# Bank Linkages, Diversification, and Contagion

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June 19, 2013

**Abstract**

The relation between international financial linkages and the synchronization of business cycles is ambiguous. In cross-section, business cycles in countries with large cross-holdings of financial assets are highly correlated; but controlling for country-pair fixed effects, capital tends to flow between economies that are out of sync. This could mean that highly correlated economies tend to be financially integrated because of time-invariant social or cultural commonalities, or that the consequences of financial linkages on cycle synchronization depend on the frequency of observation. This paper introduces a panel estimation where long and short run relationships can be estimated simultaneously. It shows that both low and high frequency changes in financial integration have negative consequences on the international synchronization of cycles over time. Recent vintages of loans only matter in the short run, while older vintages matter in the long run. Interestingly, both effects are driven by bank loans to the non-financial sector, rather than by interbank lending.

JEL classification: F30, F44

Keywords: business cycle, synchronization, financial integration

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## 1 Introduction

The relation between international financial linkages and the synchronization of business cycles is ambiguous. In cross-section, business cycles in countries with large cross-holdings of financial assets are highly correlated (see Imbs, 2006); but over time, capital flows between economies that are out of sync (see Kalemli-Ozcan, Papaioannou and Peydro, 2013 - KPP from now on). This could mean the former result is driven by time-invariant omitted variables, for instance of a social or cultural nature, that create both highly correlated cycles and large financial linkages. But long run phenomena are typically associated with cross-sectional evidence, whereas short run ones are identified in time series within-group in the panel. Thus an alternative interpretation is that low frequency increases in capital cross-holdings tend to favor contagion across countries in the long run, whereas in the short run capital flows reflect a diversification motive between countries with negatively correlated cycles.

The estimations that exist in the literature focus on one frequency range, at the exclusion of all others. For example, between-group estimates are obtained in simple cross-section, where the short-run relation between finance and cycle synchronization is not controlled for. If some of the variables at play contain unit roots, Engle and Granger (1987) have shown it is important to control for long-run cointegration to evaluate short-run dynamics. They developed the error correction model (ECM) to estimate both effects at once. The argument generalizes to stationary variables, in autoregressive distributed lag (ARDL) models. ARDL models identify simultaneously short and long run relations between variables that are stationary, but display sophisticated dynamic interactions. Pesaran and Shin (1999) have shown the two models have similar asymptotic properties whether non-stationarity is an issue, or not.

This paper adapts both approaches to the question at hand. What are the long and short run relations between the cross-holdings of financial assets and the international synchronization of business cycles in a framework where both are estimated simultaneously? The question is important from a statistical standpoint, as the cross-sectional and the within-group estimations are both special cases of the ARDL models (and the ECM). In fact, cross-sectional and within-group estimates each conflate short and long run relations, which renders their interpretation difficult.

The question is also important economically, because cross-holdings of capital are stocks, and thus typically very persistent in normal times. But they are also occasionally affected by sudden large reversals, as in the recent episode. It is of the essence to disentangle precisely the consequences of these short run reversals, from those of normal time accumulation. Econometrically, that must be done in one single estimation, in the form of an ARDL model or an ECM. Only then is it possible to know the relative magnitude of the short vs. long run consequences of capital cross-holdings.

This paper first implements both estimators on conventional data and conventional measures of the variables of interest, where the sign reversal just described prevails. Financial linkages $\kappa_t$ are measured using bilateral BIS international banking statistics on locational basis, normalized in a variety of ways, and cycle correlations $\rho_t$ are measured for each year as the bilateral difference in growth rates. With these data, the cross-section of bilateral cycle synchronization correlates positively with the cross-section of bilateral financial linkages (the between country-pair estimate). But changes in cycle synchronization correlate negatively with changes in financial linkages, the within country-pair estimate. This is the key result in KPP.

The within country-pair estimate is a special case of the ARDL model (or equivalently the ECM), where lagged dependent variables are set to zero, and the relation between $\kappa_t$ and $\rho_t$ is static. The point estimate is neither a pure short run nor a pure long run effect: in fact, it is a combination of both. The same is true of the between country-pair estimate. Thus, both approaches in the literature identify a specific range of the dynamic relation between $\kappa_t$ and $\rho_t$, but neither is immediately interpretable as short or long run. When the same data are used to implement the ARDL model (or the ECM), the results point to negative and strongly significant estimates of the relation between $\kappa_t$ and $\rho_t$ both at short and long horizons. Importantly, this holds within country-pair, as the ARDL (or the ECM) models we estimate always include country-pair fixed effects. In other words, low frequency changes in capital cross-holdings continue to reflect a diversification motive, just like the short run, with coefficient estimates that are approximately of the same magnitude. Neither slow moving changes in cross-holdings of financial claims, nor sudden reversals in capital flows appear to have contagious consequences on cycle synchronization, at least when measured using bank loan data.

This dynamic feature of the inter-relations between $\kappa_t$ and $\rho_t$ is robust in the data. The paper verifies that it holds equally in the ARDL and the ECM, whether the stock of financial linkages is measured in the beginning or at the end of year $t$, and whether controls for bilateral goods trade or for EMU membership are included. As in Kalemli-Ozcan, Papaioannou and Perri (2013), the exclusion of the crisis years post 2007 tends to exacerbate the negative short-run effect, which virtually disappears from the data post-2008. The results are also invariant to country coverage, as they hold whether the sample includes 36 countries at various levels of development, or focuses on the reduced sample of 13 industrial countries included in the analysis in KPP.

Bilateral bank claims tend to exacerbate the output effects of asymmetric real shocks, as they change in response to international differentials in returns in order to smooth consumption. This magnification is the key mechanism in KPP, and it increases with the extent of financial linkages. It is in essence a high frequency mechanism, defined by the impact response of capital cross-holdings to real shocks. The data suggest that slow moving changes in the stock of cross-holdings are also negatively correlated with slow moving changes in cycle synchronization. A natural interpretation is that bank lending is allocated to insure against shocks in the short run, and to take advantage of return differentials in the long run: as countries growth rates slowly converge, banks curtail lending.

Do different kinds of financial flows have the same short- and long-run implications on business cycle correlations? To answer this question, a measure of financial integration is computed using data on syndicated lending only, collected from Dealogic Loan Analytics data at individual bank level. The results are unambiguous: syndicated bank lending has similar, if anything larger, effects on business cycle synchronization than total bank claims reported by the BIS. An added advantage of Dealogic Loan Analytics data is their information on loan vintages, which can help distinguish short from long run consequences of bank lending. Consistent with the ECM results, recent loans only have negative short-run effect, while older loans that change at a lower frequency are the only ones with negative long run consequences. The result is suggestive that recent vintages of loans help deliver short-run diversification, as they can change at relatively high frequencies. The accumulated stock of old vintages cannot: it changes slowly, and correlates negatively with slow moving changes in return differentials, as if it were chasing high returns.

Finally, for both BIS data and Loan Analytics, total loans are decomposed into claims on financial and non-financial sectors, and the analysis repeated. Both short and long run effects are at work via lending to the non-financial sector. In contrast, loans to financial institutions have some significant consequences on business cycles in the short run, but not in the long run. In other words, both diversification and returns chasing correspond to loans that are contracted with the real economy. Loans between banks have little systematic consequences on cycle synchronization, especially in the long run. This could be because contagion is at play there, and offsets the mechanisms that exist for lending to the real economy.

The effects of loans to non-financial institutions confirm unambiguously the diversification role played by bank lending to the real sector, both at short and long horizons. Lending to financial sector, in contrast, appears to reflect different motives. Two questions emerge from this analysis. First, are there characteristics of bank lending to financial sector that are observably associated with contagion, i.e. that translate in more synchronized cycles? Second, are there networks of international investment other than bank lending that have had contagious consequences on cycles before 2007? If not, the Great Recession will truly have been a global shock that is unprecedented in history.

The rest of the paper is structured as follows. Next section describes the empirical methodology used in order to account simultaneously for the short and long term consequences of financial linkages. Section 3 introduces the data and measurement of the main variables of interest. Section 4 presents the results and section 5 concludes.

## 2 Empirical methodology

Let $\rho_t$ be a measure of business cycle synchronization between countries $i$ and $j$, where the country-pair subscript is omitted for clarity. Analogously, denote with $\kappa_t$ the bilateral financial integration between countries $i$ and $j$ measured at the beginning of year $t$. The autoregressive distributed lag (ARDL) model writes

$$\rho_t = \alpha_{ij} + \gamma t + \sum_{s=1}^{S} \beta_s \rho_{t-s} + \sum_{p=0}^{P} \delta_p \kappa_{t-p} + \varepsilon_t. \tag{1}$$

Equation (1) nests the pure cross-sectional estimation with $\gamma = 0$, $\beta_s = 0$ for all $s \geq 1$ and $\delta_p = 0$ for all $p > 0$. The between country-pair effect is simply given by $\alpha_{ij}$. The pure within country-pair estimate obtains, in turn, when $\beta_s = 0$ for all $s \geq 1$, and $\delta_p = 0$ for all $p > 0$. In both instances, the serial correlation in $\rho_t$ is assumed away, and the relation between $\rho_t$ and $\kappa_t$ is constrained to be static. The two estimations are in fact identical, but the former focuses on estimates of $\alpha_{ij}$, whereas the latter is interested in estimates of $\delta_0$. The question is whether long-run estimates of $\delta_0$ continue to be positive even in the presence of $\alpha_{ij}$.

Subtracting $\rho_{t-1}$ from both sides of equation (1) yields the following error correction representation of the ARDL model:

$$\Delta\rho_t = \alpha_{ij} + \gamma t - \sum_{q=1}^{S-1}\left(\sum_{s=q+1}^{S}\beta_s\right)\Delta\rho_{t-q} + \delta_0\Delta\kappa_t$$
$$-\sum_{\tau=1}^{P}\left(\sum_{p=\tau}^{P}\delta_p\right)\Delta\kappa_{t-\tau} + \left(\sum_{s=1}^{S}\beta_s - 1\right)\left(\rho_{t-1} - \frac{\sum_{p=0}^{P}\delta_p}{1-\sum_{s=1}^{S}\beta_s}\kappa_{t-1}\right) + \varepsilon_t, \tag{2}$$

where $\Delta\diamond_t = \diamond_t - \diamond_{t-1}$. The contemporaneous short run effect of $\kappa_t$ on $\rho_t$ is given by $\delta_0$, while the long-run effect is given by $\sum_{p=0}^{P}\delta_p/(1-\sum_{s=1}^{S}\beta_s)$, i.e., the negative of the ratio of the coefficient on $\kappa_{t-1}$ to the coefficient on $\rho_{t-1}$ in the EC model. Both are estimated in the within-group dimension, since intercepts specific to each country pair are included in equation (2). This is important as these country pair fixed effects control for any time-invariant commonalities between countries $i$ and $j$, such as economic, social or cultural links, which could affect simultaneously $\rho_t$ and $\kappa_t$. In addition, equation (2) also accounts for common dynamics in $\rho_t$ and $\kappa_t$ by including year fixed effects. Pesaran and Shin (1998) show that equations (1) and (2) have similar asymptotic properties, whether or not stationarity is an issue in $\kappa_t$ and $\rho_t$.

If $\rho_t$ is stationary, the ARDL model can imply a sign reversal at different horizons, if estimates of $\delta_0$ and $\sum_{p=0}^{P}\delta_p$ are found to have opposite signs. In the literature on business cycle synchronization, no attention has been paid to the serial correlation properties of $\rho_t$ and $\kappa_t$, which are typically constrained to zero. In fact the pure within-group estimation in KPP can be interpreted as both the contemporaneous short run and a fraction of the long run effect in equation (2): In the version of equation (1) where $\beta_s = 0$ for all $s \geq 1$, and $\delta_p = 0$ for all $p > 0$, $\delta_0$ can be negative and significant for three reasons: the true short run effect is negative, or the true long run effect is negative, or both. Equation (2) is needed to know which one prevails in the data.

Equations (1) and (2) present an additional econometric difficulty: endogeneity. As argued in

KPP, capital cross-holdings can themselves respond to the nature of cycle correlation. A diversification motive implies that financial flows are large between dissimilar economies, a negative correlation between $\rho_t$ and $\kappa_t$, but with the causality going from output synchronization to capital flows. KPP address the issue with an instrument that tracks the steps of financial deregulation in each country, but decided at the European level and thus presumably exogenous to country-specific developments. Of course, this instrument is not available for other countries than the sample of industrialized European economies. Fortunately, a key conclusion of KPP is that the negative effect of $\kappa_t$ on $\rho_t$ is not a manifestation of reverse causality: their within-group estimate is negative whether $\kappa_t$ is instrumented, or not. This is reassuring for it suggests the endogeneity of $\kappa_t$ is not a crucial issue in equation (1).

## 3 Data sources and variable definitions

The time pattern of business cycles synchronization is of the essence in this paper, just as it is in KPP. The measure for $\rho_t$ has to be varying at relatively high frequency: it is given by

$$\rho_{1t} = -\left|(\ln Y_{i,t} - \ln Y_{i,t-1}) - (\ln Y_{j,t} - \ln Y_{j,t-1})\right|$$

where $Y_{i,t}$ is GDP in country $i$ at time $t$. This approach is taken directly from KPP and from Giannone, Lenza, and Reichlin (2008). As in these papers, GDP data are taken from World Development Indicator series on real GDP. Since the instrument tracking European financial deregulation is not imperative in this paper, the sample includes 36 countries, listed in the Appendix, with an unbalanced panel yearly observations from 1980 to 2011.[1] This is larger than the sample of industrial economies used in KPP.

There are many alternatives ways to compute cycle synchronization. Pearson correlation coef-

[1]Data exist for most, but not all of the 630 resulting country pairs.

ficients are an obvious one, see Frankel and Rose (1998). But since they must be estimated over time, they do not go without problems for the purpose at hand. For instance, if Pearson correlation coefficients are computed over rolling time periods, their consecutive realizations will display persistence as a mere result of their construction, rather than for fundamental reasons (see for instance Doyle and Faust, 2005). If instead Pearson correlation coefficients are computed over non overlapping time periods, then the time dimension of $\rho_t$ becomes substantially smaller and short-run effects become difficult to capture. This represents a difficulty when estimating equations (1) or (2), where the time pattern of $\rho_t$ is of the essence. For instance, yearly data between 1980 and 2011 imply a maximum of 6 observations, far from sufficient to estimate an ARDL model.

KPP also introduce a time-varying measure of $\rho_t$ that can be computed year by year. It is inspired by Morgan, Rime, and Strahan (2004), and takes the following form:

$$\rho_{2t} = -\left|\nu_{i,t} - \nu_{j,t}\right|,$$

where $\nu_{i,t}$ is the residual of the regression $\ln Y_{i,t} - \ln Y_{i,t-1} = \alpha_i + \phi_t + \nu_{i,t}$, of GDP growth on a country-specific intercept and a common trend. Note that $\rho_{2t}$ can be rewritten as

$$\rho_{2t} = -\left|(\ln Y_{i,t} - \ln Y_{i,t-1}) - (\ln Y_{j,t} - \ln Y_{j,t-1}) - (\alpha_i - \alpha_j)\right|.$$

There is an important difference between $\rho_{1t}$ and $\rho_{2t}$: the latter is actually purged from long run differences in average GDP growth rates, with consequences on its serial correlation. This means that measuring cycle correlation using $\rho_{1t}$ or $\rho_{2t}$ will have consequences in an ARDL model where the serial correlation in cycle synchronization is accounted for. If anything, the long run relation between $\rho_{2t}$ and $\kappa_t$ should be weakened relative to $\rho_{1t}$: if it survives to measuring cycle correlations with $\rho_{2t}$, the long run effect of $\kappa_t$ on $\rho_t$ must be a strong and robust feature of the data.

The paper uses two main sources of data for financial integration $\kappa$. The first is similar to KPP, and builds from the total bilateral claims data collected by the Bank of International Settlements (BIS) locational banking statistics. All series are reported in U.S. dollars, and are deflated by the U.S. CPI. The main text makes use of the stocks of claims, and $\Delta\kappa_t$ is just that: the first difference in stock. Since short run changes in capital cross-holdings are important in this paper, the alternative valuation-adjusted flows, as computed by the BIS, are also used in place of $\Delta\kappa_t$. These adjustments typically reflect exchange rates movements. All of the paper's results are insensitive to this alternative. The paper also breaks down total claims into those that are reported to be outside of the banking sector, and the residual, claims on the banking sector.

BIS data are reported at the country level and offer limited details. A potentially fruitful alternative exists in the detailed syndicated loan data collected by Dealogic, known as Loan Analytics. These can be aggregated to compute the exposure of banks to financial and to non-financial sectors across all covered countries. By analogy with BIS locational data, exposure can then be aggregated by bank nationality. Exposure is computed by assuming that all loans are fully drawn and are not repayed until maturity date. The total amount of each loan is pro-rated across all syndicate participants, to compute total amounts of loans outstanding given the issue and the maturity date, as of the end of each year for each country pair. Loan Analytics data, like BIS data, allow to differentiate between exposure to financial and non-financial sectors. In addition, because we know the loan origination date, we can separate loans that were extended prior to year $t$ from loans extended in year $t$.

Measures of $\kappa_t$ must be normalized. The literature has proposed three such normalizations, with no obvious reason to favor any. The first one normalizes BIS (or Loan Analytics) data by the sum of country pair populations; the second one uses the bilateral sum of their GDPs, and the third one the sum of BIS-reported total claims on all countries, all in a given year. That third variable represents the share of the total claims of country $i$ that are held vis-à-vis country $j$. All shares are expressed in logarithms. In each case, financial integration is measured as of the beginning of each period.

There are other controls that have been shown to belong in equation (1), seeking to explain the cross section of $\rho_t$. The most prominent one is bilateral trade in goods (see Frankel and Rose, 1998, Baxter and Kouparitsas, 2005, among many others). This is computed from bilateral exports value, reported by the IMF Direction of Trade Statistics (DOTS), as the ratio of total trade to the bilateral sum of GDPs in each country pair.

Appendix reports the persistence of all synchronization and financial integration measures. Persistence is estimated in regressions of each variable on its own lag and its own lagged first-difference with country-pair and year fixed effects. Regardless of the sample, $\rho_{1t}$ is serially correlated, with persistence between 0.2 and 0.3. Unsurprisingly, $\rho_{2t}$ is less persistent with serial correlation around 0.15. Financial integration measures are very persistent, with coefficients above 0.8.

# 4 Results

The relation between financial integration and synchronization displays complex dynamics. To illustrate this fact, Figure 1 reports the cross-section of $\rho_{1t}$ (on the vertical axis) and $\kappa_t$ (on the horizontal axis) for a few specific years. The size of each point reflects the strength of bilateral goods trade, and $\kappa_t$ is normalized by population. Throughout the sample, the relation is unstable, with large shifts along the vertical axis, reflecting changes in cycles synchronization. For instance, a very clear decoupling is apparent in the late 1990's and into the early 2000's. It is also apparent that both financial integration and synchronization measures increased over time for most country pairs, illustrating the existence of low frequency phenomena in equations (1) and (2). On average, the cross-sectional relation between $\rho_{1t}$ and $\kappa_t$ appears to be upward sloped, but it is unclear whether this can be explained away just by common trends or country-pair averages.

Figure 2 reports the results of the same exercise, where for each considered year, $\Delta\rho_{1t}$ and $\Delta\kappa_t$ are now reported on the vertical and horizontal axes, respectively. Most observations are close to zero, and display more extreme realizations, which is not surprising given that measurement error is magnified in first differences. Negative correlations between $\Delta\rho_{1t}$ and $\Delta\kappa_t$ are apparent for a few years.

Figure 3 reproduces the scatterplot corresponding to 2009 in Figure 1, but now highlights the path of the country pair USA-France from 1980. This example helps illustrate the within group dynamics for a specific pair: clearly, both $\rho_{1t}$ and $\kappa_t$ have displayed a positive trend between France and the USA since 1980. But there were also episodes when financial integration kept increasing, while synchronization fell dramatically: in the early 1980s, the early 1990s, and the early 2000s, years of U.S recessions. Therefore, at least in the case of the linkages between the US and France, the overall long run trend is positive, but that is interrupted by short-lived episodes of negative correlation.

### 4.1 Short-Run and Long-Run

These patterns are consistent with the findings in the literature, which we now replicate. In line with KPP, cycle synchronization is measured by $\rho_{1t}$, and cross-holdings are based on BIS claims data, normalized by population, GDP and total claims. In Tables 1 and 2, the first three columns represent the largest possible sample of countries warranted by BIS data, up to 34 countries for 561 country pairs, depending on the weighting, with coverage from 1980 to 2007. The sample is limited by the inclusion of controls for bilateral trade in columns (4)-(6), and constrained further in columns (7) and (8) to only contain the 13 industrial countries used in KPP. All regressions include year fixed effects.

Table 1 reports the cross-sectional results, i.e. the between-group coefficient estimates of $\rho_{1t}$ regressed on $\kappa_t$. As in Imbs (2006), the coefficient estimates are always positive and significant at 1 or 5% confidence level. Table 2 reports the within-group estimates from the same regression, using the same range of alternative measures of $\kappa_t$, controls for trade, and alternative samples. As in KPP, the within-group coefficient estimates are always negative and significant at the 1% confidence level.

Table 3 presents the results of the ECM presented in equation (2). We choose $S = 2$ and $P = 1$ or 2 because none of the additional lagged variables were significant in any specification. Therefore the first 4 columns report results for $P = 1$, and the last 4 report results for $P = 2$. For each group of four columns, capital cross-holdings $\kappa_t$ are measured with BIS data, scaled in turn by population, GDP, and total claims. The fourth and last columns focus on the sample of countries in KPP. For clarity, the implied short-run and long-run coefficients are reported at the bottom of the table, along with their P-values (the short run coefficient is just $\delta_0$) with P-value corresponding to the t-test, while the P-value for the long run effect computed using F-test.

All specifications confirm serial correlation in $\rho_t$ is an important feature of the data, and that $\kappa_{t-1}$ (and $\Delta\kappa_t$) have distinct, significant effects on $\rho_t$. Given these facts, there will be a long run effect of $\kappa_t$ on $\rho_t$, even in a pure within-group estimation as equation (2). The bottom of Table 3 confirms this to be the case in all eight specifications: with $\kappa_t$ normalized by population or by GDP, the long run effect is negative and significant at 1% confidence level, and that is also true in the reduced sample used in KPP. Only when $\kappa_t$ is measured as a share of total claims is the effect somewhat less significant, at the 5% confidence level with $P = 1$ and at 10% confidence level with $P = 2$. The short run effect is, as well, negative and significant across all specifications – interestingly with the exception of the reduced sample used in KPP with $P = 1$, where the effect is not statistically different from zero (due to a larger standard error — the point estimate is roughly the same). Both short and long run coefficients have approximately the same magnitude, with the exception of specification 4, in KPP sample, where the long run effect is substantially larger.

Table 4 reports robustness tests for the ECM regressions. In order to use the largest sample possible, and to challenge our weakest results, we limit this analysis to BIS-weighted measure of financial integration. The upper panel runs several variations of the benchmark specification of equation (2), while still measuring correlations with $\rho_{1t}$. The lower panel runs the same variations using $\rho_{2t}$. Column (1) in the upper panel repeats the benchmark regression, for the ease of comparison. Across both panels, column (2) reports the results when $\kappa_t$ is measured at the end instead of the beginning of each period, column (3) reports the ARDL results from the estimation of equation (1), and column (4) combines both alterations. The last four specifications modify the estimation sample: column (5) includes years post-2007, and the last two specifications compute $\kappa_t$ from syndicated loan data excluding and including post-2007 years, respectively.

Several results are worth emphasizing. First, across both panels of Table 4, both short run (within) negative effects and long run (within) negative effects survive.The magnitude of the point estimates is also largely unchanged. Second, the timing of measurement for $\kappa_t$ matters very little, which is not surprising given the persistence in this stock measure. Third, results are virtually identical for the estimations of equations (1) and (2), which confirms the asymptotic findings in Pesaran and Shin (1999). Whether non-stationarity is an issue or not, ECM and ARDL are asymptotically equivalent. Fourth, including the crisis years post-2007 weakens the significance of the negative short run effect of financial integration, as in Kalemli-Ozcan, Papaioannou and Perri (2013). In fact, in two cases short-run effect is weakened so much that it becomes insignificant when we include crisis years: with $\rho_1$ and BIS-based $\kappa$ and with $\rho_2$ and Loan Analytics-based $\kappa$. Fifth and finally, both short and long run effects prevail if $\kappa_t$ is computed from an alternative data source, and if correlations are measured using $\rho_{2t}$. The latter fact is interesting, for it suggests there are long run effects of $\kappa_t$ on $\rho_t$ even when the persistence of $\rho_t$ is limited by construction: these must be a robust feature of the data.

Unreported additional robustness tests show that substituting $\Delta\kappa_t$ with valuation-adjusted flow measures (reported by BIS), or with new syndicated loan origination (for Loan Analytics) does not alter the results.[2] This suggests short-run effects are not driven by movements in the exchange rates or by the maturation of previously issued loans. We also find that the results are robust to controlling for trade integration and allowing synchronization to be different in different time periods for pairs where both countries are EMU members, or only one country is an EMU member.

These results imply that diversification is not the only mechanism for negative relation between bank linkages and cycle synchronization, as diversification implies contemporaneous, or short-run, response of lending to growth differences. One mechanism for such low-frequency relation could be return chasing — as banks observe converging trends, they reduce their exposure to countries that are becoming more similar.

### 4.2 Decomposition of financial linkages measures

If it is true that both short run changes in lending and long run financial claims accumulation tend to be associated with negatively correlated cycles, a similar result should appear when short- vs. long-lived changes in $\kappa_t$ are isolated differently. Loan Analytics data make it possible to actually identify the vintage of each loan, and thus verify whether recent loans at each point in time have different consequences on $\rho_t$ than older vintages. To that end, we decompose the stock of previously issued loans in Loans Analytics data into loans of different vintages: recent issues and older issues. We use two alternative thresholds for splitting loans into recent and older issues — 1 or 2 years. We do not split $\Delta\kappa_t$ because it is only affected by new issues and repayments, i.e. change in the stock of older issues is only due to maturation, which we do not believe to be informative.

Table 5 reports the results of estimating equation (2) with this decomposition: the first two

[2]The difference between change in total exposure from syndicated loans and new loan origination is the amount of loans that matured in year $t$.

specifications exclude the crisis years, the last two do not, and once again $P = 1$ while $S = 2$. Thus, both short and long run effects can be estimated for each loan vintage; they are reported at the bottom of the Table. In columns (1) and (3) recent loans are defined as those that were originated no more than one year prior to the the exposure measurement. In columns (2) and (4), loans are recent if they were originated no more than two years prior. Regardless of how loan data are split, the short-run effect remains negative, the long-run effect of older issues is negative and statistically significant, while the long-run effect of recent loans is not statistically significant. These results are not affected by whether or not crisis years are included. They confirm that the frequency of changes in financial linkages is a factor in determining their consequences on cycle correlations. For countries that are becoming slowly out of sync, the stocks of banking claims tend to be dominated by older vintages.

Table 6 proceeds with a decomposition of $\kappa_t$ into loans extended to financial companies, and loans made to the non-financial sector. To maximize coverage, $\kappa_t$ is normalized everywhere by total claims from BIS, and the specification is akin to the first half of Table 3, with $P = 1$ while $S = 2$. The first two columns focus on the pre-crisis period, the last two include the crisis years. For each sample, the first specification decomposes $\kappa_t$ from the BIS data, and the second uses Loan Analytics (LA) data.

Results in Table 6 suggest that both of the relations just documented are channeled via loans between banks and the real sector. In BIS data, the short run (negative) effect prevails for both components of $\kappa_t$, whether the loans are extended to financial firms or not. But in Loan Analytics data, it is only loans to the real sector that have a significant effect in the short run. Similarly, long run effects are only significant for loans made to the non-financial sector, irrespective of how $\kappa_t$ is measured. In addition, none of these conclusions depend on whether the crisis years are included, an intriguing result given the anecdotal view that interbank linkages are key to explaining the recent global recession. It must be that the end effects of financial linkages on *real* business cycles depend at the end of the day on credit to the real sector.

## 5 Conclusion

Changes in the intensity of financial linkages have negative consequences for the international correlation of business cycles at all frequencies. At high frequencies, this corresponds to a well known diversification motive. At low frequencies, it may represent returns chasing: banks choose to curtail lending between countries whose growth rates converge. These conclusions are driven primarily by loans made to the real economy. Lending to financial sector, in contrast, does not correlate systematically with cycle synchronization. This could potentially be the result of diversification motives being obscured by contagion.

# References


Baxter, Marianne and Michael A. Kouparitsas (2005). "Determinants of business cycle comovement: a robust analysis," *Journal of Monetary Economics,* 52(1): 113-157.

Doyle, Brian M. and Jon Faust (2005). "Breaks in the Variability and Comovement of G-7 Economic Growth," *The Review of Economics and Statistics*, 87(4): 721-740.

Engle, Robert F. and C.W.J. Granger (1987). "Co-Integration and Error Correction: Representation, Estimation, and Testing," *Econometrica*, 55(2):251-276.

Frankel, Jeffrey A. and Andrew K. Rose (1998). "The Endogeneity of the Optimum Currency Area Criteria," *Economic Journal*, 108(449): 1009-25.

Giannone, Lenza, and Reichlin (2008). "Business cycles in the Euro Area," in Alesina, Alberto and Giavazzi, Francesco, eds. *Europe and the Euro*, Chicago University Press, Chicago, IL.

Imbs, Jean (2006) "The Real Effects of Financial Integration," *Journal of International Economics*, 68(2):296-324.

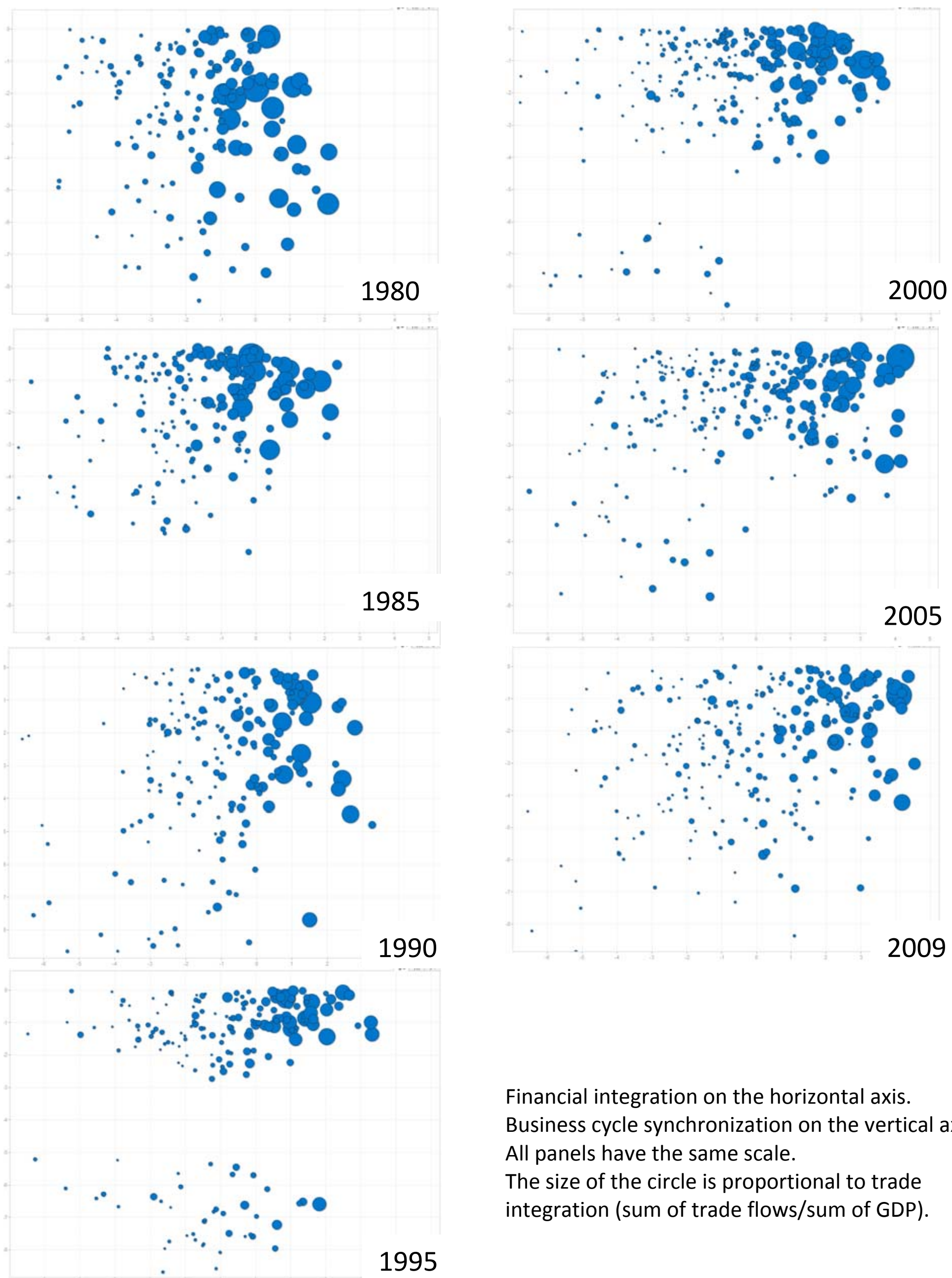
Kalemli-Ozcan, Sebnem, Elias Papaioannou and Jose Luis Peydro (2013) "Financial Regulation, Financial Globalization and the Synchronization of Economic Activity," *Journal of Finance*, 68(3): 1179-1228.

Kalemli-Ozcan, Sebnem, Elias Papaioannou and Fabrizio Perri (2013) "Global Banks and Crisis Transmission," *Journal of International Economics*, 89: 495-510.

Morgan, Donald, Bertrand Rime, and Philip E. Strahan (2004). "Bank Integration and State Business Cycles," *The Quarterly Journal of Economics*, 119(4): 1555-1584.

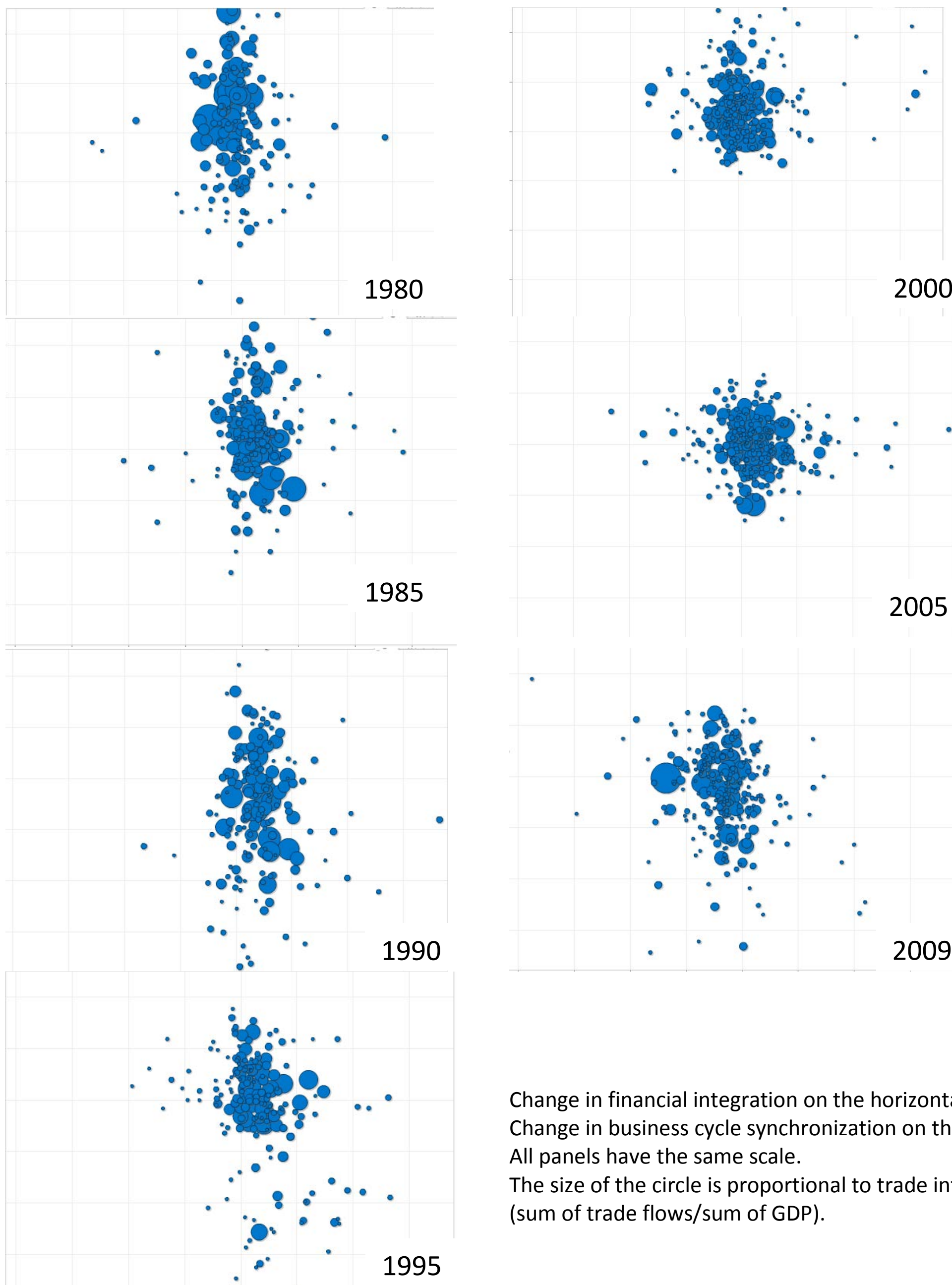
Pesaran, Hashem H. and Yongcheol Shin (1999), "An autoregressive distributed lag modelling approach to cointegration analysis,"' Ch. 11 in S. Strom (ed.), *Econometrics and Economic Theory in the 20th Century: The Ragnar Frisch Centennial Symposium*, Cambridge University Press, Cambridge, MA.

Figure 1: Financial integration and business cycle synchronization over time




Financial integration on the horizontal axis.
Business cycle synchronization on the vertical axis.
All panels have the same scale.
The size of the circle is proportional to trade integration (sum of trade flows/sum of GDP).

Figure 2: Changes in financial integration and business cycle synchronization over time




Change in financial integration on the horizontal axis.
Change in business cycle synchronization on the vertical
All panels have the same scale.
The size of the circle is proportional to trade integration
(sum of trade flows/sum of GDP).

Figure 3: Financial integration and business cycle synchronization: an example

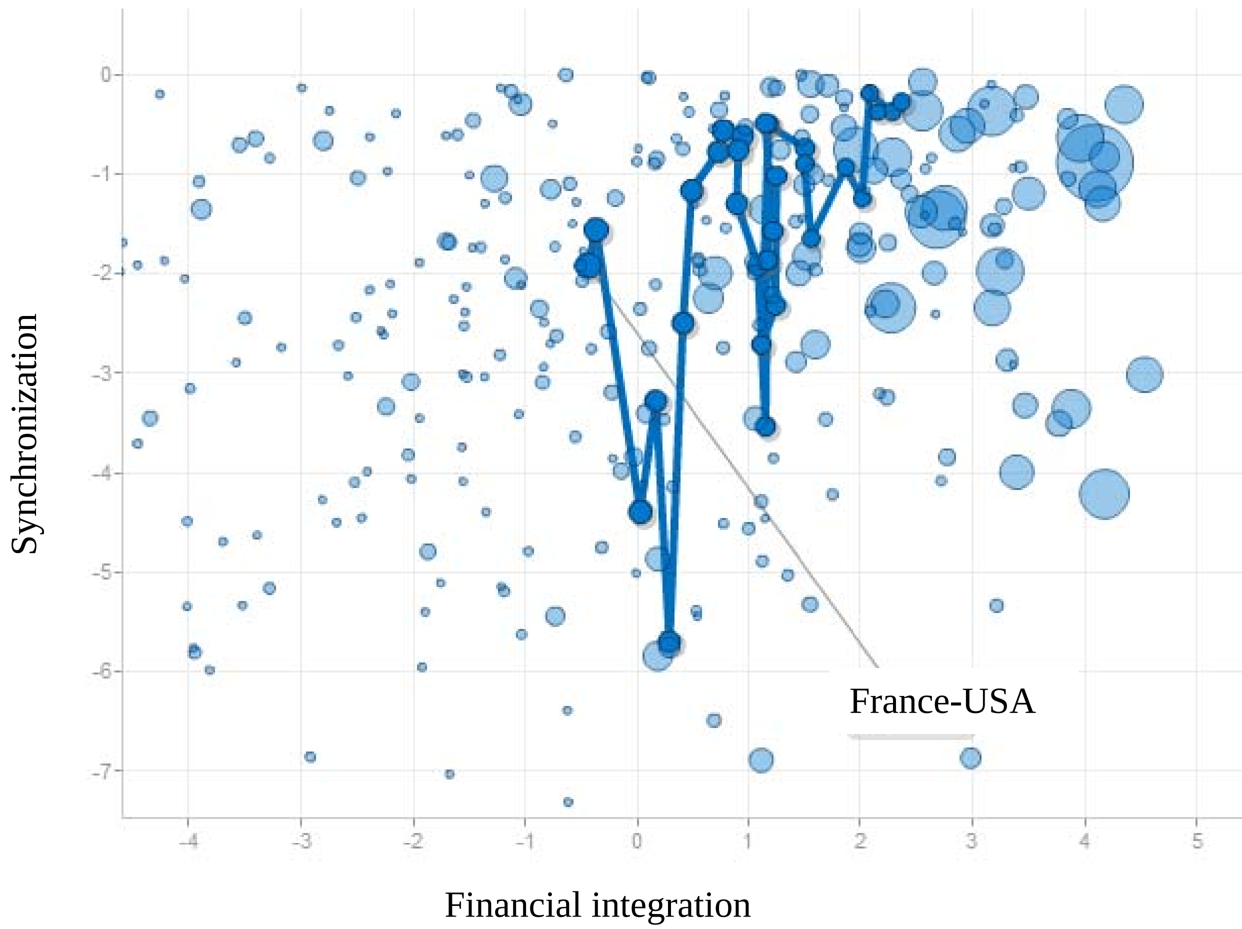


Table 1: Cross-section. Between regression.

| | Pop weigh | GDP weight | BIS weight | Pop weigh | GDP weight | BIS weight | KPP sample<br>Pop weigh | <br>GDP weight |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| $\kappa_t$ | 0.274*** | 0.237*** | 0.233*** | 0.187*** | 0.150*** | 0.148** | 0.133** | 0.139** |
| | (0.0293) | (0.0387) | (0.0444) | (0.0356) | (0.0486) | (0.0606) | (0.0536) | (0.0534) |
| Trade | | | | 0.0770 | 0.134** | 0.164*** | | |
| | | | | (0.0568) | (0.0609) | (0.0599) | | |
| Observations | 11355 | 11355 | 11825 | 6176 | 6176 | 6176 | 1991 | 1991 |
| Adjusted $R^2$ | 0.233 | 0.161 | 0.140 | 0.415 | 0.378 | 0.371 | 0.203 | 0.210 |

Dependent variable is $\rho_{1t}$. BIS-based financial integration variables weighted as indicated.
Year fixed effects included in all regressions.
Standard errors are in parentheses. *(P< 0.10), **(P< 0.05), ***(P< 0.01)

Table 2: Within effects. Fixed effects regression.

| | | | | | | | KPP sample | |
|---|---|---|---|---|---|---|---|---|
| | Pop weigh | GDP weight | BIS weight | Pop weigh | GDP weight | BIS weight | Pop weigh | GDP weight |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| $\kappa_t$ | -0.143*** | -0.141*** | -0.0958*** | -0.204*** | -0.213*** | -0.127*** | -0.343*** | -0.355*** |
| | (0.0267) | (0.0276) | (0.0293) | (0.0300) | (0.0311) | (0.0333) | (0.0406) | (0.0416) |
| Trade | | | | -0.402*** | -0.387*** | -0.464*** | | |
| | | | | (0.0939) | (0.0943) | (0.0938) | | |
| Observations | 11355 | 11355 | 11825 | 6176 | 6176 | 6176 | 1991 | 1991 |
| Within $R^2$ | 0.0797 | 0.0795 | 0.0782 | 0.0975 | 0.0976 | 0.0926 | 0.135 | 0.135 |

Dependent variable is $\rho_{1t}$. BIS-based financial integration variables weighted as indicated.
Country pair and year fixed effects included in all regressions.
Standard errors are in parentheses. *(P< 0.10), **(P< 0.05), ***(P< 0.01)

Table 3: ECM

| | Pop weigh | GDP weight | BIS weight | BIS + KPP | Pop weigh | GDP weight | BIS weight | BIS + KPP |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| $\rho_{t-1}$ | -0.723*** | -0.723*** | -0.738*** | -0.702*** | -0.725*** | -0.725*** | -0.736*** | -0.688*** |
| | (0.0119) | (0.0119) | (0.0117) | (0.0290) | (0.0122) | (0.0122) | (0.0119) | (0.0292) |
| $\Delta\rho_{1t-1}$ | -0.0328*** | -0.0329*** | -0.0220** | -0.000918 | -0.0224** | -0.0225** | -0.0132 | -0.000538 |
| | (0.00957) | (0.00958) | (0.00936) | (0.0241) | (0.00977) | (0.00977) | (0.00955) | (0.0245) |
| $\Delta\kappa_t$ | -0.147*** | -0.125** | -0.122** | -0.186 | -0.154*** | -0.138** | -0.132** | -0.279* |
| | (0.0508) | (0.0509) | (0.0526) | (0.140) | (0.0558) | (0.0562) | (0.0575) | (0.144) |
| $\Delta\kappa_{t-1}$ | | | | | -0.0364 | -0.0206 | -0.0402 | 0.105 |
| | | | | | (0.0516) | (0.0517) | (0.0533) | (0.141) |
| $\kappa_{t-1}$ | -0.0966*** | -0.0955*** | -0.0755** | -0.318*** | -0.0891*** | -0.0891*** | -0.0598* | -0.249*** |
| | (0.0284) | (0.0295) | (0.0315) | (0.0613) | (0.0309) | (0.0321) | (0.0346) | (0.0646) |
| Observations | 10778 | 10778 | 11225 | 1704 | 10224 | 10224 | 10648 | 1635 |
| Within $R^2$ | 0.416 | 0.416 | 0.421 | 0.419 | 0.416 | 0.416 | 0.419 | 0.423 |
| SR effect | -0.147*** | -0.125** | -0.122** | -0.186 | -0.154*** | -0.138** | -0.132** | -0.279* |
| LR effect | -0.134*** | -0.132*** | -0.102** | -0.453*** | -0.123*** | -0.123*** | -0.0813* | -0.362*** |

Dependent variable is $\Delta\rho_{1t}$. BIS-based financial integration variables weighted as indicated.
KPP indicates sample limited to countries in KPP. Country pair and year fixed effects included in all regressions.
Standard errors are in parentheses.*(P< 0.10), **(P< 0.05), ***(P< 0.01)

Table 4: Robustness of ECM results.

| | Benchmark | EOP $\kappa$ | ARDL | ARDL + EOP $\kappa$ | + crisis years | LA $\kappa$ | LA $\kappa$ + crisis |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| | Dependent variable is $\Delta\rho_{1t}$ | | Dependent variable is $\rho_{1t}$ | | Dependent variable is $\Delta\rho_{1t}$ | | |
| $\rho_{t-1}$ | -0.738*** | -0.732*** | 0.240*** | 0.233*** | -0.723*** | -0.856*** | -0.860*** |
| | (0.0117) | (0.0115) | (0.00948) | (0.00933) | (0.0107) | (0.0156) | (0.0143) |
| $\Delta\rho_{1t-1}$ | -0.0220** | -0.0352*** | | | -0.0233*** | 0.0524*** | 0.0492*** |
| | (0.00936) | (0.00924) | | | (0.00870) | (0.0120) | (0.0112) |
| $\rho_{t-2}$ | | | 0.0220** | 0.0352*** | | | |
| | | | (0.00936) | (0.00924) | | | |
| $\Delta\kappa_t$ | -0.122** | -0.137*** | | | -0.0758 | -0.274*** | -0.208*** |
| | (0.0526) | (0.0514) | | | (0.0462) | (0.0763) | (0.0708) |
| $\kappa_{t-1}$ | -0.0755** | -0.0789*** | 0.0468 | 0.0578 | -0.0666** | -0.149*** | -0.129*** |
| | (0.0315) | (0.0305) | (0.0516) | (0.0505) | (0.0276) | (0.0381) | (0.0338) |
| $\kappa_t$ | | | -0.122** | -0.137*** | | | |
| | | | (0.0526) | (0.0514) | | | |
| Observations | 11225 | 11764 | 11225 | 11764 | 13408 | 7181 | 8823 |
| Within $R^2$ | 0.421 | 0.419 | 0.139 | 0.134 | 0.409 | 0.450 | 0.448 |
| SR effect | -0.122** | -0.137*** | -0.122** | -0.137*** | -0.0758 | -0.274*** | -0.208*** |
| LR effect | -0.102** | -0.108*** | -0.102** | -0.108*** | -0.0921** | -0.174*** | -0.150*** |
| | Dependent variable is $\Delta\rho_{2t}$ | | Dependent variable is $\rho_{2t}$ | | Dependent variable is $\Delta\rho_{2t}$ | | |
| $\rho_{t-1}$ | -0.839*** | -0.835*** | 0.187*** | 0.175*** | -0.826*** | -1.005*** | -0.981*** |
| | (0.0121) | (0.0120) | (0.00941) | (0.00932) | (0.0111) | (0.0163) | (0.0149) |
| $\Delta\rho_{1t-1}$ | 0.0254*** | 0.0101 | | | 0.0239*** | 0.0987*** | 0.0820*** |
| | (0.00929) | (0.00915) | | | (0.00868) | (0.0119) | (0.0111) |
| $\rho_{t-2}$ | | | -0.0254*** | -0.0101 | | | |
| | | | (0.00929) | (0.00915) | | | |
| $\Delta\kappa_t$ | -0.130** | -0.171*** | | | -0.106** | -0.158** | -0.107 |
| | (0.0509) | (0.0500) | | | (0.0441) | (0.0734) | (0.0667) |
| $\kappa_{t-1}$ | -0.0731** | -0.0843*** | 0.0566 | 0.0869* | -0.0977*** | -0.147*** | -0.123*** |
| | (0.0305) | (0.0296) | (0.0499) | (0.0491) | (0.0264) | (0.0367) | (0.0318) |
| $\kappa_t$ | | | -0.130** | -0.171*** | | | |
| | | | (0.0509) | (0.0500) | | | |
| Observations | 11225 | 11764 | 11225 | 11764 | 13408 | 7181 | 8823 |
| Within $R^2$ | 0.463 | 0.462 | 0.136 | 0.131 | 0.450 | 0.517 | 0.504 |
| SR effect | -0.130** | -0.171*** | -0.130** | -0.171*** | -0.106** | -0.158** | -0.107 |
| LR effect | -0.0872** | -0.101*** | -0.0872** | -0.101*** | -0.118*** | -0.146*** | -0.125*** |

Dependent variable as indicated. Financial integration variables weighted by BIS exposures.
Country pair and year fixed effects included in all regressions.
Standard errors are in parentheses.*(P< 0.10), **(P< 0.05), ***(P< 0.01)

Table 5: ECM. Distinguishing between vintages of syndicated loan exposures

| | Excluding crisis years | | Including crisis years | |
|---|---|---|---|---|
| | recent =< 1 year | recent =< 2 years | recent =< 1 year | recent =< 2 years |
| | (1) | (2) | (3) | (4) |
| $\rho_{t-1}$ | -0.838*** | -0.839*** | -0.837*** | -0.838*** |
| | (0.0189) | (0.0189) | (0.0172) | (0.0172) |
| $\Delta\rho_{1t-1}$ | 0.0587*** | 0.0594*** | 0.0414*** | 0.0419*** |
| | (0.0150) | (0.0150) | (0.0139) | (0.0139) |
| $\Delta\kappa_t$ | -0.281** | -0.324*** | -0.238** | -0.265*** |
| | (0.110) | (0.110) | (0.100) | (0.101) |
| $\kappa_{t-1}^{recent}$ | -0.0398 | -0.0176 | -0.0459 | -0.0226 |
| | (0.0305) | (0.0184) | (0.0282) | (0.0167) |
| $\kappa_{t-1}^{older}$ | -0.0497*** | -0.0862*** | -0.0365** | -0.0605*** |
| | (0.0162) | (0.0219) | (0.0146) | (0.0199) |
| Observations | 4742 | 4742 | 6028 | 6028 |
| Within $R^2$ | 0.458 | 0.458 | 0.453 | 0.454 |
| SR effect | -0.281** | -0.324*** | -0.238** | -0.265*** |
| LR effect: recent | -0.0475 | -0.0210 | -0.0548 | -0.0270 |
| LR effect: older | -0.0593*** | -0.103*** | -0.0436** | -0.0722*** |

Dependent variable is $\Delta\rho_{1t}$. LA-based financial integration variables weighted by BIS total exposures.
Country pair and year fixed effects included in all regressions.
Standard errors are in parentheses.*(P< 0.10), **(P< 0.05), ***(P< 0.01)

Table 6: ECM. Distinguishing between claims on non-financial and financial sectors.

| | Excluding crisis years | | Including crisis years | |
|---|---|---|---|---|
| | BIS-based $\kappa$ | LA-based $\kappa$ | BIS-based $\kappa$ | LA-based $\kappa$ |
| | (1) | (2) | (3) | (4) |
| $\rho_{t-1}$ | -0.747*** | -0.869*** | -0.732*** | -0.859*** |
| | (0.0121) | (0.0171) | (0.0111) | (0.0156) |
| $\Delta\rho_{1t-1}$ | -0.0249** | 0.0668*** | -0.0260*** | 0.0547*** |
| | (0.00965) | (0.0133) | (0.00898) | (0.0123) |
| $\Delta\kappa_t^{nonfin}$ | -0.164*** | -0.242*** | -0.151*** | -0.234*** |
| | (0.0504) | (0.0707) | (0.0456) | (0.0679) |
| $\kappa_{t-1}^{nonfin}$ | -0.116*** | -0.143*** | -0.0993*** | -0.134*** |
| | (0.0301) | (0.0381) | (0.0264) | (0.0346) |
| $\Delta\kappa_t^{fin}$ | -0.187*** | 0.00398 | -0.120*** | -0.0146 |
| | (0.0416) | (0.0479) | (0.0367) | (0.0436) |
| $\kappa_{t-1}^{fin}$ | -0.0330 | 0.00846 | -0.0250 | -0.0470* |
| | (0.0279) | (0.0314) | (0.0245) | (0.0279) |
| Observations | 10636 | 6006 | 12698 | 7376 |
| Within $R^2$ | 0.424 | 0.456 | 0.412 | 0.450 |
| SR effect: nonfin | -0.164*** | -0.242*** | -0.151*** | -0.234*** |
| LR effect: nonfin | -0.155*** | -0.164*** | -0.136*** | -0.156*** |
| SR effect: fin | -0.187*** | 0.00398 | -0.120*** | -0.0146 |
| LR effect: fin | -0.0442 | 0.00974 | -0.0342 | -0.0547* |

Dependent variable is $\Delta\rho_{1t}$. Financial integration variables weighted by BIS total exposures.
Country pair and year fixed effects included in all regressions.
Standard errors are in parentheses. *(P< 0.10), **(P< 0.05), ***(P< 0.01)

## Appendix.

Countries included in the largest sample are: US, UK, Austria, Belgium, Denmark, France, Germany, Italy, Luxembourg, Netherlands, Norway, Sweden, Canada, Japan, Finland, Greece, Ireland, Portugal, Spain, Turkey, Australia, South Africa, Brazil, Chile, Peru, Venezuela, Egypt, Hong Kong, India, Indonesia, Korea, Malaysia, Philippines, Thailand, China, Hungary.

**Persistence of $\rho$ and $\kappa$ measures** These are estimated as regression on lagged dependent variable and lagged first difference of dependent variable, as well as country pair fixed effects and year fixed effects.

| | Full sample | KPP sample |
|---|---|---|
| $\rho_1$ | | |
| $\rho_{1t-1}$ | 0.271*** | 0.329*** |
| | (0.00271) | (0.0276) |
| $\Delta\rho_{1t-1}$ | -0.0616*** | -0.0328 |
| | (0.00217) | (0.0233) |
| $\rho_1$ | | |
| $\rho_{1t-1}$ | 0.244*** | 0.154*** |
| | (0.00275) | (0.0298) |
| $\Delta\rho_{2t-1}$ | -0.0593*** | 0.0601*** |
| | (0.00217) | (0.0231) |
| Population weight | | |
| $\kappa_{t-1}$ | 0.832*** | 0.904*** |
| | (0.00486) | (0.0121) |
| $\Delta\kappa_{t-1}$ | 0.0711*** | -0.204*** |
| | (0.00866) | (0.0238) |
| GDP weight | | |
| $\kappa_{t-1}$ | 0.823*** | 0.899*** |
| | (0.00502) | (0.0123) |
| $\Delta\kappa_{t-1}$ | 0.0722*** | -0.206*** |
| | (0.00866) | (0.0238) |
| BIS claims weight | | |
| $\kappa_{t-1}$ | 0.804*** | |
| | (0.00518) | |
| $\Delta\kappa_{t-1}$ | 0.0748*** | |
| | (0.00849) | |
| Loan Analytics BIS claims weight | | |
| $\kappa_{t-1}$ | 0.879*** | |
| | (0.00512) | |
| $\Delta\kappa_{t-1}$ | 0.0886*** | |
| | (0.0106) | |