*Financial interdependence and contagion: the
transmission of financial stress from the United States to
Latin America*

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Abstract

In this paper I analyse how has the financial interdependence and contagion among LAC-6 countries and the United States changed in the last 15 years, as well as the transmission channels of these cross-market linkages (measured with financial stress indexes). Results show that, in average across the full sample and the whole period 2000-2014, around 34% of the financial stress in the United States has been transmitted to LAC-6 countries. However, after a careful break down, it is noted that this financial interdependence is much larger with Chile, Colombia, Mexico, and Peru (ranges between 40% and 49%), and that a significant increase in the transmission of stress occurred during the 2008 crisis. As for the transmission channels, both trade and financial linkages have a significant impact in the transmission of financial stress from the United States. Nonetheless, the effect of trade linkages is always larger than the one of financial linkages, pointing to this mechanism as the main channel of financial interdependence and contagion between LAC-6 countries and the United States during the last 15 years.

Keywords: financial interdependence, contagion, financial stress, real linkages, financial linkages

JEL Classification Code: F30; F36; G15;

1 Introduction

One of the characteristics of recent global financial development has been the significant increase in economic and financial integration among economies. This deeper integration provides more and better mechanisms to shift resources from those countries who own them but can not or do not want to use them, to those countries that can use them but do not own them. Hence, in certain way, the financial system can be seen as the “engine of a decentralized market economy” [Wolf, 2010].

However, when finance goes wrong, globalization leads to more devastating consequences as financial crises in the late 20th century and in the 21st century have shown. This easier shock transmission results mainly from direct connections between markets, increasing perceptions of unexpected weakness in similar countries after one suffers an economic breakdown, and heightened perception of risk caused by one crisis. Additionally, the scale of financial globalization has given rise to financing conditions set in the main world financial centres for the rest of the markets. The landscape that emerges is one of strong global financial cycles characterized by large comovement in asset prices, gross flows and leverage [Rey, 2013].

The 2008 financial crisis and the subsequent efforts of Central Banks in advanced markets to promote economic recovery in their countries portray this landscape fairly. Nowadays, concern around the globe, and specially in emerging markets, has to do with the effects that the recovery of the United States, and the normalization of monetary policy by the Federal Reserve, may produce abroad (see IMF, 2014. and IMF, 2015. *Global Financial Stability Report* for an extensive review of the challenging transitions that the global financial system, and particularly emerging economies, are currently undergoing).

Given the importance of this financial integration and the impact of shocks in advanced economies in emerging economies, in this paper I address two main questions: i) How has the financial interdependence and contagion among Latin American countries (LAC-6, namely: Argentina, Brazil, Chile, Colombia, Mexico and Peru) and the United States changed in the last 15 years?; ii) What are the transmission channels of these linkages and how do they vary among countries?.

Using Forbes and Rigobon concepts [Forbes and Rigobon, 2001], I define interdependence as “cross market linkages in all states of the world”, while contagion is defined as “a significant increase in cross market linkages after a shock to the United States”. I will measure cross market

linkages as the transmission of financial stress, which is defined as “a period when the financial system of a country is under strain and its ability to intermediate impaired”, and is measured as an “index that primarily relies on price movements relative to past levels or trends to proxy for the presence of strains in financial markets and on intermediation” [Tytell et al., 2009]. By analysing financial stress transmission changes over the last 15 years, I am able to capture linkages in all state of the world (the long term cross market linkages), as well as contagion during the 2008 financial crises. As for the transmission channels, both real and financial linkages will be tested for each LAC-6 country.

My main findings indicate that in average across the full sample and the whole period 2000-2014, around 34% of the financial stress in the United States has been transmitted to LAC-6 countries. However, after a careful break down, it is noted that this financial interdependence is much larger with Chile, Colombia, Mexico and Peru (ranges between 40% and 49%), and that a significant increase in the transmission of stress occurred during the 2008 crisis.

As for the transmission channels, results show that both trade and financial linkages have a significant impact in the transmission of financial stress from the United States. Nonetheless, the effect of trade linkages was always larger than the one of financial linkages, pointing to this mechanism as the main channel of financial interdependence and contagion between LAC-6 countries and the United States during the last 15 years.

The rest of the paper is organized as follows. Section 2 discusses the theory and evidence on financial shocks and contagion transmission. Section 3 presents the empirical methodology. Section 4 describes the data. Section 5 presents the results. And Section 6 concludes.

2 Literature Review on Financial Shocks and Contagion

My investigation is related to several strands of literature that study financial interdependence and financial contagion; a line of research that expanded vastly after the 1994 economic crisis in Mexico, 1997 Asian financial crisis, 1998 Russian financial crisis, and the Argentine economic crisis (1999-2002).

First, I contribute to research that analyses financial interdependence and contagion. As mentioned earlier, I build upon Forbes and Rigobon’s definitions:

it is only contagion if cross market comovement increases significantly after a shock.

If the comovement does not increase significantly, then any continued high level of market correlation suggests strong linkages between the two economies that exist in all states of the world (interdependence) [Forbes and Rigobon, 2001]

These authors point towards the relevance of understating markets level of integration during both periods of stability and crisis, which I do by analysing the period 2000-2015 that comprises the financial crisis of 2008 and the financial turmoil after mid-2013, as well as more tranquil times.

Second, my investigation is related to this large research that explores how financial turmoil is transmitted, in particular, it is related to two papers: Kaminsky *et al.*(2003) and Forbes and Chinn (2004). Kaminsky *et al.*(2003) focus on the financial turmoil in the end of last century, and analyse why financial contagion across borders occurs in some cases but not others. Through a theoretical and empirical revision, authors find three key elements that distinguish the cases where contagion occurs from those where it does not: an abrupt reversal in capital inflows, surprise announcements, and a leveraged common creditor. As for the channels of propagation, they find that financial linkages and investors herding behavior are the most prominent channels. Forbes and Chinn (2004) explore if real and financial linkages among countries can explain the comovement of market returns between the world's largest markets and other financial markets. They discover that from 1996-2000, real and financial linkages became more important determinants of how shocks are transmitted from large economies to other markets; yet, real linkages (direct trade), still appeared to be the most important determinant. While I use a similar methodology to Forbes and Chinn (2004), the main difference with this paper is that I take a time-varying approach and a different period to estimate financial contagion; this allows me to deepen in the change of shocks' transmission over time, as well as in the particular mechanisms. Additionally, by focusing on single countries I am able to explore aspects that escape from panel-type analyses, such as country specific characteristics, and insights on various channels of transmission, which differ among countries and along time.

Third and lastly, I contribute to the economic and financial research that uses a financial stress index to understand the channels of financial transmission. This type of indexes have become increasingly useful to monitor financial markets after the 2008 crisis (e.g Federal Reserve Bank of St. Louis (2010), Hollo *et al.*(2012) and Cabrera *et al.*(2014) for the Colombian case). Of most

relevance to my work is Tytell *et al.*(2009), who construct a new financial stress index for emerging markets, and study how financial stress is transmitted from advanced to emerging economies. The authors find that the extent of pass-through of financial stress is related to the depth of financial linkages. There are three main differences between Tytell *et al.*(2009) and my work, through which I add on the existing literature: i) I focus only on the United States as the originator of financial stress, since it was the epicentre of 2008 financial crisis, as well as the source of global liquidity in the last five years through the accommodative monetary policy adopted by the Federal Reserve (quantitative easing *QE*); ii) I use a rolling window regression to estimate financial stress transmission, this allows me to how cross market linkages have vary over time, and to have a time-varying parameter to explore further on the mechanisms through which this cross market comovement results; iii) By covering the 2009-2014 period, I am able to incorporate the impact of the beginning and end of the QE policies.

3 Empirical Methodology

In this section, I present the financial stress index (FSI) that will be used throughout the investigation. Further on, I show the econometric model that will assess, in first place, the degree and change in comovement between the United States and LAC-6 financial stress indexes and in second place, the mechanisms/channels that allow this transmission.

3.1 Measuring Financial Stress

The economic and financial literature on financial crises has largely relied on historical narrative of crisis episodes, and, empirically, in binary variables to show whether or not a crisis occurred (see Reinhart and Rogoff (2009)). Both approaches have contributed in an important way to the understanding of financial crises; nonetheless, they are less useful to measure stress propagation since they don't provide a measure of the intensity of the crisis, and ignore the "near miss" events. Additionally, most analysis focus on debt, currency and banking crises, leaving aside other scopes of financial stress (such as security-markets stress).

Although there is no consensus on a definition of financial stress or risk, the International Monetary Fund and the Bank for International Settlements describe systemic risk as "a risk of disruption

to financial services that i) is caused by an impairment of all parts of the financial system and ii) has the potential to have negative consequences for the real economy”, [BIS et al., 2009].

Lall *et al.* (2009) constructed a financial stress index (FSI) for advanced economies to characterize financial turmoil and its impact on the real economy. Based on this index, Tytell *et al.* (2009) proposed a similar methodology to measure financial stress in emerging economies. Both indexes have been widely accepted and used in the last years by several authors, and I will use them in this study as well. The FSIs were provided by one of the authors in May 2015, and are available as of December 2014. The description of both United States FSI and LAC-6 FSI is summarized below:

Financial stress is defined as a period when the financial system of a country is under strain and its ability to intermediate impaired. When measuring stress, the index primarily relies on price movements relative to past levels or trends to proxy for the presence of strains in financial markets and on intermediation. The FSI for advanced economies comprises seven variables, which serve to capture three financial market segments (banking, securities markets, and exchange markets). The seven components are the banking-sector beta, the TED spread, inverted, term spreads, stock market returns, time-varying stock market return volatility, sovereign debt spreads, and exchange market volatility. AS for emerging markets FSI, the five components are the banking-sector beta, stock market returns, time-varying stock market return volatility, sovereign debt spreads, and an exchange market pressure index (EMPI).

The indexes are a composite measure of these subindices and captures price changes in these markets relative to past trends as they are likely to show strain in financial markets or intermediation. Each variable is demeaned and divided by its standard deviation, that is, each variable is standardized. To yield the aggregate financial stress index the components are summed up.

A value of zero implies neutral financial market conditions on average across the subindices, while positive values imply financial strain (i.e. prices are on average above means or trends). A value of 1 indicates a one-standard deviation from average conditions across subindices. A value of 1.5 or higher has in the past been associated with a crisis. [Tytell et al., 2009]

3.2 Stress Transmission

As mentioned earlier, the economic and financial literature that studies financial interdependence and contagion has found that financial turmoil can spread rapidly. As for the linkages that allow this transmission, real and financial linkages, as well as investors herding behavior, have been identified as the determinants.

Recently, Forbes [Forbes, 2012] surveyed the economic literature that defined, measured and identified financial contagion and the channels by which it could occur. The author categorized the empirical strategies that attempted to measure contagion in five main groups: probability analysis, cross-market correlations, VAR models, latent factor / GARCH models, and extreme value analysis; as for the transmission mechanisms, Forbes grouped 4 main channels: trade, banks, portfolio investors, and fundamentals reassessment.

To evaluate the transmission of financial stress from the United States to LAC-6 countries using the FSIs, I will use a two-stage approach, a method used by Forbes and Chin (2004). In Stage 1 I will estimate cross market linkages as transmission coefficients in an auto-regressive model; in Stage 2 I will analyse the determinants of these linkages taking into account the main channels identified by the specialized literature.

Stage 1

To examine financial stress comovement between LAC-6 countries and the United States, I will estimate the following equation through an ARX rolling window model. I will analyse each Latin American country separately. I use an ARX to incorporate the inertia observed in financial series; it also has the advantage of considering the dynamic effects of both the dependent and exogenous variables included in the empirical exercise (this will allow me to have a clean estimator of comovement between the financial stress indexes). As for the rolling window model, it repeats the ARX regression using subsamples of total data by shifting the start and end points with a fixed window; I use it in order to have a time-varying coefficient that captures the changes in financial stress transmission from the United States to LAC-6 countries:

$$FSI_{t(i)}^L = \alpha_i + \sigma_{1(i)} FSI_{t-1(i)}^L + \dots + \sigma_{p(i)} FSI_{t-p(i)}^L + \beta_{1(i)} FSI_{t(i)}^{USA} + \beta_{2(i)} FSI_{t-1(i)}^{USA} + \dots + \beta_{s(i)} FSI_{t-s(i)}^{USA} + \vec{X}_{t(i)}^L + \delta_{1(i)} FSI_{t(i)}^{LAC} + e_{t(i)}^L, \quad i = 1, \dots, n \quad (1)$$

where FSI^L stands for the financial stress index of each of LAC-6 countries, FSI^{USA} stands for the financial stress index of the United States, $\vec{X}$ is a vector of control variables (common shocks and fundamentals), FSI^{LAC} stands for the financial stress of the other LAC-6 countries, t is a time index (monthly), and i is the number of rolling regressions. If the total observation number is N , the window size is set to be w months, and the increment interval between the adjacent rolling regressions is one month, then n is written as follows: $n = \lceil \frac{N-w}{1} \rceil + 1$

The common shocks and fundamentals that I include are the following: commodity prices, interest rate gap for short term loans between each LAC-6 country and the United States, and capital controls¹. As for the financial stress from the other LAC-6 countries, FSI^{LAC} , I include it to control for horizontal contagion. This measure is constructed by aggregating (using GDP weights) the FSI across all LAC-6 countries, except country L , and “cleaning” this stress index from any contributions of FSI^{USA} or common shocks and fundamentals. The latter is done by modelling FSI^{LAC} as a function of FSI^{USA} and $\vec{X}_{t(i)}^L$, and using the residuals.

Note that the FSI are included in levels, considering that these are all I(0) series. Lag orders P and S will be chosen for each specification according to conventional information criteria.²

In this stage I will differentiate as well for interdependence and contagion (following Forbes and Rigobon (2001)) by statistically testing differences in the transmission coefficients in tranquil and crisis episodes (as a crisis episode I consider the 2008 global financial crisis). I will also compute dynamic multipliers to analyse the effect of a one-time shock to the United States financial stress index on the other countries’ financial stress.

Stage 2

In this stage I will explore the extent of contemporary comovement between financial stress in-

¹Measured with Chin-Ito Index of financial openness.

²the Dicky-Fuller test that showed stationarity of the series, as well as the test of the lag order selection, are available upon request

dicators (captured by $\beta_{1(i)}$) in (1). This parameter can also be written as $\beta_{1,t}$, as the increment interval is one month. For each country I model this time varying parameter as a function of two channels or mechanisms: trade linkages(TL), and financial linkages (FL). Trade linkages are measured as exports to the United States, while controlling for price effects by including the terms of trade. Financial linkages include bank lending and capital flows (portfolio flow, both equity and bond). Additionally, in order to correct for the possibility of measurement error in $\beta_{1,t}$ in the first stage, I included a dummy variable in those months when $\beta_{1,t}$ was not significant at a 10% level.

$$\beta_{1,t}^L = \alpha_1 + \sum_{k,t} \alpha_k TL_{k,t}^L + \sum_{m,t} \alpha_m FL_{m,t}^L + d_t + u_t \quad (2)$$

with k denoting types of trade linkages, m types of financial linkages, d the dummy variable for those months when $\beta_{1,t}$ was not statistically significant, and t the monthly index.

4 Data and Descriptive Statistics

In this section I provide a description of the data that will be used in the estimations: the financial stress indexes, and the transmission channels. Additionally, I will present some stylized facts on the comovement between the FSI for LAC-6 and the one for the United States.

4.1 Financial Stress Comovement

Figure 1 below shows the financial stress indexes estimated by Tytell *et al.* (2009), it compares the FSI for each LAC-6 country with the FSI of the United States. Although there is high variation in the data, some interesting facts are worth noticing.

First, there is a strong visual link among each pair of FSI, with local peaks in the two indexes broadly coincident. Not surprisingly, the surge in financial stress in the United States during the financial crisis of 2008 is also observed in all LAC-6 countries. In fact, in Chile, Colombia, Mexico, and Peru, the highest peak in the index throughout the period 2000-2015 also occurs in 2008 during the crisis. Second, Argentina and United States' FSI don't seem to correlate very strongly. Moreover, the financial crisis of 2008 doesn't seem to have particularly affected Argentina: its level of financial stress during the midst of the global financial crisis is observed in many other episodes. Although uncommon, this behavior is to be expected considering the 1998-2002 Argentine great

depression that among other things, included the biggest sovereign default in history after Greece. Ever since, Argentina has been locked out of international capital markets. Third, Brazil's FSI also seems to correlate weakly with United States' FSI, and, similar to Argentina, its highest peak in financial stress is not observed during the 2008 crisis but in 2002. In that year the economy was suffering from fiscal and current account problems, and the prospect that economic policies would be significantly altered after the presidential elections.

Figure 1: Financial Stress Indexes

Source: [Tytell et al., 2009]

As a first statistical approach, I estimated simple correlation coefficients for each LAC-6 country and the United States, throughout the whole period 2000-2014 (Table 1). In line with the previous visual analysis and as expected considering the deep commercial linkages, Mexico's FSI

exhibits the highest correlation with the United States FSI. Colombia, Peru, and Chile follow, with strong correlations as well (close to 0.5). Brazil and Argentina, on the other hand, have a weak and a 0 correlation respectively. Considering the previous explanations, these results are unsurprising.

I also estimated simple correlation coefficients in a time varying approach with rolling windows of 36 months and 48 months. Results are displayed in Figure 2 and are very similar for both windows. For all countries, the highest level of correlation (above 0.5) is observed in the beginning of 2009, during the peak of the 2008 global financial crisis. The correlation remains high for almost two years, and starts to decline by the end of 2011. Correlation then starts to increase again in mid-2013 and continues to rise as of December 2014. In general, these results are as expected.

Table 1: FSI Correlation with USA FSI - coefficients 2000-2014

	<i>ARG</i>	<i>BRA</i>	<i>CHL</i>	<i>COL</i>	<i>MEX</i>	<i>PER</i>
Corr.	-0.01	0.15	0.47	0.52	0.66	0.49

Source: Author calculations

Figure 2: FSI Correlation with USA FSI - coefficients 2000-2014 - rolling window

Source: Author calculations

Additionally, I performed Granger-type causality tests for checking the FSI direction of causality between each LAC-6 country and the United States. Table 2 below shows the p-values for the test. The first row *USA-cause* checks causality running from the United States FSI to LAC-6 countries FSI. The second row *USA-caused* checks causality running from LAC-6 countries FSI to United States FSI.

Results show that: *i*) causality runs unidirectionally from the United States FSI to that of Chile, Colombia and Peru; *ii*) between Mexico and United States FSI, causality runs in both directions;

iii) there is no Granger-type causality between Argentina and United States FSI, and Brazil and United States FSI. Hence, It is reasonable to calculate the effect of changes in the United States FSI on the FSI of Chile, Colombia, Mexico, and Peru. As for Argentina and Brazil, results should be treated more carefully.

Table 2: Granger Causality Test. H_0 : no Granger causality (p-values)

	<i>ARG</i>	<i>BRA</i>	<i>CHL</i>	<i>COL</i>	<i>MEX</i>	<i>PER</i>
<i>USA-cause</i>	0.546	0.240	0.063*	0.047**	0.023**	0.037**
<i>USA-caused</i>	0.937	0.999	0.208	0.372	0.092*	0.849

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Source: Author calculations

4.2 Measures of trade and financial linkages

In this section I briefly summarize the size and evolution of the linkages that I will use to evaluate interdependence and contagions between LAC-6 economies and the United States.

Trade: the economic literature has historically considered trade channels to play a significant role in bilateral country linkages, and particularly as transmission mechanisms during times of crisis. “A crisis in one country can reduce income and the corresponding demand for imports, thereby affecting exports from other countries through bilateral trade” [Forbes, 2012].

As the left pannel in Figure 3 shows, LAC-6 monthly exports to the United States before the global financial crisis were recorded at USD 25 billion; however, during the crisis exports drop to USD 13-15 billion, shrinking by more that USD 10 billion. For a country such as Mexico where exports to the United States account for nearly 80% of its total exports, this trade shock had a profound impact in its external accounts. On the other hand, for Brazil the slowdown in United States demand for its exports may not have had such a impact, considering that Brazil’s main trade partner is China and the United States only represents nearly 10% of its exports.

Figure 3: Exports to the United States

Source: Bloomberg. Author calculations

Portfolio flows: there is an extensive literature on the mechanisms through which investors transmit shocks across countries. In sum, after a shock to one country, investors are forced to sell assets in other countries to rebalance their portfolios. Additionally, in environments of high risk aversion or informational asymmetries, investors may overreact and sell asset across countries because they may find less costly to “herd” by following other investors [Forbes, 2012]. Recent research with micro-level data on mutual funds by Raddatz and Schmukler (2012) finds that investors and managers respond to country returns and crises pro-cyclically, exposing countries in their portfolios to foreign shocks.

Capital flows are reported in each country’s balance of payments statistics. However, a disadvantage of using this data is its low frequency (quarterly or annualy) and disaggregation. Hence, to proxy for capital flows in a monthly and disaggregate basis, I used information from Emerging Portfolio Fund Research (EPFR). EPFR tracks traditional and alternative funds domiciled globally with 16 trillion in total assets, and delivers data on bond and equity country flows. The information in EPFR is a subset of all portfolio flows to emerging markets. In fact, according to [Pant and Miao, 2012], EPFR data on bond and equity flows is a coincident indicator of capital flows and is a good indicator on foreign investors’ sentiment.

Total EPFR equity and bond flows for each LAC-6 country are presented in the Appendix (7.1); however, for the rest of the analysis I will only use flows from global emerging market funds and Latin America regional funds³. As shown in the Appendix, flows from these funds account for

³After 2010 there is a disturbance in EPFR data due to an expansion in the coverage of the database. I selected the funds that reported flows investment over the whole period

most of the share of total flows and exhibit the same behavior

Figure 4 displays the selected EPFR equity and bond flows for LAC-6 countries. Several things are worth noticing. First, equity flows exhibit a more volatile behavior than bond flows. Second, equity flows are mostly concentrated in Brazil, whereas bond flows also have a high participation in Mexico. Third, negative bond gross flows are observed during the 2008 crisis and in mid-2013 when the Federal Reserve discussed for the first time the ending of quantitative easing policies; on the other hand, negative equity gross flows are observed in more episodes.

Figure 4: EPFR Portfolio flows

Source: EPFR. Author calculations

Banks: another relevant financial channel of contagion are banks and other financial intermediaries, since a shock to one country may lead banks to reduce their credit supply to other countries, and therefore to reduce liquidity and increase the cost of credit [Forbes, 2012]. Moreover, contagion could be deepened if there are high degrees of leverage, and extensive interconnections. According to Ahrend and Goujard (2013), bank lenders transmitted financial turmoil during the 2008 global financial crisis.

I obtained information on bilateral links between banks in the United States and Latin America from the U.S Department of the Treasury, and corresponds to U.S banks claims on foreigners (banks, official institutions, and persons) in each of LAC-6 countries. The data includes “claims arising from deposits from foreign entities, financial instruments including short-term negotiable securities such as U.S. Treasury bills and certificates with an original maturity of one year or less, borrowings from foreigners and loans and other credits to foreigners” [TreasuryInternationalCapitalSystem, 2007].

The left panel in Figure 5 below shows United States banking claims stock on LAC-6 coun-

tries between 2003 and 2014, while the right panel displays the monthly change. Between 2003 and 2007 claims on LAC-6 countries were recorded at USD 50 billion, and didn't change much monthly. On the contrary, between 2008 and 2009 a high volatility is observed, claims on LAC-6 countries doubled between 2006 and 2008, and then declined almost by USD 30 billion in a matter of months. Since 2011 an upward trend is observed.

Figure 5: U.S. Banking Claims on Foreigners

Source: U.S Department of the Treasury. Author calculations

5 Results

Stage 1

Table 3 provides a summary of the results from the first stage regressions for the complete sample 2000-2014, only β_1 , the coefficient for FSI_t^{USA} , is shown. I estimated two specifications of the model, with and without the control variables of common shocks, fundamentals, and contagion from the LAC-6 countries. Row 1 -*Simple*- shows the results for equation (1) without the control variables, and Row 2 -*Multiple*- shows the results for equation (1) with the control variables. The complete results are available in the Appendix (7.2).

The signs and magnitude of the transmission coefficients of financial stress from the United States to LAC-6 countries are in line with the previous correlation coefficients, and are robust to different specifications of the model. The transmission coefficients are both statistically and economically significant in the 6 countries, with $\beta_1 = 0.34$ on average for the full sample. These comovement parameters vary across countries: i) Argentina exhibits the weakest beta, only 10% of stress in the United States is transmitted to this country; ii) Brazil's FSI comoves also weakly

with United States FSI, only 22%-26% of stress in the latter is transmitted to the former. iii) As for Chile, Colombia, Mexico, and Peru, a high transmission coefficient is observed, ranging between 0.4 and 0.48.

Table 3: ARX Regression 2000-2014, $\beta_{1,t}$

	<i>ARG</i>	<i>BRA</i>	<i>CHL</i>	<i>COL</i>	<i>MEX</i>	<i>PER</i>
Simple	0.0990**	0.263***	0.485***	0.444***	0.395***	0.445***
Multiple	0.0612*	0.221***	0.418***	0.410***	0.381***	0.404***

*** p<0.01, ** p<0.05, * p<0.1

Source: Author calculations

The aforementioned results can be understood as long-term transmission coefficients, and can be interpreted as the financial interdependence of each LAC- country with the United States. However, to address how has this comovement varied over the last 15 years, and specifically, to test whether financial stress transmission increased during the 2008 crisis, a time varying approach is necessary. The different panels in Figure 6 exhibit the rolling window betas $\beta_{1,t}$ between 2004 and 2014 for each country. The betas below correspond to a 48 month rolling window; however, results didn't vary significantly if a 36 month window or a 60 month window was used.

As expected, the strength and significance of the stress transmission coefficient not only varies among countries, but also over time. It appears that while Brazil and Chile experienced stronger financial spillovers in the past, Colombia, Mexico and Peru, saw a more intense transmission during the 2008 crisis. Argentina's beta, on the other hand, only shows statistical significance after 2009, and it has remained in low levels since.

Figure 6: ARX Rolling Window Regression, $\beta_{1,t}$

Figure 6: Financial Stress Index

Source: Author calculations

From the figures above it is possible to observe in all countries, except Argentina, a peak in the transmission of financial stress during the 2008 crisis. In order to test whether this could be considered as financial contagion -“significant increase in cross market linkages after a shock to the United States” [Forbes and Rigobon, 2001]- , I performed a two sample t – $test$ to compare the beta coefficients during the 2008 crisis with the rest of the period of analysis.

Results in Table 4 show that the non-crisis betas of Colombia, Mexico and Peru were significantly lower than the crisis beta. In the case of Chile, there was not a significant difference. As for Brazil, the crisis coefficient was significantly lower. Considering these results, it is possible to say that during the 2008 global financial crisis there was contagion effect from the United States to Colombia, Mexico, and Peru when analysing cross market linkages with financial stress indexes.

Additionally, in order to assess the performance of the model, an impulse-response analysis was conducted to explore LAC-6 FSI behavior to a one time shock in United States FSI. These dynamic multipliers were estimated as the derivatives: $\frac{\delta FSI_{L,t}}{\delta FSI_{USA,t}}, \frac{\delta FSI_{L,t+1}}{\delta FSI_{USA,t}}, \frac{\delta FSI_{L,t+2}}{\delta FSI_{USA,t}}, \dots, \frac{\delta FSI_{L,t+K}}{\delta FSI_{USA,t}}$.

Table 4: Two sample t test

	Coefficients			P-values		
	Non-crisis	Crisis	Difference	$H_a : diff < 0$	$H_a : diff \neq 0$	$H_a : diff > 0$
Brazil	0.310	0.1822	0.128	1.00	0.00	0.00
Chile	0.523	0.467	0.056	0.981	0.037	0.019
Colombia	0.412	0.508	-0.096	0.00	0.00	1.00
Mexico	0.352	0.457	-0.105	0.00	0.00	1.00
Peru	0.319	0.485	-0.165	0.00	0.00	1.00

Source: Author calculations

Responses of LAC-6 FSI to a one time shock in United States FSI are shown in Figure 7. An element worth highlighting is that an increase in financial stress in the United States will result also in a hike in financial stress in all LAC-6 countries. However, the magnitude and duration of the shock varies. For instance, Argentina and Brazil show the lowest and shortest response, after 3 months there appears to be no longer an effect. On the contrary, the response in Chile, Colombia, Mexico, and Peru is larger and more persistent over time.

Figure 7: Dynamic multipliers of FSI. Response of LAC-6 FSI to shocks to United States FSI

Source: Author calculations

Stage 2

The results for the second stage for each country are shown below. For an easier interpretation and comparison, in the next tables I reported the results as standardized beta coefficients. The complete

results are shown in the Appendix (7.2).

Results indicate that changes both in trade and financial linkages have a significant impact on the transmission of financial stress from the United States. This is true for all LAC-6 countries and for different model specifications ⁴. However, the magnitude of this impact varies across countries. Although each country has its own dynamic, there are some general results worth highlighting:

- 1 In all countries (except Argentina) a negative change in trade linkages (that is, a contraction in exports) had the expected effect: an increase in the transmission of financial stress.
- 2 On the other hand, when analysing financial linkages, a decrease in negative gross flows had the expected result in Brazil, Chile, and Colombia; but for Mexico and Peru the direction of the result was not as clear.
- 3 The magnitude of the effect of trade linkages is always larger than the one of financial linkages. Hence, it is possible to say that between 2000 and 2014, trade was the main channel of financial interdependence between LAC-6 countries and the United States
- 4 The odd results of Argentina are not surprising, since, as mentioned before, from 2002 onwards the country has been locked out of international capital markets. Hence, its financial market doesn't respond to foreign shocks as expected. Argentina's results are shown in the Appendix (7.2).

Brazil: a decline in trade is associated with an increase in stress transmission from the United States (column 1): a one standard deviation decrease in exports to the U.S yields a 0.25 increase in the standard deviation of the stress transmission. As for financial linkages (column 2), a one negative standard deviation in gross bond flows produces a 0.13 increase in the standard deviation of stress transmission. Equity flows and banking claims don't have a statistically significant effect. When analysing simultaneously all the linkages (column 3), it is difficult to identify the most important linkage, due to positive correlations among them. However, the effect of exports remained negative and statistically significant.

⁴Robustness tests indicate that results are very similar when considering the stress transmission coefficients if a 36 month window or a 60 month window was used

Table 5: Stage 2 regression - Brazil- Robust normalized beta coefficients

	1	2	3
Bond flows		-0.127*	0.027
Equity flows		0.113	-0.066
Banking claims		0.006	0.056
Exports	-0.246***		-0.263***
T. of trade	-0.463***		-0.468***
Observations	120	120	120
R-squared	0.631	0.278	0.637

*** p<0.01, ** p<0.05, * p<0.1

Chile: a decline in trade is associated with an increase in stress transmission from the United States (column 1): a one standard deviation decrease in exports to the U.S yields a 0.45 increase in the standard deviation of the stress transmission. As for financial linkages (column 2), a one negative standard deviation in gross bond flows produces a 0.12 increase in the standard deviation of stress transmission. Equity flows and banking claims don't have a statistically significant effect. When analysing simultaneously all the linkages (column 3), the direction and magnitude of these effects remains; however, trade linkages seem to have a more profound effect in the transmission of financial stress from the United States to Chile.

Table 6: Stage 2 regression - Chile- Robust normalized beta coefficients

	1	2	3
Bond flows		-0.124*	0.091
Equity flows		-0.014	-0.241***
Banking claims		-0.078	-0.054
Exports	-0.449***		-0.512***
T. of trade	-0.301***		-0.28***
Observations	120	120	120
R-squared	0.414	0.026	0.454

*** p<0.01, ** p<0.05, * p<0.1

Colombia: a decline in trade is associated with an increase in stress transmission from the United States (column 1): a one standard deviation decrease in exports to the U.S yields a 0.65 increase in the standard deviation of the stress transmission. As for financial linkages (column 2), a one negative standard deviation in gross bond flows doesn't produce a significant standard deviation in stress transmission; while equity flows seem to have an opposite effect. Banking claims don't

have a statistically significant effect. When analysing all the linkages g simultaneously (column 3), the direction and magnitude of these effects remains; however, again, trade linkages seem to have a more profound effect in the transmission of financial stress from the United States to Colombia.

Table 7: Stage 2 regression - Colombia - Robust normalized beta coefficients

	1	2	3
Bond flows		-0.074	0.037
Equity flows		0.208*	0.044
Banking claims		-0.031	-0.002
Exports	-0.647***		-0.635***
T. of trade	0.191**		0.183*
Observations	120	120	120
R-squared	0.334	0.077	0.339

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Mexico: a decline in trade is associated with an increase in stress transmission from the United States (column 1): a one standard deviation decrease in exports to the U.S yields a 0.3 increase in the standard deviation of the stress transmission. As for financial linkages (column 2), a one negative standard deviation in gross bond flows produces a 0.27 decrease in the standard deviation of stress transmission (an unexpected result). Equity flows and banking claims have the expected direction, but don't have a statistically significant effect. When analysing all the linkages simultaneously (column 3), the direction and magnitude of these effects remains; however, trade linkages continue to have a deep effect in the transmission of financial stress from the United States to Mexico.

Table 8: Stage 2 regression - Mexico- Robust normalized beta coefficients

	1	2	3
Bond flows		0.277***	0.239***
Equity flows		-0.068	-0.054
Banking claims		-0.015	-0.005
Exports	-0.3**		-0.292**
T. of trade	0.491***		0.457***
Observations	120	120	120
R-squared	0.137	0.108	0.181

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Peru: a decline in trade is associated with an increase in stress transmission from the United

States (column 1): a one standard deviation decrease in exports to the U.S yields a 0.52 increase in the standard deviation of the stress transmission. As for financial linkages (column 2), a one negative standard deviation in gross bond flows produces a 0.18 decrease in the standard deviation of stress transmission (an unexpected result). Equity flows and banking claims don't have a statistically significant effect. When analysing simultaneously all the linkages (column 3), trade linkages seem to have a more profound effect in the transmission of financial stress from the United States to Peru.

Table 9: Stage 2 regression - Peru- Robust normalized beta coefficients

	1	2	3
Bond flows		0.18***	0.164***
Equity flows		0.059	-0.036
Banking claims		-0.03	-0.022
Exports	-0.519***		-0.482***
T. of trade	0.398***		0.319***
Observations	120	120	120
R-squared	0.789	0.714	0.807

*** p<0.01, ** p<0.05, * p<0.1

6 Concluding Remarks

In this paper I analysed how the financial interdependence and contagion among LAC-6 countries (Argentina, Brazil, Chile, Colombia, Mexico and Peru) and the United States had changed in the last 15 years, as well as the transmission channels of these cross-market linkages. Understanding the channels through which shocks are transmitted across countries is a key issue for policymakers, particularly in the current context of financial turmoil resulting from the expected changes in the monetary policy in the United States.

Economic and financial literature on contagion has focused mainly on equity, bond, and exchange rate markets due to the high frequency availability of the data. Instead, my investigation uses a financial stress index that comprises banking, securities markets, and exchange markets. Hence, this could be considered a more comprehensive analysis that captures financial markets turmoil and contagion in a wider dimension.

I found that, in average across the full sample and the whole period 2000-2014, around 34%

of the financial stress in the United States has been transmitted to LAC-6 countries. However, after a careful break down, it is noted that this financial interdependence is much larger with Chile, Colombia, Mexico, and Peru (ranges between 40% and 49%), and that a significant increase in the transmission of stress occurred during the 2008 crisis.

The difference in stress transmission to LAC-6 countries, both in tranquil times and crises periods, has an interesting implication, as it highlights the importance of deeper financial markets in absorbing foreign shocks. For instance, due to the geographical proximity and high commercial integration (among other aspects) between the United States and Mexico, one might expect the latter to be more affected by financial shocks in the former than the other LAC-6 countries. However, this is not the case. According to the results, the stress transmission coefficients were larger in Colombia and Chile. Mexico's lower sensibility to shocks in the United States can be understood when considering that it has deeper financial markets than the rest of Latin America.

As for the transmission channels, results show that both trade and financial linkages have a significant impact in the transmission of financial stress from the United States. Nonetheless, the effect of trade linkages was always larger than the one of financial linkages, pointing to this mechanism as the main channel of financial interdependence and contagion between LAC-6 countries and the United States during the last 15 years.

7 Appendix

7.1 Data selection

Figure 8: Equity and bond flows

7.2 Estimations

Stage 1

Table 10: Stage 1 regression - simple

	<i>ARG</i>	<i>BRA</i>	<i>CHL</i>	<i>COL</i>	<i>MEX</i>	<i>PER</i>
FSI_t^{USA}	0.0990*** (0.0379)	0.263*** (0.0469)	0.485*** (0.0412)	0.444*** (0.0602)	0.395*** (0.0390)	0.445*** (0.0302)
FSI_{t-1}^{USA}	-0.0339 (0.0370)	-0.103* (0.0542)	-0.0843 (0.0613)	0.0250 (0.0388)	-0.0873** (0.0439)	-0.0832** (0.0393)
FSI_{t-1}^L	0.629*** (0.0591)	0.511*** (0.0814)	0.538*** (0.0735)	0.603*** (0.0662)	0.343*** (0.0945)	0.392*** (0.0786)
FSI_{t-2}^L	0.206*** (0.0605)	0.264*** (0.0682)	0.181*** (0.0665)	0.124* (0.0738)	0.140** (0.0706)	0.460*** (0.0697)
Constant	-0.140 (0.595)	-0.331 (0.539)	-0.437 (0.480)	-0.235 (0.451)	-0.940*** (0.198)	-0.512 (0.721)
Observations	178	178	178	178	178	177

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Stage 2

Table 11: Stage 1 regression - multiple

	<i>ARG</i>	<i>BRA</i>	<i>CHL</i>	<i>COL</i>	<i>MEX</i>	<i>PER</i>
FSI_t^{USA}	0.0612 (0.0497)	0.221*** (0.0511)	0.418*** (0.0479)	0.410*** (0.0586)	0.381*** (0.0399)	0.404*** (0.0370)
FSI_{t-1}^{USA}	-0.0584 (0.0459)	-0.154** (0.0669)	-0.191*** (0.0571)	-0.0440 (0.0488)	-0.118*** (0.0398)	-0.158*** (0.0416)
FSI_{t-1}^L	0.622*** (0.0661)	0.488*** (0.0697)	0.273*** (0.0725)	0.503*** (0.0733)	0.315*** (0.0871)	0.338*** (0.0780)
FSI_{t-2}^L	0.181*** (0.0678)	0.136** (0.0642)	0.0953 (0.0732)	0.0189 (0.0723)	0.0956 (0.0693)	0.391*** (0.0664)
<i>I. rate gap</i>	0.0280 (0.0178)	0.223*** (0.0420)	0.161* (0.0898)	0.199* (0.111)	0.126** (0.0624)	0.594*** (0.222)
<i>K. controls</i>	0.678 (1.014)	-1.566 (2.013)	-2.657*** (0.943)	-6.777*** (1.634)	-2.230 (1.724)	
<i>Com. prices</i>	-0.0306** (0.0146)	-0.0459*** (0.0177)	-0.0556*** (0.0186)	-0.0487** (0.0224)	-0.0250* (0.0133)	-0.0222 (0.0180)
FSI_t^{LAC}	0.242** (0.0948)	0.615*** (0.132)	0.816*** (0.104)	0.512*** (0.135)	0.461*** (0.0644)	0.465*** (0.0855)
Constant	-0.595 (0.600)	-2.252* (1.293)	1.294 (0.897)	1.188 (0.963)	-0.112 (1.262)	-1.460*** (0.566)
Observations	177	177	177	177	177	177

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 12: Stage 2 regression - Argentina

	1	2	3
Bond flows		-0.000*** (0.000)	-0.000*** (0.000)
Equity flows		-0.000 (0.000)	0.000 (0.000)
Banking claims		0.000 (0.000)	-0.000 (0.000)
Control stage 2	-0.094*** (0.018)	-0.148*** (0.022)	-0.104*** (0.019)
Exports	0.000 (0.000)		0.000 (0.000)
T. of trade	0.009*** (0.002)		0.009*** (0.002)
Constant	-0.124** (0.060)	0.170*** (0.010)	-0.103* (0.059)
Observations	120	120	120
R-squared	0.553	0.368	0.579

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 13: Stage 2 regression - Brazil

	1	2	3
Bond flows		-0.000* (0.000)	0.000 (0.000)
Equity flows		0.000 (0.000)	-0.000 (0.000)
Banking claims		0.000 (0.000)	0.000 (0.000)
Control stage 2	-0.218*** (0.030)	-0.210*** (0.026)	-0.219*** (0.031)
Exports	-0.000*** (0.000)		-0.000*** (0.000)
T. of trade	-0.026*** (0.004)		-0.026*** (0.004)
Constant	0.637*** (0.074)	0.341*** (0.023)	0.651*** (0.070)
Observations	120	120	120
R-squared	0.631	0.278	0.637

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 14: Stage 2 regression - Chile

	1	2	3
Bond flows		-0.000*	0.000
		(0.000)	(0.000)
Equity flows		-0.000	-0.000***
		(0.000)	(0.000)
Banking claims		-0.000	-0.000
		(0.000)	(0.000)
Control stage 2	-0.035	-0.028	-0.006
	(0.026)	(0.020)	(0.024)
Exports	-0.000***		-0.000***
	(0.000)		(0.000)
T. of trade	-0.004***		-0.004***
	(0.001)		(0.001)
Constant	0.926***	0.487***	0.976***
	(0.068)	(0.016)	(0.068)
Observations	120	120	120
R-squared	0.414	0.026	0.454

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 15: Stage 2 regression - Colombia

	1	2	3
Bond flows		-0.000	0.000
		(0.000)	(0.000)
Equity flows		0.000*	0.000
		(0.000)	(0.000)
Banking claims		-0.000	-0.000
		(0.000)	(0.000)
Control stage 2	-0.199***	-0.208***	-0.201***
	(0.013)	(0.033)	(0.022)
Exports	-0.000***		-0.000***
	(0.000)		(0.000)
T. of trade	0.002**		0.002*
	(0.001)		(0.001)
Constant	0.498***	0.427***	0.497***
	(0.052)	(0.013)	(0.055)
Observations	120	120	120
R-squared	0.334	0.077	0.339

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 16: Stage 2 regression - Mexico

	1	2	3
Bond flows		0.000*** (0.000)	0.000*** (0.000)
Equity flows		-0.000 (0.000)	-0.000 (0.000)
Banking claims		-0.000 (0.000)	-0.000 (0.000)
Control stage 2	-0.130** (0.057)	-0.169*** (0.065)	-0.125* (0.065)
Exports	-0.000** (0.000)		-0.000** (0.000)
T. of trade	0.019*** (0.005)		0.018*** (0.005)
Constant	0.310*** (0.058)	0.373*** (0.010)	0.315*** (0.060)
Observations	120	120	120
R-squared	0.137	0.108	0.181

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 17: Stage 2 regression - Peru

	1	2	3
Bond flows		0.000*** (0.000)	0.000*** (0.000)
Equity flows		0.000 (0.000)	-0.000 (0.000)
Banking claims		-0.000 (0.000)	-0.000 (0.000)
Control stage 2	-0.302*** (0.020)	-0.290*** (0.013)	-0.309*** (0.021)
Exports	-0.000*** (0.000)		-0.000*** (0.000)
T. of trade	0.004*** (0.001)		0.003*** (0.001)
Constant	0.702*** (0.045)	0.433*** (0.011)	0.701*** (0.048)
Observations	120	120	120
R-squared	0.789	0.714	0.807

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

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