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Abstract

We analyze the effect of central bank transparency on cross-border bank activities. Based on a panel gravity model for cross-border bank claims for 21 home and 47 destination countries from 1998 to 2010, we find strong empirical evidence that a rise in central bank transparency in the destination country, on average, increases cross-border claims. Using interaction models, we find that the positive effect of central bank transparency on cross-border claims is only significant if the central bank is politically independent. Central bank transparency and credibility are thus considered complements by banks investing abroad.

Keywords: central bank transparency, cross-border banking, gravity model

JEL Classification: E58, F30, G15

1. Introduction

Asymmetric information is a deterrent to cross-border investment. The existing literature has examined different sources of informational frictions that impede cross-border investments. These frictions include geographical distance (see, e.g., Portes et al. (2001), Buch (2005), Portes and Rey (2005) or Daude and Fratzscher (2008)), national differences in accounting standards (Ahearne et al. (2004) or Eichler (2012)), regulatory differences (Buch (2003)) and the opacity of information provided by the government or companies in a country (Gelos and Wei (2005)).

Our paper examines the effect of monetary policy transparency on cross-border investment activities of banks as a so far undocumented source of asymmetric information. When investing abroad, banks take several risks, such as interest rate, exchange rate and inflation risks, which depend on current and future monetary policy. The degree of monetary policy transparency of the host country's central bank would therefore affect the outcome of a bank's investment decision. A higher degree of central bank transparency should therefore attract bank investments from abroad.

To the best of our knowledge, we are the first to focus on the impact of central bank transparency on banks' cross-border investments. From theory, there are several reasons to assume that greater central bank transparency should attract cross-border investment. Greater transparency increases the central bank's ability to manage expectations, thereby reducing financial market volatility (Chortareas et al. (2002), De Mendonça and Filho (2007), Demertzis and Hallett (2007), Dincer and Eichengreen (2014)). The effect of central bank transparency on expectations can be theoretically justified by standard theories of the term structure, as communication concerning future monetary policy improves the predictability of future short-term interest rates and, hence, enhances the information concerning medium and long-term interest rates (Blinder et al. (2008)). Thus, a higher transparency score and the resulting enhancement in the predictability of future monetary policy should reduce the uncertainty of the payoff of the investment. Ceteris paribus, and assuming risk averse investors, this effect should increase the expected utility of the investment, and hence, the investor should assign a higher portfolio weight to countries with transparent monetary policy regimes. Therefore, we expect central bank transparency in the destination country to have a positive effect on cross-border banking.

To empirically analyze the effect of central bank transparency, we use a panel of cross-border bank claims for 21 home and 47 destination countries for the period 1998-2010. Our results are based on a unique dataset combining data on consolidated cross-border claims provided by the Bank for International Settlements (BIS), with data on central bank transparency provided by Dincer and Eichengreen (2014).[1] We apply a gravity model for cross-border bank claims using the Poisson Pseudo-Maximum-Likelihood (PPML) estimator, as proposed by Santos Silva and Tenreyro (2006). The approach allows us to circumvent a potential parameter bias that is associated with the standard

[1] The construction of the index is explained in section 2. This index is based on Geraats (2002) and can be decomposed into political, economical, procedural, policy and operational dimensions of central bank transparency.

Ordinary Least Squares estimation approach of the log-linearized version of the gravity model. Our results provide robust evidence that a rise in central bank transparency in the destination country increases cross-border claims. On average, our results suggest that a one standard deviation increase in the central bank transparency index yields an increase in cross-border claims of approximately 6.5 percent. This finding is robust to a battery of sensitivity checks. Interestingly, interaction models reveal that the size of this effect critically depends on the political independence of the central bank. Only if the host country's central bank is sufficiently independent, banks consider released information credible and increase their investment when monetary policy transparency is improved. In addition, we test for the sub-categories of central bank transparency (political, economic, procedural, policy, and operational transparency) and find that political and economic transparency have the largest impact on banks' cross-border investment.

Our paper contributes to several strands in the literature. First, our results are consistent with papers showing that central bank transparency improves the predictability of financial market variables, as those variables move well in advance of the announcement of the official policy rate in periods after which transparency reforms in central banks have been introduced (see, e.g., Muller and Zelmer (1999), Clare and Courtenay (2001), Coppel and Connolly (2003), Lange et al. (2003) or Swanson (2006)). In a more recent contribution, Neuenkirch, (2012) has found additional evidence that central bank transparency reduces variation and bias in expectations in money markets. Other papers have found evidence that communication events of central banks indeed convey useful information for financial market participants (see, e.g., Reeves and Sawicki (2007) or Ehrmann and Fratzscher (2009)).

Some studies directly analyze the effect of central bank transparency on forecasts. Ehrmann et al. (2012) find that central bank transparency reduces the dispersion of forecasts among professional forecasters, and hence, the obtained results substantiate previous findings of Crowe and Meade (2008) and Crowe (2010).[2] Furthermore, Hubert (2015) finds that the release of central bank inflation forecasts influences private inflation forecasts, while private forecasts do not affect central bank forecasts. These results provide further empirical evidence that central bank transparency increases the predictability of monetary policy at least a-priori.[3]

Second, we contribute to the strand of literature focusing on the determinants of banks' cross-border activities. Using a detailed micro data set of cross-border activities for all German banks, Buch et al. (2011) find descriptive evidence that heterogeneity in bank size and productivity impacts the volume and mode of international activities of German banks. Interestingly, deviating from the size pecking

[2] Crowe and Meade (2008) find that improvements in transparency increase the usage of this information in the private sector. Crowe's (2010) study finds that the implementation of inflation targeting has led to convergence in forecasts. As Crowe (2010) argues, this convergence is due to the increase in transparency that is established by the implementation of inflation targeting.

[3] Our hypothesis of the effect of central bank transparency on cross-border banking assumes only this a-priori improvement in the predictability of monetary policy. Whether it really has improved the predictability ex-post is not necessary.

order, which has been found for manufacturing firms empirically, they find that even very small banks hold some type of foreign asset. At least for the German banking system, this shows the large degree of internalization in asset holdings and suggests that even small banks are directly exposed to risks of international financial markets.

Focusing more on determinants of cross-border bank investment at the macro-level, Blank and Buch (2007), for example, analyze whether the establishment of the common currency union has fostered banking integration in the member states of the euro area. Overall, they find a positive effect of the Euro on banking integration.

Further determinants that affect cross-border bank activities include institutional quality and the stringency of bank regulation. Papaioannou (2009), for example, finds that higher institutional quality seems to attract cross-border bank flows. In contrast, the stringency of bank regulation acts as a push factor that pushes cross-border bank activities toward more lax regulatory regimes. Multiple studies find empirical evidence for such regulatory arbitrage in cross-border bank flows (see, e.g., Bremus and Fratzscher (2015), Houston et al. (2012)) and in cross-border bank acquisitions (Karolyi and Taboada (2015)).

With the emerging global financial crisis, a number of studies have devoted their analysis to changes in the pattern of international banking activities. Cerutti et al. (2015) analyze the change in the composition of syndicated and non-syndicated cross-border lending during the global financial crisis. They find evidence that the detrimental effect of informational asymmetries between borrowing and lending countries increased during the crisis. Furthermore, the transmission of shocks and liquidity risks through international banks has been analyzed by Cetorelli and Goldberg (2011), Buch and Goldberg (2015) and Claessens and van Horen (2014). De Haas and Van Horen (2013) find that the retrenchment in cross-border loans after the collapse of Leman Brothers was also lower in countries that were geographically closer. Because the effect of informational asymmetries on cross-border activities of banks seem to be well accepted (see also Buch (2003)), we contribute by analyzing the specific effect of central bank transparency on cross-border bank claims, where a higher transparency level reduces informational asymmetries between investors and the central bank.

The rest of this paper is organized as follows: In section 2, we describe the data we use and focus on the construction of the central bank transparency index as well as its evolution over time and across countries. In section 3, we present our empirical strategy for analyzing the effect of central bank transparency on cross-border bank claims. In particular, we discuss the choice of the Pseudo Poisson-Maximum-Likelihood estimator that is used to estimate a gravity model. In section 4, we analyze the effect of central bank transparency on cross-border bank claims. We further evaluate whether this effect depends on the political independence of the central bank and whether different dimensions of the central bank transparency index impact cross-border claims heterogeneously. Section 5 concludes the paper.

2. Data Description

To test our hypothesis, we use a bilateral panel data set containing annual data from 1998 to 2010 for 21 home and 47 destination countries. Table A1 describes all respective data sources. Table A2 repots summary statistics.

2.1. Banks' cross-border activities

The dependent variable of our empirical model is bilateral cross-border claims of the domestic/home banking sector against the foreign/destination country. Data are obtained from the International Banking Statistics Database of the Bank for International Settlements (BIS). This database reports cross-country claims in two different ways: Locational Banking Statistics (LBS) and Consolidated Banking Statistics (CBS). In the LBS, the residence of the banking office is the basic organizing principle that determines the reporting and the counterparty country. For the CBS, the residence of the controlling parent institution is the concept that is used to assign the positions of banks to different countries. As a result, the CBS nets out all inter-office activities, while the LBS contains international transactions between affiliated banks.

For our analysis, we employ the CBS data on the immediate risk basis, as this statistic has superior coverage for our purposes and mitigates issues such as different inter-office accounting practices of banks that would arise with the LBS (Buch et al. (2010)). Another advantage is that third-party effects of affiliated banks residing in financial centers are not an issue for the CBS. In contrast, financial centers such as London pose an issue for controlling for these third-party effects in the case of the LBS.[4]

Claims in the CBS, measured in million US-Dollars, contain all financial assets with the exception of financial derivatives. That includes, among others, deposits and balances placed with banks, loans and advances, trade-related credits, holdings of securities and holdings of notes and coins (BIS (2013)). Because these claims are denominated in current US-Dollars, we have adjusted the data to constant 2005 US-Dollars in order to obtain claims defined in real terms. We further use end-of-year values for our analysis, as the central bank transparency index is defined on a yearly basis.

2.2. Central Bank Transparency

To measure central bank transparency, we employ the index provided by Dincer and Eichengreen (2014), which is a replicated and updated version of Eijffinger and Geraats (2006). Based on the coding of central bank law and the actual information dissemination practices of the central bank, this index reveals the extent of monetary policy information the domestic central bank releases to the

[4] For example, the lending activity of a German bank to a borrower residing in India through a subsidiary located in a financial center such as the United Kingdom would be recorded as two separate claims in the LBS, while the CBS records the direct claim of a German bank to India and hence eliminates such third-party effects of financial centers (see, e.g., Herrmann and Mihaljek (2013)).

public. This index contains data on central bank transparency for 120 central banks over a period of 13 years, from 1998 to 2010.[5] [6] The broad country and time coverage of this index makes it possible to analyze the effect of central bank transparency within a gravity model framework on cross-border bank claims.

One important feature of the transparency data is that there is sufficient variation across both countries and time. Figure 1 (a) depicts the evolution of central bank transparency across selected countries. Large differences among central banks can be detected in this figure. While some central banks had a relatively high transparency score at the beginning of our sample—and hence, central bank transparency increased only slightly for those central banks within our sample—there were also countries such as Hungary whose central banks radically increased their transparency. The majority of emerging market economies followed similar trends in improving central bank transparency during the period of investigation. However, many central banks have remained very opaque, such as India and Russia (see Figure 1 (a)). Uruguay has even reduced central bank transparency during the sample period.

To highlight the cross-country heterogeneity in central bank transparency at the regional and global levels, Figures 1 (b) and 2 depict the index for Latin American countries and the index at the global level (for 2010), respectively.

[Figures 1 - 2 here]

Another important feature of this index is that it addresses the complexity and multidimensionality of central bank transparency as a concept. Constructed in accordance with the taxonomy of central bank transparency of Geraats (2002), the index can be disaggregated into five sub-categories: political, economic, procedural, policy and operational aspects of transparency.

Political transparency refers to the transparency of central banks with respect to their policy objectives. In more detail, this dimension captures whether the central bank releases a formal statement about its policy objective and whether there is a clear prioritization in the case of multiple objectives. It also addresses the question of whether there is a quantification of the main objective and whether there are institutional arrangements or explicit contracts between the government and the central bank regarding instrument independence.

Economic transparency focuses on the disclosure of economic information that is needed in order to conduct monetary policy. Hence, this involves all information on whether the central bank releases quarterly data on the five most important macroeconomic variables, namely, money supply, inflation,

[5] De Haan et al. (2004) and Siklos (2002) provide alternative central bank transparency indices.

[6] Because the data for 120 central banks contain central banks of two currency unions—the Economic and Monetary Union of the European Union (hereafter, EMU) and the Eastern Caribbean Currency Union—the dataset covers more than 120 countries. For countries joining the EMU during the period, we use the transparency scores of the European Central Bank beginning with the year of official EMU membership. For the previous years, we use the scores of the respective central bank of the country.

unemployment, GDP and capacity utilization; whether it discloses information concerning the macroeconomic models that are employed in order to conduct policy analysis; and whether the central bank publishes forecasts for these main variables frequently.

The third dimension, procedural transparency, relates to the disclosure of the monetary policy decision process. This includes information on whether the central bank is transparent in following a specific policy rule or strategy that describes the monetary policy framework, whether it gives policy deliberations and whether it releases voting records.

Policy transparency refers to the prompt announcement of the monetary policy decision, whether there is an explanation available for the monetary policy decision and whether the central bank is transparent about its inclinations for future monetary policy.

Operational transparency relates to the evaluation of monetary policy. This involves disclosure of information regarding whether the central bank has achieved its main operating target, whether it has been successful concerning its macroeconomic goals and whether it provides information on unexpected macroeconomic disturbances that have affected the monetary transmission mechanism.

To construct this index, Dincer and Eichngreen (2014) obtained data from central bank homepages as well as from annual reports and then assigned a score to an answer for each question. For each question, the maximum score for the individual central bank is one. In some cases, if the central bank fulfills the requirements partly, a score of 0.5 will be assigned for the question. Because the composite index is the sum of the individual scores of each question, possible scores range from a minimum of zero to a maximum of 15. However, no central bank in the sample reaches this maximum score; the Sveriges Riksbank, the most transparent central bank, has a score of 14.5. The least-transparent central bank is the central bank of the Cayman Islands, which is the only central bank in this sample that has a score of zero over the whole sample period.

By comparing the different sub-categories, Figure 3 shows that central banks seem to achieve their overall transparency score differently. For example, the Federal Reserve, a relatively transparent central bank from the perspective of the overall index, is relatively opaque regarding the political dimension of central bank transparency, whereas it has a relatively high score in the policy dimension. In the same fashion, Argentina is much more opaque in its economic transparency, while it is transparent with regard to the dimension of political transparency. The same applies for most countries in this sample. Overall, there is large heterogeneity with respect to the sub-categories of central bank transparency in the sample.

Analyzing this variation of different transparency dimensions across central banks might shed additional light on the question of how central banks can increase the availability of foreign funds in their country.

[Figure 3 here]

2.3. Control Variables

Because our empirical strategy involves the estimation of a gravity model, we include the standard gravity model variables, such as the geographical distance between the capitals of countries, contiguity, common official language and common legal origin. These bilateral and time-invariant variables are employed to control for cultural similarities, legal similarities and information asymmetries that exist as a result of distance. Additional to those time-invariant variables, the gravity model includes the economic mass measured by real GDP of the destination as well as the home country.[7]

Because the effect of central bank transparency might also depend on the political independence of the central bank, we use two different measures to capture the concept of central bank independence. The first measure addresses the question of the legal independence of central banks, while the second measure attempts to measure actual central bank independence. Both measures have been proposed by Cukierman et al. (1992) and have been used in multiple studies (for the legal index, see, e.g., Hau (2002) or Julio and Yook (2012), and for the de facto index, see De Haan and Siermann (1996), De Haan and Koi (2000) or Dreher et al. (2010)).

For the de jure index of central bank independence, we use an updated version provided by Bodea and Hicks (2015a, 2015b). This de jure index uses information available from central bank charters in order to evaluate the degree of legal independence. In contrast, the actual independence measure takes a different approach. Because the enforcement of statutory regulations depends on institutional quality, the de facto central bank independence might differ from the legal status of the respective central bank. To address this shortcoming of the legal independence index, the actual central bank independence index evaluates the degree to which the central bank's governor is replaced on an irregular basis. Therefore, actual central bank independence measures the number of irregular central bank governor turnovers within a specific time period. The calculated irregular central bank governor turnover ratio is then used as a proxy for the de facto central bank independence. The necessary data to calculate these ratios are obtained from the Dreher et al. (2010) updated database.

Apart from these variables, there are a number of other control variables:

To control for the development of the banking system that potentially affects the stock of cross-border claims, we use the relative size of the banking system measured as total banking assets to GDP (Bremus (2015), Cerutti et al. (2015)).

We also account for capital controls that might restrict cross-border capital flows using the capital account openness index developed by Chinn and Ito (2006). Furthermore, we include two measures of financial integration. First, we include a dummy variable for common membership in the Economic and Monetary Union (EMU). Common EMU membership is used to capture effects of financial integration that occur due to the establishment of the EMU. For example, Blank and Buch (2007) find

[7] More information on variable definitions and data sources can be found in the data appendix (Table 1).

empirical evidence for a reduction in intermediation costs for members of the EMU. Apart from this de jure index of financial integration, we construct a de facto financial integration measure to test the robustness of our results. This measure is defined as the ratio of the sum of a country's foreign total assets and foreign total liabilities relative to GDP. The data used to calculate this measure are obtained from the Lane and Milesi-Ferretti (2007) updated database.

We add public debt to GDP to control for fiscal solvency of the host country's government. First, it is less attractive for a bank to lend to a country with an excessively indebted government. Second, sovereign risk can deteriorate banking sector stability by reducing the value of banks' sovereign bond holdings or the value of public guarantees for banks (Acharya et al. (2014), Gennaioli et al. (2014)).

Because our hypotheses are based on standard portfolio theory, we also include volatility measures for inflation, exchange rate and stock market returns in the baseline specification. The volatility measures are defined as bilateral variables. Inflation as well as stock market volatility are defined as the yearly standard deviation of inflation and real stock market return, respectively. Both measures capture the volatility difference between the destination and the home country. The exchange rate is already defined as a bilateral variable because it measures the value of the currency of the destination country with respect to the currency of the home country. In addition to these volatility measures, we include the yearly average of the inflation rate, the real stock market return and the change in the exchange rate.

For the purpose of robustness checks, we include variables such as inflation targeting to control for other central bank characteristics. Furthermore, we control for banking system characteristics such as banking sector concentration, private credit to GDP ratio, the bank capital to GDP ratio and the z-score. All of these measures are obtained by the Global Financial Development Database (Čihák et al. (2012)).

To control for institutional quality, we employ the World Governance Indicators as well as the Polity IV scores. Because multiple studies have found that regulatory arbitrage can influence cross-border claims (e.g., Houston et al. (2012)), we employ the following indices: Overall Capital Stringency index, Capital Regulatory index, Private Monitoring Index, Independence of Supervisory Authority, Official Supervisory Power, Overall Independence of the Supervisory Authority and the Overall Restrictions on Bank Activities from the Barth et al. (2004) updated database. These indices are only available for four survey waves corresponding to the years 1999, 2003, 2007 and 2011. To apply these data in our panel estimation, we follow a commonly chosen approach in the literature (see, e.g., Houston et al. (2012) or Karolyi and Taboada (2015)). For the years 1999-2002, we use the data from the first wave; for the years 2003-2006, we use those of the second wave; and for the years 2007-2010, we use those of the third wave. Theses variables are defined on a bilateral basis, as regulatory arbitrage depends on regulatory differences.

3. Empirical Strategy and Estimation Approach

To test empirically whether central bank transparency affects the cross-border lending of banks, we employ a gravity model estimation approach. Given the bilateral nature of our dependent variable (bilateral claims of banks from a source to a destination country), the gravity model is a natural choice. This approach originated in the international trade literature with the purpose of analyzing the patterns of bilateral trade flows (see, e.g., Aitken (1973), Thursby and Thursby (1987), Anderson and Yotov (2010) or Melitz and Toubal (2014)).

More recently, this model has been adopted in fields other than the trade literature. Apart from the analysis of bilateral foreign direct investment flows and stocks (see, e.g., Wei (2000), Bevan and Estrin (2004) or Daude and Stein (2007)) or equity investment (Portes and Rey (2005), Lane and Milesi-Ferretti (2008)), the gravity model approach is widely applied in the context of cross-border banking (see, e.g., Bouvatier and Delatte (2014), Kleimeier et al. (2012), Hermann and Mihaljek (2013), Van Rijckeghem and Weder di Mauro (2013), Cerutti et al. (2015), Karolyi and Taboada (2015)). We follow this literature by employing a gravity model with data on cross-border activities of banks from the international banking statistics of the BIS as the dependent variable.

However, estimating the log-linearized gravity equation has two important limitations. First, the log-linearization of the dependent variable causes all observations with a zero value to be systematically omitted. This, in turn, can create a severe bias, as important information cannot be included in the analysis. Because banking systems do not maintain cross-border activities in all possible destination countries, this implies that our dataset contains zero exposures and that log-linearization might result in biased parameter values.[8]

Second, Santos Silva and Tenreyro (2006) have shown that the OLS estimation of the log-linearized gravity model creates a bias in the parameter values in the presence of heteroscedasticity and that the size of this bias is of practical relevance. This parameter bias is related to the well-known Jensen's inequality, which states that the logarithm of the expected value of a random variable $\tilde{e}$ is not the same as the expected value of a logarithmized random variable $\tilde{e}$:

$$(1) \quad ln\left(E\left[\tilde{e}\right]\right) \neq E\left[ln(\tilde{e})\right]$$

Because the latter depends on higher moments of its distribution, the heteroscedasticity of the error term leads to a correlation with the explanatory variables in the log-linear OLS estimation. Hence, this correlation violates the standard OLS assumptions concerning the consistency of the estimates and therefore lies at the root of this bias. After comparing the performance of different estimation methods with respect to the reduction of this bias, Santos Silva and Tenreyro (2006) recommend employing the

[8] Although in our data set this issue is less severe, as only approximately seven percent of the cross-border claims contain zero values.

Poisson Pseudo-Maximum-Likelihood (hereafter, PPML) estimator, as this method performs the best and eliminates this bias.

An important feature of the PPML estimator is that the gravity model is estimated in its original exponential form and, hence, is not subject to the bias created by the log-linear transformation of the data, as the dependent variable enters the model in levels. The PPML estimator has additional useful properties compared with alternative estimation methods, such as non-linear least squares (see, e.g., Frankel and Wei (1993)). For example, the PPML estimator gives the same weight to all observations, while non-linear least square estimators give more weight to observations that are noisier (Santos Silva and Tenreyro (2006)).[9]

Furthermore, the interpretation of parameter values resulting from the PPML estimation is straightforward. If the explanatory variable is a logarithmic transformation, then the parameter obtained by PPML will be interpreted as elasticity. If the explanatory variable enters in levels, then the parameter has to be interpreted as semi-elasticity. This is because, even though PPML is a non-linear estimation, the marginal effect expressed as elasticity or semi-elasticity is linear.[10]

Thus, to circumvent the problem of biased parameter values, we estimate the gravity model applying the PPML method. Therefore, the baseline estimation equation takes the following form:

$$(2) \quad cbc_{i,j,t} = exp[\alpha_0 + \beta_1 \cdot cbt_{j,t} + \beta_2 \cdot cbt_{i,t} + \gamma_1 \cdot X_{j,t} + \gamma_2 \cdot X_{i,t} + \gamma_3 \cdot G_{i,j} + \alpha_j + \alpha_i + \tau_t] + \varepsilon_{i,j,t}$$

where cbc_{ijt} is defined as cross-border claims between the home country i and the destination country j in period t and enters the equation in levels. The right hand side of the equation is expressed as an exponential model in accordance with the PPML method.

The main variable of interest is the central bank transparency of the destination country $cbt_{j,t}$. In addition, we include the central bank transparency of the home country $cbt_{i,t}$. The matrices $X_{j,t}$ and $X_{i,t}$ are time varying control variables of the home (*i*) and the destination country (*j*), respectively. The matrix $G_{i,j}$ includes the standard bilateral time-invariant variables of a gravity model, such as the distance between the capitals of the home and destination countries or common legal origin. In our baseline specification, we also control for home and destination country fixed effects, α_i and α_j, respectively, as well as for time fixed effects τ_t.[11] $\varepsilon_{i,j,t}$ is the error term.

Because we expect central bank transparency to increase the predictability of monetary policy for the destination country, which in turn should be a pull factor for cross-border claims, we expect β_1 to be

[9] Santos Silva and Tenreyo (2006) discuss the issues that arise with the estimation using a gamma PML estimator. Apart from the theoretical reasoning for the superiority of the PPML estimator, Santos Silva and Tenreyro (2006) present evidence that under different patterns of heteroscedasticity the PPML estimator performs the best among various other estimation methods. See Fally (2015) for further useful properties of the PPML estimator.

[10] In Appendix A2, we show mathematically that this parameter interpretation is valid.

[11] A detailed data description can be found in section 2.

positive. Whether β_2 is positive or negative is unclear a-priori. A lower predictability of monetary policy in the home country could be a push factor, or, ceteris paribus, it could encourage domestic banks to increase their cross-border claims, as a higher predictability of the domestic monetary policy stabilizes the expectations for the bilateral exchange rate. Although we provide no prediction for β_2, controlling for the transparency of the domestic central bank is necessary to avoid omitted variable bias.

As we have already argued in the introduction, the effect of central bank transparency on cross-border claims might conditional on the political independence of the central bank.[12] To account for such heterogeneity in the effect of central bank transparency, we augment the gravity model by an interaction term. The gravity interaction model is similar to the baseline model (2), but it includes a multiplicative interaction term between central bank transparency and central bank independence in the destination country *j* as well as the constitutive terms of the interaction term as single variables:[13]

$$(3) \qquad cbc_{i,j,t} = \exp\left[baseline + \beta_3 \cdot cbi_{j,t} + \beta_4 \cdot cbi_{i,t} + \beta_5 \cdot cbt_{j,t} \times cbi_{j,t}\right] + \varepsilon_{i,j,t}$$

Equation (3) is also estimated by employing the PPML estimator. The interpretation of the corresponding conditional marginal effects is analogous to the OLS case, since the conditional marginal effect expressed as an elasticity or semi-elasticity is a linear function.[14]

4. Empirical Results

In this section, we start with the results of our baseline estimation (Table 3). Then we test its robustness to see whether the obtained results remain stable for different estimation specifications (Tables 4 and 5). Also, we include further variables that might impact cross-border claims (Tables 6 to 9).

Furthermore, we extend our baseline model by interaction terms to test for heterogeneous effects of central bank transparency. Because political dependence might undermine the credibility of the central bank's announcement, we argue that transparency will be more effective at increasing cross-border claims if the central bank is sufficiently independent. To test for such complementarity, we employ a de jure and a de facto measure for central bank independence (Table 10). In addition, we examine whether different dimensions of central bank transparency affect cross-border claims in a different way (Tables 11 and 12).

[12] In section 4.3, we discuss the reasoning for this conditionality in greater detail.

[13] Only including the interaction term without the single terms would cause a bias (Brambor et al. (2006)). We also control for the central bank independence in the home country to avoid omitted variable bias.

[14] The validity of this claim is mathematically shown in Appendix A3.

4.1. Baseline Estimation

The results of our baseline estimation (Equation (2)) are shown in Table 3. Our measure of central bank transparency is included in all estimations. The four specifications include different combinations of the returns and volatilities of the exchange rate and stock indices.[15] We additionally control for destination and home country fixed effects as well as year fixed effects. Standard gravity model variables such as distance and common language account for time-invariant bilateral fixed effects. Robust standard errors are clustered at the country pair level.

[Table 3 here]

Across all specifications, we find strong evidence that an increase in central bank transparency in the destination country increases cross-border bank claims from the home country to the destination country. This effect is statistically significant at least at the 5 percent level.[16] An increase of the central bank transparency index of one unit (which equals approximately one within standard deviation in our sample) in the destination country is associated with an increase in cross-border claims of approximately 6.5 percent, on average, in all four specifications. Given the annual average increase in cross-border claims during this period of 7.6 percent, this effect is also economically significant.[17] This implies that banks indeed seem to take the amount of information released by the central bank of the destination country into account when deciding in which country to invest.[18] Thus, these results are in line with our previous hypothesis that an increase in central bank transparency improves the predictability of monetary policy in the destination country and, hence, reduces the uncertainty that is related to monetary policy surprises that might influence the return of the investment. By increasing the transparency of its central banks, countries may thus attract bank investment from abroad.

Regarding the control variables, we find reasonable results for the commonly used gravity variables. A higher log geographical distance reflecting a higher level of potential informational asymmetries between foreign and domestic investors (see, e.g., Portes and Rey (2005)) decreases cross-border claims significantly. More foreign funding is obtained for an increasing size of the economy, which

[15] We assume that uncertainty should be an important determinant of banks' investment decisions. For example, Buch et al. (2015) show that a higher level of uncertainty reduces banks' total loan supply. This effect might also be prevalent for cross-border lending activities. Therefore, we include measures capturing different aspects of economic volatility.

[16] In addition to these four specifications reported in Table 3, we tested all possible combinations of these three different volatility measures. These additional results are, of course, available upon request.

[17] We use the geometric instead of the arithmetic mean to determine the average growth in cross-border claims. Because there are countries that have experienced a drastic increase in cross-border claims from one year to the next, the results from the arithmetic mean will be misleading, as this would overstate the actual growth rate.

[18] We use the term invest rather than lend because the CBS measure includes more than just loans. However, loans are likely to be the dominant type of claim.

might be related to more-profitable investment opportunities. This economic mass effect, however, is only statistically significant for the destination country.[19]

For both the destination and the home country, there is a positive and highly significant effect of the relative size of the banking system on cross-border claims. Home countries with a larger banking system are thus more likely to expand abroad and to direct their claims toward destination countries with a sizeable banking system. We also find that the capital account openness of the destination country increases cross-border claims, but the effect is not statistically significant for the home country. This seems reasonable, as fewer restrictions make cross-border activities more attractive (Houston et al. (2012)). Government debt in the home country seems to increase cross-border claims as well. A potential explanation for this would be that an increase in sovereign debt in the home country increases the concern of a spillover effect on domestic banks. To diversify against such a domestic spillover effect, banks increase their claims against other countries. Common membership in the EMU has a positive impact on banks' cross-border activities, reflecting a high level of financial integration within the Euro Area.

As expected, we find evidence for a mitigating effect of two out of three volatility measures on cross-border claims. Hence, a higher level of economic uncertainty decreases banks' propensity to expand across borders. Differences between volatility in the real stock market return of the destination and the home country and the volatility of the bilateral exchange rate are statistically significant and have a negative effect on cross-border claims. Interestingly, we find that a decrease in stock market returns in the destination country increases cross-border claims. A potential explanation of this effect is that because the cross-border claims might consist of claims on equity, such a relationship may indicate that banks conduct anti-cyclical investment behavior. By the same token, the quite limited but positive impact of the bilateral exchange rate on cross-border claims can be explained. The result suggests that banks prefer to invest in countries with devalued currencies.

4.2. Robustness

To test the robustness of the results, we perform a broad set of sensitivity analyses. First, we substitute the destination and home country fixed effects with bilateral fixed effects. Because these bilateral fixed effects control for all time-invariant bilateral factors affecting cross-border claims, variables such as contiguity, common official language, common legal origin and geographical distance are omitted (see Table 4).

[Table 4 here]

[19] There may be two reasons for this. First, the parameter value might not be statistically significant simply because the variation within the data of the lending countries is rather limited in comparison to the destination country. The CBS entails more destination countries than reporting countries by construction of the dataset. Also, the reporting countries mainly contain industrialized economies, and greater heterogeneity prevails in the sample of the destination countries. The second possibility is that the size of the banking system is an additional mass component.

Qualitatively and quantitatively, our basic results remain nearly unaltered. An increase in the central bank transparency index by one unit increases cross-border claims by approximately 6 percent on average. These results remain highly statistically significant.

Second, we estimate the baseline specification based on a cross-section, using average values over the period from 1998 to 2010. One drawback of the cross-sectional approach is that one cannot control for individual unobservable country-specific characteristics. Table 5 shows the results from the cross-sectional estimation of the baseline model.

[Table 5 here]

The results again suggest that central bank transparency exerts a positive and highly statistically significant effect on cross-border claims. Because all cross-country time-invariant variation is captured by the destination country and home country fixed effects in the panel estimation, it is not surprising that we obtain larger parameter values that range from 0.106 to 0.079 in the cross-sectional estimation. Nevertheless, the effect of central bank transparency remains very robust, even within a cross-sectional estimation.

Apart from these different estimation approaches, there might be other variables that alter the results obtained by the baseline specification. Hence, we control for further central bank characteristics besides central bank transparency, such as legal central bank independence. This legal central bank transparency variable has been developed by Cukierman et al. (1992). There are two versions of this index, one weighted (lvaw) and one unweighted (lvau). We add both variables separately as control variables. Finally, we also include a dummy that equals one if the central bank employs an inflation targeting regime. Table 6 shows these results.

[Table 6 here]

An increase in the central bank transparency index by one unit is associated with an increase in cross-border bank claims of 6.9 to 7.5 percent. In all specifications, this effect remains highly statistically significant at the 1 percent level.[20] Thus, the central bank transparency index does not capture other institutional characteristics of the central bank, such as political independence or inflation targeting. The variables capturing independence and inflation targeting do not appear to be statistically significant in any specification.

For further robustness, we test whether the inclusion of variables capturing institutional quality affect our results. For example, Houston et al. (2010) show that the expansion of banks into foreign markets

[20] Due to data availability of the central bank independence measure, our sample is slightly reduced when these variables enter the estimation.

depends on the institutional environment. The variables employed for this purpose are the World Bank's Governance Indicators. The corresponding results are reported in Table 7.

[Table 7 here]

The parameter values of the central bank transparency index remain robust and highly significant.[21] That is, our results appear to show an isolated effect of central bank transparency on cross-border claims; the transparency index does not seem to capture the general effect of institutional quality on bank investment. The institutional variables themselves exert different effects on cross-border bank claims. For the indicators "voice and accountability", "regulatory quality" and "control of corruption" of the destination country, we find a positive and significant effect on cross-border claims. Because the parameter values for the indicators "regulatory quality" and "control of corruption" are also negative and significant for the home country, we identify both variables as pull factors. The indicator "voice and accountability" in the home country also increases cross-border claims. This suggests that an increase in democratic accountability and freedom increases cross-border claims both from the home country and to the destination country. Interestingly, the index "government effectiveness" of the home and the destination country decreases cross-border claims. Overall, the statistical significance of the central bank transparency index of the destination country remains unaffected.

In a further robustness test, we employ various variables capturing financial market characteristics. Hence, we implement a de facto financial market integration measure, private credit to GDP, a measure of the concentration of the banking system, the z-score and the bank capital to asset ratio.

Table 8 reports the results of this robustness test.

[Table 8 here]

Across all specifications, the parameter of the central bank transparency index of the destination country again remains statistically significant at the 1 percent level. For the first four specifications, the parameter value ranges from 0.064 to 0.069, which is similar to our baseline results. Interestingly, banks do not take financial market characteristics into account when investing in foreign markets. A possible explanation may be that the pros and cons of financial instability cancel each other out. For example, more banking sector instability may attract more foreign banks because credit demand cannot be satisfied by fragile domestic banks. However, higher levels of banking sector instability may also signal higher credit risk, which should deter foreign banks from entering the domestic market.

Finally, we evaluate whether variables that are supposed to capture regulatory arbitrage might distort our main results. Evidence for regulatory arbitrage has been found by Houston et al. (2012), Ongena et

[21] We also used the Policy IV score that captures the extent of democratization of a country as a control variable. The effect of central bank transparency was statistically significant at the 1 percent level with a parameter value of approximately 0.065.

al. (2013) and Ohls et al. (2015). We include the bilateral difference of 7 different variables that capture the stringency of regulation in the destination and the home country. Table 9 reports the results.

[Table 9 here]

Similar to our previous robustness tests, even when controlling for differences in the stringency in regulatory systems between the destination and the home country, the positive effect of central bank transparency in the home country remains highly significant, with p-values below the 1 percent level. This robustness also translates to the size of the parameter values. Most of these values are even slightly larger compared to the results obtained by the baseline estimation. Only in the fifth specification, which includes the destination-home country difference in the official supervisory power index, is the parameter value slightly lower. Differences in the parameter size might be due to differences in the data availability of the additional control variable. Nevertheless, these results bolster the validity of our baseline results even further, as the statistical significance and size of the parameter values are quite similar. Furthermore, our results do not contradict the hypothesis of regulatory arbitrage, as we find evidence in the case of four out of seven variables, while the remaining three variables are not statistically significant.

4.3. Central Bank Transparency and Independence

The previous section has presented robust evidence that central bank transparency in the destination country plays an important role in banks' international activities. In the following section, we shed light on the link between central bank transparency and central bank independence. Our hypothesis is that the effect of central bank transparency depends on the bank's degree of political independence. Because independent central banks are less subject to changing political influences, their announcements are more credible, and investors give more weight to central bank transparency.

First, increasing the temptation of politicians to engage in inflationary monetary policy before the election period in order to improve the chances of reelection poses incentives to politically dependent monetary policy makers to deviate from prior announcements. Second, electoral uncertainty itself might cause the monetary policy announcement to be less credible because the new government might replace the central bank governor, making any previous announcements null and void. Because economic agents and, in our case, banks are likely aware of the political uncertainty and the conflicting incentives of politically dependent policy makers, they will place more weight on the information released by independent, and hence more credible, monetary policy makers. Thus, following this reasoning, we assume that the effect of monetary policy transparency critically depends on the level of central bank independence. For higher levels of independence, we would expect a greater impact of transparency on banks' cross-border investment.

To test the hypothesis of a conditional effect of central bank transparency on cross-border banking, we use two alternative measures for central bank independence. First, for the de jure independence of the central bank, we employ the Cukierman et al. (1992) measure of legal central bank independence. Second, Cukierman et al. (1992) proposed a proxy measure of de facto independence. This de facto measure is the irregular central bank turnover ratio. The higher the turnover ratio, the more likely it is that the central bank is less independent.

In the first and second specifications, we separately employ the unweighted (lvau) and weighted (lvaw) versions of the legal central bank independence measure. Finally, the third specification contains the de facto central bank transparency measure. As in the previous equation in our robustness section, we control for all the variables of the fourth version of our baseline specification (Table 3, column IV). The results of the multiplicative interaction model (Equation (3)) are reported in Table 10.

[Table 10 here]

Because all of our modifying variables are continuous, the "raw" coefficients obtained from the interaction model regression results should not be interpreted. Instead, we focus on the marginal effect of central bank transparency on cross-border investment and the corresponding standard errors (Brambor et al. (2006)).[22] [23]

Figure 4 (a) depicts the total marginal effect of central bank transparency on cross-border claims conditional on the de jure central bank independence measure (lvaw) and the corresponding 95 percent confidence interval. Additionally, the histogram depicting the distribution of this independence index within the estimation sample is included in this figure.

From this figure, we can infer that the effect of central bank transparency is increasing in the de jure central bank independence measure. However, this effect becomes statistically significant for the 5 percent level at a value of approximately 0.56 of the de jure central bank independence measure. The corresponding marginal effect is 0.056. Above this critical level of central bank independence, the effect of an increase of one unit in central bank transparency increases cross-border claims at least by approximately 5.6 percent. This effect further increases until approximately 14 percent.[24]

Figure 4 (b) depicts the marginal effect of the central bank transparency index of the destination country on cross-border claims conditional on the de facto measure of central bank independence that

[22] The marginal effect and the corresponding standard errors are calculated according to Equations (10) and (11), which can be found in Appendix A3.

[23] Because the parameter values for the interaction with the de jure central bank independence measure are positive for both the unweighted (lvau) and weighted (lvaw) versions, a higher independence seems to increase the effect of central bank transparency on cross-border banking. In the same vein, lower de facto central bank independence, which is a higher irregular governor turnover ratio, results in a less-pronounced effect of central bank transparency.

[24] For expositional purposes, we employed only the weighted central bank independence indicator (lvaw) for the analysis of the total marginal effect. Using the unweighted version (lvau) instead does not alter our results in any way.

is the irregular central bank governor turnover ratio.[25] [26] Additionally, the histogram depicting the distribution of this de facto independence measure within the estimation sample as well as the 95 percent confidence interval are included in this figure.

[Figure 4 here]

In accordance with Table 10, the marginal effect of central bank transparency on cross-border claims conditional on the irregular central bank governor turnover ratio is decreasing. The effect becomes insignificant at an irregular central bank governor turnover ratio of 16.[27] Hence, the marginal effect of central bank transparency at the critical level of the irregular central bank governor turnover ratio is approximately 0.05. That is, an increase of one unit of the central bank transparency index is associated with an increase in cross-border claims of approximately 5 percent, given an irregular central bank governor turnover ratio slightly below 16. Given the minimum ratio, which equals the maximum degree of central bank independence, an increase by one unit of the central bank transparency index increases cross-border claims by approximately 12.5 percent. Comparing the results obtained from Figure 4 (a) and (b), the marginal effects at the critical and maximum levels of central bank independence are relatively similar. Hence, we conclude that the effect of central bank transparency is conditional on the political independence of the central bank. This finding is in line with our hypothesis that a more credible central bank, achieved by political independence, increases the effectiveness of the central bank transparency in attracting cross-border bank claims. Banks appear to believe in the credibility of information released by the central bank and invest accordingly only if it has a sufficient level of political independence.

4.4. Central Bank Transparency Dimensions

In this section, we investigate whether different aspects of central bank transparency have different effects on banks' cross-border investment. The answer to this question will assist in deriving more sophisticated policy implications. Table 11 shows the results testing the unconditional effects of the respective sub-category of central bank transparency.[28]

[25] The irregular central bank governor turnover can be calculated using different time intervals. That applied in this analysis is calculated for the period 1990 to 2010. For robustness, we also calculated these measures for the period 1998 to 2010 and 1970 to 2012 (full sample available). However, our results remain qualitatively unaltered from our first measure.

[26] Although the interaction term in Table 10 is not statistically significant at any conventional level, it is possible that the total marginal effect can exert a conditional effect if the covariance term of the relevant parameters is negative (Brambor et al. (2006)). Hence, only analysis of the total marginal effect with the corresponding standard errors is capable of yielding any valid inference from our multiplicative interaction model.

[27] This ratio can be understood as the percentage of how many times in a given period there was an irregular central bank governor turnover. Therefore, a ratio of 16 gives the percentage or likelihood of an irregular governor turnover for a given year within the period from 1990 to 2010.

[28] Table 13 summarizes the results obtained from the analysis of the effects of different central bank transparency dimensions on cross-border bank claims.

[Table 11 here]

The results suggest that the individual dimensions of central bank transparency contribute differently to the increase in cross-border claims. An increase of one within standard deviation of the political dimension of central bank transparency in the destination country increases cross-border claims by approximately 4.9 percent on average, while in the case of economic transparency, this effect is approximately 6.4 percent on average. Both effects are statistically significant, with p-values of 0.029 and 0.003, respectively. Interestingly, in the case of economic transparency, we find evidence that an increase of one within standard deviation in the home country reduces cross-border claims by approximately 5.2 percent on average.[29] This effect is also statistically significant at the 1 percent level. Hence, economic transparency might act as a pull factor for cross-border claims. The remaining three dimensions of central bank transparency, namely, procedural, policy, and operational transparency, seem to play a minor role, and we do not obtain significant results. Thus, the results of the baseline regressions appear to be driven by variation in political and economic transparency.

Because we have found empirical evidence that central bank independence impacts the quantitative effect of central bank transparency on cross-border claims, it is likely that this translates into the effects of the individual dimensions of central bank transparency. Hence, we also estimate a multiplicative interaction model for the different dimensions of central bank transparency. Table 12 reports the estimation results of the multiplicative interaction model.

[Table 12 here]

As discussed above, the results presented in the standard regression table are less informative. Thus, we focus on analyzing the total marginal effect given a certain level of legal central bank independence. Figures 5 to 6 display the marginal effects of the different central bank transparency dimensions on cross-border claims conditional on de jure central bank independence.

Starting with the political dimension of central bank transparency, the critical level of central bank independence for which the marginal effect of this dimension becomes statistically significant at the 5 percent level is approximately 0.5 (Figure 5(a)). The corresponding marginal effect of this dimension equals approximately 0.33. That is, an increase of one unit in the political central bank transparency dimension in the destination country increases cross-border claims by approximately 33 percent on average. This effect is increasing in the de jure index of central bank independence. For a maximum possible value of central bank independence of 0.94, an increase in central bank transparency in the destination country increases cross-border claims by 68 percent on average. Because this dimension

[29] The within standard deviation of the political and economic transparency dimensions for the destination country equal 0.157 and 0.492, respectively, while the within standard deviation of the economic transparency in the home country equals 0.513. Parameter values of Table 11 can be used to calculate the standardized marginal effects.

captures the transparency concerning the monetary policy objectives of the central bank, this information is relatively easy to understand and contains relevant information to predict future monetary policy. Hence, the relatively large marginal effect seems reasonable.

For the marginal effect of the economic transparency dimension, the critical level of the central bank independence measure is approximately 0.59 (Figure 5 (b)). At this level, the marginal effect becomes statistically significant at the 5 percent level, and an increase by one unit in this dimension increases cross-border claims by approximately 11.6 percent. This effect increases even further: for the maximum observed level of central bank independence (0.94), a one unit change in this dimension increases cross-border claims by approximately 22.9 percent.

[Figure 5 here]

For procedural central bank transparency (Figure 6 (a)), the critical value of legal central bank independence is approximately 0.73. An increase by one unit of this dimension increases cross-border claims by approximately 14 percent, on average, at this critical value. At the maximum observed value of independence, an increase in this dimension by one unit increases cross-border claims by approximately 27 percent on average.

The results obtained for the policy central bank transparency dimension are relatively similar to the results of the procedural dimension (Figure 6 (b)). For the policy dimension, the critical value of the central bank independence measure is approximately 0.72 and the corresponding marginal effect expressed as a semi-elasticity is approximately 0.17. As the central bank independence reaches its maximum value of 0.94, this effect increases to 0.286. That is, an increase by one unit of this dimension increases cross-border claims by approximately 28.6 percent on average.

Compared to the political and economic dimensions, both the procedural and the policy dimensions become significant only at a high level of central bank independence (see Table 13). This is also in line with the results of the baseline estimation. One possible explanation for these differences might be that central bank independence becomes much more important when the information provided is not that clearly related to the future monetary policy, and political influence might dilute the precision of the information released by the central bank. While political and economic transparency are much more closely related to the objectives of the central bank and the economic situation, this informational content might be much easier to interpret and less affected by political influences than voting records, the release of minutes or policy deliberations.[30] For example, the informational content of policy deliberations might contain relatively soft information compared to the hard economic data released by the central bank. This type of information released in the form of policy deliberations might give politically dependent central bankers some leeway to send a more ambiguous signal.

[30] Political transparency includes whether a central bank provides a numerical target. In case of economic central bank transparency, economic data and forecasts are also stated in numerical terms that are much more difficult to dilute through political influence, and thus, they are more explicit.

Because politically dependent central bankers are more likely to experience conflicting goals between monetary policy objectives and other political objectives, they might prefer such ambiguity. Thus, central bank independence might be much more important for the procedural and policy dimensions of central bank transparency, as shielding from political influences might also enhance the precision of the signal. However, when political independence is sufficiently strong, the marginal effect is slightly lower compared to the political and economic transparency dimension.[31]

[Table 13 here]

In contrast to the previous dimensions, the conditional marginal effect of the operational transparency dimension is negative and becomes statistically significant at the 5 percent level at a critical value of 0.6 of the legal central-bank independence measure (Figure 6 (c)). The corresponding marginal effect is approximately 0.16. At the highest possible value of central bank independence, an increase of the operational transparency index by one unit is associated with a decrease in cross-border claims of 33.6 percent on average.

[Figure 6 here]

This result is quite surprising, given that transparency is generally assumed to improve the predictability of monetary policy (Geraats (2002)).

However, there are two distinctive features of operational transparency that might help explain why we observe a decreasing effect on cross-border bank claims. First, operational central bank transparency is inherently backward-looking. Releasing information on whether the central bank has achieved its monetary and macroeconomic goals or whether the monetary policy transmission was affected by unexpected macroeconomic disturbances entails an evaluation of the previous monetary policy. Second, this evaluation process assumes that economic agents are already aware of the aspects of monetary policy that are evaluated. Hence, a high level of operational transparency depends on the transparency achieved in the previous four dimensions of central bank transparency.

Both features taken together might create an asymmetry in the way market participants perceive the signal given by operational central bank transparency. On the one hand, if the central bank achieves its goals and there are no unexpected disturbances that affected the monetary policy transmission mechanism, then market participants might believe that the monetary policy of the central bank performs as expected. On the other hand, if the monetary policy evaluation turns out to be suboptimal, then the central bank does not meet the expectations, and this might create bad news that undermines the credibility of the central bank. This could also increase the uncertainty about the effectiveness of

[31] To evaluate the different impacts of these dimensions, Table 13 depicts the standardized marginal effects of each dimension.

monetary policy in general, and hence, affect the investment decision of the bank. Interestingly, this argumentation can also be interpreted in line with Morris and Shin (2002).

They argue that economic agents might overreact to public information as it might provide an anchor point for potential coordination among economic agents. However, because public information is costless, this might pose an incentive to become overly reliant on public information and, thus, decrease the effort to obtain costly private information. This type of overreliance on the public signal, according to their argument, can be welfare reducing because the public signal is noisy. Hence, it becomes possible that this overreliance creates a wedge between expectations and the true value of fundamentals. Although our analysis is not directly concerned with welfare implications, this literature might explain the negative effect of operational central bank transparency on cross-border claims. If economic agents do overreact to public information, and hence, to the forward looking transparency dimensions, the backward looking feature of operational transparency might reveal that the signal of the forward looking transparency dimensions was noisier than previously anticipated. From this perspective, the operational transparency would also act as a correction mechanism to the previous overreaction of the public signal. Nevertheless, it might still be possible that this effect could increase the uncertainty regarding future monetary policy and, thus, deter cross-border claims.[32]

5. Concluding Remarks

In this paper, we study the impact of central bank transparency on cross-border bank investment. Using a panel data set of 21 home and 47 destination countries for the period 1998 to 2010, we find robust evidence that a one standard deviation increase in central bank transparency is associated with an increase in cross-border claims of approximately 6.5 percent. This effect is economically significant, given an average annual growth rate of cross-border claims of 7.6 percent during this period. Employing a large set of robustness tests, these results remain unaltered.

Furthermore, we show that the size of this effect critically depends on a sufficient level of political independence of the respective central bank. Because central bank independence ensures that political influence is limited, published information by the central bank concerning monetary policy becomes more reliable. Therefore, our results suggest that, indeed, this "credibility by delegation" effect of central bank independence amplifies the positive effect of central bank transparency on cross-border bank claims. Only if political independence exceeds a critical level, central bank transparency has a significant impact on cross-border claims.

In addition, distinguishing among different dimensions of central bank transparency, we find, unsurprisingly, that political and economic transparency exerts the strongest effect on cross-border

[32] Morris and Shin (2005) give an example of a data revision of the Bank of England that has led to "some scrutiny and comment from the press" (Morris and Shin (2005), p. 9). In the same vein, Geraats (2002) guesses that one reason central banks might abstain from releasing such information is that they might feel "embarrassed" if they have to inform the public about shocks they were unable to anticipate (Geraats (2002), p. F556).

claims. For both dimensions, a relatively low level of central bank independence is needed to obtain a statistically significant effect. This contrasts with the effect of the procedural and policy dimension, which requires a much higher level of central bank independence to have a significant impact. In contrast, operational transparency has a negative effect on cross-border bank claims. This may be due to two distinct features of this dimension that might give rise to an asymmetry in how this signal is perceived by market participants. First, it contains information on the evaluation of monetary policy that makes it inherently backward looking; second, it depends on the transparency previously achieved in other dimensions. Despite this negative effect, we are careful not to overstate this result.

Some policy implications can be derived from our results. Our findings suggest that increases in central bank transparency can increase the availability of foreign bank funds. However, the existence and size of this effect depends critically on the level of central bank independence. Thus, the political independence of the central bank also has to be taken into account in any central bank transparency reform that aims, at least partially, at attaining additional foreign bank funds.

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Figures and Tables

Table 1: Variables and Data Source

Category	Variable	Definition	Source
Cultural and legal similarity	Distance	bilateral	CEPII Database
	Common language	bilateral	CEPII Database
	Common border	bilateral	CEPII Database
	Common legal origin	bilateral	CIA World Factbook
General economy	Real GDP	i, j	World Bank WDI
	Gross government debt (share to GDP)	i, j	IMF WEO
	Inflation	i, j	Thomson/Reuters: Datastream
	Exchange rates	bilateral	IMF IFS
	Stock market returns	i, j	Thomson/Reuters: Datastream
Banking system characteristics	Size of the banking system	i, j	World Bank - Global Financial Development Database
	Bank capital to assets	i, j	World Bank - Global Financial Development Database
	Concentration	i, j	World Bank - Global Financial Development Database
	Z-score	i, j	World Bank - Global Financial Development Database
	Private credit of money deposit banks (to GDP)	i, j	World Bank - Global Financial Development Database
Institutional quality	Polity IV score	i, j	Systemic Peace Database
	Control of corruption	i, j	World Bank: World Governance Indicators
	Government effectiveness	i, j	World Bank: World Governance Indicators
	Regulatory quality	i, j	World Bank: World Governance Indicators
	Political stability/No violence	i, j	World Bank: World Governance Indicators
	Rule of law	i, j	World Bank: World Governance Indicators
	Voice and accountability	i, j	World Bank: World Governance Indicators
Globalization	Globalization index	i, j	KOF
	Financial integration	i, j	Lane and Milesi-Ferretti (2007) database
Regulation	Capital controls	i, j	Chinn-Ito Index (2006)
	Overall capital stringency index	bilateral	Barth et al. (2004) database
	Capital regulatory index	bilateral	Barth et al. (2004) database
	Private monitoring index	bilateral	Barth et al. (2004) database
	Independence of supervisory authority	bilateral	Barth et al. (2004) database
	Official supervisory power	bilateral	Barth et al. (2004) database
	Overall independence of the supervisory authority	bilateral	Barth et al. (2004) database
	Overall restrictions on bank activities	bilateral	Barth et al. (2004) database
Central Bank characteristics	Central bank transparency	i, j	Dincer and Eichengreen (2014)
	Central bank independence (lvau, lvaw)	i, j	Hicks, R. and Bodea, C. (2015a) (2015b)
	Irregular central bank governor turnover	i, j	Dreher/Sturm/De Haan (2010)
	Inflation targeting	i, j	Minea and Tapsoba (2014), Rose (2007) and central bank homepages

Table 1 continued …

Category	Variable	Definition	Source
Risk - volatility measures	Std. deviation of inflation rate (quarterly)	bilateral	Thomson/Reuters: Datastream
	Stock market volatility (monthly)	bilateral	Thomson/Reuters: Datastream
	Std. of bilateral exchange rate change (monthly)	bilateral	IMF IFS

Notes: This table describes the variables used in the empirical analysis, it provides information concerning the definition of these variables and the data sources. Variables are either defined on a bilateral basis or on a country specific basis. The bilateral definition depends on whether the variable itself is naturally defined in a bilateral context e.g. geographical distance or exchange rates or whether it is constructed as a bilateral variable e.g. volatility measures and regulation variables, which are defined as the difference between the destination and the home country. The definition "i, j" means that the variable is included separately in the estimation equation for the home and for the destination country.

Table 2: Descriptive Statistics

Variables:	pairwise correlation with CBT	mean	std.	std. (within)	min.	max.
cross-border claims (CBS)	0.2319	12748.39	41172.63	12153.03	0	677845.6
central bank transparency	1	8.50	2.73	1.01	1	14.5
political central bank transparency	0.48	2.57	0.67	0.17	0.5	3
economic central bank transparency	0.86	1.89	0.93	0.47	0	3
procedural central bank transparency	0.57	1.26	0.74	0.27	0	3
policy central bank transparency	0.77	1.41	0.78	0.31	0	3
operational central bank transparency	0.85	1.38	0.71	0.24	0	3
real GDP (mn USD)	0.19	1060968	2162696	177848.5	5769.32	13700000
government debt to GDP	0.34	52.97	32.53	9.25	3.05	215.95
inflation rate	-0.30	3.50	4.52	3.23	-6.15	92.65
inflation rate volatility (dif.)	-0.39	0.0031	0.0076	0.0055	-0.0229	0.0619
real stock market return	-0.17	0.29	2.89	2.72	-9.36	21.84
stock market volatility (dif.)	-0.11	0.0043	0.0415	0.0356	-0.2572	0.2570
exchange rate (bil.)	-0.06	62.73	926.18	886.2716	-8.87	20480.46
exchange rate volatility (bil.)	-0.15	0.0276	0.03	0.0226	0.00	0.16
bank system size	0.36	100.37	51.93	18.61	51.93	245.13
bank concentration	0.12	68.96	19.25	8.54	21.84	100.00
bank capital to asset ratio	-0.49	7.57	2.73	1.05	1.50	15.30
private credit of money deposit banks to GDP	0.35	87.27	50.33	18.56	10.85	237.58
z-score	0.03	14.43	8.08	3.34	-4.14	45.67
legal unweighted CBI (lvau)	0.32	0.68	0.21	0.05	0.12	0.95
legal weighted CBI (lvaw)	0.31	0.68	0.21	0.05	0.17	0.94
irregular central bank governor turnover ratio	-0.16	11.20	8.05	0.00	0.00	35.00
inflation targeting	0.21	0.39	0.49	0.17	0	1
voice and accountability	0.65	0.77	0.77	0.11	-1.68	1.83
rule of law	0.56	0.84	0.87	0.10	-1.17	2.00
regulatory quality	0.56	0.96	0.66	0.11	-0.78	2.08
control of corruption	0.52	0.87	0.98	0.14	-1.13	2.50
government effectiveness	0.54	1.00	0.79	0.13	-1.20	2.36
political stability no violence	0.33	0.36	0.86	0.22	-2.19	1.67

Table 2 continued …

Variables:	pairwise correlation with CBT	mean	std.	std. (within)	min.	max.
polity IV score	0.58	8.19	4.00	0.80	-10	10
capital openness	0.53	0.78	0.30	0.10	0	1
financial integration	0.21	389.43	470.99	139.92	64.78	3306.18
overall capital stringency index (dif.)	0.04	-0.23	2.25	1.28	-6	6
capital regulatory index (dif.)	-0.02	-0.23	2.61	1.59	-7	7
private monitoring index (dif.)	-0.10	0.20	2.00	1.06	-5	6
independence of bank supervisory authority (dif.)	0.07	-0.02	0.67	0.36	-1	1
official supervisory power (dif.)	-0.13	0.21	-10.12	10.62	4	16
overall independence of supervisory authority (dif.)	0.05	0.01	1.01	0.55	-3	3
overall restrictions on banking activities (dif.)	-0.07	0.54	2.59	1.22	-7	9
common legal origin (bil.)	0.08	0.23	0.42	0	0	1
common official language (bil.)	0.10	0.07	0.25	0	0	1
distance between capitals (bil.)	-0.20	5373.82	4155.47	0	59.62	19079.88
contiguity (bil.)	0.12	0.06	0.24	0	0	1

***Notes*:** This table shows the summary statistics for the variables employed for our empirical analysis. It includes the pairwise correlation between the central bank transparency indicator of Dincer and Eichengreen (2014) and other explanatory variables, the mean value (mean), the overall standard deviation (std.) and the within standard deviation (std. (within)) as well as the minimum (min.) and maximum (max.) value. CBI denotes the legal central bank independence indicator form Cukierman et al. (1992), where lvau denotes the unweighted and lvaw the weighted index. The corresponding sample of these statistics are from the baseline estimation (see Table 3), and hence, for the variables that are included in this estimation, the number of observations equals 6532. As this dataset is based on bilateral data, variables that are defined on a bilateral basis are denoted either by "(bil.)" or if they are defined as difference between destination and home country by "(dif.)". All other variable statistics are calculated for the destination country.

Table 3: Benchmark Regression Results

	I	II	III	IV
central bank transparency (dest.)	0.066**	0.065**	0.063**	0.063**
	(0.026)	(0.025)	(0.026)	(0.025)
central bank transparency (home)	0.017	0.024	0.008	0.014
	(0.023)	(0.023)	(0.023)	(0.022)
distance (bilat.)	-0.365***	-0.357***	-0.365***	-0.357***
	(0.057)	(0.055)	(0.057)	(0.055)
contiguity (bilat.)	0.003	0.004	0.006	0.005
	(0.083)	(0.083)	(0.083)	(0.083)
common language (bilat.)	0.000	-0.011	-0.002	-0.011
	(0.127)	(0.128)	(0.127)	(0.128)
common legal origin (bilat.)	0.235***	0.239***	0.238***	0.241***
	(0.079)	(0.079)	(0.079)	(0.079)
ln GDP (dest.)	1.407***	1.462***	1.378***	1.411***
	(0.326)	(0.328)	(0.326)	(0.326)
ln GDP (home)	0.718	0.555	0.414	0.389
	(1.024)	(1.006)	(0.981)	(0.973)
size of banking system (dest.)	0.003***	0.003***	0.003***	0.003***
	(0.001)	(0.001)	(0.001)	(0.001)
size of banking system (home)	0.002**	0.002***	0.002***	0.002***
	(0.001)	(0.001)	(0.001)	(0.001)
capital openness (dest.)	0.653***	0.668***	0.592***	0.608***
	(0.223)	(0.227)	(0.224)	(0.228)
capital openness (home)	0.463	0.525	0.370	0.474
	(0.847)	(0.865)	(0.874)	(0.882)
government debt (dest.)	-0.002	-0.001	-0.001	-0.000
	(0.002)	(0.002)	(0.002)	(0.002)
government debt (home)	0.006***	0.006**	0.005**	0.005**
	(0.002)	(0.002)	(0.002)	(0.002)
EMU (bilateral)	0.639***	0.571***	0.634***	0.569***
	(0.099)	(0.090)	(0.099)	(0.090)
inflation rate (dest.)	-0.010	-0.011	-0.012	-0.012
	(0.008)	(0.008)	(0.009)	(0.009)
inflation rate (home)	-0.023	-0.020	-0.021	-0.021
	(0.021)	(0.021)	(0.021)	(0.021)
inflation rate volatility (bilat.)	-0.013	-0.014	-0.016	-0.017
	(0.027)	(0.028)	(0.028)	(0.028)
exchange rate change (bilat.)		3.5E-05***		1.5E-05
		(1.5E-05)		(2.1E-05)
exchange rate volatility (bilat.)		-0.028***		-0.027**
		(0.011)		(0.011)
stock market return (dest.)			-0.018***	-0.019***
			(0.006)	(0.006)
stock market return (home)			-0.002	-0.007
			(0.007)	(0.007)

Table 3 continued …

	I	II	III	IV
stock market volatility (bilat.)			-0.012***	-0.010*
			(0.004)	(0.005)
year fixed effects	YES	YES	YES	YES
dest. and home country fixed effects	YES	YES	YES	YES
observations	6,532	6,532	6,532	6,532
R-squared	0.916	0.919	0.916	0.919

Notes: This table reports the results of the Poisson Pseudo-Maximum-Likelihood (PPML) estimation for the baseline regressions (I - IV). Since PPML is the estimation method, the dependent variable, that is bilateral cross-border claims, is given in levels. The variable of our main interest is the central bank transparency index of Dincer and Eichengreen (2014) for the destination country. The explanatory variables include the standard gravity variables as well as variables capturing the size of the banking system, the capital openness of the country and the debt of the government as a share to GDP (see Table 1). Variables with "ln" in front enter the estimation equation as a logarithmic transformation. This regression also includes different variables capturing economic volatility. The labels "(bilat.)", "(home)" and "(dest.)" behind the variable names denote whether a variable is a bilateral variable, refers to the home or the destination country, respectively. The sample contains 21 home and 47 destination countries over the time period 1998-2010 and is held constant over all four specifications. All regressions take home and destination country fixed effects as well as year fixed effects into account. Standard errors are clustered by bilateral relationship and are depicted in parentheses. ***, **, and * denote the 1%, 5% and 10% level of significance, respectively.

Table 4: Robustness Bilateral Fixed Effects

	I	II	III	IV
central bank transparency (dest.)	0.062**	0.062**	0.060**	0.060**
	(0.025)	(0.025)	(0.025)	(0.024)
central bank transparency (home)	0.046**	0.050**	0.036	0.039*
	(0.023)	(0.023)	(0.022)	(0.022)
ln GDP (dest.)	1.586***	1.613***	1.539***	1.557***
	(0.331)	(0.331)	(0.328)	(0.327)
ln GDP (home)	0.469	0.364	0.296	0.294
	(0.996)	(0.985)	(0.959)	(0.954)
size of banking system (dest.)	0.003***	0.003***	0.003***	0.003***
	(0.001)	(0.001)	(0.001)	(0.001)
size of banking system (home)	0.003***	0.003***	0.003***	0.003***
	(0.001)	(0.001)	(0.001)	(0.001)
capital openness (dest.)	0.479**	0.485**	0.435**	0.438**
	(0.209)	(0.211)	(0.209)	(0.211)
capital openness (home)	0.396	0.368	0.189	0.199
	(0.504)	(0.494)	(0.519)	(0.508)
government debt (dest.)	-0.002	-0.001	-0.001	-0.001
	(0.002)	(0.002)	(0.002)	(0.002)
government debt (home)	0.006**	0.005**	0.005**	0.005**
	(0.002)	(0.002)	(0.002)	(0.002)
EMU (bilateral)	0.052	0.070	0.051	0.056
	(0.204)	(0.208)	(0.193)	(0.198)

Table 4 continued …

	I	II	III	IV
inflation rate (dest.)	-0.012	-0.012	-0.014	-0.014
	(0.009)	(0.008)	(0.009)	(0.009)
inflation rate (home)	-0.018	-0.017	-0.020	-0.020
	(0.020)	(0.020)	(0.020)	(0.020)
inflation rate volatility (bilat.)	0.007	0.007	0.004	0.004
	(0.029)	(0.029)	(0.030)	(0.030)
exchange rate change (bilat.)		2.5E-05**		8.0E-06
		(1.1E-05)		(1.6E-05)
exchange rate volatility (bilat.)		-0.014**		-0.014**
		(0.006)		(0.006)
stock market return (dest.)			-0.017***	-0.017***
			(0.006)	(0.006)
stock market return (home)			-0.012*	-0.014**
			(0.007)	(0.007)
stock market volatility (bilat.)			-0.008**	-0.007
			(0.004)	(0.004)
year fixed effect	YES	YES	YES	YES
country pair fixed effect	YES	YES	YES	YES
observations	6,919	6,919	6,919	6,919
R-squared	0.960	0.961	0.960	0.961

Notes: This table reports the results of the Poisson Pseudo-Maximum-Likelihood (PPML) estimation for the baseline regressions (I - IV). Since PPML is the estimation method, the dependent variable, that is bilateral cross-border claims, is given in levels. The variable of our main interest is the central bank transparency index of Dincer and Eichengreen (2014) for the destination country. The explanatory variables include the standard gravity variables as well as variables capturing the size of the banking system, the capital openness of the country and the debt of the government as a share to GDP (see Table 1). This regression also includes different variables capturing economic volatility. The labels "(bilat.)", "(home)" and "(dest.)" behind the variable names denote whether a variable is a bilateral variable, refers to the home or the destination country, respectively. The sample contains 21 home and 47 destination countries over the time period 1998-2010 and is held constant over all four specifications. In contrast to Table 3 this regression takes account of bilateral fixed effects as well as year fixed effects. As a result the standard time invariant gravity variables are omitted. Standard errors are clustered by bilateral relationship and are depicted in parentheses. ***, **, and * denote the 1%, 5% and 10% level of significance, respectively.

Table 5: Robustness Cross-Section Results.

	I	II	III	IV
central bank transparency (dest.)	0.106***	0.104***	0.079***	0.083***
	(0.033)	(0.032)	(0.027)	(0.027)
central bank transpareny (home)	-0.070*	-0.074**	-0.058*	-0.057
	(0.036)	(0.037)	(0.034)	(0.036)
distance (bilat.)	-0.380***	-0.371***	-0.388***	-0.375***
	(0.053)	(0.053)	(0.049)	(0.048)
contiguity (bilat.)	-0.189	-0.186	-0.196	-0.196
	(0.142)	(0.141)	(0.139)	(0.137)
common language (bilat.)	0.233	0.231	0.272**	0.245*
	(0.149)	(0.158)	(0.135)	(0.144)
common legal origin (bilat.)	0.087	0.097	0.091	0.100
	(0.105)	(0.104)	(0.103)	(0.102)
ln GDP (dest.)	0.898***	0.897***	0.853***	0.851***
	(0.041)	(0.040)	(0.037)	(0.036)
ln GDP (home)	0.918***	0.935***	0.966***	0.976***
	(0.061)	(0.065)	(0.059)	(0.062)
size of banking system (dest.)	0.004***	0.004***	0.004***	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)
size of banking system (home)	0.010***	0.010***	0.011***	0.011***
	(0.001)	(0.001)	(0.001)	(0.001)
capital openness (dest.)	1.078***	1.061***	0.995***	0.916***
	(0.296)	(0.289)	(0.325)	(0.329)
capital openness (home)	-2.868***	-3.226***	-3.224***	-3.582***
	(0.874)	(0.984)	(1.159)	(1.321)
government debt (dest.)	-0.009***	-0.010***	-0.008***	-0.008***
	(0.002)	(0.002)	(0.002)	(0.002)
government debt (home)	-0.017***	-0.018***	-0.018***	-0.019***
	(0.003)	(0.003)	(0.003)	(0.003)
EMU (bilateral)	0.599***	0.593***	0.664***	0.577**
	(0.140)	(0.205)	(0.152)	(0.234)
inflation rate (dest.)	0.046***	0.049***	0.045**	0.051**
	(0.017)	(0.018)	(0.021)	(0.022)
inflation rate (home)	-0.754***	-0.799***	-0.799***	-0.827***
	(0.095)	(0.107)	(0.096)	(0.106)
inflation rate volatility (bilat.)	0.032	-0.016	-0.201	-0.228
	(0.145)	(0.146)	(0.158)	(0.158)
exchange rate change (bilat.)		3.1E-04		1.9E-04
		(1.9E-04)		(2.0E-04)
exchange rate volatility (bilat.)		-0.006		-0.042
		(0.083)		(0.081)
stock market return (dest.)			0.147*	0.143*
			(0.080)	(0.080)
stock market return (home)			-0.042	-0.052
			(0.181)	(0.191)

Table 5 continued…

	I	II	III	IV
stock market volatility (bilat.)			-0.095***	-0.095***
			(0.028)	(0.028)
observations	913	913	913	913
R-squared	0.837	0.837	0.867	0.869

***Notes*:** This table reports the results of the Poisson Pseudo-Maximum-Likelihood (PPML) estimation for the baseline regressions (I - IV) in the cross-section of bilateral relationships. In order to control for year effects we use the average value of the time period 1998-2010 for the variables in our cross-section estimation. Since PPML is the estimation method, the dependent variable, that is bilateral cross-border claims, is given in levels. The variable of our main interest is the central bank transparency index of Dincer and Eichengreen (2014) for the destination country. The explanatory variables include the standard gravity variables as well as variables capturing the size of the banking system, the capital openness of the country and the debt of the government as a share to GDP (see Table 1). This regression also includes different variables capturing economic volatility. The labels "(bilat.)", "(home)" and "(dest.)" behind the variable names denote whether a variable is a bilateral variable, refers to the home or the destination country, respectively. Standard errors are clustered by bilateral relationship and are depicted in parentheses. ***, **, and * denote the 1%, 5% and 10% level of significance, respectively.

Table 6: Robustness Central Bank Characteristics

	I	II	III
central bank transparency (dest.)	0.072***	0.072***	0.067***
	(0.027)	(0.027)	(0.026)
central bank transparency (home)	0.021	0.021	0.010
	(0.024)	(0.024)	(0.021)
...			
controls included	YES	YES	YES
...			
CBI lvau (dest.)	-0.490	—	—
	(0.324)		
CBI lvau (home)	-0.091	—	—
	(0.376)		
CBI lvaw (dest.)	—	-0.458	—
		(0.312)	
CBI lvaw (home)	—	-0.094	—
		(0.368)	
inflation targeting (dest.)	—	—	-0.111
			(0.108)
inflation targeting (home)	—	—	0.124
			(0.113)
year fixed effect	YES	YES	YES
dest. and home country fixed effect	YES	YES	YES
observations	5,848	5,848	6,532
R-squared	0.923	0.923	0.919

***Notes*:** This table reports the results of the Poisson Pseudo-Maximum-Likelihood (PPML) estimation that includes additional variables capturing central bank characteristics Since PPML is the estimation method, the dependent variable, that is bilateral cross-border claims, is given in levels. The variable of our main interest is the central bank transparency index of Dincer and Eichengreen (2014) for the destination country. Additional variables we control for are the unweighted legal central bank independence index "CBI (lvau)", the weighted legal central bank independence index "CBI (lvaw)" and a dummy variable that captures whether a central bank is classified as an inflation targeter. Besides these variables, we include the same control variables as of Table 3 Equation IV (see also Table 1). The labels "(bilat.)", "(home)" and "(dest.)" behind the variable names denote whether a variable is a bilateral variable, refers to the home or the destination country, respectively. All regressions take home and destination country fixed effects as well as year fixed effects into account. Standard errors are clustered by bilateral relationship and are depicted in parentheses. ***, **, and * denote the 1%, 5% and 10% level of significance, respectively.

Table 7: Robustness Institutional Quality

	I	II	III	IV	V	VI
central bank transparency (dest.)	0.076***	0.059**	0.069***	0.063***	0.055**	0.063**
	(0.024)	(0.026)	(0.024)	(0.024)	(0.023)	(0.026)
central bank transparency (home)	0.015	0.032	0.044**	0.012	0.058**	0.004
	(0.022)	(0.023)	(0.022)	(0.022)	(0.023)	(0.022)
...						
controls included	YES	YES	YES	YES	YES	YES
...						
voice & accountability (dest.)	0.435**	__	__	__	__	__
	(0.195)					
voice & accountability (home.)	0.414**	__	__	__	__	__
	(0.190)					
regulatory quality (dest.)	__	0.216**	__	__	__	__
		(0.105)				
regulatory quality (home)	__	-0.433***	__	__	__	__
		(0.135)				
government effectiveness (dest.)	__	__	-0.168*	__	__	__
			(0.091)			
government effectiveness (home)	__	__	-0.519***	__	__	__
			(0.110)			
rule of law (dest.)	__	__	__	0.178	__	__
				(0.153)		
rule of law (home)	__	__	__	0.278	__	__
				(0.193)		
control of corruption (dest.)	__	__	__	__	0.194**	__
					(0.083)	
control of corruption (home)	__	__	__	__	-0.388***	__
					(0.117)	
political stability & no violence (dest.)	__	__	__	__	__	0.014
						(0.072)
political stability & no violence (home)	__	__	__	__	__	0.213**
						(0.087)
year fixed effects	YES	YES	YES	YES	YES	YES
dest. and home country fixed effects	YES	YES	YES	YES	YES	YES
observations	6,532	6,532	6,532	6,532	6,532	6,532
R-squared	0.920	0.921	0.921	0.918	0.920	0.919

Notes: This table reports the results of the Poisson Pseudo-Maximum-Likelihood (PPML) estimation with additional variables controlling for institutional quality. For this purpose we employ the World Governance Indicators. Since PPML is the estimation method, the dependent variable, that is bilateral cross-border claims, is given in levels. The variable of our main interest is the central bank transparency index of Dincer and Eichengreen (2014) for the destination country. As explanatory variables we include the same variables as in Table 3 Equation IV (see also Table 1). The labels "(bilat.)", "(home)" and "(dest.)" behind the variable names denote whether a variable is a bilateral variable, refers to the home or the destination country, respectively. All regressions take home and destination country fixed effects as well as year fixed effects into account. Standard errors are clustered by bilateral relationship and are depicted in parentheses. ***, **, and * denote the 1%, 5% and 10% level of significance, respectively.

Table 8: Robustness Financial Market Characteristics

	I	II	III	IV	V
central bank transparency (dest.)	0.064***	0.068***	0.066***	0.069***	0.100***
	(0.024)	(0.023)	(0.025)	(0.023)	(0.027)
central bank transparency (home)	0.018	0.040*	0.015	0.015	-0.029
	(0.023)	(0.023)	(0.022)	(0.022)	(0.028)
...					
controls included	YES	YES	YES	YES	YES
...					
financial integration (dest.)	0.000	__	__	__	__
	(0.000)				
financial integration (home.)	0.000	__	__	__	__
	(0.000)				
private credit to GDP (dest.)	__	0.005	__	__	__
		(0.005)			
private credit to GDP (home)	__	0.008*	__	__	__
		(0.004)			
bank concentration (dest.)	__	__	-0.000	__	__
			(0.001)		
bank concentration (home)	__	__	0.000	__	__
			(0.002)		
z-score (dest.)	__	__	__	-0.001	__
				(0.003)	
z-score (home)	__	__	__	-0.004	__
				(0.004)	
bank capital to asset ratio (dest.)	__	__	__	__	-0.021
					(0.015)
bank capital to asset ratio (home)	__	__	__	__	-0.011
					(0.026)
year fixed effects	YES	YES	YES	YES	YES
dest. and home country fixed effects	YES	YES	YES	YES	YES
observations	6,532	6,532	6,288	6,390	4,659
R-squared	0.919	0.918	0.921	0.919	0.918

***Notes*:** This table reports the results of the Poisson Pseudo-Maximum-Likelihood (PPML) estimation including additional variables to control for financial market characteristics. For this purpose we include a variable "financial integration", which is the share of the sum of foreign assets and foreign liabilities to GDP, the share of private credit to GDP as a measure for the depth of financial institutions, a variable capturing the concentration of the banking sector, which is the share of the sum of the assets of the three largest banks to the assets of all commercial banks. We also control for the stability of the financial sector by including the z-score and the bank capital to asset ratio. Other control variables are given in Table 3 Equation IV (see also Table 1). Since PPML is the estimation method, the dependent variable, that is bilateral cross-border claims, is given in levels. The variable of our main interest is the central bank transparency index of Dincer and Eichengreen (2014) for the destination country. The labels "(bilat.)", "(home)" and "(dest.)" behind the variable names denote whether a variable is a bilateral variable, refers to the home or the destination country, respectively. All regressions take home and destination country fixed effects as well as year fixed effects into account. Standard errors are clustered by bilateral relationship and are depicted in parentheses. ***, **, and * denote the 1%, 5% and 10% level of significance, respectively.

Table 9: Robustness Regulatory Arbitrage

	I	II	III	IV	V	VI	VII
central bank transparency (dest.)	0.079***	0.077***	0.066***	0.069***	0.060***	0.107***	0.073***
	(0.025)	(0.024)	(0.024)	(0.024)	(0.023)	(0.026)	(0.024)
central bank transparency (home)	0.005	0.009	0.008	0.011	0.015	0.074**	0.013
	(0.022)	(0.022)	(0.022)	(0.022)	(0.023)	(0.033)	(0.023)
...							
controls included	YES	YES	YES	YES	YES	YES	YES
...							
overall capital stringency index (bilat.)	-0.020**	—	—	—	—	—	—
	(0.008)						
capital regulatory index (bilat.)	—	-0.016**	—	—	—	—	—
		(0.006)					
private monitoring index (bilat.)	—	—	0.012	—	—	—	—
			(0.011)				
independence of supervisory authority-bank (bilat.)	—	—	—	-0.033	—	—	—
				(0.037)			
official supervisory power (bilat.)	—	—	—	—	0.010	—	—
					(0.007)		
independence of supervisory authority-overall (bilat.)	—	—	—	—	—	-0.057*	—
						(0.034)	
overall restrictions on banking activities (bilat.)	—	—	—	—	—	—	-0.023**
							(0.011)
year fixed effects	YES	YES	YES	YES	YES	YES	YES
dest. and home country fixed effects	YES	YES	YES	YES	YES	YES	YES
observations	6,154	5,959	5,724	6,086	6,403	4,337	5,983
R-squared	0.920	0.920	0.920	0.919	0.919	0.927	0.920

***Notes*:** This table reports the results of the Poisson Pseudo-Maximum-Likelihood (PPML) estimation that includes differences between the stringency of banking regulations. For this purpose we employ the most relevant indices from the Barth et al. (2006) updated database. As these indices are only available for the survey waves 1999, 2003, 2007 and 2011, we interpolate the dataset as described in the data section. The variables are expressed as the bilateral difference between the destination and the home country in order to capture regulatory arbitrage. Since PPML is the estimation method, the dependent variable, that is bilateral cross-border claims, is given in levels. The variable of our main interest is the central bank transparency index of Dincer and Eichengreen (2014) for the destination country. The other control variables employed are given in Table 3 Equation IV (see also Table 1). The labels "(bilat.)", "(home)" and "(dest.)" behind the variable names denote whether a variable is a bilateral variable, refers to the home or the destination country, respectively. All regressions take home and destination country fixed effects as well as year fixed effects into account. Standard errors are clustered by bilateral relationship and are depicted in parentheses. ***, **, and * denote the 1%, 5% and 10% level of significance, respectively.

Table 10: Central Bank Independence and Central Bank Transparency

	I	II	III
CBT (dest.)	-0.039	-0.066	0.125***
	(0.077)	(0.076)	(0.047)
CBT (home)	0.020	0.021	0.015
	(0.024)	(0.023)	(0.022)
...			
controls included	YES	YES	YES
...			
legal CBI (lvau) (dest.)	-1.836**	__	__
	(0.910)		
legal CBI (lvaw) (dest.)	__	-2.182**	__
		(0.931)	
CBT (dest.) x legal CBI (lvau) (dest.)	0.173*	__	__
	(0.103)		
CBT (dest.) x legal CBI (lvaw) (dest.)	__	0.218**	__
		(0.103)	
CBT (dest.) x de facto CBI (dest.)	__	__	-0.005
			(0.003)
year fixed effects	YES	YES	YES
dest. and home country fixed effects	YES	YES	YES
observations	5,848	5,848	6,532
R-squared	0.923	0.923	0.919

***Notes*:** This table reports the results of the Poisson Pseudo-Maximum-Likelihood estimation (PPML) of a multiplicative interaction model in order to capture a non-linear effect of central bank transparency conditional to the political independence of the central bank. For this purpose we estimate three different specification. In the first specification we employ the unweighted legal central bank independence measure as our conditional variable (lvau). In the second we interact the central bank transparency measure with the weighted legal central bank independence measure (lvaw) and for the third specification central bank transparency is interacted with the irregular central bank turnover ratio as a measure for de facto independence. Since PPML is the estimation method, the dependent variable, that is bilateral cross-border claims, is given in levels. The variable of our main interest that is the central bank transparency index of Dincer and Eichengreen (2014) for the destination country is denoted as "CBT". We employ the same control variables as in Table 3 Equation IV. The labels "(bilat.)", "(home)" and "(dest.)" behind the variable names denote whether a variable is a bilateral variable, refers to the home or the destination country, respectively. All regressions take home and destination country fixed effects as well as year fixed effects into account. Standard errors are clustered by bilateral relationship and are depicted in parenthesis. ***, **, and * denote the 1%, 5% and 10% level of significance, respectively.

Table 11: Central Bank Transparency Dimensions

	I	II	III	IV	V
political central bank transparency (dest.)	0.315**	__	__	__	__
	(0.156)				
political central bank transparency (home)	-0.130	__	__	__	__
	(0.111)				
economic central bank transparency (dest.)	__	0.130***	__	__	__
		(0.045)			
economic central bank transpareny (home)	__	-0.101***	__	__	__
		(0.038)			
procedural central bank transparency (dest.)	__	__	0.033	__	__
			(0.073)		
procedural central bank transparency (home)	__	__	0.167***	__	__
			(0.052)		
policy central bank transparency (dest.)	__	__	__	0.088	__
				(0.076)	
policy central bank transparency (home)	__	__	__	0.337***	__
				(0.106)	
operational central bank transparency (dest.)	__	__	__	__	-0.137
					(0.084)
operational central bank transparency (home)	__	__	__	__	0.008
					(0.087)
...					
controls included	YES	YES	YES	YES	YES
...					
year fixed effects	YES	YES	YES	YES	YES
dest. and home country fixed effects	YES	YES	YES	YES	YES
observations	6,532	6,532	6,532	6,532	6,532
R-squared	0.919	0.918	0.920	0.918	0.918

***Notes*:** This table reports the results of the Poisson Pseudo-Maximum-Likelihood (PPML) estimation for the decomposition of the central bank transparency index in its individual dimensions. Since PPML is the estimation method, the dependent variable, that is bilateral cross-border claims, is given in levels. The variables of our main interest are the sub-categories (political, economic, procedural, policy and operational) of the central bank transparency index of Dincer and Eichengreen (2014). The explanatory variables include the standard gravity variables as well as variables capturing the size of the banking system, the capital openness of the country and the debt of the government as a share to GDP. This regression also includes different variables capturing economic volatility. The labels "(bilat.)", "(home)" and "(dest.)" behind the variable names denote whether a variable is a bilateral variable, refers to the home or the destination country, respectively. The sample contains 21 home and 47 destination countries over the time period 1998-2010 and is held constant over all four specifications. All regressions take home and destination country fixed effects as well as year fixed effects into account. Standard errors are clustered by bilateral relationship and are depicted in parentheses. ***, **, and * denote the 1%, 5% and 10% level of significance, respectively.

Table 12: Legal Independence and Central Bank Transparency Dimensions

	I	II	III	IV	V
political CBT (dest.)	-0.090	—	—	—	—
	(0.268)				
economic CBT (dest.)	—	-0.074	—	—	—
		(0.160)			
procedural CBT (dest.)	—	—	-0.317	—	—
			(0.220)		
policy CBT (dest.)	—	—	—	-0.217	—
				(0.248)	
operational CBT (dest.)	—	—	—	—	0.160
					(0.241)
...					
controls included	YES	YES	YES	YES	YES
...					
political CBT (dest.) x legal CBI (dest.)	0.823*	—	—	—	—
	(0.468)				
economic CBT (dest.) x legal CBI (dest.)	—	0.323	—	—	—
		(0.197)			
procedural CBT (dest.) x legal CBI (dest.)	—	—	0.626*	—	—
			(0.330)		
policy CBT (dest.) x legal CBI (dest.)	—	—	—	0.534	—
				(0.338)	
operational CBT (dest.) x legal CBI (dest.)	—	—	—	—	-0.527
					(0.360)
year fixed effects	YES	YES	YES	YES	YES
dest. and home fixed effects	YES	YES	YES	YES	YES
observations	5,848	5,848	5,848	5,848	5,848
R-squared	0.923	0.922	0.924	0.922	0.922

***Notes*:** This table reports the results of the Poisson Pseudo-Maximum-Likelihood (PPML) estimation of an multiplicative interaction model. In this estimation the effect of different central bank transparency dimensions conditional to legal central bank independence (lvaw) on cross-border claims is estimated. Since PPML is the estimation method, the dependent variable, that is bilateral cross-border claims, is given in levels. The variable of our main interest that is the central bank transparency index of Dincer and Eichengreen (2014) for the destination country is denoted as "CBT". The control variables in this regression are the same as in Table 3 Equation IV. The labels "(bilat.)", "(home)" and "(dest.)" behind the variable names denote whether a variable is a bilateral variable, refers to the home or the destination country, respectively. All regressions take home and destination country fixed effects as well as year fixed effects into account. Standard errors are clustered by bilateral relationship and are depicted in parentheses. ***, **, and * denote the 1%, 5% and 10% level of significance, respectively.

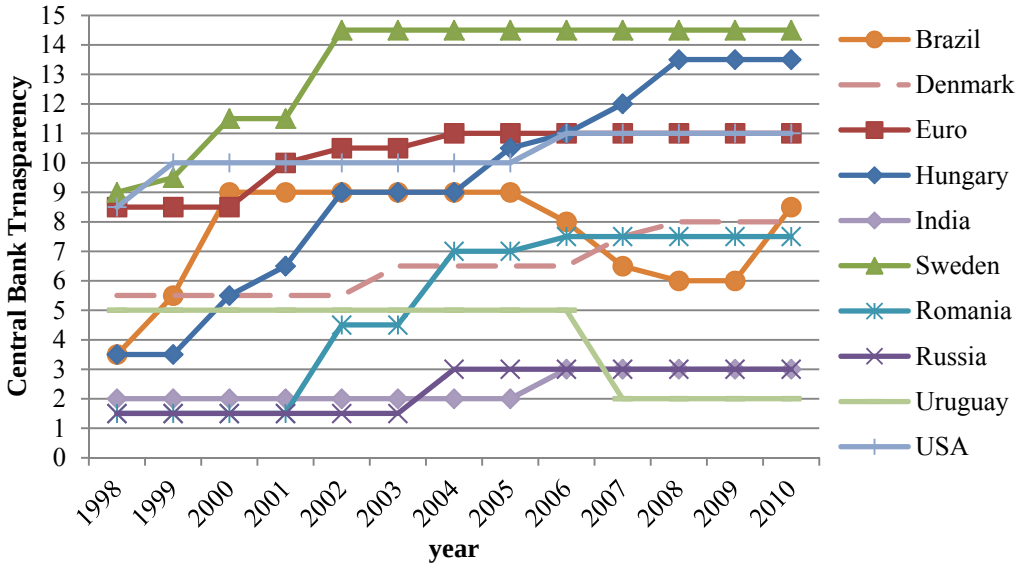
Table 13: Central bank transparency dimensions - summary of results

CBT dimension	baseline specification		interaction model	
	standardized average marginal effect	statistical significance	critical value of CBI	max. total standardized marginal effect
political	0.049	YES	0.514	0.107
economic	0.064	YES	0.588	0.113
procedural	0.010	NO	0.728	0.078
policy	0.026	NO	0.713	0.084
operational	-0.033	NO	0.603	-0.080

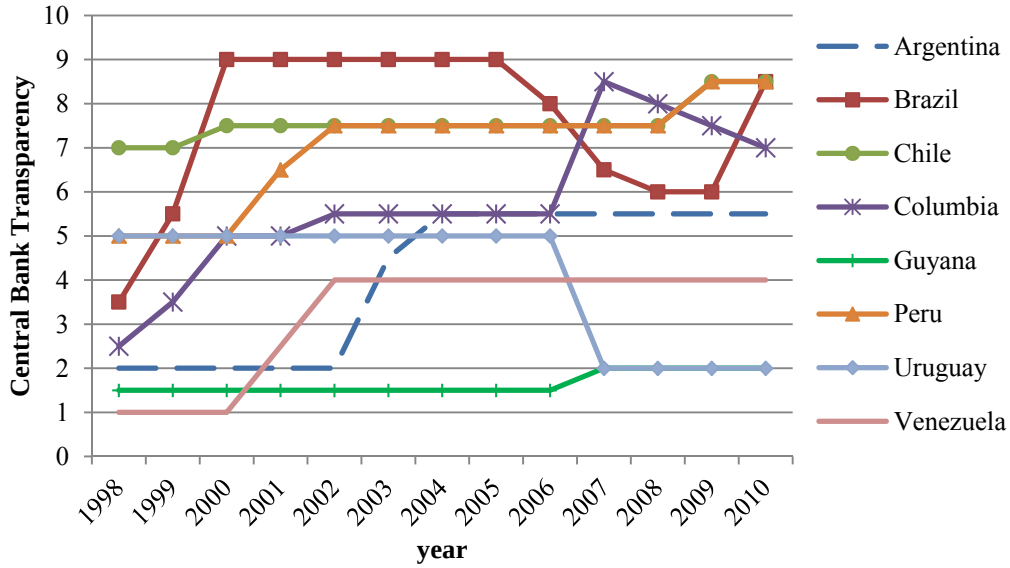
Notes: This table summarizes the obtained results from our analysis of the effect of different central bank transparency dimensions on cross-border claims. For the baseline specification, we depict the standardized average marginal effect as well as the statistical significance of this effect. Standardization refers to the increase of one within standard deviation of the corresponding central bank transparency dimension. In case of our interaction model analysis, we show the critical value of the legal (lvaw) central bank independence index for which the total marginal effect turns significant at the 5 percent level. In addition, we also depict the maximum standardized marginal effect in the last column.

Figure 1: The Evolution of Central Bank Transparency

(a) For Selected Central Banks

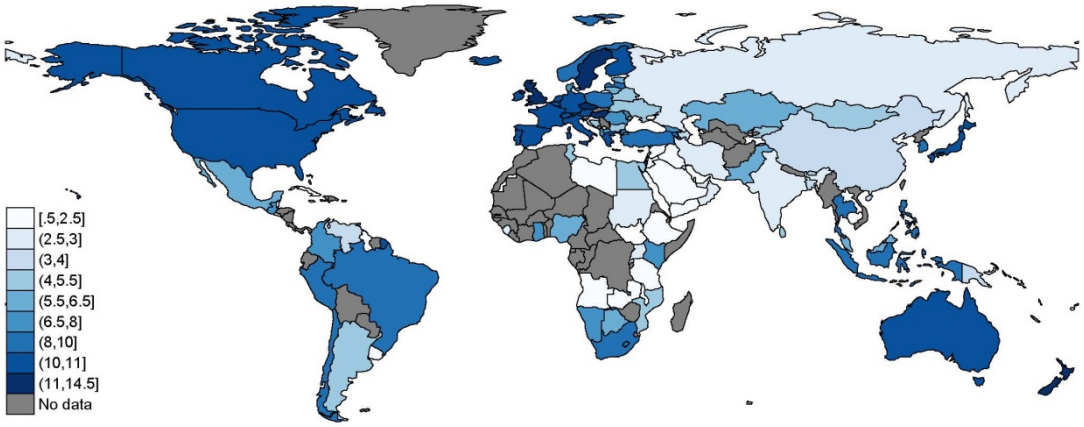


(b) For Latin American Central Banks



***Notes*:** This figure depicts the evolution of the central bank transparency index of Dincer/Eichengreen (2014) for selected central banks (Panel (a)) and for Latin American central banks (Panel (b)) from 1998 to 2010. This index is defined on a scale from 0 to 15, where higher values indicated a higher level of transparency. The purpose of this figure is to demonstrate the diversity of this index across central banks and time also within a specific geographic region.

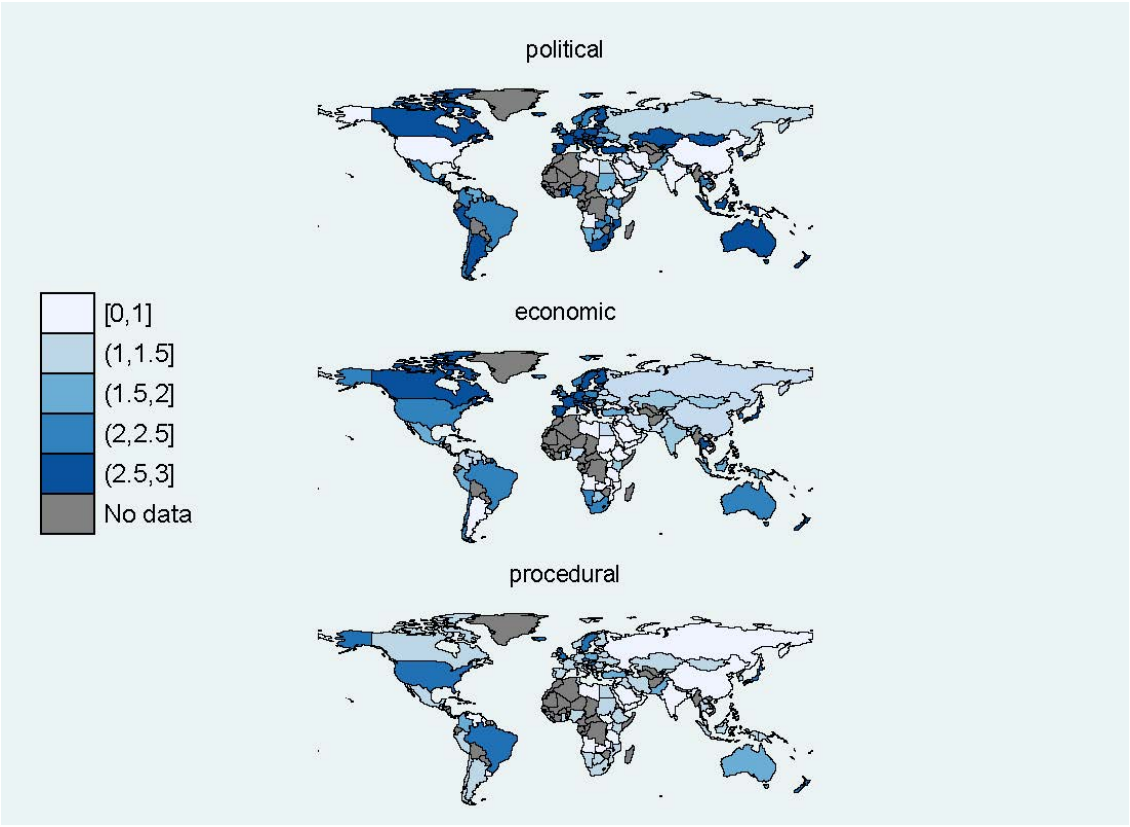
Figure 2: Central Bank Transparency across the World in 2010



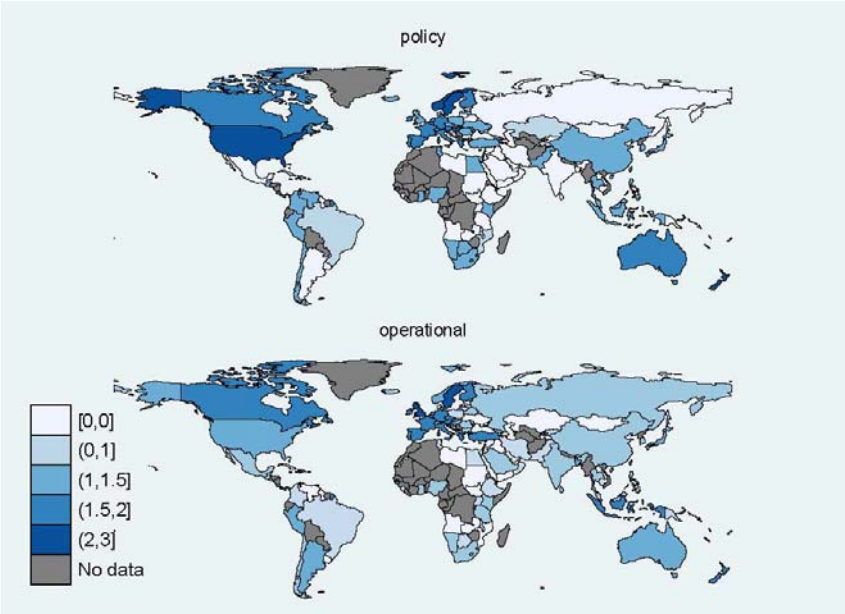
***Notes*:** This figure is an illustration of how central bank transparency differs according to the Dincer and Eichengreen (2014) index around the world in 2010 and further demonstrates the extensive coverage of this index. This index is defined on a scale from 0 to 15, where higher values indicated a higher level of transparency. In this graph a darker color shade depicts higher levels of central bank transparency. The grey shaded areas indicate those countries where no data is available.

Figure 3: Central Bank Transparency Dimensions across the World in 2010

(a) Political, Economic and Procedural Central Bank Transparency

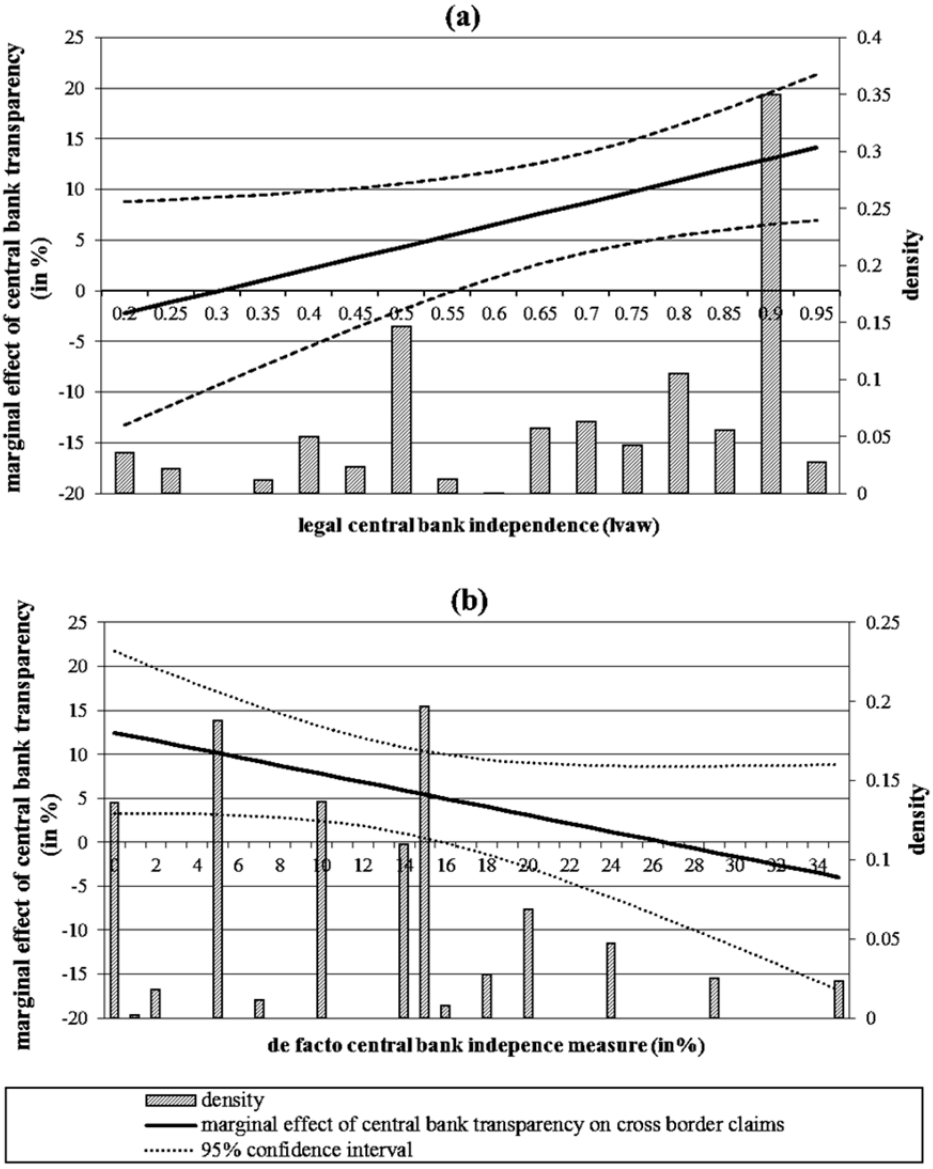


(b) Policy and Operational Central Bank Transparency



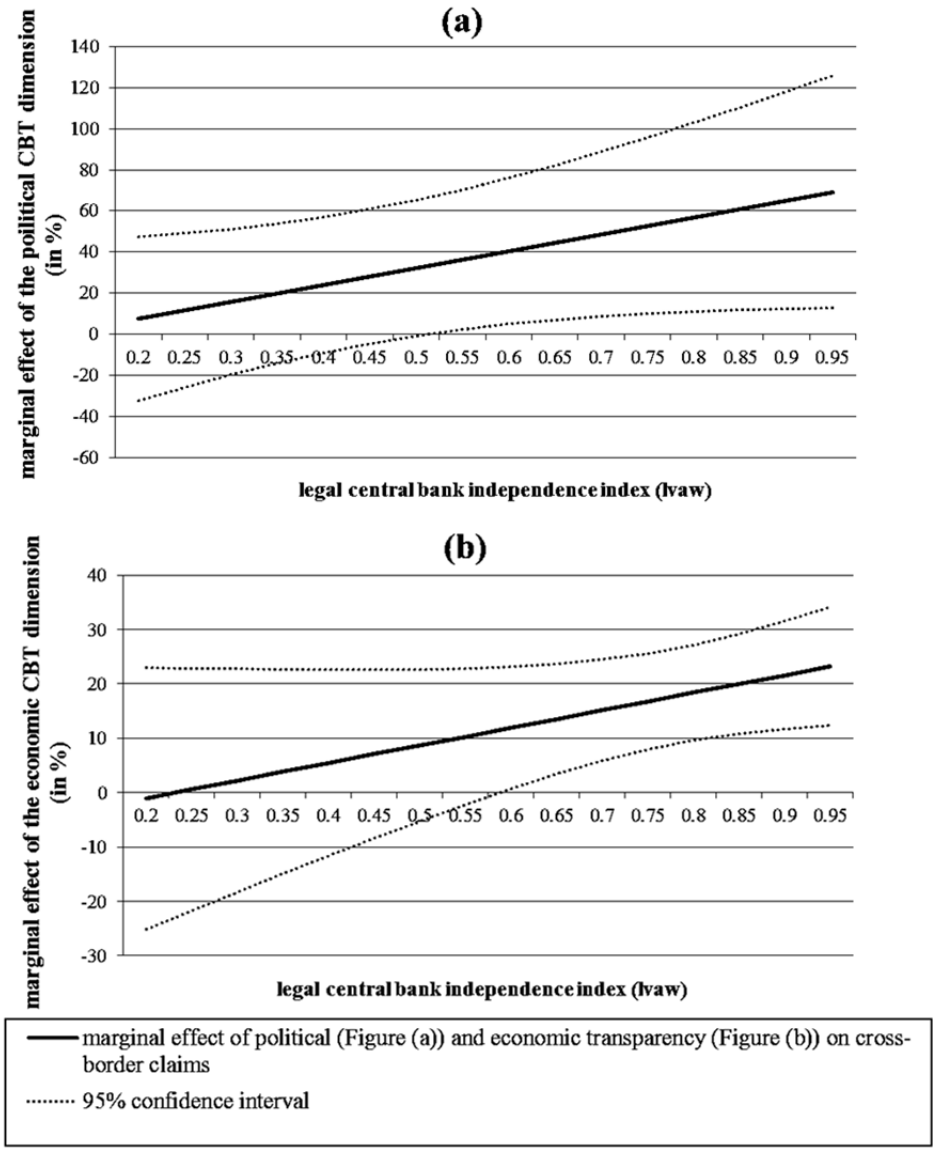
Notes: This figure displays the political, economic and procedural dimensions (Panel (a)) and the policy and operational dimensions (Panel (b)) of the central bank transparency index of Dincer and Eichengreen (2014). The dimensions of this index are constructed in accordance to the taxonomy of Geraats (2002). Each dimension is defined on a scale from 1 to 3, where higher values indicate a greater level of transparency. The grey shaded areas indicate those countries where no data is available.

Figure 4: Marginal Effect of Central Bank Transparency on Cross-Border Claims Conditional on Central Bank Independence



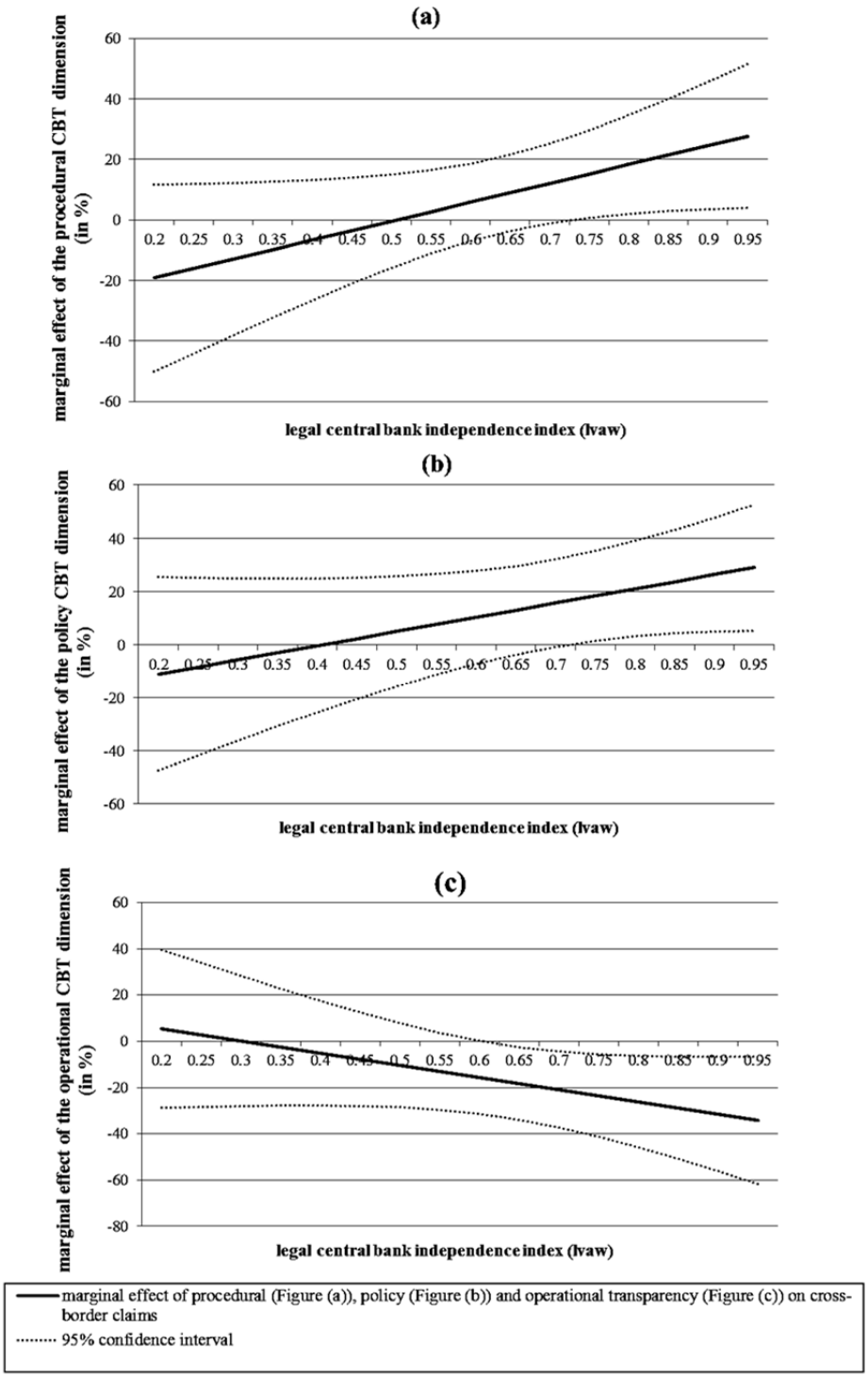
***Notes*:** Figure 4 displays the marginal effect of central bank transparency on cross-border claims conditional on political central bank independence. While Panel (a) depicts this effect conditional on the legal index of central bank independence index (lvaw), Panel (b) shows this marginal effect conditional on the de facto central bank independence (in %). The indices employed are defined in the following way: The central bank transparency index is defined on a scale from 0 to 15, the legal central bank independence index is defined on a continuous scale between 0 and 1, and the de facto measure is expressed in percentage terms from 0 to 100 percent. Higher values for the central bank transparency index as well as for the legal central bank independence index indicate a greater level of transparency or independence. As the de facto central bank independence index is measured by the irregular central bank governor turnover ratio multiplied by 100, a lower value indicates higher central bank independence. While the values on the horizontal axis depict the values of the legal index (Panel (a)) or the de facto measure (Panel (b)), the vertical axis on the left-hand side depicts the corresponding value of the marginal effect of a one unit increase in the central bank transparency index on cross-border bank claims conditional on a value of the central bank independence. The solid line represents the total marginal effect and the dashed lines constitute the corresponding 95 percent confidence interval. The vertical bars reflect the distribution of the modifying variable, the legal central bank independence index.

Figure 5: Marginal Effect of Political and Economic Central Bank Transparency on Cross-Border Claims Conditional on Legal Central Bank Independence



Notes: Figure 5 displays the marginal effect of the political and the economic central bank transparency dimension on cross-border claims conditional on the legal central bank independence index. The political (Panel (a)) and the economic (Panel (b)) central bank transparency dimension are defined on a scale from 0 to 3. The legal central bank independence index is defined on a continuous scale between 0 and 1. Higher values indicate a greater level of transparency and independence. The values on the horizontal axis depict the values of the legal index of central bank independence, the vertical axis depicts the corresponding value of the marginal effect of a one unit increase in the political (Panel (a)) or economic (Panel (b)) central bank transparency dimension conditional on a value of the legal central bank independence index. The solid line represents the total marginal effect and the dashed lines constitute the corresponding 95 percent confidence interval.

Figure 6: Marginal Effect of Procedural, Policy and Operational Central Bank Transparency on Cross-Border Claims Conditional on Legal Central Bank Independence



Notes: Figure 6 displays the marginal effect of the procedural, policy and operational central bank transparency dimension on cross-border claims conditional on the legal central bank independence index. All three transparency dimensions are defined on a scale from 0 to 3. The legal central bank independence index is defined on a continuous scale from 0 to 1. Higher values indicate a greater level of transparency or independence. The horizontal axis depicts the legal index of central bank independence. The vertical axis depicts the value of the marginal effect of a one unit increase in the economic central bank transparency dimension conditional on a value of the legal central bank independence index. The solid line represents the total marginal effect and the dashed lines constitute the corresponding 95 percent confidence interval.

Appendix

Appendix A1: Countries Included in the Baseline Estimation

home countries	Austria, Brazil, Canada, Chile, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Mexico, Netherlands, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States
destination countries	Austria, Bulgaria, Bahrain, Brazil, Canada, Chile, China, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong, Hungary, Indonesia, Ireland, Israel, Italy, Japan, Korea, Kuwait, Lithuania, Malta, Mexico, Nigeria, Netherlands, Norway, Peru, Philippines, Poland Portugal, Qatar, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Thailand, Turkey, United Kingdom, United States, South Africa

Appendix A2: PPML and Parameter Interpretation

Estimation equation of the gravity model:

(1) $y_i = exp(x_i \cdot \beta) + \varepsilon_i$ (see: Santos Silva and Tenreyro (2006) Equation (6))

PPML estimates Equation (1) directly. It is important to note that y_i always enters Equation (1) in levels. To show that the parameter β can be interpreted as an elasticity in the case where x_i enters Equation (1) as a logarithmic transformation, we start by calculating the marginal effect and then express this effect as an elasticity.

(2) $y_i = exp(\beta_0 + \beta_1 \cdot ln(x_i)) + \varepsilon_i$

(3) $$\frac{\delta y_i}{\delta x_i} = \left(\frac{\beta_1}{x_i}\right) \cdot exp(...)$$

The elasticity is defined as the relative change in y_i, given a relative change in x_i, which is defined as:

(4) $$\Theta_{\delta y / \delta x} = \frac{\frac{\delta y_i}{y_i}}{\frac{\delta x_i}{x_i}} = \frac{\delta y_i}{\delta x_i} \cdot \frac{x_i}{y_i}$$

Hence, one simply has to apply Equation (4) on (3). So after extending Equation (3) as an elasticity one obtains:

(5) $$\Theta_{\delta y / \delta x} = \frac{\delta y_i}{\delta x_i} \cdot \frac{x_i}{y_i} = \frac{\left(\frac{\beta_1}{x_i}\right) \cdot exp(...) \cdot x_i}{exp(...)} = \beta_1$$

Hence, we have demonstrated that β_1 can be interpreted as an elasticity if x_i enters Equation (1) as a logarithmic transformation.

Following the same procedure as above, one can show that if x_i enters Equation (1) in levels the obtained parameter will equal the marginal effect expressed as a semi-elasticity.

(6) $y_i = exp(\beta_0 + \beta_1 \cdot x_i) + \varepsilon_i$

(7) $$\frac{\delta y_i}{\delta x_i} = (\beta_1) \cdot exp(...)$$

Semi-elasticities are defined as:

(8) $$\Phi_{\delta y / \delta x} = \frac{\frac{\delta y_i}{y_i}}{\delta x_i} = \frac{\delta y_i}{\delta x_i} \cdot \frac{1}{y_i}$$

Applying (8) on (7), we obtain the marginal effect expressed as a semi-elasticity:

(9) $$\Phi_{\delta y / \delta x} = \frac{\delta y_i}{\delta x_i} \cdot \frac{1}{y_i} = \frac{(\beta_1) \cdot exp(...)}{exp(...)} = \beta_1$$

Hence, we have demonstrated that β_1 can be interpreted as a semi-elasticity if x_i enters Equation (1) in levels.

Appendix A3: PPML and Interaction Models

Estimation equation of the gravity model:

(1) $y_i = exp(x_i \cdot \beta) + \varepsilon_i$ (see: Santos Silva and Tenreyro (2006) Equation (6))

Using OLS estimation method the model can be linearized by log-linearization, however, as Santos Silva and Tenreyro (2006) point out, this comes at the cost of biased parameter values in the case of heteroscedasticity of the error term. Instead of taking the logarithms, PPML estimates Equation (1) directly. In order to obtain the elasticities and/or semi-elasticities y_i has to be in levels while x_i is in logarithms if elasticities want to be obtained or also in levels in the case of semi-elasticities. Why this has to be the case one can easily see by calculating the first derivative of (1) and then express this marginal effect as an elasticity/semi-elasticity.
In the following, we will do the same for an multiplicative interaction model. This shows that the equations of the marginal effect in the case for OLS (see Brambor et al. 2006) are valid also in the case of PPML.

First consider the case of elasticities:

(2) $$y_i = exp(\beta_0 + \beta_1 \cdot ln(x_i) + \beta_2 \cdot z_i + \beta_3 \cdot ln(x_i) * z_i) + \varepsilon_i$$
(Equation (2) is expressed in linear terms)

Using Equation (2), one can calculate the elasticity of the change in x_i conditional to z_i.

(3) $$\frac{\delta y_i}{\delta x_i} = \left(\frac{\beta_1}{x_i} + \frac{\beta_3}{x_i} \cdot z_i \right) \cdot exp(...)$$

Equation (3) represents the marginal effect of a change in x_i on y_i. Since both variables are in levels this is only the marginal effect. One can also easily see why a non-linear estimation technique like PPML is needed in order to estimated this non-linear marginal effect. However, this is only the marginal effect that is not expressed as an elasticity. The elasticity is defined as the relative change in y_i, given a relative change in x_i, which is defined as:

$$\Theta_{\delta y/\delta x} = \frac{\frac{\delta y_i}{y_i}}{\frac{\delta x_i}{x_i}} = \frac{\delta y_i}{\delta x_i} \cdot \frac{x_i}{y_i} \tag{4}$$

Hence, one simply has to employ Equation (4) on (3). So after extending Equation (3) as an elasticity one obtains:

$$\Theta_{\delta y/\delta x} = \frac{\delta y_i}{\delta x_i} \cdot \frac{x_i}{y_i} = \frac{\left(\frac{\beta_1}{x_i} + \frac{\beta_3}{x_i} \cdot z_i\right) \cdot exp(...) \cdot x_i}{exp(...)} = \beta_1 + \beta_3 \cdot z_i \tag{5}$$

The corresponding standard error of this elasticity is then given by (6):

$$\sigma_\Theta = \sqrt{Var\left(\hat{\beta}_1\right) + z_i^2 \cdot Var\left(\hat{\beta}_3\right) + 2 \cdot z_i \cdot Cov\left(\hat{\beta}_1 \hat{\beta}_3\right)} \tag{6}$$

Turning to the second case, semi-elasticities:

$$y_i = exp(\beta_0 + \beta_1 \cdot x_i + \beta_2 \cdot z_i + \beta_3 \cdot x_i * z_i) + \varepsilon_i \tag{7}$$

This is the estimation equation in the case of semi-elasticities. Hence, x_i enters in levels and not in the logarithmic form.

Analogous to Equation (2) the marginal effect is given by:

$$\frac{\delta y_i}{\delta x_i} = (\beta_1 + \beta_3 z_i) \cdot exp(...) \tag{8}$$

Semi-elasticities are defined as:

$$\Phi_{\delta y/\delta x} = \frac{\frac{\delta y_i}{y_i}}{\frac{\delta x_i}{}} = \frac{\delta y_i}{\delta x_i} \cdot \frac{1}{y_i} \tag{9}$$

And we can simply obtain the semi-elasticity for (8):

$$\Phi_{\delta y/\delta x} = \frac{\delta y_i}{\delta x_i} \cdot \frac{1}{y_i} = \frac{(\beta_1 + \beta_3 \cdot z_i) \cdot exp(...)}{exp(...)} = \beta_1 + \beta_3 \cdot z_i \tag{10}$$

And the corresponding standard error:

(11) $$\sigma_{\Phi} = \sqrt{Var\left(\hat{\beta}_1\right) + z_i^2 \cdot Var\left(\hat{\beta}_3\right) + 2 \cdot z_i \cdot Cov\left(\hat{\beta}_1 \hat{\beta}_3\right)}$$

This equals the computation of the marginal effect for OLS (Brambor et al. (2006) Equation (8)).

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