (0.019) |
| $log(gdp_i)$ | 0.088 | (0.267) | -0.175 | (0.257) | 0.134 | (0.314) |
| $log(gdp_j)$ | 0.861*** | (0.316) | 0.812*** | (0.301) | 1.425**** | (0.395) |
| $log(distw_{ij})$ | -0.678**** | (0.045) | -0.678**** | (0.045) | -0.600**** | (0.055) |
| $contig$ | 0.004 | (0.118) | 0.005 | (0.118) | -0.035 | (0.102) |
| $comlangof$ | 0.406**** | (0.085) | 0.406**** | (0.085) | 0.387**** | (0.082) |
| $col45$ | -0.055 | (0.144) | -0.054 | (0.144) | 0.360** | (0.170) |
| $comcur$ | 0.672**** | (0.010) | 0.671**** | (0.010) | 0.706**** | (0.102) |
| $log(gdpcap_i)$ | 0.392 | (0.279) | 0.682** | (0.268) | 0.261 | (0.316) |
| $log(gdpcap_j)$ | 0.078 | (0.352) | 0.141 | (0.320) | -0.671* | (0.385) |
| Robust SEs adjusted for k clusters: | 10 037 | | 10 037 | | 8 842 | |
| $R^2$ | 0.8705 | | 0.8725 | | 0.910 | |
| Pairs | 10 146 | | 10 146 | | 8 942 | |
| Observations | 182 035 | | 182 035 | | 160 426 | |
| Mean of $ba_{ij}$ | 2 301 mln $ | | 2 301 mln $ | | 2 282 mln $ | |
| Median of $ba_{ij}$ | 0 mln $ | | 0 mln $ | | 0 mln $ | |
| Min of $ba_{ij}$ | 0 mln $ | | 0 mln $ | | 0 mln $ | |
| Max of $ba_{ij}$ | 1 481 374 mln $ | | 1 481 374 mln $ | | 1 481 374 mln $ | |

Significance at the 10%, 5%, 1% and 0.1% levels denoted by *, **, *** and ****.

Theory and previous literature predict that the marginal effects of the economic masses should be positive and that of distance should be negative. This is the case almost constantly. The distance effect is highly statistically significant, negative and also broadly in line with the magnitude of effects found in previous papers, notably Brei and von Peter (2018). The effects of the other controls are broadly in line with what one would expect based on

previous results.

The measures for implemented MPMs are added in specification (2). Puzzlingly, the marginal effect from more MPMs implemented is statistically significant only when these tools are implemented in the origin country. The effect from MPMs targeting borrowers is positive, i.e. when a new domestic MPM targeting borrowers is implemented, banks tend to increase their cross-border activities. On the other hand, when domestic regulators implement a new MPM targeting financial institutions, banks tend to retreat to the home markets and decrease foreign lending. However, these results indicate no effect on cross-border lending stemming from foreign regulation. When digging deeper into the data, I find that off-shore financial centers may play an outsized role in specifications (1) and (2).

An important trade-off to keep in mind of the BIS Locational Banking Statistics data is that while it is ideal for studying the geography of banking as it follows the *residence principle* similar to balance of payments, it is indeed locational, not consolidated over banking concerns. This means that intra-group transactions are not netted out and the role of the largely intermediary offshore financial centers may skew the results[36]. Offshore financial centers are an important player in international banking and thus pairs, where a offshore financial center is at either end make up a non-negligible share of the pairs in the sample. However, the offshore financial centers are in essence only intermediaries of banking assets: The capital flows passing through these countries is not driven by supply and demand of credit stemming from the economy itself. It might thus be that if MPMs are implemented in these countries, they have a very different channel of effect from other countries. To address at least the concern that offshore financial centers are driving the results, I drop the countries classified by BIS as offshore financial centers[37] from specification (3). The marginal effects from MPMs targeting borrowers increase modestly, but

[36]For a thorough discussion and a case for using the BIS Lcational Banking Statistics, see Brei and von Peter, 2018. On the other hand, for arguments on why one should use the BIS Consolidated Banking Statistics, see Cerutti and Zhou, 2018b, and Cerutti and Zhou, 2017.

[37]Bahamas, Bahrain, Curacao, Hong Kong and Singapore.

remain broadly the same. Interestingly, the marginal effects from more MPMs targeting financial institutions do change quite a lot. Most importantly, now the negative effects from MPMs targeting financial institutions implemented in either the origin or the destination country become clearly significant and much larger in absolute value.

How should one interpret these marginal effects? The first thing to note is that interestingly, the marginal effects from either type of regulation are qualitatively the same regardless of whether it is implemented in the destination or the origin country. It seems that more MPMs targeting borrowers implemented is always associated with more cross-border lending, whereas more MPMs targeting financial institutions is always associated with less cross-border lending. These results are somewhat puzzling, because they on the one hand seem to confirm the usual hypotheses on regulatory arbitrage[38], and on the other hand reject them. In what follows, I will discuss the interpretation of first the results related to MPMs targeting borrowers and second the results related to MPMs targeting financial institutions.

The positive marginal effect from **MPMs targeting borrowers** implemented in the origin country (i.e. $mpib_i$) means that as more tools restricting the amount of credit domestic households can take on[39] are implemented, domestic banks tend to extend more credit abroad. One could argue that this is an indication of regulatory arbitrage: If, ceteris paribus, regulation restricts lending to domestic clients, an internationally active bank can extend credit to countries where this is not the case. The marginal effect from MPMs targeting borrowers in the destination country (i.e. $mpib_j$) is also positive, though not statistically significant. A significant positive effect would indicate that the scope of regulation in the destination country might not cover foreign banks, thus creating a funding advantage for these banks.

On the other hand, the negative marginal effects from **MPMs targeting financial institutions** implemented in either the origin or the destination

[38] See e.g. Reinhardt and Sowerbutts, 2015.

[39] Recall that MPMs targeting borrowers included caps to debt-to-income and loan-to-value ratios.

country are negative and clearly significant. The negative effect from MPMs targeting financial institutions implemented in the destination country (i.e. $mpif_j$) seems intuitive: Internationally active banks retreat from more heavily regulated markets, fully in line with the idea that banks wish to "optimize" their regulatory landscape, but not confirming the existence of a "funding advantage" for foreign banks due to gaps in regulatory oversight, as found by Reinhardt and Sowerbutts (2015) for UK banks. But my results also show that in the face of more MPMs targeting financial institutions implemented in the origin market (i.e. $mpif_i$), banks *also* tend to decrease foreign lending and retreat from foreign markets. This result is somewhat puzzling when compared to a common notion of regulatory arbitrage, i.e. banks always moving away from more heavily regulated markets. The result could be understood so that when the domestic macroprudential stance is tightened, banks retreat from the more risky foreign markets in order to be better positioned to comply with the more stringent regulatory rules at home. Perhaps foreign markets are inherently more risky to banks, due to say information disadvantages, and thus retreating from foreign markets reduces risks to banks' balance sheets.

It should be noted that these results appear somewhat contradictory to results found in other papers. Most of the previous work find a positive relationship between domestically implemented macroprudential policy and foreign lending extended by *domestic* banks. For example Cerutti et al. (2017a) find a positive relationship between the use of macroprudential tools and cross-border lending. Also Avdjiev et al. (2017) find that tightening of macroprudential regulation has an expansionary effect on cross-border lending. Contrary to this, I find that banks only increase foreign lending in the face of more domestic MPMs targeting borrowers. As a response to more MPMs targeting financial institutions, banks do not simply retreat from a more heavily regulated foreign market, but they also retreat from foreign markets when regulation becomes more stringent in the domestic market. My results also do not support the existence of funding advantage or opportunity for regulatory arbitrage for banks operating in a country where they are not under the national supervi-

sion, as argued for by Reinhardt and Sowerbutts (2015): This would warrant a positive effect from macroprudential regulation in the destination country. The differences in data sources and estimation methods certainly might play a role in producing the differing results. For start, I separate between different categories of MPMs, whereas many papers consider the effect of an aggregate index or of a single measure. It could also be that the apparent disharmony between these results simply reflects the fact that the gravity approach allows for a more nuanced picture as it allows for considering both directions of a bilateral relationship separately instead of netting them together. In fact, the picture becomes even more nuanced still, when the large sample comprising very different countries is divided into smaller sub-samples.

A reasonable question when working with a data set including countries as different as the US and Afghanistan would be that what could the average marginal effects possibly tell us about the true effect for these profoundly different countries. We are well aware of how different economic realities, financial market characteristics and enforcement of regulation can be in different countries. However, given the very broad coverage of the data, it is possible to consider country groups differentiated by income[40] separately. This, albeit simple, division of the sample seems sensible when one keeps in mind the apparent differences in the use of MPMs that arose from the simple GMPI-data (recall figure 1). This is just what I have done in the specifications (4)-(9), results for which are presented in Tables 11, 12 and 13. In specifications (4) and (5), I compare sub-samples where origin country is an advanced economy and where the origin country is an emerging country[41]. Further, in specifications (6) and (7), sub-samples of only advanced economies and emerging economies respectively are considered. In specification (8) and (9), the sub-samples are further restricted. In specification (8) only advanced economies that are also BIS reporting countries are included: These are the countries

[40]Of course, one could divide the sample in to different sub-samples also following other lines, such as the relative size of the banking sector, financial market characteristics or details of the regulatory environment. However, an indicator for income group is easily available for all countries in the sample.

[41]The classification of countries is taken from World Economic Outlook by the IMF.

with highly developed banking sectors. In specification (9) only major emerging markets[42] are considered: According to the GMPI-data, these countries have implemented substantially more macroprudential instruments than other countries have. To hold the results comparable to specification (3), offshore financial centers are excluded from specifications (4)-(9).

**Table 11:** Results for different origin countries

| Specification: | (4) AEs as origin country | | (5) EMDEs as origin country | |
|---|---|---|---|---|
| $mpib_i$ | 0.110*** | (0.035) | 0.152*** | (0.049) |
| $mpib_j$ | -0.009 | (0.031) | 0.134*** | (0.048) |
| $mpif_i$ | -0.131**** | (0.025) | 0.111**** | (0.020) |
| $mpif_j$ | -0.057*** | (0.020) | -0.100**** | (0.028) |
| $log(gdp_i)$ | -0.382 | (0.761) | 0.867**** | (0.234) |
| $log(gdp_j)$ | 1.345*** | (0.390) | 2.290*** | (0.860) |
| $log(distw_{ij})$ | -0.630**** | (0.058) | -1.433**** | (0.120) |
| $contig$ | -0.063 | (0.104) | -0.251 | (0.271) |
| $comlangof$ | 0.398**** | (0.092) | 0.516**** | (0.143) |
| $col45$ | 0.128 | (0.247) | 0.591*** | (0.179) |
| $comcur$ | 0.738**** | (0.109) | -2.444**** | (0.493) |
| $log(gdpcap_i)$ | 0.752 | (0.772) | -0.329* | (0.190) |
| $log(gdpcap_j)$ | -0.620 | (0.378) | -1.467 | (0.916) |
| Robust SEs adjusted for k clusters: | 10 037 | | 4 855 | |
| $R^2$ | 0.9155 | | 0.7201 | |
| Pairs | 3 778 | | 4 926 | |
| Observations | 67 720 | | 88 424 | |
| Mean of $ba_{ij}$ | 5 042 mln $ | | 267 mln $ | |
| Median of $ba_{ij}$ | 6 mln $ | | 0 mln $ | |
| Min of $ba_{ij}$ | 0 mln $ | | mln $ | |
| Max of $ba_{ij}$ | 1 481 374 mln $ | | 113 972 mln $ | |

Significance at the 10%, 5%, 1% and 0.1% levels denoted by *, **, *** and ****.

Table 11 documents the estimation results for when the country of origin is an advanced economy and for when the country of origin is an emerging economy. Notice that the destination countries are not restricted. Interesting differences in the effects of macroprudential regulation emerge, but they are not entirely clear-cut. The effects from **MPMs targeting borrowers** in either the origin or the destination country remain broadly the same when origin countries are restricted to AEs. A positive marginal effect from $mpib_i$

[42] Argentina, Brazil, Bulgaria, Chile, China, Colombia, Hungary, India, Indonesia, Malaysia, Mexico, Peru, Philippines, Poland, Romania, Russia, South Africa, Thailand and Turkey.

means that banks appear to respond to new MPMs in the origin country by moving lending abroad. When the origin countries are restricted to be EMDEs, the positive marginal effect becomes larger and highly statistically significant regardless of whether the new MPMs are implemented in the origin or the destination country. Thus, banks resident in EMDEs appear to increase cross-border lending also in destination countries as a response to a new MPM implemented there.

Again, the marginal effects from **MPMs targeting financial institutions** hardly change from the un-restricted sample to the sample where origin countries are restricted to AEs. This could imply that the banks resident in AEs drive the results for the whole sample, which seems plausible. For EMDEs, the qualitative difference in the results emerges for MPMs implemented in the origin country: The marginal effect turns positive. That is, more MPMs targeting financial institutions in EMDEs is associated with more cross-border lending. This is consistent with the hypothesis of regulatory arbitrage, i.e. banks moving lending away from more regulation. On the other hand, more MPMs implemented in the destination countries, advanced or emerging, is associated with less cross-border lending. Thus the funding advantage consistent with an opportunity for regulatory arbitrage is not confirmed for this part of the puzzle. The results point to the direction of a difference of some sorts between the income groups, warranting a deeper dive into the sample.

In Table 12 similar results are given for more restricted sub-samples. In specification (6) the country pairs are restricted so that only advanced economy countries enter the sub-sample. In specification (7) only emerging and developing economy countries do. For AEs, the marginal effects remain broadly as before, perhaps indicating that for banks resident in AEs, the main markets are other AEs. For EMDEs, the change in effects is quite substantial. Especially, now the difference between the effects from MPMs targeting financial institutions become very pronounced between the two country groups.

The marginal effects from **MPMs targeting borrowers** remain statistically significant only in the case of banks operating in AEs and MPMs imple-

**Table 12:** Results for different country groups

| Specification: | (6) Only AEs | | (7) Only EMDEs | |
|---|---|---|---|---|
| $mpib_i$ | 0.111*** | (0.037) | 0.031 | (0.189) |
| $mpib_j$ | -0.003 | (0.037) | -0.008 | (0.118) |
| $mpif_i$ | -0.137**** | (0.027) | 0.313**** | (0.070) |
| $mpif_j$ | -0.090**** | (0.023) | 0.287**** | (0.065) |
| $log(gdp_i)$ | -0.508 | (0.780) | -0.512 | (0.503) |
| $log(gdp_j)$ | 1.051 | (0.792) | -1.487 | (1.020) |
| $log(distw_{ij})$ | -0.668**** | (0.067) | -2.063**** | (0.127) |
| $contig$ | -0.065 | (0.111) | -0.450 | (0.421) |
| $comlangof$ | 0.348**** | (0.092) | 0.473* | (0.257) |
| $col45$ | -0.455 | (0.395) | -1.197 | (0.782) |
| $comcur$ | 0.909**** | (0.112) | 1.833** | (0.746) |
| $log(gdpcap_i)$ | 0.824 | (0.794) | 0.310 | (0.446) |
| $log(gdpcap_j)$ | -0.432 | (0.799) | 0.497 | (0.766) |
| Robust SEs adjusted for k clusters: | 1 003 | | 2 162 | |
| $R^2$ | 0.9221 | | 0.6118 | |
| Pairs | 1 012 | | 2 244 | |
| Observations | 18 031 | | 40 301 | |
| Mean of $ba_{ij}$ | 17 539 mln $ | | 48 mln $ | |
| Median of $ba_{ij}$ | 418 mln $ | | 0 mln $ | |
| Min of $ba_{ij}$ | 0 mln $ | | 0 mln $ | |
| Max of $ba_{ij}$ | 1 481 374 mln $ | | 39 695 mln $ | |

Significance at the 10%, 5%, 1% and 0.1% levels denoted by *, **, *** and ****.

mented in the origin country. For banks operating in EMDEs, MPMs targeting borrowers appear to play no role in determining the level of cross-border lending. This doesn't seem that surprising when one recalls that there are only two MPMs targeting borrowers included in the index and they are both related to mortgage lending[43], which may not be a core business for many internationally active banks.

The effects from **MPMs targeting financial institutions** are highly statistically significant across the board, but interestingly, the effect is qualitatively opposite for banks operating in AEs and for banks operating in EMDEs. For banks operating in AEs the marginal effect on cross-border lendign from more MPMs targeting financial institutions is always negative. On the other hand, for banks operating in EMDEs the effect is always positive.

That is, for banks resident in AEs and extending credit to other AEs, the implementation of MPMs is always associated with less cross-border lending.

[43] A cap on loan-to-value and debt-to-income ratios.

The negative marginal effect from $mpif_j$ indicates that these banks seem to move away from more heavily regulated other AEs. This means that there is no indication of a funding advantage in AE countries due to the possibility of circumvention of macroprudential regulation. But, more surprisingly, these banks also seem to retreat from foreign markets when domestic regulation is tightened. This could be in order to reduce risks and comply more easily with the increased regulation: It could be that banks view foreign lending as inherently more risky due to an informational disadvantage.

On the other hand, banks resident in EMDEs appear to increase cross-border activity in other EMDEs when more MPMs targeting financial institutions are implemented regardless of whether they are implemented domestically or in the destination country. That is, banks resident in EMDEs increase their lending in other EMDEs when domestic regulatory stance tightens: Perhaps because they have the possibility to escape more stringent domestic macroprudential regulation by shifting lending abroad. But they also extend more credit to other EMDEs when the destination country implements more MPMs targeting financial institutions. This indeed is in accordance with the hypothesis on the existence of a funding advantage for foreign banks in EMDEs due to gaps in the coverage of regulation.

If the sample is restricted further, the differences become even more pronounced. In specifications (8) and (9) the sample is restricted to AEs reporting to BIS (i.e. the AEs with significant banking sectors) and the major EME countries respectively. The results are given in Table 13. Qualitatively the marginal effects from MPMs targeting financial institutions remain the same, but their absolute values become larger.

What could explain this stark qualitative difference between the effects from macroprudential regulation to banks operating in countries belonging to the different income groups? One explanation could hinge on differences in how thoroughly macroprudential regulation can be enforced in the different country groups. If the opportunities for regulatory arbitrage are different for banks operating in the different country groups, this puzzle would be internally

**Table 13:** Results for different country groups

| Specification: | (8) | | (9) | |
|---|---|---|---|---|
| | Only AEs reporting to BIS | | Only the major EMEs | |
| $mpib_i$ | 0.117*** | (0.038) | -0.573* | (0.302) |
| $mpib_j$ | -0.001 | (0.038) | 0.181 | (0.224) |
| $mpif_i$ | -0.140**** | (0.027) | 0.329**** | (0.082) |
| $mpif_j$ | -0.092**** | (0.023) | 0.317**** | (0.072) |
| $log(gdp_i)$ | -0.458 | (0.802) | -0.926 | (4.664) |
| $log(gdp_j)$ | 1.145 | (0.825) | -3.600 | (4.732) |
| $log(distw_{ij})$ | -0.649**** | (0.069) | -1.495**** | (0.206) |
| $contig$ | -0.063 | (0.113) | 0.088 | (0.261) |
| $comlangof$ | 0.354**** | (0.093) | 0.475 | (0.317) |
| $col45$ | -0.498 | (0.499) | - | (-) |
| $comcur$ | 0.919**** | (0.113) | - | (-) |
| $log(gdpcap_i)$ | 0.768 | (0.817) | 1.783 | (4.510) |
| $log(gdpcap_j)$ | -0.548 | (0.839) | 1.785 | (4.543) |
| Robust SEs adjusted for k clusters: | 503 | | 269 | |
| $R^2$ | 0.9174 | | 0.798 | |
| Pairs | 506 | | 270 | |
| Observations | 9 107 | | 4 860 | |
| Mean of $ba_{ij}$ | 34 183 mln $ | | 108 mln $ | |
| Median of $ba_{ij}$ | 4 621 mln $ | | 0 mln $ | |
| Min of $ba_{ij}$ | 0 mln $ | | 0 mln $ | |
| Max of $ba_{ij}$ | 1 481 374 mln $ | | 25 409 mln $ | |

Significance at the 10%, 5%, 1% and 0.1% levels denoted by *, **, *** and ****.

logical. Regulatory arbitrage arises when banks can exploit gaps in regulatory oversight. One example would be the case where domestic banks are able to escape domestic regulation by increasing their cross-border activity. In this case, domestic regulators would not be able to enforce the effect of MPMs on foreign lending happening e.g. via foreign branches. Thus, more MPMs implemented in the domestic economy would result in more cross-border lending. A second example would be that foreign banks and their branches are not covered by regulation in a destination country as the banks resident in that country are. Thus foreign banks should be able to make use of a funding advantage. Then a new MPM implemented in a destination country would lead to more cross-border lending extended to customers resident in that country.

If one assumes that the degree with which regulators can enforce prudential regulation is different in AEs and EMDEs, the results are plausible and consistent with one another. In AEs macroprudential regulation may on average have a very good coverage: Regulation is enforced also on the cross-border

activities of domestic banks and also on the operations of branches of foreign banks. This would leave banks little or no opportunities to engage in regulatory arbitrage when operating in AEs. On the other hand, in EMDEs prudential regulation might be less thoroughly enforced or the regulatory system more likely to have gaps in coverage. This would then allow banks to benefit from regulatory arbitrage: They would be willing to increase activities abroad when domestic regulatory stance tightens, and on the other hand be able to make use of a funding advantage in other EMDEs.

From the results and reasoning above, different opportunities for regulatory arbitrage for banks operating in AEs and EMDEs emerges as a candidate for a logical explanation for the somewhat surprising large and qualitatively different results for cross-border spillover effects from MPMs. Given that the banking sectors, the regulatory frameworks and the financial environment are very different in, say, Netherlands and Thailand, this does seem entirely plausible. Further validation of the hypothesis would however require a much deeper dig into the use of MPMs, details of macroprudential regulation and characteristics of regulatory oversight in general in the different countries. The survey responses forming the basis of the GMPI-data do in principle allow this, but this would require quite an amount of data work. A most fertile ground for future research, one might add.

# 5 Conclusions

This paper sets out to add to the knowledge on cross-border spillovers from macroprudential policy measures. My results show that the effect of nationally implemented MPMs indeed spill across borders via international bank lending. Interestingly, and warranting future research on reasons why, the spillovers from MPMs are of opposite signs for advanced market economies and for emerging and developing market economies. I argue that this difference could be explained by differences in how thoroughly macroprudential regulation can be implemented and to what extent banks can engage in regulatory arbitrage.

By combining data on the use of macroprudential regulation, locational data on bilateral bank asset holdings and a standard set of gravity controls I build a data set spanning the years 2000-2017 and 10 146 country pairs, resulting in over 180 000 observations. I estimate a gravity model of international financial asset trade applied to international banking where the use of MPMs in the origin and the destination country enter as friction variables in addition to the standard gravity controls. The results from a PPML estimation, able to take into account the large share of zero observations, heteroscedasticity and clustering present in the data, show that the marginal effects of MPMs targeting financial institutions implemented in either the origin or the destination country indeed are statistically significant. Thus, the existence of spillovers from MPMs targeting financial institutions are confirmed also in the gravity set-up. For MPMs targeting borrowers, the results are not as clear-cut, but some spillovers appear to exist.

In addition to confirming the existence of spillovers, I find that the sign of the effect depends on the income group of the countries in which banks operate. For banks operating in AEs, the marginal effect from MPMs targeting financial institutions is negative regardless of whether the new MPMs are implemented in the origin country or the destination country. That is, in addition to these banks appearing to retreat from more heavily regulated foreign markets, they

also appear to retreat from foreign markets when more MPMs are implemented in the origin country. I argue that this could be an indication of little or no opportunities for regulatory arbitrage for banks in AEs. On the contrary, for banks operating in EMDEs, the effect from new MPMs in the origin or the destination country is positive. Thus these banks seem to shift lending abroad when domestic regulatory stance tightens, but also when this happens in the destination markets. This could imply avenues for regulatory arbitrage: The banks are able to benefit from shifting lending to less regulated foreign markets, but they are also able to make use of a funding advantage due to gaps in regulatory oversight in the destination country. I argue that different opportunities for regulatory arbitrage could provide a logical explanation for the large and qualitative differences in marginal effects for the different country groups. However, further validation of the hypothesis would require a much deeper dig into the characteristics of macroprudential policy in the different country groups.

As such, my results serve to illustrate the differences across policy responses across countries with different banking sectors, regulatory frameworks and financial environments. The obvious policy implication from the results is that there are leakages and spillovers from macroprudential policy that may not be as expected. This should be taken into account by policy makers, even more so as the use of MPMs appears set to become even more prevalent. These results also call for further research, digging deeper into what drives the different spillover effects from MPMs in these different country groups.

From the policy discussion on the international and national fora it is clear that a deeper understanding is needed of the effectiveness of MPMs and of their interaction with other policy measures. This is especially warranted in relation to the EMDEs vulnerable to large and fast-moving capital flows. The role of macroprudential policy in fending off the effects of a next big crisis may be instrumental. Thus, it is of utmost importance to have a fundamental understanding of the capabilities and limitations of the different MPMs as well as an understanding of the implications of the possible cross-border spillovers.

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