International bank portfolios: short- and long-run responses to the business cycle[*]

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Abstract

International bank portfolios constitute a large component of international country portfolios. Yet, their response to macroeconomic conditions and their impact on the international transmission of business cycle developments remain largely unexplored. We use a novel dataset on banks' international portfolios to answer three questions. First, what are the long-run determinants of banks' international portfolios? Second, how do banks' international portfolios adjust to short-run macroeconomic developments? Third, does the speed of adjustment change with the degree of financial integration? We provide evidence of significant long-run cointegration relationships between cross-border assets and liabilities of banks and key macroeconomic variables. Both the long-run determinants of banks' international portfolios and the short-run dynamics show a significant degree of heterogeneity across countries and, to some extent, over time. Gravity-type variables help to explain differences in the speed of adjustment to new equilibria.

1. Motivation

International portfolios of commercial banks constitute a large component of international country portfolios.[1] International debt instruments amount to the equivalent of 200% of the GDP of industrialised and about 100% of the GDP of emerging markets and developing countries.[2] They are about four times the size of international equity holdings (Lane and Milesi-Ferretti (2006) and Sørensen et al (2006)). In recent years, the share of bank assets

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[1] In the following, we use the term (international) 'bank portfolios' to denote the cross-border assets and liabilities of commercial banks. The term 'country portfolios' denotes the international investment position of countries. In addition to bank portfolios, it comprises international portfolio investments (debt and equity) and stocks of foreign direct investment.

[2] 'Debt instruments' denotes the sum of assets and liabilities.

and money market flows in gross international capital movements has even increased (Becker and Clifton (2006)).

International debt flows are not only important quantitatively, they also have a higher standard deviation than other capital flows (Kose et al (2006)). This may explain the conventional wisdom that high debt flows expose countries to risks from financial openness. The risk of international debt flows is less evident, however, when considering that international debt holdings contribute to income smoothing across countries (Sørensen et al (2006)). Also, when scaling the standard deviation of capital flows by the respective means, debt flows are not really distinguishable from other types of capital flows (Kose et al (2006)).

In this paper, we look at the role of banks' international portfolios for the exposure of countries to macroeconomic developments from a different angle. We ask whether and how quickly international portfolios of commercial banks react to macroeconomic developments at home and abroad. We depart from earlier work in two main regards. First, we analyse the short-run *and* the long-run determinants of banks' international asset portfolios in an integrated empirical model. Second, we use information on bilateral bank portfolios of OECD countries. Using bilateral quarterly data, we can provide more precise measures of domestic and foreign macroeconomic developments than previous studies. We focus on banking data because comparable evidence at the bilateral level is not available for other asset holdings.[3] In studying the determinants of bilateral cross-border bank portfolios, we provide answers to the following questions:

First, what are the long-run determinants of banks' international portfolios? In finding the determinants of the stocks of banks' cross-border assets and liabilities, earlier literature has been fairly successful. Buch (2003), for instance, studies bilateral cross-border asset holdings of banks that report to the Bank for International Settlements (BIS). She finds that, apart from market size, regulations and information costs affect the patterns of cross-border asset holdings. Buch, Driscoll, and Ostergaard (2005) explain the deviation of banks' portfolios from an optimal mean-variance portfolio. Similarly, gravity-type models perform quite well in explaining cross-border portfolio holdings (see, e.g., IMF (2006)). However, these papers do not study the dynamic adjustments of banks to changes in macroeconomic conditions.

Second, what shapes the short-term dynamics of banks' international portfolios? The response of bilateral bank lending to cyclical factors has been studied less frequently and only for selected countries and time periods. Goldberg (2005) uses bank-level data for US banks. Buch, Carstensen, and Schertler (2005) use a dataset similar to ours but focus on a shorter time period. These studies show that explaining cross-border capital flows is much more difficult than explaining stocks of cross-border assets and liabilities.[4] Although standard proxies for business cycle developments such as interest rates and GDP growth rates do have a significant impact on banks' international activities, the impact of these variables is not very stable over time and across countries. Moreover, the explanatory power of these regressions is low.

Third, what is the impact of financial integration on the speed of adjustment of banks' international portfolios? Instead of estimating the short- and long-run determinants of banks' portfolios separately, we use a panel cointegration model that allows us to estimate different

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[3] An exception is the IMF's International Portfolio Investment Survey. However, these data are available only for selected years and not on a quarterly basis. See, for instance, DeSantis and Gérard (2006) for a recent study using these data.

[4] A related strand of the literature studies the transmission of shocks during financial crises through the international activities of banks. See, e.g., Weder and Van Rijckeghem (2003) or Peek and Rosengren (1997). Jeanneau and Micu (2001) use BIS data to study the determinants of bank assets in emerging markets.

short-run dynamics across countries while restricting the long-run cointegration vector to be identical across host countries. The loading matrix, which provides information on the speed of adjustment to a new steady state,[5] is allowed to vary across reporting countries (Breitung (2005)). We expect that the speed of adjustment to short-run macroeconomic fluctuations is higher in more integrated financial markets. Since our estimates yield information on the speed of adjustment to a new equilibrium for different country pairs, we can analyse whether the dynamic responses of banks to macroeconomic developments differ across countries in a systematic way. Hence, in a last step, we use gravity-type regressors as well as information on the openness and structure of countries' financial system to explore systematic patterns in the speed of adjustment to new equilibria.

One special feature of our dataset is that we can analyse adjustment patterns inside and outside the Euro Area. We have data from reporting countries inside the Euro Area (Belgium, Germany, France, Italy, the Netherlands) and outside the Euro Area (Hong Kong SAR, Japan, Switzerland, United Kingdom, United States). As recipient countries, we use information on all OECD countries. Hence, we can study whether the degree of financial integration among the EU countries has an impact on the determinants of bank portfolios, and to what extent adjustment patterns are affected by exchange rate valuation effects. Using OECD countries only has the additional advantage that we exclude emerging markets which were directly affected by the financial crises of the late 1990s.

The data that we use for this paper are richer than data used in earlier studies for four reasons. First, we use data for banks from ten BIS reporting countries. In contrast to Goldberg (2005), we can study the impact of business cycle developments on cross-border portfolios of banks from more than one source country. Second, we use quarterly data for a 10-year period (1995-2005) to study the determinants of banks' portfolios for the pre- and the post-Euro period. Third, we study cross-border lending and borrowing instead of focusing on cross-border asset holdings only. And, fourth, in contrast to research based on the comprehensive datasets on country portfolios compiled by Lane and Milesi-Ferretti (2006), we have information on bilateral financial linkages.

In Section 2, we provide a brief theoretical background for our empirical analysis. In Section 3, we describe the data. In Section 4, we look at banks' international portfolios and other cross-border asset holdings to obtain an idea of how representative banks' portfolios are for total country portfolios. In Section 5, we analyse the long-run and short-run determinants of banks' cross-border activities using a panel cointegration framework. Section 6 concludes and summarises the main results. We provide evidence on significant long-run cointegration relationships between cross-border assets and liabilities of banks and key macroeconomic variables. Both the long-run determinants of banks' international portfolios and the short-run dynamics show heterogeneity across countries and, to some extent, over time. Gravity-type variables help to explain differences in the speed of adjustment to new equilibria across countries.

2. Theoretical background

Our aim in this paper is to analyse the response of banks' international portfolios to macroeconomic developments. In the theoretical literature, the patterns of international bank portfolios and the transmission of macroeconomic shocks across countries have largely been covered separately. Traditionally, open economy macroeconomic models do not assign an

5 Throughout the paper, we distinguish the speed of adjustment as captured by the loading coefficient from the short-run dynamics as captured by the impact of lagged variables on the change in bank portfolios.

explicit role to financial intermediation and to the composition of international country portfolios.

Recently, dynamic general equilibrium models of open economies have been set up to incorporate international portfolio choices. Evans and Hnatkovska (2005) and Tille (2005), for instance, model international equity and bond holdings within the framework of an open economy macroeconomic model, but both contributions abstract from banks. Ghironi, Lee, and Rebucci (2007) derive a portfolio structure assuming that perfectly competitive financial intermediaries charge (exogenously given) fees on financial market transactions.

Most of these models focus on the linkages between two countries rather than modelling bilateral linkages between a larger set of countries in the context of portfolio models. Portfolio models, in turn, often do not consider different types of macroeconomic shocks. Hence current theoretical models are not very well suited to explain the increasing share of bilateral 'diversification trade' in financial assets: "*At the moment, we have no integrative general-equilibrium monetary model of international portfolio choice, although we need one* (Obstfeld (2004), p 19).

In the remainder of this section, we review the basic adjustment mechanisms of international debt holdings in a simple partial equilibrium framework. We also sketch how banks could be integrated into such a model.

The standard two-country textbook model views changes in cross-border debt holdings of countries as the result of the intertemporal optimisation of households (Obstfeld and Rogoff 1996). Assume that consumers are endowed with output Y_1 in period one and Y_2 in period two. They allocate these endowments to achieve optimal consumption plans C_1 and C_2. Utility of households depends on each period's consumption level and is additively separable with regard to time $u = u(C_1, C_2) = u(C_1) + \beta u(C_2)$, with β as subjective time-preference factor.

Domestic households can raise their first-period consumption over and above first-period income if they borrow internationally: $C_1 = Y_1 - B_2$, where B_2 represents net foreign assets at the end of period one. In the second period, households have to repay their borrowings: $C_2 = Y_2 + (1+r)(Y_1 - C_1)$ where *r* denotes the world market interest rate. Even in this simple textbook model, the impact of changes in the world market interest rate on consumption and bond holdings is ambiguous. It depends on the relative strength of income, substitution, and wealth effects, reflecting the impact of an interest rate change on bond returns and lifetime income. This can be shown using an isoelastic utility function and solving the household's optimisation problem to obtain first and second period consumption:

$C_1 = \frac{1}{1 + (1+r)^{\sigma-1}\beta^{\sigma}}\left(Y_1 + \frac{Y_2}{1+r}\right)$ and $C_2 = (1+r)^{\sigma}\beta^{\sigma}C_1$, where σ denotes the coefficient of risk aversion. Hence, the impact of interest rates on consumption and the demand for bonds is ambiguous: $\frac{\partial C_1}{\partial r}, \frac{\partial B_2}{\partial r} \gtrless 0$.

In this two country setting, the equilibrium with non-zero net foreign assets, the implied international capital flows are one-directional: domestic households would borrow in the foreign economy, but there is no two-way asset trade between the home and the foreign economy.

In reality, households do not buy and sell foreign bonds directly. Instead, most of the international transactions of households are intermediated by commercial banks. Introducing banks into the above framework would necessitate adding a couple of features that characterise (international) banking markets. A full-fledged model of the international bank would, for instance, require modelling the maturity transformation function of banks, the principle-agent relationships between banks and their customers, or the principle-agent relationships between bank managers and owners. Yet, addressing these aspects is beyond the scope of this paper.

One simple way of linking the choice problem of households with the international portfolio choices of banks would be to assume that households do not invest directly in the foreign economy. Instead, they hold deposits with their local banks. Banks can additionally raise deposits abroad, and they lend to domestic and foreign customers. In deciding on their optimal asset choices, banks have to consider the intertemporal optimisation choices of households. As explained above, however, these would not give rise to two-way ‘diversification trades’ (Obstfeld (2004)).

Non-zero bilateral asset holdings could be introduced by assuming that banks themselves optimise their portfolios in a mean-variance framework. The objective function of the representative bank would be increasing in expected profits and decreasing in portfolio variance (see Freixas and Rochet (1998) for a closed-economy application). If domestic and foreign banks have – in principle – access to the same types of financial assets, it is reasonable to assume that the banks have different comparative advantages in serving domestic and foreign customers. More specifically, the costs of supplying financial services internationally are likely to be higher than in the national context. Under appropriate assumptions concerning the costs of cross-border financial transactions, domestic and foreign banks will then hold different portfolios of cross-border assets *and* liabilities.

These considerations have three main implications for our empirical work. First, the link between cross-border asset holdings and interest rates is ambiguous from a theoretical point of view. In the intertemporal optimisation decision of households, income and substitution effects work in two different directions. It is, ultimately an empirical question whether cross-border assets and liabilities increase or decrease in the rates of return. Second, adding portfolio considerations (of banks) gives a rationale for two-way ‘diversification trade’ in cross-border financial assets and liabilities. Third, market size has a positive impact on international portfolio holdings. In contrast, costs of cross-border financial transactions have a negative impact.

3. The data

Rather than testing a particular structural model, the aim of this paper is to provide evidence on the links between banks’ international portfolios and macroeconomic variables. In this section, we describe the data on banks’ international portfolios as well as the macroeconomic data that we use for our empirical analysis. Details are given in the Appendix.

3.1 Banks’ international portfolios

Our data on banks’ international portfolios come from the BIS. We have quarterly data for the years 1995-2005 on bilateral cross-border assets and liabilities for ten BIS reporting countries (Belgium, Germany, France, Hong Kong SAR, Italy, Japan, the Netherlands, Switzerland, United Kingdom, United States).[6] As recipient countries, we use all OECD countries. The data are aggregated across individual banks in each reporting country, but they are disaggregated by the country of destination.

6 For reasons of data confidentiality, we do not report descriptive statistics for Hong Kong SAR and Italy but we use data for these countries in pooled regressions.

The BIS collects information from national central banks on the cross-border assets and liabilities of commercial banks. Whereas the reporting area was formerly restricted mainly to OECD countries, the set of countries has been enlarged over the years to include large emerging markets and financial centres. Until recently, however, data on bilateral activities *among* the BIS reporting countries have not been published by the BIS. Hence, we resort to unpublished data, which have kindly been made available by the BIS' International Financial Statistics group. These data allow for an analysis also of the assets and liabilities *among* the reporting countries for an extended time range.

The BIS publishes two sets of banking statistics. The locational statistics are based on the balance of payments principle, i.e. they include gross on-balance sheet asset and liability positions of resident banks vis-à-vis non-residents (BIS 2006). Information is thus given on a direct, counterparty basis. In the following, we will denote these positions as banks' cross-border assets and liabilities. These data are in principle available from the early 1970s on a bilateral basis. In addition to aggregated positions by country, the BIS asks reporting banks for a breakdown into different types of borrowers (banks/non-banks) and for the currency composition of cross-border portfolios. We have information on the amounts denominated in Euros, Yen, Pounds Sterling, Swiss Francs, US Dollars and other currencies. Each position is given in US Dollars.

In contrast to the locational statistics, the second set of statistics, the BIS consolidated statistics, consolidate inter-office positions among banks and their foreign affiliates. The consolidated statistics provide a more detailed picture of the exposure of banks from specific reporting countries to foreign countries and thus of the ultimate risk positions. The consolidated statistics are also more detailed with regard to the sector coverage than the locational statistics. However, a breakdown into different currencies is not available.

We use the locational instead of the consolidated banking statistics for two main reasons. First, a currency breakdown, which helps in assessing the impact of exchange rate changes on cross-border positions, is available for the locational, but not for the consolidated statistics. Second, the geographical dimension is more explicit in the locational than in the consolidated statistics since the former are based on the balance of payments principle. Essentially, the locational statistics allow the assets and liabilities of residents in countries A and B to be related to macroeconomic developments in countries A and B. In the consolidated statistics, some assets and liabilities between residents in countries A and B are netted out if the residents belong to the same banking group. Nevertheless, it would be interesting to test the stability and robustness of our results using the consolidated instead of the locational statistics. Also, accounting for indirect effects, as funds may be channelled through other countries C, should be addressed in future work.

As regards the impact of valuation changes, we check the robustness of our results by using data corrected and data uncorrected for exchange rate changes. To correct the data for exchange rate changes with respect to the US Dollar, we convert the original data on assets and liabilities into constant US Dollars using the procedure of the BIS in its Quarterly Review (2006). Since the currency breakdown is given in US Dollars, we first transform each series into its original currency for every period t, x_t^{NC}, and then adjust for valuation changes due to changes in the US Dollar by applying the following formula:

$$x_t^c = \sum_{i=1}^{k} \frac{x_{t,i}^{NC}}{e_0^{NC/USD}}$$

where $e_0^{NC/USD}$ is the exchange rate of the national currency to the US Dollar ($\frac{NC}{USD}$) in Q4 1995, the beginning of the sample period, and k is the number of currencies.

Over time, several changes to the reporting requirements and the coverage of the data have been made. Based on a manual summarising these changes provided by the BIS, we have checked whether these changes affect our data in a significant way. Yet, most of these changes were of relatively small magnitude and indistinguishable from other fluctuations in the time series under study. Hence, we use the original but seasonally adjusted data in the following.

3.2 Explanatory variables

As our main explanatory variables, we include domestic and foreign real GDP – as proxies for real activity – and domestic and foreign real interest rates – as proxies for the rates of return on financial assets. Our dependent variable is specified in real terms as well, i.e. we deflate nominal variables with the domestic consumer price index. We capture rates of return at home and abroad using short-term interest rates with a maturity of three months.

In addition to GDP and interest rates, we include the bilateral exchange rate as an additional explanatory variable. Although we can correct the data for changes in the US Dollar exchange rate, as described above, their adjustment for all remaining exchange rate fluctuations has been difficult. The reason for this is that we do not know the breakdown of assets and liabilities in all currencies, and that information on the currency composition of assets and liabilities is not available for some countries. Hence, the bilateral exchange rate is included to pick up remaining exchange rate valuation effects. The exchange rate series are obtained from Datastream. To avoid structural breaks, the exchange rate series for member countries of the Euro Area are denominated in local currency versus the US Dollar even after the adoption of the Euro, i.e. the exchange rate given in Euros in terms of the US Dollar has been multiplied by the official conversion rate of the respective member country.

All of our explanatory variables are provided by Datastream. When available, we use seasonally adjusted real GDP data, and we seasonally adjust all remaining GDP series using the US Census Bureau's X12 seasonal adjustment procedure as implemented in *EViews*. The data stem from the OECD and national sources and have been retrieved through Datastream. To all other time series which initially have not been seasonally adjusted we apply the same methodology.

4. Descriptive statistics

In the theoretical discussion above, we have assumed that banks' international portfolios can be viewed as being representative for larger classes of country portfolios. Whether this analogy holds is, of course, an empirical question. Evidence provided in Sørensen et al (2006) shows that the ratios of portfolio equity, debt, and FDI to GDP are highly correlated. It is therefore difficult to separate their impact on the degree of risk sharing and consumption smoothing across borders. However, Sørensen et al (2006) do not analyse banks' portfolios and other components of country portfolios separately, as we do here. We begin with a comparison of banks' and other international portfolios, focusing in particular on shifts in the importance of the Euro Area. In addition, we first provide descriptive evidence on the correlation between banks' international portfolios and key macroeconomic variables such as GDP and interest rates.

The focus of this paper is on the long- and short-run determinants of international asset portfolios and the impact of financial integration on adjustment patterns. Ideally, we would like to address these issues using an encompassing dataset including information on bilateral holdings of all types of financial assets for a large range of countries and over a long time range. Unfortunately, such data are unavailable.[7] Still, our data are relatively representative also for a larger class of international financial assets since bank portfolios account for a considerable part of country portfolios. In the following, we compare total claims of banks as given in Table 9A of the BIS consolidated statistics published in its Quarterly Review with data on country portfolios from the Coordinated Portfolio Investment Survey (CPIS), which is conducted by the IMF. These data are available on a bilateral basis for a large cross-section of countries for the years 2001 to 2004. In contrast to the data used for the regression-based analysis below, these data consolidate claims of domestic banks on their foreign affiliates, which improves comparability with the portfolio data. Using these data, the ratio of total claims of banks to total portfolio investments for Germany amounts to 90% in 2001 and 85% in 2004. In the United Kingdom, banks' assets add up to more than 90% of total portfolio investment. The ratio is lower in the United States and Japan, where claims of banks in 2004 amount to 46% and 24%, respectively. Hence, we use information on a significant part of country portfolios.

Not only do international bank portfolios account for a significant fraction of country portfolios, but both are also highly correlated. Figure 1 compares international bank portfolios and country portfolios with regard to different countries by plotting correlation coefficients between bank and country assets against those for liabilities. Since the data on country portfolios are only available for the years 2001 to 2004, we convert banks' assets and liabilities into yearly averages. In the top panel of Figure 1, correlations are shown year-by-year. Correlations between bank and country assets and between bank and country liabilities are positive and lie in a range from 0.4 to 0.9. Overall, the countries with the highest correlations are Japan, the United Kingdom, the United States, Germany, and France. There is little variation in the coefficients over the four years.

To further investigate the relationship between bank and country portfolios, the bottom panel of Figure 1 presents the correlation coefficients of bilateral portfolio positions for the years 2001 to 2004. Even though there are some negative correlations, the scatter-plots are more concentrated in regions exhibiting positive correlation coefficients. The only exception is Japan, which shows an evenly spread scatter-plot. All in all, we conclude that bank assets and liabilities are positively related to country portfolios.

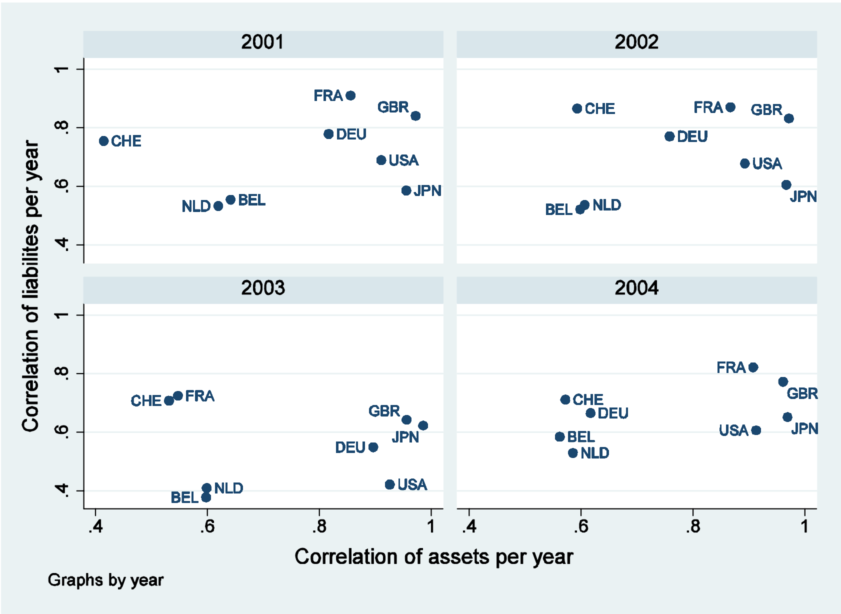
While Figure 1 reveals that bank portfolios are highly correlated with country portfolios, it does not show the importance of two-way asset trade or, in other words, the importance of 'diversification trade' in financial assets. Figure 2 therefore gives a measure of the importance of bilateral financial linkages as proposed by Obstfeld (2004). Applying a frequently-used indicator of the importance of intra- versus inter-industry trade in goods, Obstfeld computes the Grubel-Lloyd index $GL_{it} = 1 - \frac{|FA_{it} - FL_{it}|}{FA_{it} + FL_{it}}$ where FA = cross-border assets, FL = cross-border liabilities, i = reporting country, and t = time, as a measure of the importance of countries' two-way trade in financial assets. A high value of this index indicates that diversification finance is important. Using data on countries' aggregated international portfolios, Obstfeld reports average values for GL of 0.83 for developing countries and 0.67 for emerging markets. Our own measures using aggregate bank portfolios show similar values for most reporting countries except Japan, where the mean GL index was 0.5. Moreover, the GL indices have been relatively stable over time.

[7] To the best of our knowledge, data similar to the encompassing datasets compiled by Lane and Milesi-Ferretti (2006) are unavailable on a bilateral and/or on a quarterly basis.

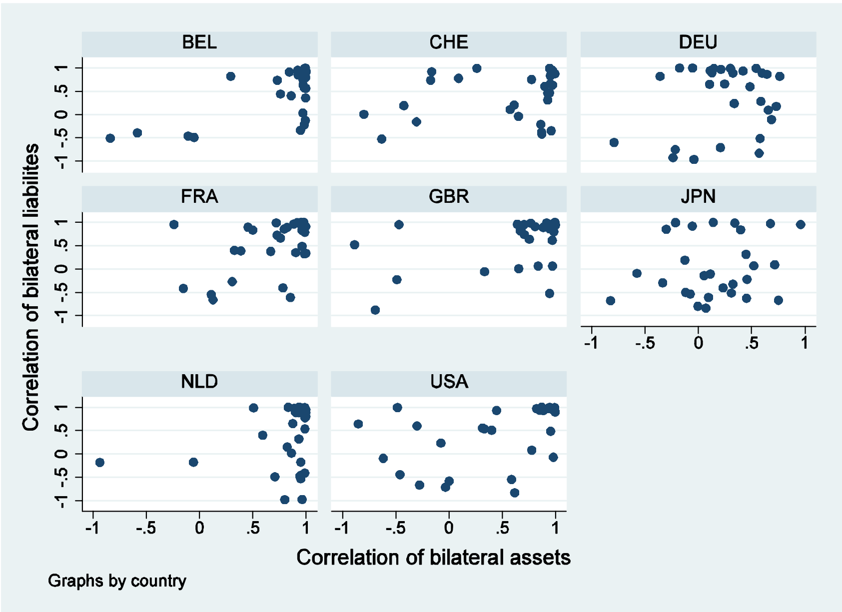
Figure 1

Correlation of banks' international portfolios and country portfolios

(a) On a yearly basis



(b) On a bilateral basis

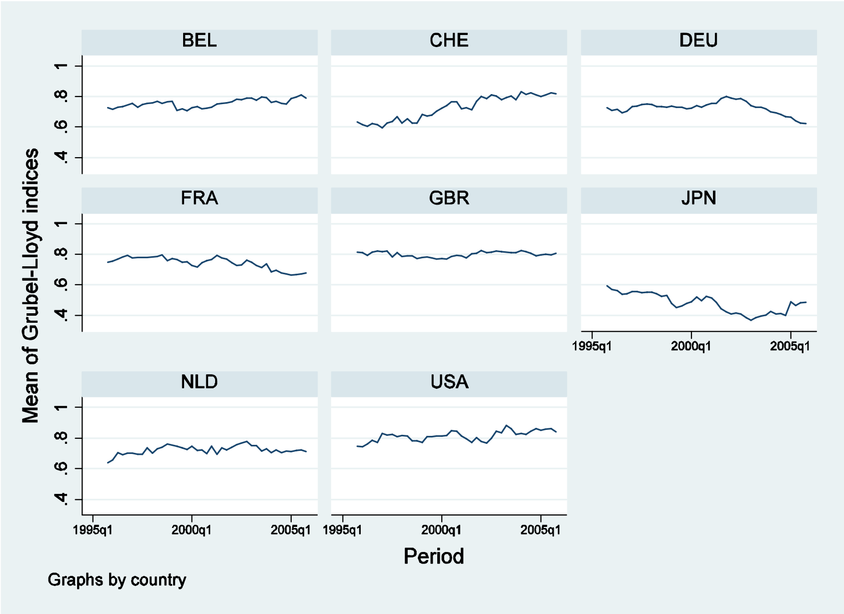


Note: Correlation coefficients between banks' cross-border assets and liabilities and those held by countries as reported in the Coordinated Portfolio Investment Survey of the IMF for 2001 to 2004. BEL = Belgium, CHE = Switzerland, DEU = Germany, FRA = France, GBR = United Kingdom, JPN = Japan, NLD = Netherlands, USA = United States.

Finally, we have run simple gravity-type regressions in order to check whether stocks of foreign bank assets and liabilities are correlated with macroeconomic variables. These regressions show that foreign GDP has a positive, and distance has a negative impact on cross-border assets and liabilities. The results for interest rates are mixed, with a mostly insignificant foreign interest rate and a positive impact of the domestic interest rate on cross-border liabilities. Finding a weak or even unexpected impact of interest rates on cross-border asset holdings is not necessarily at odds with the earlier empirical literature. Niehans (1994) has even argued that empirical studies using interest rates to explain international capital flows are inherently flawed for two reasons. First, the link between capital flows and interest rates depends on the type of underlying shock. Second, interest rate arbitrage may take place even without changes in the underlying quantities. This argument may in fact hold in a world with complete asset markets and a full set of contingent claims. In the more general case, however, international adjustment following exogenous shocks should take place also through a restructuring of international asset portfolios (Obstfeld (2004)).

Figure 2

Grubel-Lloyd indices for banks' international portfolios



Mean of Grubel-Lloyd Indices for international bank portfolios. BEL= Belgium, CHE = Switzerland, DEU = Germany, FRA = France, GBR = United Kingdom, JPN = Japan, NLD = Netherlands, USA = United States.

5. Short- and long-run adjustment of banks' international portfolios

Earlier empirical literature on international (bank) portfolios has been quite successful in explaining levels of activity (the 'long run'), but it has been less successful in explaining the flow data (the 'short run'). In this section, we test whether analysing the short- and long-run determinants of banks' portfolios simultaneously helps to bridge the gap between these two strands of the literature.

5.1 The empirical model

Our empirical model proceeds in four steps.

First, we test for the presence of unit roots in our data.

Second, since we cannot confidentially reject the presence of unit roots, we test for the presence of a cointegration relationship among our variables of interest, using different panel cointegration tests. We also estimate the long-run cointegration coefficients. The long-run cointegration relationships are assumed to differ across reporting countries but to be homogeneous across recipient countries. As we use a fixed effects estimator, time-invariant variables such as the distance between two countries drop out.

Third, with the estimates for the long-run cointegration coefficients at hand, we estimate the short-run dynamics of banks' cross-border assets and liabilities in an error-correction model. We estimate this model separately for each of the cross-sections, restricting the long-run parameters to those found in the cointegration model. These estimates provide us with a measure of the speed of adjustment to the long-run equilibrium, which is allowed to be heterogeneous also over the recipient countries.

Fourth, we use gravity-type variables to explain the speed of adjustment to a new equilibrium, i.e. the loading coefficients obtained from the error-correction model.

We use a panel data set of assets and liabilities that banks in country i hold in country j at time t. Our panel comprises ten reporting countries (i = 10), 30 recipient countries (j = 30)[8] (N = 300), and 41 time periods (1995:Q4 – 2005:Q2). We eliminate incomplete cross-sections, which reduces the total number of cross-sectional observations to N = 221. The number of included recipient countries varies according to the respective reporting country. We have the largest number of observations for Belgium (25 recipient countries), followed by France, the Netherlands and Switzerland (24), the United Kingdom (23), Germany (22) and the United States (21). The fewest observations are available for Japan (15). Hence, the total number of panel observations ranges from 1,025 to 615 observations across reporting countries.

Table 1

Descriptive statistics

Variable	Obs	Mean	Std dev	Minimum	Maximum
Cross-border assets	9,061	22,818	51,621	7.07	603,053
Cross-border liabilities	9,061	16,704	36,501	1.24	366,845
GDP *i*	9,061	1,015,981	1,844,988	36,015	6,443,341
GDP *j*	9,061	561,112	1,358,656	1,125	6,443,341
Bilateral exchange rate	9.061	59.75	282.39	0.0003	3,245
Real short-term interest rate *i*	9,061	1.70	1.81	–1.60	10.84
Real short-term interest rate *j*	9,061	2.19	2.66	–7.40	24.78
Bilateral exports	9,061	2,311	4,039	18.71	36,704
Bilateral imports	9,061	2,132	3,778	6.46	40,409
Log cross-border assets	9,061	8.42	2.00	1.96	13.31
Log cross-border liabilities	9,061	7.87	2.25	0.21	12.81
Log GDP *i*	9,061	12.51	1.52	10.49	15.68
Log GDP *j*	9,061	11.57	1.75	7.03	15.68
Log bilateral exchange rate	9,061	–0.67	3.31	–8.08	8.08
Log bilateral exports	9,061	6.70	1.47	2.93	10.51
Log bilateral imports	9,061	6.50	1.63	1.87	10.61

This table reports summary statistics for a balanced panel (T = 41 and N = 221). Assets, liabilities, and GDP are in millions of US Dollars. Interest rates are denoted in percent. The bilateral exchange rate is in price quotation. Data are averages across all reporting and recipient countries for the full time period.

[8] We exclude Turkey because of its high inflation and interest rate environment.

Our baseline specification includes domestic and foreign GDP, domestic and foreign real (short-term) interest rates, and the bilateral exchange rate as explanatory variables. Table 1 provides descriptive statistics for the variables used in the regressions. We specify our models separately for banks' cross-border assets and liabilities. Granger tests for non-causality run on first differences of assets and liabilities show no significant causal relationships between the two (results not reported).

5.2 Panel unit root tests

Since we are using quarterly data over a time period of 10 years, we test for non-stationarity of the time series (Table 2). Tests proposed by Levin, Lin, and Chu (2002) (LLC), and Im, Pesaran, and Shin (2003) (IPS) indicate that only foreign GDP is non-stationary. For domestic GDP, a common unit root is rejected by the LLC test, while according to the IPS test, an individual unit root cannot be rejected. For the bilateral exchange rates, the LLC test cannot reject the null of a common unit root while the IPS test rejects the null of individual unit root processes in the data. For the interest rate differential, bilateral export and imports, both tests reject the existence of a unit root. In addition, we find, perhaps surprisingly, that our main dependent variables, bilateral assets and liabilities, appear to be stationary. Only the LLC cannot reject the null of a common unit root for cross border assets. However, in contrast to LLC and IPS, the test by Hadri (2000) has the null of no common unit root, which is rejected in all cases, implying the existence of a unit root in each series.

These panel unit root tests require the time dimension to be large relative to the number of cross-sections. If we test for unit roots for every reporting country separately, neither the LLC nor the IPS test can reject the null hypothesis of a unit root for foreign assets except for the Netherlands, where an individual unit root process is rejected by the IPS test. For cross-border liabilities, a common unit root is not rejected for any of the reporting countries by the LLC test, contrary to the IPS test, which cannot reject the null of a unit root.

One reason for this mixed picture could be the violation of the usual assumption of cross-sectional independence made by these tests. As Banerjee, Marcellino, and Osbat (2005) argue, if the cross sections are cointegrated, the null hypothesis of a unit root is rejected too often even if the series actually are non-stationary. This may point to the importance of influences on international capital markets such as changes in US interest rates. However, we leave the test for cross-sectional cointegration for future research. We instead proceed under the assumption that cross-border assets and liabilities are integrated of degree one and that we have to take the spurious correlation problem into account, as in time series applications. Hence, in the next step, we establish whether there are long-run cointegration relationships among our variables of interest.

5.3 Long-run determinants of banks' cross-border assets and panel cointegration tests

Since we cannot confidently reject the presence of a unit root in our data, we next estimate whether there is a long-run cointegration relationship among bilateral bank portfolios and macroeconomic variables. We provide estimates for the full sample but we also estimate the long-run determinants of banks' assets and liabilities for each reporting country separately, to allow for cross-country heterogeneity in the long-run cointegration relationships. The panels for each of the reporting countries have a dimension comparable to those of other macro-panels, and panel estimators assuming a similar dimension of N and T can be applied.

Table 2
Panel unit root tests

(a) Levels

Variable	Observations	Cross-sections	LLC	IPS	Hadri
Log cross-border assets	8,693	221	1.25	–2.17**	31.15***
Belgium	998	25	–0.11	–0.42	12.17***
France	942	24	1.79	1.80	10.05***
Germany	858	22	1.47	–0.04	6.23***
Japan	597	15	1.38	1.47	8.06***
Netherlands	948	24	–1.82**	–4.42***	8.24***
Switzerland	941	24	–0.92	–0.33	12.27***
United Kingdom	898	26	0.80	–1.59*	9.23***
United States	821	21	0.03	0.17	9.70***
Log cross-border liabilities	8,703	221	–3.90***	–10.14***	27.10***
Belgium	977	25	–2.15**	–3.51***	8.67***
France	945	24	–1.66**	–3.08***	5.43***
Germany	866	22	–1.50*	–5.88***	9.32***
Japan	592	15	–1.06	–2.37***	9.77***
Netherlands	944	24	–1.41*	–3.13***	7.92***
Switzerland	950	24	–1.02	–4.43***	8.93***
United Kingdom	889	23	–0.82	–1.82**	11.77***
United States	825	21	0.53	–2.47***	8.14***
Interest rate differential	8,576	221	–10.37***	–13.19***	19.34***
Log bilateral exchange rate	8,433	221	19.00	–24.72***	10.90***
Log bilateral exports	8,722	221	–4.42***	–7.84***	29.34***
Log bilateral imports	8,669	221	–3.49***	–9.70***	26.25***
Log domestic GDP	8,414	221	–4.23***	–1.16	39.00***
Log foreign GDP	8,567	221	3.59	7.86	40.85***

This table reports the test statistics of panel unit root tests based on: Levin, Lin, and Chu (LLC) (2002) (H0: common unit root), Im, Pesaran, and Shin (IPS) (2003) (H0: individual unit root), and Hadri (2000) (H0: no common unit root). The maximum lag length was automatically chosen based on the SIC lag selection criterion. Reported observations are those used by the LLC test. Newey-West bandwidth selection uses a Bartlett kernel. *** = significant at the 1% level.

Table 2
Panel unit root tests

(b) First differences

Variable	Observations	Cross-sections	LLC	IPS	Hadri
Log cross-border assets	8,473	221	–68.22***	–79.36***	8.60***
Belgium	950	25	–20.56***	–25.25***	3.57***
France	927	24	–22.89***	–25.69***	1.56*
Germany	834	22	–15.02***	–21.43***	2.28**
Japan	584	15	–16.46***	–18.10***	1.33*
Netherlands	920	24	–25.62***	–31.64***	3.97***
Switzerland	929	24	–29.68***	–31.62***	2.91***
United Kingdom	889	23	–23.10***	–25.81***	4.26***
United States	792	21	–22.14***	–22.56***	4.60***
Log cross-border liabilities	8,437	221	–78.14***	–88.14***	5.08***
Belgium	938	25	–23.05***	–26.38***	2.59***
France	899	24	–24.62***	–26.32***	0.93
Germany	846	22	–24.92***	–29.55***	1.00
Japan	571	15	–22.67***	–21.58***	1.71**
Netherlands	921	24	–28.23***	–33.77***	2.91***
Switzerland	917	24	–27.12***	–29.70***	1.70**
United Kingdom	883	23	–23.54***	–26.99***	2.42***
United States	817	21	–26.00***	–30.41***	–0.59
Interest rate differential	8,331	221	–51.87***	–66.99***	–2.63
Log bilateral exchange rate	8,349	221	–4.26***	–65.33***	3.76***
Log bilateral exports	8,511	221	–77.22***	–89.51***	1.69**
Log bilateral imports	8,479	221	–71.68***	–85.64***	2.81***
Log domestic GDP	8,541	221	–36.96***	–49.46***	9.02***
Log foreign GDP	8,500	221	–42.19***	–52.81***	6.68***

This table reports the test statistics of panel unit root tests based on: Levin, Lin, and Chu (LLC) (2002) (H0: common unit root), Im, Pesaran, and Shin (IPS) (2003) (H0: individual unit root), and Hadri (2000) (H0: no common unit root). The maximum lag length was automatically chosen based on the SIC lag selection criterion. Reported observations are those used by the LLC test. Newey-West bandwidth selection uses a Bartlett kernel. *** = significant at the 1% level.

Our main empirical model is a cointegrated panel VAR model. The presence of a cointegration relationship is tested using a two-step estimator. For a VAR(1) model, the cointegrated model has the following VECM representation (Breitung (2005)):

$$\Delta y_{it} = \alpha_i \beta' y_{i,t-1} + \varepsilon_{it} \quad (1)$$

with $t = 0,1,\ldots,T$ and $i = 1,\ldots,N$, $E(\varepsilon_{it}) = 0$, $\Sigma_i = E(\varepsilon_{it}\varepsilon'_{it})$. This specification assumes the long-run cointegration relationship (β) to be identical across cross-sections while the loading coefficients and thus the speed of adjustment (α_i) varies for each cross-sectional observation. This assumption is key for our purposes as we can interpret the speed of adjustment as a measure of the degree of financial integration. Our expectation is that the speed of adjustment increases in the degree of integration of financial markets.

Estimating equation (1) proceeds in two steps. In a first step, the matrix β is estimated based on a consistent estimator of the short-run parameters α_i and of Σ_i. As $T \to \infty$, a consistent estimator of α_i can be obtained by estimating separate models for each cross-section unit N. At this stage, the restriction that the cointegration vectors are the same over the cross-sections is ignored. In a second step, the cointegration matrix β can be estimated by running an OLS regression on the pooled regression.

Table 3 gives the results of the panel cointegration tests and the estimates for the cointegration vectors for the full sample. Panel (a) gives the results using cross-border assets as the dependent variable. As regressors, we include domestic and foreign GDP, domestic and foreign interest rates, and the bilateral exchange rate. All variables except interest rates are in logs, and the coefficients can be interpreted as elasticities. In Panel (b), we present the same specifications but using cross-border liabilities as the dependent variables. Each regression is estimated for the full sample, for the Euro Area sub-sample, and for each of the reporting countries separately. To save space, we present the results of the two-step estimator introduced above. Results using a fully modified or a dynamic OLS model are qualitatively the same (see also Section 5.4).

Generally, the cointegration tests suggest that there is a long-run cointegration relationship among the variables at the 1% level of significance. The explanatory power of our model differs for assets and liabilities (see also Table 4). For cross-border assets, the R^2 is around 0.2 for the full sample and 0.7 for the Euro Area sub-sample. For cross-border liabilities, the explanatory power is much lower (0.06 and 0.23, respectively). For the individual reporting countries, the (unreported) R^2 ranges from 0.17-0.18 (Switzerland and the United States) to 0.72 for the Euro Area and 0.51 for Germany. For cross-border liabilities, we generally obtain lower R^2s. In the case of bonds issued by banks, the geographical location of the ultimate owners and of the owners reported in the data may not coincide. This could explain the relatively low explanatory power for foreign liabilities.

The most consistent result that we obtain is a positive impact of foreign GDP on cross-border assets and liabilities.[9] It is robust across all reporting countries, the full sample, and the Euroland sub-sample. This confirms the results of the scatter plots above. Also, the magnitude of the coefficient estimates is similar across different specifications. For the full sample, the long-run elasticity is higher for cross-border assets (about 2 for the full sample) than for cross-border liabilities (about 0.5). One reason for some of the relatively high elasticities could be that, over the sample period, the share of cross-border assets and liabilities relative to GDP has been increasing.

[9] The only exception are cross-border liabilities of Japanese banks.

Table 3
Panel cointegration tests

	Log dom GDP	Log for GDP	Log bil exch rate	Int rate differential	Cointeg-ration	*N*	*T*
(a) Cross-Border Assets							
Full sample	–0.68*** (–6.18)	2.32*** (24.74)	–1.79*** (–17.90)	0.01*** (2.61)	Yes	221	41
Euro Area	–1.09*** (–4.35)	2.84*** (12.34)		0.03*** (5.09)	Yes	41	28
Belgium	–2.22*** (–4.14)	4.45*** (9.54)	–3.01*** –(5.75)	0.05*** (5.29)	Yes	25	41
France	–0.44 (–1.22)	2.55*** (8.22)	–1.78*** (–5.19)	0.02*** (3.61)	Yes	24	41
Germany	–4.11*** (–16.92)	4.60*** (23.70)	–3.97*** (–15.43)	0.03*** (6.22)	Yes	22	41
Netherlands	–0.40 (–1.11)	2.02*** (6.21)	–1.92*** (–5.44)	–0.01 (–1.02)	Yes	24	41
Japan	–0.45 (–1.47)	1.92*** (8.69)	–0.87*** (–3.80)	0.02** (2.00)	Yes	15	41
Switzerland	0.56** (2.25)	0.65*** (3.07)	–0.07 (–0.29)	–0.02*** (–3.18)	Yes	24	41
United Kingdom	0.59** (2.55)	0.71*** (3.24)	–0.85*** (–3.79)	0.001 (0.13)	Yes	23	41
United States	2.30*** (4.79)	0.29 (0.77)	–0.41 (–1.09)	–0.04*** (–4.04)	Yes	21	41
(b) Cross-Border Liabilities							
Full sample	0.46*** (3.54)	0.57*** (5.19)	0.21* (1.77)	–0.02*** (–6.86)	Yes	221	41
Euro Area	2.09** (4.98)	–0.57 (–1.49)		0.06*** (5.26)	Yes	41	28
Belgium	–1.36*** (–2.79)	3.25*** (7.65)	–2.56*** (–5.38)	0.004 (0.48)	Yes	25	41
France	–0.45 (–0.93)	1.27*** (3.06)	–0.80* (–1.75)	–0.04*** (–4.54)	Yes	24	41
Germany	–3.84*** (–14.28)	3.72*** (17.30)	–2.47*** (–8.67)	0.02*** (3.53)	Yes	22	41
Netherlands	0.82* (1.72)	–0.38 (–0.88)	–2.05*** (–4.39)	–0.01 (–1.08)	Yes	24	41
Japan	3.27*** (6.30)	–1.72*** (–4.69)	3.66*** (9.58)	–0.06*** (–4.31)	Yes	15	41
Switzerland	–0.43* (–1.83)	0.78*** (3.91)	–0.29 (–1.31)	0.003 (0.51)	Yes	24	41
United Kingdom	1.44*** (5.72)	0.32 (1.33)	0.48** (1.98)	–0.02*** (–3.14)	Yes	23	41
United States	–0.41 (–0.98)	1.35*** (4.11)	–0.37 (–1.15)	–0.02*** (–2.76)	Yes	21	41

This table reports results of panel cointegration tests using a full balanced sample. The interest rate differential is the difference between domestic and foreign interest rates. The bilateral exchange rate is not available for the Euro Area countries as these estimates capture only the post-1999 period. Panel cointegration tests are based on the methods proposed by Kao (1999) and Pedroni (1999). The two-step estimator is based on Breitung (2005). The bilateral exchange rate is not available for the Euro Area countries.

Table 4

Panel cointegration tests – different estimation methods

Sample	Method	Log Domestic GDP	Log Foreign GDP	Log bilateral exchange rate	Interest rate differential	R^2	*N*	*T*
Cross-Border Assets								
Full	OLS	–0.93*** (–5.68)	2.54*** (17.00)	–1.97*** (–12.38)	0.01*** (3.20)	0.22	221	41
Full	FMOLS	–1.05*** (–6.27)	2.63*** (17.17)	–1.93*** (–11.87)	0.01** (2.39)	0.22	221	41
Full	DOLS	–0.91*** (–5.16)	2.40*** (14.91)	–1.78*** (–10.36)	0.001 (0.41)	0.24	221	41
Euro Area	OLS	–1.49*** (–3.39)	3.27*** (7.72)		0.03*** (3.65)	0.68	41	28
Euro Area	FMOLS	–1.24*** (–2.72)	3.02*** (8.67)		0.02** (2.36)	0.67	41	28
Euro Area	DOLS	–1.05** (–2.13)	2.69*** (5.80)		0.02*** (2.81)	0.72	41	28
Cross-Border Liabilities								
Full	OLS	0.27 (1.39)	0.72*** (4.05)	0.07 (0.37)	–0.02*** –(6.02)	0.06	221	41
Full	FMOLS	0.15 (0.76)	0.76*** (4.19)	–0.09 (–0.48)	–0.02*** (–6.65)	0.06	221	41
Full	DOLS	0.34 (1.63)	0.63*** (3.32)	0.13 (0.63)	–0.02*** (–4.24)	0.06	221	41
Euro Area	OLS	2.24** (2.49)	–0.74 (–0.86)		0.07*** (3.64)	0.22	41	28
Euro Area	FMOLS	2.36** (2.53)	–0.83 (–0.93)		0.08*** (3.90)	0.21	41	28
Euro Area	DOLS	2.67*** (2.65)	–1.15 (–1.19)		0.10*** (4.54)	0.24	41	28

Notes: See Table 3. FMOLS = fully modified OLS estimator. DOLS = dynamics OLS estimator. The bilateral exchange rate is not available for the Euro Area countries.

in contrast, the impact of domestic GDP differs for cross-border assets and liabilities. We find a negative impact on cross-border assets for the full sample and for the Euro Area sub-sample, whereas the effect on cross-border liabilities is positive. One interpretation would be that a higher domestic GDP is associated with a higher demand for credit. Hence, cross-border lending contracts and cross-border liabilities increase. For the individual reporting countries, however, there is no consistent effect of domestic GDP. One explanation is that, for the country-by-country regressions, domestic GDP captures general trends in the data and thus the time series dimension only. For each recipient country, domestic GDP is identical, and it might thus capture general trend developments in the reporting countries.

Turning next to the impact of real interest rates on cross-border assets and liabilities, we find a couple of significant results. An increase in the interest rate differential between the home and the foreign economy raises cross-border assets and lowers cross-border liabilities in the full sample. If the interest rate differential and simple arbitrage considerations alone were the determinants of cross-border asset holdings, we would rather expect the opposite: cross-border assets should decrease as the interest rate differential between the home and the foreign economy widens, and cross-border liabilities should increase. The counterintuitive results for the full sample are confirmed by most of the results for the individual reporting countries. For four countries, we reconfirm the positive impact of the interest rate differential on cross-border assets. We find the expected negative impact only for Switzerland and the United States. For cross-border liabilities, we find the same negative impact as for the full sample for four countries, and a positive effect only for Germany.

There are several possible explanations for this result. First, our current specification takes only insufficient account of exchange rate expectations. Second, from a theoretical point of view, the link between cross-border assets and the interest rate differential is not clear-cut. It may depend on the nature of the underlying shocks driving interest rates, and its sign depends on the relative strength of income and substitution effects.

We can check whether the results for interest rates are due to the fact that we take only insufficient account of exchange rate expectations. We have sufficient observations to re-estimate the model for the Euro Area countries and for the post-1999 period only. In this sub-sample, changes in bilateral nominal exchange rates are irrelevant. For cross-border liabilities, the effect of the interest rate differential is indeed positive for the Euro Area sub-sample. However, the positive effect on cross-border assets is confirmed. Explanations of the sometimes unexpected interest rate effects can thus not be based on exchange rate expectations alone.

The log of the bilateral exchange rate has a negative impact on cross-border assets and a mixed impact on cross-border liabilities. Results for the exchange rate are difficult to interpret. We include the bilateral exchange rate, but the assets and liabilities are denominated in US Dollars. Hence, valuation changes are driven by movements of the bilateral exchange rates to the US Dollar *and* by the currency of denomination of assets and liabilities. To isolate the effect of the US Dollar exchange rate, we re-run the model using assets and liabilities in constant US Dollars, as described above. Results for the data in constant US Dollars are given in Table 5. They are practically unchanged in terms of the qualitative results and the significance of the coefficients. If anything, there are some changes in the results for Switzerland.

5.4 Robustness tests

We run several sets of robustness tests. First, we test whether our main results change as we include bilateral trade in our cointegration regression. Second, we use different methods for estimating the long-run coefficients. Third, we drop individual regressors successively to test for the effect of multicollinearity among the regressors. Fourth, we study the cross-border assets and liabilities of banks and non-banks separately. Finally, we estimate the model for different time periods.

Bilateral trade: Turning to the effects of bilateral trade first, we check whether the transmission of macroeconomic developments through international bank portfolios depends on the degree of trade integration between two countries. Earlier work by, for instance, Forbes and Chinn (2004) shows that bilateral trade affects financial linkages and the transmission of shocks between financial markets to a significant degree.

To measure the importance of bilateral trade, we retrieve data from the IMF's Direction of Trade Statistics (DOTS). Bilateral data are available at a quarterly frequency. Results are reported in Table 6. The reason for including trade is that – presumably – a large share of cross-border bank lending is trade-related. If foreign importers receive trade credits from foreign banks, we would expect a positive correlation between bilateral foreign assets and exports and between cross-border liabilities and imports.[10] In addition, we also include the sum of exports and imports in all equations. All trade variables are in logs.

Table 5

Panel cointegration tests – constant US Dollars

	Log domestic GDP	Log foreign GDP	Log bilateral exchange rate	Interest rate differential	Cointeg-ration	*N*	*T*
(a) Cross-Border Assets							
France	–1.09*** (–2.86)	2.66*** (8.21)	–2.00*** (–5.57)	0.03*** (4.32)	Yes	24	41
Germany	–5.21*** (–20.50)	4.85*** (23.88)	–4.29*** (–15.95)	0.04*** (6.28)	Yes	22	41
Netherlands	–0.56 (–1.45)	1.79*** (5.13)	–1.64*** (–4.33)	–0.0002 (–0.03)	Yes	24	41
Japan	–0.88*** (–2.80)	1.87*** (8.37)	–0.84*** (–3.63)	0.02*** (2.25)	Yes	15	41
Switzerland	–0.16 (–0.64)	0.84*** (3.91)	–0.40* (–1.64)	–0.01*** (–2.58)	Yes	24	41
United States	2.30*** (4.79)	0.29 (0.77)	–0.41 (–1.09)	–0.04*** (–4.04)	Yes	21	41
(a) Cross-Border Assets							
France	–0.87* (–1.83)	1.25*** (3.09)	–0.83* (–1.86)	–0.03*** (–3.46)	Yes	24	41
Germany	–4.92*** (–17.84)	3.98*** (18.07)	–2.80*** (–9.59)	0.02*** (3.59)	Yes	22	41
Netherlands	0.67 (1.42)	0.10 (0.23)	–1.75*** (–3.71)	–0.004 (–0.43)	Yes	24	41
Japan	2.70*** (5.29)	–1.69*** (–4.68)	3.63*** (9.67)	–0.06*** (–4.18)	Yes	15	41
Switzerland	–1.09*** (–4.82)	0.99*** (4.81)	–0.66*** (–2.87)	0.005 (1.05)	Yes	24	41
United States	–0.41 (–0.98)	1.35*** (4.12)	–0.37 (–1.15)	–0.02*** (–2.76)	Yes	21	41

Notes: See Table 3. The dependent variable is measured in constant US Dollars using the method described in Section 3.1.

The first result that can be observed from Table 6 is that all previous qualitative results carry over if we include foreign trade. There are only very few coefficients which switch from being significant in the baseline specification to being insignificant in the specification including trade, or vice versa. Also, the coefficient estimates are similar in magnitude, and there is generally no consistent pattern of coefficient increase or decrease. Hence, we do not find evidence that omitting trade from our baseline specification affects the main results.

[10] Results using the sum of exports and imports are qualitatively the same as results using imports and exports separately.

Table 6

Panel cointegration tests – including foreign trade

(a) Cross-Border Assets

	Log domestic GDP	Log foreign GDP	Log bil exchange rate	Interest rate differential	Log bilateral exports	Cointeg-ration	*N*	*T*
Full sample	–0.69*** (–6.85)	1.97*** (21.70)	–1.61*** (–17.27)	0.001 (0.61)	0.34*** (11.73)	Yes	221	41
Euro Area	–1.20*** (–5.08)	2.77*** (11.91)		0.03*** (5.53)	0.15* (1.77)	Yes	41	28
Belgium	–2.57*** (–6.09)	4.02*** (10.50)	–3.08*** (–7.42)	0.02*** (2.72)	0.52*** (6.12)	Yes	25	41
France	–0.42 (–1.22)	2.07*** (6.76)	–1.52*** (–4.60)	0.02*** (2.68)	0.49*** (6.02)	Yes	24	41
Germany	–3.03*** (–12.30)	2.75*** (10.81)	–2.52*** (–9.23)	0.02*** (3.83)	0.93*** (9.87)	Yes	22	41
Netherlands	–1.18*** (–4.10)	1.45*** (5.55)	–2.07*** (–7.37)	–0.02*** (–3.28)	1.00*** (15.66)	Yes	24	41
Japan	–0.43 (–1.45)	2.14*** (8.50)	–0.91*** (–3.93)	0.02* (1.91)	–0.26** (–2.21)	Yes	15	41
Switzerland	0.57** (2.34)	0.66*** (2.87)	–0.05 (–0.19)	–0.02*** (–3.09)	–0.02 (–0.25)	Yes	24	41
United Kingdom	0.54** (2.45)	0.87*** (4.07)	–0.96*** (–4.47)	0.001 (0.39)	–0.29*** (–4.14)	Yes	23	41
United States	2.04*** (4.29)	0.52 (1.38)	–0.59 (–1.60)	–0.04*** (–3.79)	–0.36*** (–2.83)	Yes	21	41

(a) Cross-Border Assets

	Log domestic GDP	Log foreign GDP	Log bil exchange rate	Interest rate differential	Log bilateral imports	Cointeg-ration	*N*	*T*
Full sample	0.26** (2.06)	0.41*** (3.90)	0.25** (2.19)	–0.02*** (–8.07)	0.35*** (11.68)	Yes	221	41
Euro Area	1.84*** (4.41)	–0.43 (–1.14)		0.06*** (5.28)	0.08 (0.79)	Yes	41	28
Belgium	–1.34*** (–2.96)	2.72*** (6.85)	–2.29*** (–5.18)	–0.004 (–0.45)	0.53*** (6.86)	Yes	25	41
France	–0.37 (–0.81)	1.09*** (2.75)	–0.66 (–1.51)	–0.05*** (–5.48)	0.01 (0.09)	Yes	24	41
Germany	–3.72*** (–14.05)	3.42*** (14.93)	–2.23*** (–7.70)	0.02*** (2.70)	0.28*** (3.49)	Yes	22	41
Netherlands	0.79* (1.77)	0.23 (0.58)	–1.88*** (–4.36)	–0.01 (–1.61)	0.15* (1.94)	Yes	24	41
Japan	1.41*** (2.58)	–1.95*** (–5.64)	3.48*** (9.75)	–0.07*** (–5.27)	1.59*** (6.85)	Yes	15	41
Switzerland	–0.72*** (–3.56)	0.83*** (4.69)	–0.36* (–1.79)	0.002 (0.45)	0.26*** (5.49)	Yes	24	41
United Kingdom	1.42*** (5.83)	0.23 (0.98)	0.52** (2.22)	–0.02*** (–3.63)	0.10* (1.67)	Yes	23	41
United States	–1.12 ** (–2.52)	1.09*** (3.35)	–0.21 (–0.65)	–0.03*** (–2.97)	0.60*** (4.04)	Yes	21	41

Notes: See Table 3. The bilateral exchange rate is not available for the Euro Area countries.

Generally, we find a positive link between banks' cross-border activities and trade. The link between imports and liabilities is positive except for the Euro Area and France, where we find an insignificant effect. The link between exports and assets is positive as well except for Japan, the United Kingdom, and the United States where we find a negative and significant effect. For Switzerland, the link between exports and assets is insignificant. Overall, these results confirm that banks' international activities are trade-related, but these links do not affect the impact of return differentials.

Alternative cointegration estimators: In addition, we check the robustness of our results for the full sample and for the Euro Area sub-sample using different estimators for the long-run cointegration coefficients. Results using an OLS estimator, a fully modified OLS (FMOLS) model (Pedroni (1999)), and a dynamic OLS (DOLS) model (Kao and Chiang (2000)) are presented in Table 4. Both the FMOLS and the DOLS estimator address serial correlation and the potential endogeneity of the regressors. The FMOLS estimator corrects the OLS estimator non-parametrically, while the DOLS estimator uses information from past and future leads and lags of all variables.

For gross cross-border assets, the results are basically unchanged. For cross-border liabilities, in contrast, the log bilateral exchange rate becomes insignificant for the full sample, and foreign GDP becomes insignificant for the Euro Area. Unreported regressions for the individual reporting countries provide fairly consistent results for the different models, and none of the coefficients switches in sign.

Multicollinearity: To check whether including several macroeconomic variables, which are potentially correlated to each other, affects our results, we re-run each model, dropping individual explanatory variables successively. This also addresses the concern that interest rates may be a poor proxy for the long-run macroeconomic environment as they could reflect endogenous policy responses of the central banks. In unreported regressions, we find the most stable results for foreign GDP and the interest rate differential. Results for domestic GDP and for the bilateral exchange rate switch in some of these regressions from being positive to negative, or vice versa. One possible explanation for these somewhat unstable results is that domestic GDP picks up a time trend in the data. For the exchange rate, we have no strong priors about the expected coefficient sign. Both domestic GDP and the bilateral exchange rate thus pick up the effects of the other, omitted explanatory variables. These robustness tests show that the results for foreign GDP and in particular for the interest rate differential are quite robust. In future work, it seems worthwhile to explore the effects of alternative return measures to account for the fact that rates of return tend to vary substantially over time and across asset classes (Lane and Milesi-Ferretti (2003)).

Banks versus non-banks: Finally, we run the regressions separately for cross-border assets and liabilities vis-à-vis banks and non-banks. Table 7 presents the results for the full sample and for the Euro Area sample, using different cointegration estimators. The first thing to notice is that the explanatory power of our model for assets and liabilities vis-à-vis non-banks is much higher than for assets and liabilities vis-à-vis banks. One reason for this could be that banks are active mostly on the wholesale market, for which macroeconomic fundamentals are less relevant than for the retail market.

Also, we obtain more significant coefficient estimates for non-banks. For total assets in the full country sample, the most important difference between banks and non-banks is the sign of the interest rate differential. For banks, we obtain the same positive sign as before, whereas for non-banks we now obtain the (expected) negative sign. For the Euro Area though, this pattern reverses. Here, we have a positive sign for the non-banks and a negative sign for the banks. Turning to cross-border liabilities, we find quite significant differences between banks and non-banks with regard to the impact of the remaining explanatory variables as well. As regards the sign of the interest rate differential, the results for the Euro Area are again in line with expectations for banks. For the full sample, in contrast, results show that the unexpected negative sign is driven by liabilities vis-à-vis banks.

Table 7

Panel cointegration tests – banks versus non-banks

(a) Full sample

	Log domestic GDP	**Log foreign GDP**	**Log bil exchange rate**	**Interest rate diff**	R^2	**Log domestic GDP**	**Log foreign GDP**	**Log bil exchange rate**	**Interest rate diff**	R^2
	Assets vis-à-vis non-banks					**Assets vis-à-vis banks**				
FMOLS	–1.13*** (–5.33)	2.60*** (13.41)	–2.05*** (–9.89)	–0.01*** (2.62)	0.13	0.08 (0.46)	0.02 (0.14)	0.11 (0.65)	0.02*** (6.62)	0.005
DOLS	–0.62*** (–2.77)	2.08*** (10.19)	–1.57*** (–7.21)	–0.01** (–2.28)	0.15	–0.29 (–1.56)	0.32* (1.87)	–0.21 (–1.14)	0.01*** (3.13)	0.01
Two-step	–0.26* (–1.79)	1.86*** (14.86)	–1.41*** (–10.57)	–0.01*** (–3.86)		–0.40*** (–3.22)	0.44 (4.19)***	–0.37*** (–3.31)	0.02*** (7.69)	
	Liabilities vis-à-vis non-banks					**Liabilities vis-à-vis banks**				
FMOLS	0.0005 (0.003)	1.58*** (9.28)	–0.70*** (–3.84)	0.001 (0.23)	0.13	0.15 (0.67)	–0.82*** (–4.01)	0.60*** (2.78)	–0.24*** (–6.11)	0.02
DOLS	0.34* (1.76)	1.21*** (6.74)	–0.40** (–2.08)	0.003 (0.73)	0.15	–0.003 (–0.01)	–0.57*** (–2.67)	0.53** (2.30)	–0.02*** (–4.38)	0.03
Two-step	0.34*** (2.61)	1.34*** (12.18)	–0.43*** (–3.67)	0.01** (2.25)		0.07 (0.48)	–0.70*** (–5.56)	0.60*** (4.45)	–0.02*** (–7.64)	

(b) Euro area

	Log domestic GDP	**Log foreign GDP**	**Log bil exchange rate**	**Interest rate diff**	R^2	**Log domestic GDP**	**Log foreign GDP**	**Log bil exchange rate**	**Interest rate diff**	R^2
	Assets vis-à-vis non-banks					**Liabilities vis-à-vis banks**				
FMOLS	0.55 (0.75)	1.73** (2.44)		0.05*** (3.27)	0.52	–1.80*** (–3.22)	1.29** (2.41)		–0.03** (–2.38)	0.07
DOLS	0.74 (0.93)	1.43* (1.88)		0.06*** (3.34)	0.61	–1.79*** (–2.97)	1.32** (2.28)		–0.03*** (–2.67)	0.10
Two-step	0.53 (1.29)	1.67*** (4.39)		0.07*** (6.07)		–1.77*** (–5.80)	1.30*** (4.64)		–0.03*** (–4.02)	
	Liabilities vis-à-vis non-banks					**Liabilities vis-à-vis banks**				
FMOLS	2.69*** (3.27)	–1.12 (–1.42)		–0.04** (–2.16)	0.22	–0.33 (–0.29)	0.29 (0.27)		0.11*** (4.78)	0.02
DOLS	3.07*** (3.45)	–1.51* (–1.77)		–0.02 (–1.22)	0.26	–0.41 (–0.33)	0.37 (0.31)		0.12*** (4.62)	0.06
Two-step	3.04*** (6.89)	–1.43*** (–3.54)		–0.01 (–0.55)		–1.13** (–2.12)	0.99** (2.03)		0.06*** (4.78)	

Notes: See Table 3. FMOLS = fully modified OLS estimator. DOLS = dynamic OLS estimator. The bilateral exchange rate is not available for the Euro Area countries. The number of observations is T = 41 and N = 222 for the full sample and T = 28 and N = 44 for the Euro Area sub-sample.

Sample splits: Our data cover a time period characterised by severe financial crises in some emerging markets in the late 1990s. Although the use of data for OECD countries limits the direct impact of these crises on our model, indirect effects might well affect our estimates, and banks may, in particular, have changed their portfolio strategies in response to the crises. To test whether our results are stable, we thus re-run the empirical model for different time periods, i.e. the first half of the sample (1995:Q4-2000:Q4), the post-crises period (1998:Q1-2005:Q4), and the last half of the sample (2001:Q1-2005:Q4). In unreported regressions, we do indeed find that the sign of the interest rate variables has not been stable over time. In most cases, the signs switch over time, and we find somewhat greater evidence for the expected signs in the second half of the sample. Also, the explanatory power of our model improves over time.

In contrast, the positive impact of foreign GDP on cross-border assets generally remains positive across the different sample periods. Results for the different sample periods confirm that domestic GDP picks up cyclical variations in the data. Hence, the impact is not very stable over time. The same is true for the impact of the bilateral exchange rate on cross-border liabilities. However, for cross-border assets, exchange rates continue to have a negative (or insignificant positive) impact.

5.5 Short-run determinants of banks' cross-border assets

Results presented so far inform us about the long-run determinants of banks' international portfolios but not about the response of banks' portfolios to short-run macroeconomic developments. Also, we have not yet estimated the speed of adjustment to a new long-run equilibrium.

One way to obtain these two pieces of information is to estimate an error-correction model which allows us to decompose the short- and long-run determinants of banks' international portfolios:

$$\Delta y_t = \alpha_o - \alpha_1 \left[y_{t-1} - \boldsymbol{\beta}' \mathbf{x}_t \right] + \sum_{k=1}^{4} \gamma_k \Delta y_{t-k} + \sum_{k=0}^{4} \boldsymbol{\delta}'_k \, \Delta \mathbf{x}_{t-k} + \varepsilon_t \qquad (2)$$

where $\mathbf{x}_t$ is a vector of explanatory (exogenous) variables, and $\boldsymbol{\beta}$ is the vector of long-run coefficients obtained from the estimation of equation (1) above. The lagged terms on the RHS of this equation capture short-run macroeconomic dynamics. We estimate this model separately for each reporting-recipient country pair on the 41 quarterly time series observations. We set the lag length at t = 4.

The loading coefficient $0 < |\alpha_1| < 1$ measures the persistence of deviations of cross-border assets and liabilities from their long-run equilibrium, i.e. from the error-correction term in brackets. The dependent variable is the first difference of the logarithm of cross-border bank assets and liabilities (Δy_t), i.e., we look at percentage changes in banks' cross-border activities. Below, we use the loading coefficients obtained from the estimation of equation (2) to check whether the speed of adjustment to a new equilibrium differs systematically across the country pairs.

One difficulty in estimating equation (2) directly is that it includes lagged dependent variables, which, in a panel framework, leads to biased coefficients. Moreover, standard remedies used in panel applications where N is large relative to T cannot be used here. Our solution is similar in spirit to the two-step cointegration tests used in time series applications. With the estimates of the long-run cointegration parameters obtained above at hand, we have an estimate for the error-correction term for each reporting country. We assume this long-run cointegration relationship to be homogeneous for all recipient countries but we allow the short-run dynamics and the loading coefficients to differ for each country pair. We then estimate the error-correction model for each of the cross-sections separately. Since we have established the presence of cointegration relationships among the variables of interest, we can proceed under the assumption that our parameter estimates follow a normal distribution and that standard critical values apply.

In a final step, we thus regress the loading coefficients (α_1) obtained from equation (2) on standard gravity-type variables (log distance, log size of the reporting and the recipient country). Additionally, we include variables which measure the degree of financial integration, such as a dummy variable indicating whether the two countries are members of the European Union, whether the two countries are members of the Euro Area, and dummy variables for the presence of capital controls on cross-border financial credits. We also include a proxy for the total country risk, taken from *Euromoney*. Data for country risk and for the presence of capital controls are averages over the post-1995 period. Results are reported in Table 8.

Table 8

Gravity Regressions Explaining Loading Coefficients

	Assets				**Liabilities**			
	No weights	No weights	Weighted	Weighted	No weights	No weights	Weighted	Weighted
Log GDP *i*	–0.022*	–0.02	–0.012*	–0.017*	–0.01	0.00	0.00	–0.01
	(2.09)	(1.47)	(1.86)	(1.65)	(0.82)	(0.15)	(0.27)	(0.45)
Log GDP *j*	0.00	–0.01	0.00	0.00	0.00	–0.02	0.00	–0.01
	(0.58)	(0.82)	(0.18)	(0.33)	(0.19)	(1.24)	(0.78)	(0.65)
Log distance *ij*	–0.02	–0.01	–0.012*	–0.01	–0.02	–0.01	–0.015*	–0.02
	(1.50)	(0.68)	(1.69)	(0.78)	(1.08)	(0.55)	(1.68)	(1.12)
Both Euro Area members (0/1)	–0.03	–0.04	–0.01	–0.03	–0.03	0.02	–0.03	–0.03
	(1.07)	(0.84)	(0.68)	(0.80)	(0.60)	(0.40)	(1.44)	(0.71)
Both EU members (0/1)	0.00	0.04	0.00	0.02	0.01	0.03	0.01	0.01
	(0.00)	(0.71)	(0.18)	(0.36)	(0.14)	(0.33)	(0.47)	(0.20)
Euromoney total risk index *i*	0.001*	0.00	0.001**	0.00	0.00	–0.003***	0.00	–0.001***
	(2.59)	(0.75)	(2.22)	(0.10)	(0.85)	(3.03)	(0.49)	(3.18)
Euromoney total risk index *j*	0.00	0.00	0.00	–0.002**	0.00	0.00	0.00	0.00
	(0.61)	(0.31)	(0.40)	(2.48)	(1.33)	(0.05)	(0.40)	(1.33)
Capital controls *i*	0.07	◊	0.04	◊	0.52	◊	0.05	◊
	(0.26)		(0.22)		(1.51)		(0.24)	
Capital controls *j*	–0.04	0.02	–0.01	0.00	0.03	0.02	0.02	0.02
	(1.29)	(0.18)	(0.29)	(0.01)	(0.77)	(0.18)	(1.05)	(0.31)
Constant	0.37*	0.33	0.20**	0.29	0.23	0.24	0.13	0.30
	(2.33)	(1.12)	(1.97)	(1.32)	(1.20)	(0.71)	(1.13)	(1.25)
Fixed effects *i*	no	yes	no	yes	no	yes	No	Yes
Fixed effects *i*	no	yes	no	yes	no	yes	No	Yes
Observations	227	227	227	227	227	227	227	227
R-squared	0.10	0.24	0.05	0.18	0.03	0.26	0.03	0.20

The dependent variable is the loading coefficient obtained from an estimate of equation (2). Weights are the inverse of the variances of equation (2). See main text and Slaughter (2001) for details on the construction of these weights. *i* = reporting country, *j* = recipient country. ◊ Variable drops out because of collinearity when country fixed effects are included. Robust *t*-statistics in brackets.

In these regressions, we have to take into consideration that the dependent variable is estimated with some degree of imprecision. We follow Slaughter (2001) in first running our equation of interest using OLS. We then use the squared residuals from this equation as the dependent variable in an equation using estimated variances of α_{ij} , squared variances, and cubed variances as regressors. From this regression, we construct the predicted values, and we use the inverse of the predicted values as weights in our original regression equation.

We report different specifications, including and excluding country fixed effects and using weighted and unweighted regressions. Not all of the results are robust across specifications, but there is some evidence that the impact of domestic market size is negative for foreign assets. This would indicate that cross-border assets and liabilities of large countries are less persistent (i.e. an increase in domestic GDP lowers α_1 in absolute terms, bringing it closer to zero). There is weak evidence for a negative impact of distance. Hence, larger distances – which can be taken as an indication for a lower degree of integration of markets and a greater degree of unfamiliarity – make adjustment to a new equilibrium faster.

The impact of recipient country risk differs for foreign assets and liabilities. Note that a higher index indicates that countries are less risky. Hence, finding a positive coefficient would imply that lower country risk makes the adjustment to a new equilibrium slower. As country risk declines, the speed of adjustment of foreign liabilities increases, and the speed of adjustment of foreign assets decreases. In other words, banks from less risky home countries hold more persistent foreign asset positions but less persistent foreign liability positions abroad.

6. Summary

Using new data on bilateral assets and liabilities of banks of ten BIS reporting countries vis-à-vis the OECD area, this paper has focused on three questions. First, what are the long-run determinants of international portfolio choices? Second, how do banks' international portfolios adjust to short-run macroeconomic developments? Third, does convergence to the long-run equilibrium change with the degree of financial integration?

Our empirical model proceeds in three steps, using panel cointegration techniques. First, we test for the presence of unit roots, which we cannot reject. Second, we test for the presence of cointegration relationships between banks' cross-border assets and liabilities and macroeconomic variables, and we estimate the long-run cointegration parameters. In a third step, we estimate heterogeneous short-run dynamics and adjustment coefficients, conditioned on the homogeneous long-run parameter restrictions.

Our research has five main findings.

First, banks' cross-border assets and liabilities and macroeconomic variables are cointegrated. The most robust results are that banks hold larger assets and liabilities in larger foreign markets. An increase in the interest rate differential between the home and the foreign economy increases cross-border assets and lowers cross-border liabilities. This result is inconsistent with a simple arbitrage model.

Second, within the Euro Area, we find a positive effect of the interest rate differential on both cross-border assets and cross-border liabilities. Unobserved exchange rate expectations can thus not explain the difference between our findings and the predictions of baseline arbitrage models.

Third, our findings are robust against including measures of bilateral trade. We confirm that banks' cross-border activities are significantly and in most cases positively related to foreign trade. The main exceptions are international financial centres, for which we find some evidence for negative links between trade and banks' cross-border assets and liabilities.

Fourth, determinants of assets and liabilities vis-à-vis banks and non-banks differ. Our model performs much better in terms of explaining the linkages between banks and non-banks than those between banks. For the full sample, results for the return proxies are also more in line with expectations for assets and liabilities vis-à-vis non-banks. For the Euro Area sub-sample, in contrast, return proxies have the expected signs for the interbank linkages.

Fifth, there is a large degree of heterogeneity across countries, both with regard to the long-run determinants of banks' international portfolios and the short-run dynamics. Geographic distance, country risk, and market size explain some of the cross-country differences in the speed of adjustment to a new equilibrium.

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Data Appendix

Cross-border assets and liabilities: Data on banks' international portfolios are taken from the Locational Statistics of the BIS. They cover worldwide international on-balance sheet assets and liabilities of BIS reporting banks, including international positions of banks' head offices in the source countries and all offices at home and abroad, in millions of US Dollars. The data are defined as in Tables 2A, 2B, 3A, and 3B of the BIS Quarterly Review. Unpublished bilateral data have kindly been provided by the Statistics Department of the BIS. Over time, several changes to the reporting limits and the country coverage have been made. However, the effects of these changes on the data we use and for the country pairs that are included are minor. The regression results are based on a balanced panel of observations for the quarters 1995:4 through 2005:4 and a total of 221 country pairs.

Exchange rates: Bilateral exchange rates are in price quotation and are calculated using exchange rate series given in national currency against the US Dollar, provided by Datastream. Exchange rates of members of the European Monetary Union are expressed in the former national currency versus the US Dollar by multiplying the exchange rate of the Euro versus the US Dollar with the official conversion rate of the respective EMU member country.

Gross domestic product (GDP): Seasonally adjusted data as provided by the OECD, in millions of US Dollars. Due to the lack of availability or short length of the time-series, seasonally unadjusted data have been used for Iceland, Luxembourg, Mexico, Poland, Sweden, Turkey, and Hong Kong SAR, with this last GDP taken from national sources as reported by Datastream. Data for the Netherlands were taken from the International Financial Statistics (IMF (2006)).

Interest rates: For most countries, we use a monthly average of the three-month interbank offered rate as reported by Datastream. We take 90-day certificates of deposit for Japan, Korea, and the United States and treasury bills with the same maturity for Australia, Canada, Hungary, Iceland, New Zealand, and Sweden. The interest rate series for Luxembourg was taken from Belgium.

Prices: Represented by each country's consumer price index taken from Datastream.

Trade: Bilateral trade data are taken from "Direction of Trade Statistics" (DOTS) of the International Monetary Fund. Data are denominated in US Dollars. Because data for Belgium are only available since 1997 and only the total value of exports and imports for Belgium and Luxembourg together is available before that date, we assign 90 percent of these values to Belgium's exports and imports for the missing observations.

All data have been seasonally adjusted using the US Census Bureau's X12 seasonal adjustment procedure as implemented in *EViews*.