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Financial autarchy as contagion protection: The case of Colombian pension funds

ABSTRACT: Regulations restricting investment by pension funds in high risk and foreign assets may quarantine member accounts from contagious transmissions during financial crises. This paper analyses contagion from US equity markets to emerging market autarchic assets (Colombian private pension funds) during the recent financial crises. We test for contagion as changes in systematic risk between financial asset returns using an M-GARCH framework, where the S&P500 is the source of contagion to the autarchic asset. We find no evidence of contagion during the 2007-2009 crises, indicating protection to plan members from regulated portfolio restrictions during this period, but contagion from US stocks and fixed interest factors is significant during the recent sovereign debt crisis.

KEYWORDS: emerging markets, global financial crisis, sovereign debt crisis, regulation, systematic risk.

The benefits and costs of regulation for financial crisis prevention and management have been intensely debated. A key issue is the extent to which regulators should attempt to quarantine domestic assets from external shocks (Houston et al. 2012; Binici et al. 2010). The question is especially important for retirement savings, where pension fund members may be compelled to contribute and invest according to regulatory guidelines rather than at their own discretion, and account balances are preserved until a prescribed age. Financial contagion may be particularly damaging to the retirement welfare of ordinary workers if poor returns occur late in working life or early in retirement when accumulations are highest. On the other hand, portfolio restrictions can create costly inefficiency. All of these influences are amplified in emerging economies where members of pension funds have scant personal resources to buffer themselves against financial shocks or inefficiency.

Here we study financial contagion originating from US equity markets during the sub-prime crisis, and its aftermath in Europe, as it impacted on regulated assets in emerging economy pension funds. We divide the recent global financial crisis into three contiguous episodes, the

subprime, credit crunch (CCC) and European sovereign debt (ESD) crises. Using these three episodes, we test for evidence of contagion to a restricted portfolio, or autarchic asset, that is, Colombian private pension funds. We define autarchy as occurring when local investors have a limited choice in portfolio selection, and ownership of the financial autarchic asset is legally mandatory. We define contagion as a significant change in co-movements of returns across markets, conditional on a crisis occurring in one market or group of markets. Contagion implies the creation of a new transmission channel above tranquil period conditions[1].

The fact that countries are generally vulnerable to systemic crisis is not contentious, and there is ample historical evidence that the causes of financial crises are not unique to each event (Reinhart and Rogoff 2008). However the recent financial crises originated in mature markets and were transmitted to emerging economies, rather than the previously more common reverse case (Fry et al. 2011). And although crises are, and will be, recurrent phenomena, there is some evidence that their effects could be mitigated by regulation.

Our contribution to the current body of literature will center on the isolation or integration of emerging market financial institutions, specifically pension funds. Prior to 2008, some indicators pointed to an improvement in the ability of emerging economies to withstand crises (Powell and Martinez 2008; Felices and Wieladek 2012). But despite reforms to financial institutions, improved reserve positions and restrictions on foreign exchange exposures, de-coupling of emerging economies from external economic and financial shocks appears to have been short-lived, especially in the face of the Great Recession (Dooley and Hutchison 2009; Felices and Wieladek 2012). Latin America and Asia have been particularly exposed to macroeconomic trade factor shocks during the recent crisis. (Bagliano and Morana 2012).

[1] See, among others, Forbes and Rigobon (2002); Pericoli and Sbracia (2003); Bekaert et al. (2005); and Dungey et al. (2005).

Although there is general agreement that no permanent de-coupling of emerging markets has occurred, there are findings that are worth further exploration. Several studies find evidence of variation among emerging economies in their degree of integration with developed economies. For example, Dufrénot et al. (2011) show that stock market volatility of Latin American economies with strong financial links to the US (such as Mexico and Chile) was highly sensitive to bad news from US banking and credit markets. However stock market volatility for Brazil, Colombia and Peru, where access to US capital markets was partly limited by regulation, seemed more affected by changes in regional stock market volatility than offshore interest rate and credit spreads. And while multi-country studies find a generally higher degree of integration at the height of the crisis, correlation increased more for developed than for emerging markets (Wang and Moore 2012).

By analyzing the extent of contagion to restricted pension assets in an emerging economy, we shed light on the effect of regulation on an important kind of inaccessible asset. We ask whether quarantining domestic savings can protect pension fund members from pervasive global financial shocks and under what circumstances this protection is effective.

We begin by describing some key features of private pension funds in Colombia, establishing that the funds are a financial autarchic asset. After describing our data, crisis episodes and other descriptive statistics for the three crisis episodes, we set out contagion models and present a new dynamic measure of systematic risk. We then present estimation and test results and conclusions.

Background: Colombian Pension Funds

Latin American private pension funds have grown rapidly in the past few decades. By 2010, the approximate amount of assets under management in Latin American funds was estimated at

around 445 billion USD [2] and their annual rate of growth of assets under management has been as high as 25.4% in the past few years.

In the prevalent defined contribution (DC) pension plans, the employer and/or employee pay a fixed contribution to a fund, and the amount of pension eventually drawn by the employee depends on his/her level of savings and investment returns, net of administrative costs and taxes, at retirement. All the risk is born by the employee with no further legal responsibilities for either the government or the employer (Impavido and Tower 2009). Compared with defined benefit plans, DC plan providers may have an incentive to engage in riskier investments in order to compete with other participants in the market. Since the consequences of an unfavorable outcome can be disastrous to the members, and given the potential for agency problems in the investment process, governments tend to set regulatory constraints on the types of assets that private funds can invest in (Arrau and Schmidt-Hebbel 1995).

Figure 1 graphs the average investment limits by asset class in the Latin-American region, and for Colombia separately, for 2010. One interesting feature of the asset allocation in Latin America is a preference for local currency assets, on average 84.9% of total investments. This may ensure that local currency pension liabilities are matched with assets, and offer a cushion against volatile international capital that have triggered many past crises in the region[3]. Further, limiting holdings of offshore assets by local investors may help to increase the breadth and depth of local stock markets (AIOS 2011).

[2] Data retrieved from the Asociacion Internacional de Organismos de Supervison de Fondos de Pensiones (AIOS) http://www.aiosfp.org/estudios_publicaciones/estudios_pub_boletin_estadistico.shtml.

[3] The effects of capital flows as triggers for financial crisis in Latin America and its policy effects have been documented in the literature: Kaminsky et al. (2003); Kaminsky and Reinhart (1999); Calvo and Reinhart (1999); Edwards (1998) and more recently Dufrénot et al. (2011).

Colombian pension portfolios are concentrated in government and public entity debt at levels well above the region's average. Although regulation allows for a maximum of 31.9% in local equity and 12% in foreign holdings, this is often not reached: Colombian pension funds are on average 80% in fixed income instruments and 20% in all other asset classes. As at August 2011, around 90% of the investments were concentrated in domestic currency fixed income and equities, and just 10% of the investments were in foreign holdings[4]. The majority of domestic currency assets were sovereign and government entity debt (over 75% of total assets) with 10% allocated to local equities and mutual funds (Superfinanciera 2011).

The effect of these regulatory constraints has become more evident during the subprime crisis. For example, Pino and Yermo (2010) observed that the real average annual rate of return for private pension funds in OECD countries in the year 2008 was -24.1%, with this large loss blamed on exposures to equity during the early stages of the crisis. By contrast, some funds from non-OECD countries (including Colombia) did not suffer losses at all during 2008 due to their high exposure to local government debt.

Investments in Colombian private pension funds can be labeled as autarchic financial assets where autarchy is obtained through a restrictive regulatory framework that favors low-risk investments in local currency. If regulation can act as a cushion for cash flow volatility in times of financial crisis, then it may be possible to reduce contagion effects. However, one important caveat is that by imposing the quantitative restrictions, pension fund managers are limited to a constrained portfolio that may not grasp the full benefits of diversification (Davis, 2000) possibly generating a suboptimal risk and return over the long run. Here we restrict ourselves to assessing

[4] In the short-term deposits in foreign currency there is also a negligible portion of hedging exchange derivates which amount to less than 0.005% of the total investment composition (Superfinanciera, 2011). It is important to mention that Colombia has a floating exchange regime and its currency is allowed to float freely against the US dollar, which is the reserve currency of choice in the Latin American region.

the extent to which these restrictions can reduce contagion during crises, as a necessary, but not sufficient, condition for justifying regulation.

Data and Summary Statistics

Pension fund data for the present study have been retrieved from ASOFONDOS[5], the private pension funds (PPFs) association in Colombia. Our sample contains the net asset value (NAV) per unit for each provider (as required by Colombian regulation) from 1 February 2005 to 31 August 2011. Before 2005, the Colombian PPFs were required by law to pay a guaranteed minimum monthly rate of return which was usually a few basis points higher than the inflation rate reported by the government. (For this reason we omit the period before February 2005.) The minimum return requirement was later modified by the *Decreto 1592 de 2004,* which created a benchmark index that consisted of a weighted average of the reported annual returns of all Colombia PPFs, the Colombian equity market index, and an international benchmark equity index (the S&P 500), scaled down by 70%, and adjusted for the amount of local equity or international investments held in each PPFs portfolio[6]. This regulation allowed the PPFs to allocate their investments across the financial instruments sanctioned by the *Superintendencia Financiera de Colombia* (SFC) investment regime[7]. (The operational regulatory framework which includes the mandatory

[5] The data was retrieved from *de Centro de Informacion Consolidada Asofondos* website (Asofondos, 2011). In Colombia, the regulation concerning the private pension system and its investment regime is contained in the *ley 100 de 1993*, as drafted and approved by the Colombian Congress. All subsequent regulations regarding the day-to-day operations of the private fund industry in Colombia are the responsibility of the *Superintendencia Financiera de Colombia (SFC),* which is the agency responsible for overseeing and regulating the activities of the financial sector in Colombia and a part of the *Ministerio de Hacienda* (Ministry of Economics and Finance).
[6] The formula for the minimum rate of return is available from the authors on request.
[7] A comprehensive list of the financial instruments can be found in the relevant articles of the *Decreto 2555 de 2011* which collects all previous regulations on the matter available at http://www.asofondos.org.co/VBeContent/newsdetail.asp?id=19&idcompany=3

investment regime for PPF operators as well as the guidelines for calculating the NAV for each fund is contained a series of documents issued by the SFC[8].)

For the period under study, we measure composite fund performance (*AGGREGATE*) by adding all the funds' reported NAV per unit for a given day. The summary statistics for each fund and the *AGGREGATE* measure are presented in Table 1. Pension fund returns are negatively skewed with a high kurtosis, a fact guiding our choice of volatility model for contagion measurement.

We use daily returns to US stocks, the S&P 500, as the common factor and source of financial shocks over the same sample. For robustness, we also repeat the same tests using the JP Morgan Emerging Market Bond Index (EMBI)[9] and the Eurozone government debt index (EFFA)[10]. A regional equity portfolio is proxied by the MCSI Emerging Market Latin American (*MXLA*)[11] index and the Colombian Peso\USD exchange rate (*COPFX*) is used to measure the contribution of the floating exchange regime in the aggregated funds' performance. These series were collected from Bloomberg.

We divide the sample into a pre-crisis phase followed by three contiguous crisis phases. The first phase 'subprime' crisis begins in July 2007, followed by the 'credit crunch' crisis (CCC) beginning when Lehman Brothers filed for bankruptcy on 15 September 2008 and ending in late

[8] These documents are: Circular Externa 007 de 1996, Circular Externa 036 de 2003, and the Decreto 1592 de 2004, Decreto 2175 de 2007, Decreto 4935 de 2009 and Decreto 2555 de 2011 which can be found at the SFC website: http://www.superfinanciera.gov.co

[9] The Emerging Market Bond Index Global is a market weighted capitalization index of Us dollar denominated bonds and Eurobonds from sovereign and quasi-sovereign entities and is a worldwide recognized benchmark for emerging markets debt.

[10] The EFFA/Bloomberg index includes all of the Eurozone government debt with maturities of more than one year is the most comprehensive Eurobond index which includes more than 364 issues form all members. The EFFA is a market weighted capitalization index.

[11] The MSCI EM (Emerging Markets) Latin America Index is a free float-adjusted market capitalization weighted index that is designed to measure the equity market performance of emerging markets in Latin America. The MSCI EM Latin America Index consists of the following 5 emerging market country indices: Brazil, Chile, Colombia, Mexico, and recently Peru as of May 30 of 2011.

October 2009. The sovereign debt crisis (ESD) was continuing at the end of our sample, so we date it from 22 October 2009 to 31 August 2011[12].

Since contagion is here defined as a significant change in co-movements of returns across markets, conditional on a crisis occurring in one market or group of markets, we begin by considering the dynamics of returns and correlation across the phases. Table 2 reports summary statistics for returns to Colombian pension funds (*AGGREGATE*), the regional equities index (*MXLA*) and the Colombian Peso/USD exchange rate (*COPFX*) with the S&P 500 for the pre-crisis, crises and total sample periods.

Correlation between *AGGREGATE* and the S&P500 declines from pre-crisis levels during the subprime crisis but is markedly higher during the ESD. *MXLA* follows a similar pattern with a sharper increase in the CCC phase. Correlation between S&P500 returns and *COPFX* is also closer to zero during the subprime phase.

The relatively low responsiveness of *AGGREGATE* to the first two crisis phases is corroborated by the SD ratios which are below one until the ESD crisis. (The SD ratios and mean ratios are calculated using the sample statistic during the crisis period in the numerator and the pre-crisis period statistic in the denominator. A ratio greater than one signals an increase in volatility/return during the crisis period over the pre-crisis period.) For other returns series (S&P500, *MXLA* and *COPFX*) the SD ratio is greater than one for all crisis phases. Also, the Sharpe Ratio[13] for *AGGREGATE* tends to outperform all other investments during all the crisis periods

[12] The key dates for the crisis were taken from the financial turmoil timeline chart from The Federal Reserve Bank of New York http://newyorkfed.org/research/global_economy/Crisis_Timeline.pdf and the crisis timeline from Bloomberg.

[13] The Sharpe ratio is the most common performance investment measure and is defined as $SR = \frac{(\overline{R_J} - \overline{R_f})}{\sigma_j}$ where $\overline{R_J}$= the average return of the security, $\overline{R_f}$= the average return of the proxy of the risk free rate in which our case is the US 10 Year Treasury index adjusted by the Colombian country premium and σ_j= the standard deviation of the security.

under observation. (Sharpe ratios are calculated from the perspective of the Colombian investor so that the returns are adjusted for the exchange rate, resulting in negative values in several cases. Other statistics are calculated in local currency.) Even though quantitative restrictions such as allocation caps can limit the upward risk/return potential of *AGGREGATE* by constraining investment portfolio, these same measures also can limit the potential for losses as observed by a higher Sharpe ratios during the different episodes of the crisis.

Contagion Model

We evaluate evidence for contagion via changes in the time varying volatility of the pension fund returns across different crisis phases. Specifically, we search for significant changes in the proportion of the filtered returns volatility that can be attributed to US stock market shocks. For comparison, we conduct the same tests for the regional stock index and the exchange rate. By implementing and estimating a conditionally heteroskedastic model of daily returns volatility via a multivariate GJR-GARCH model (Glosten et al. 1993), we avoid the criticism of unconditional correlation comparisons noted by Forbes and Rigobon (2002)[14].

We begin by applying ARMA filters to the returns series $R_{i,t}$ where $i = 1, \dots, 4$ (S&P500, *AGGREGATE, MXLA, COPFX*) to ensure residuals for the M-GARCH model are zero mean and serially uncorrelated[15]. The filtered returns are denoted $\varepsilon_{i,t}$. Using the method proposed by Bekaert et al. (2005), we treat the S&P500 as the originating source of potential contagion. The covariance of filtered returns to the S&P500 with *AGGREGATE, MXLA,* and *COPFX* respectively is:

$$h_{US,t} = \alpha_{0,US} + \alpha_{1,US}\varepsilon^2_{US,t-1} + \alpha_{2,US}I_{US,t-1}\varepsilon^2_{US,t-1} + \alpha_{3,US}h_{US,t-1}$$

[14]Similar structures are estimated by Fujii (2005), Chiang et al. (2007) and Ping and Moore (2008).
[15] AR(1) filters were sufficient for all but AGGREGATE where we used an ARMA(1,2).

$$h_{i,t} = \alpha_{0,i} + \alpha_{1,i}\varepsilon_{i,t-1}^2 + \alpha_{2,i}I_{i,t-1}\varepsilon_{i,t-1}^2 + \alpha_{3,i}h_{i,t-1}$$

$$h_{USi,t} = \alpha_{0,USi} + \alpha_{1,USi}\varepsilon_{US,t-1}\,\varepsilon_{i,t-1} + \alpha_{2,USi}I_{US,t-1}\varepsilon_{US,t-1}\,I_{i,t-1}\varepsilon_{i,t-1} + \alpha_{3,USi}h_{USi,t-1}$$

$$\begin{bmatrix}\varepsilon_{US,t}\\ \varepsilon_{i,t}\end{bmatrix} | \Omega_{t-1} \sim N\left(\begin{bmatrix}0\\0\end{bmatrix}, \begin{bmatrix}h_{US,t} & h_{USi,t}\\ h_{USi,t} & h_{i,t}\end{bmatrix}\right), \quad (1)$$

where $h_{US,t}$ is the conditional variance of filtered returns from the US (origination country), $h_{i,t}$ is the conditional variance of the filtered returns to the local or regional market index under scrutiny, $h_{USi,t}$ is the covariance between the US market and the local or regional market index and $I_{j,t-1}$is an indicator equal to one when $\varepsilon_{j,t-1}$ is negative and zero otherwise. In order to ensure that the relevant parameters are positive and avoid negative volatilities we used a diagonal BEKK specification.

Using fitted values from the M-GARCH, we can compute a single index factor as:

$$\beta_{i,t} = \frac{h_{USi,t}}{h_{US,t}} \quad (2)$$

The advantage of this specification is that it further allows us to decompose the variance of the local index returns into systematic and idiosyncratic components:

$$h_{i,t} = {\beta_{i,t}}^2 h_{US,t} + h_{ei,t}, \quad (3)$$

where $h_{i,t}$ is the variance of the index under scrutiny, ${\beta_{i,t}}^2 h_{US,t}$ is the part of the variance attributed to a common systematic transmission mechanism, and $h_{ei,t}$ is the part of the variance attributed to idiosyncratic factors. Therefore, expressing the variance decomposition as a proportion of systematic and idiosyncratic risk is straightforward:

$$u_{sys,i,t} = \frac{{\beta_{i,t}}^2 h_{US,t}}{h_{i,t}}$$

$$u_{idio,i,t} = \frac{h_{ei,t}}{h_{i,t}}$$

(4)

Evaluation of contagion from US stock market shocks proceeds along similar lines to Bekaert et al. (2005), by testing for breaks in the proportion of the variance due to systematic factors during each crisis phase. We regress the extracted systematic factors on a constant, a lagged value to control for serial correlation and indicator variables for the phases of the crisis:

$$u_{sys,i,t} = \varphi_0 + \varphi_1 u_{sys,t-1} + \varphi_2 I_{subprime,t} + \varphi_3 I_{CCC,t} + \varphi_4 I_{ESD,t} + e_{i,t}\,, or$$

$$\beta_{i,t} = \gamma_0 + \gamma_1 \beta_{i,t-1} + \gamma_2 I_{subprime,t} + \gamma_3 I_{CCC,t} + \gamma_4 I_{ESD,t} + \epsilon_{i,t} \quad (5)$$

where $I_{j,t}$ is an indicator variable that take the value of one for the respective crisis dates (subprime. CCC and ESD) and is zero otherwise. Contagion, in the form of changes to volatility transmissions from the systematic factor, is detected when coefficients on the crisis phase indicators are significantly different from zero.

Results

Graphs of the dynamic path of $u_{sys,i,t}$ and $u_{idio,i,t}$ highlight the changing impact of US stock market shocks on the inaccessible pension funds returns (*AGGREGATE*), the more tradable regional stock index (*MXLA*), and the exchange rate (*COPFX*).

Figure 2 graphs the decomposition of the conditional volatility of Colombian pension fund returns into systematic (US-sourced) and idiosyncratic components. Systematic risk increases at the beginning of the subprime crisis, decreases during the CCC and then increases dramatically during the ESD crisis. It appears that initial responses to the sub-prime and CCC crises dissipate as markets focus more on the fundamentals affecting pension fund performance, as opposed to the ESD in which the effects of bad news in fixed interest markets show up as persistently higher systematic variance.

Figure 3, which decomposes the conditional variance of *MXLA*, shows the total average systemic risk observed for the whole sample is higher than that observed for *AGGREGATE*. Consistent with some evidence for de-coupling/re-coupling, there is an increase in systematic risk before the subprime crisis that dampens during the crisis then escalates during the CCC and ESD periods.

On the other hand, *COPFX* systematic risk in Figure 4 shows a dampening effect during the subprime crisis and a sudden increase towards the end of the CCC, to levels which are maintained throughout the ESD crisis. Finally, the increase in systematic risk during mid-2006 for both *AGGREGATE* and *COPFX* is explained by three consecutive interest hikes of the Federal Reserve between March and June of 2006 that had strong effects in Latin American markets (Ocampo 2009). Three rapid hikes caused turbulence, as the cost of financing adjusted to new levels and capital flows to the region diminished while foreign borrowers reassessed their investments.

Contagion from US stock market factor

In order to investigate the presence of contagion, we conducted the test described in equation (5) for each of the systematic variance components $u_{sys,i,t}$ and time varying factor $\beta_{i,t}$ respectively. The results are summarized in Table 3. The only significant evidence of contagion from US stock volatility to the inaccessible asset, *AGGREGATE,* relate to the European sovereign debt crisis. No significant contagion is evident in the earlier periods despite the severity of the shocks. Like many other contagion studies (e.g., Dungey et al. 2010) we find some evidence of weakening links between US and regional LAC volatility during the crisis phases. Overall, graphical evidence and structural break tests confirm that the regulated assets were protected from stock market volatility contagion during the subprime crisis and its aftermath in the post-Lehman credit crunch,

but that shocks from fixed interest markets may still be transmitted, despite limited international exposure.

Contagion from Bond market factors

We drill down into the sensitivity of the autarchic assets to bond market shocks using fixed income indices as the potential sources of contagion. There are large investments in Colombian local government debt in *AGGREGATE*, so bond market shocks may be more relevant. The results are summarized in Table 4.

Some tests of $\beta_{AGGREGATE,t}$ support a finding of contagion from the EMBI during the subprime and ESD crises but not the CCC crisis. However, there is no evidence of contagion from the EMBI in any of the crises in regressions of $u_{sys,AGGREGATE,t}$. For the European index, EFFA, we find that there is evidence of contagion in the subprime and ESD crisis. This is an intriguing result since there are two reasons why one would expect the EMBI to be more significant than the EFFA as a transmission factor for contagion in *AGGREGATE*. First, the EMBI is computed from emerging market issuers (Greece included) with similar weights and Colombia is also a small component of the index. Secondly, the EFFA is a market weighted index for the whole Eurozone, so the effect of volatility of the countries in crisis should be mitigated by the larger and more stable countries in the index. However, since the majority of significant contagion is related to EFFA volatility, we conclude that it is a better proxy for the systematic factor that the S&P 500 in the case of *AGGREGATE*.

Quantile regression

One feature of the volatility models implemented here are asymmetries in the distributions of statistics of interest, in particular the conditional systematic variation proportion, $u_{sys,i,t}$. We implement quantile autoregression QAR(1) as proposed by Koenker and Xiao (2006)

in order to check the robustness of contagion tests. We generalize equation (5) and allow coefficients to be quantile dependent,

$$F^{-1}\left(\tau\middle|u_{sys,i,t}\right) = \varphi_0(\tau) + \varphi_1(\tau)F^{-1}\left(\tau\middle|u_{sys,i,t-1}\right) + \varphi_2(\tau)I_{subp,t} + \varphi_3(\tau)I_{CCC,t} + \varphi_4(\tau)I_{ESD,t} + e_{i,t}$$

where τ represents the 1%, 5%, 10%, 25%, 50%, 75%, 90%, 95%, and 99% quantiles respectively. By estimating over the extreme quantiles we can observe the structure of dependence while taking into account the asymmetric nature of our data (Baur, 2012). Specifically, we are interested in whether unusually large systematic volatility proportions are more common during crisis phases. Table 5 outlines the results. Consistent with earlier results, contagion from US stocks to pension funds is primarily confined to extreme volatility events during the sovereign debt crisis.

Conclusion

Here we study the behavior of a particularly isolated (autarchic) asset during the recent financial and sovereign debt crises. Colombian private pension funds can be seen as autarchic assets due to the strict regulatory constraints on their portfolio holdings that confine them largely to defensive, domestic currency assets. Even though these 'quantitative restrictions' can limit the risk/return potential of the autarchic portfolio, this same restrictions could also limit the potential losses in time of crisis. Preliminary analysis shows that the Sharpe ratios of an aggregate of private pension fund returns were higher than those of regional and global benchmarks during the crisis period.

We dig deeper into this question by estimating an M-GARCH structure with US stock market shocks as the systematic factor and potential source of contagion. We decompose risk into its systematic and idiosyncratic components and test for additional contagious linkages to pension

fund returns volatility. We also introduce quantile autoregression to overcome some of the limitations and biases generated by asymmetric data and to obtain a more detailed analysis of systemic risk.

We find no evidence of contagion to Colombian pension funds from US stocks during the first two phases of the subprime crisis. However, during the European sovereign debt crisis, there is strong evidence of contagion in all tests. When we allow for different channels of transmission such as the EMBI and the EFFA indices, there is evidence of contagion from fixed interest markets to pension fund volatility in the subprime and ESD crises. We also demonstrate contagion to LAC regional stocks during the Subprime and CCC episode.

Our findings are similar to Dooley and Hutchison (2009) in confirming evidence of temporary de-coupling during the year 2007. Our results are also in line with the finding of Boyer et al. (2006) that interdependence among accessible assets was greater than the inaccessible (autarchic) assets. Although there was evidence of de-coupling of the Colombian funds in the first and second crisis episodes, our findings also show a strong evidence of re-coupling at a later stage of the crisis, in line with those of Frank and Hesse (2009) in their study of the EMBI.

In other words, while restricting pension fund asset holdings to domestic currency defensive assets may quarantine returns from extreme overseas stock market turbulence, we find no evidence that turmoil in even relatively unrelated fixed interest markets can be kept at bay. Finally, and most importantly, we hope that by analyzing the effect of government regulation in emerging markets we can shed some light on whether and how the effects of contagion can be mitigated.

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Table 1. Descriptive statistics: annualized daily returns to Columbian private pension funds, 2 February 2005 – 31 August 2011.

	CitiColfondos	Horizonte	Porvenir	Protección	ING	Aggregate
Mean	8.29	9.38	7.97	9.87	8.44	8.80
Median	7.75	9.84	8.75	8.78	8.19	8.61
Maximum	22.48	21.98	18.9	25.04	21.07	21.35
Minimum	-3.10	-1.88	-3.57	-2.83	-4.10	-3.02
Std. Dev.	5.88	5.82	5.79	6.20	6.03	5.83
Skewness	-0.75	-0.62	-0.39	-0.71	-0.67	-0.71
Kurtosis	8.60	8.83	8.64	8.98	9.69	8.73
Jarque-Bera	2402	2535	2315	2696	3322	2490
Probability	0.00	0.00	0.00	0.00	0.00	0.00
Observations	1714	1714	1714	1714	1714	1714
Members* ('000)	1,533	1,701	3,096	2,050	1,161	9,541
Assets USD mil*	7,045	8,077	15,074	12,563	6,508	49,266

*As reported by Superfinanciera in January 2012

Table shows summary statistics for daily percentage changes (annualized) in net asset values per unit of Colombian Pension Funds, 2 February 2005 to 31 August 2011. Aggregate is calculated by adding all the funds' reported NAV per unit each day.

Table 2. Descriptive statistics: sub-sample

	AGGREGATE	*S&P500*	*MXLA*	*COPFX*
		Pre-crisis		
Mean (% p.a.)	7.13	9.38	38.85	-8.24
St. Dev. (% p.a.)	3.40	10.34	23.12	8.44
Sharpe ratio	0.57	-0.29	-0.26	0.01
Correlation (S&P)	0.26	-	0.64	-0.23
		Subprime		
Mean (% p.a.)	5.75	-16.37	-8.35	4.87
St. Dev. (% p.a.)	2.81	20.75	33.75	15.08
Sharpe ratio	0.35	-0.68	-0.26	0.01
Correlation (S&P)	0.22	-	0.58	-0.15
Mean ratio	0.81	-1.75	-0.21	-0.59
SD ratio	0.82	2.01	1.46	1.79
		CCC crisis		
Mean (% p.a.)	9.96	-14.63	1.14	-0.46
St. Dev. (% p.a.)	3.39	33.17	47.61	18.10
Sharpe ratio	1.62	-0.58	-0.09	-0.27
Correlation (S&P)	0.30	-	0.72	-0.24
Mean ratio	1.40	-1.56	0.03	0.06
SD ratio	0.99	3.21	2.06	2.15
		ESD crisis		
Mean (% p.a.)	8.89	-5.17	0.89	-2.04
St. Dev. (% p.a.)	4.28	27.59	38.78	14.87
Sharpe ratio	1.06	-0.42	-0.16	-0.43
Correlation (S&P)	0.36	-	0.72	-0.26
Mean ratio	1.25	-0.55	0.02	0.25
SD ratio	1.26	2.67	1.68	1.76

Table reports descriptive statistics for daily returns in local currency during pre-crisis period and crisis phases. An appreciation of the Colombian Peso produces a negative return. The Sharpe ratio is defined as $SR = \frac{(\overline{R_J} - \overline{R_f})}{\sigma_j}$ where $\overline{R_J}$= the mean return of the security, $\overline{R_f}$= the mean return of the risk free rate, the US 10 Year Treasury index adjusted by the Colombian country premium, and σ_j= the standard deviation of the security.The SD ratios and mean ratios are calculated using the sample statistic during the crisis period in the numerator and the pre-crisis period statistic in the denominator. A ratio greater than one signals an increase in volatility/return during the crisis period over the pre-crisis period.

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Table 3. Tests for contagion: US stock market to Colombian Pension Fund, LAC stocks and Colombian Peso\USD exchange rate.

Dependent Variable							
	$u_{sys,i,t}$				$\beta_{i,t}$		
Coefficient	*AGGREGATE*	*MXLA*	*COPFX*	*Coefficient*	*AGGREGATE*	*MXLA*	*COPFX*
$\varphi_{2\,Subprime}$	0.001	-0.002	-0.001	$\gamma_{2\,Subprime}$	-0.001	-0.019***	0.0024
$\varphi_{3\,CCC}$	0.000	0.003	0.001	$\gamma_{3\,CCC}$	-0.001	-0.020***	-0.001
$\varphi_{4\,ESD}$	0.005***	0.003	0.001	$\gamma_{4\,ESD}$	0.001	-0.013**	0.0001
R-squared	0.931	0.001	0.888	R-squared	0.965	0.929	0.919
S.E. of regression	0.029	0.002	0.016	S.E. of regression	0.013	0.081	0.028

Table reports tests for contagion from US stock market returns to Colombian Pension fund returns (*AGGREGATE*), Latin American stock index returns (*MXLA*) and the Colombian Peso\USD exchange rate (*COPFX*) over three crisis phases. The LHS of the table reports coefficient estimates obtained from regressing the proportion of conditional variance of returns to each local index due to US stock market shocks on a constant and indicators for crisis phases, $u_{sys,i,t} = \varphi_0 + \varphi_1 u_{sys,t-1} + \varphi_2 I_{subprime,t} + \varphi_3 I_{CCC,t} + \varphi_4 I_{ESD,t} + e_{i,t}$. The RHS of the table reports coefficient estimates obtained from regressing the single index beta (US stock market shocks) on a constant and indicators for crisis phases, $\beta_{i,t} = \gamma_0 + \gamma_1 \beta_{i,t-1} + \gamma_2 I_{subprime,t} + \gamma_3 I_{CCC,t} + \gamma_4 I_{ESD,t} + \epsilon_{i,t}$. Significant coefficients indicate contagion at the *90%, **95%, ***99% confidence level.

Table 4. Tests for contagion: Emerging market bond index and European bond index to Colombian Pension Funds.

	Dependent Variable				
	$u_{sys,AGGREGATE,t}$			$\beta_{AGGREGATE,t}$	
Coefficient	*EMBI*	*EFFA*	*Coefficient*	*EMBI*	*EFFA*
$\varphi_{2\,Subprime}$	-0..006	0.003***	$\gamma_{2\,Subprime}$	-0.016**	-0.01**
$\varphi_{3\,CCC}$	0.004	0.001	$\gamma_{3\,CCC}$	-0.01	-0.006
$\varphi_{4\,ESD}$	0.001	0.003***	$\gamma_{4\,ESD}$	0.016***	-0.013**
R-squared	0.849	0.848	R-squared	0.830	0.858
S.E. of regression	0.053	0.098	S.E. of regression	0.017	0.071

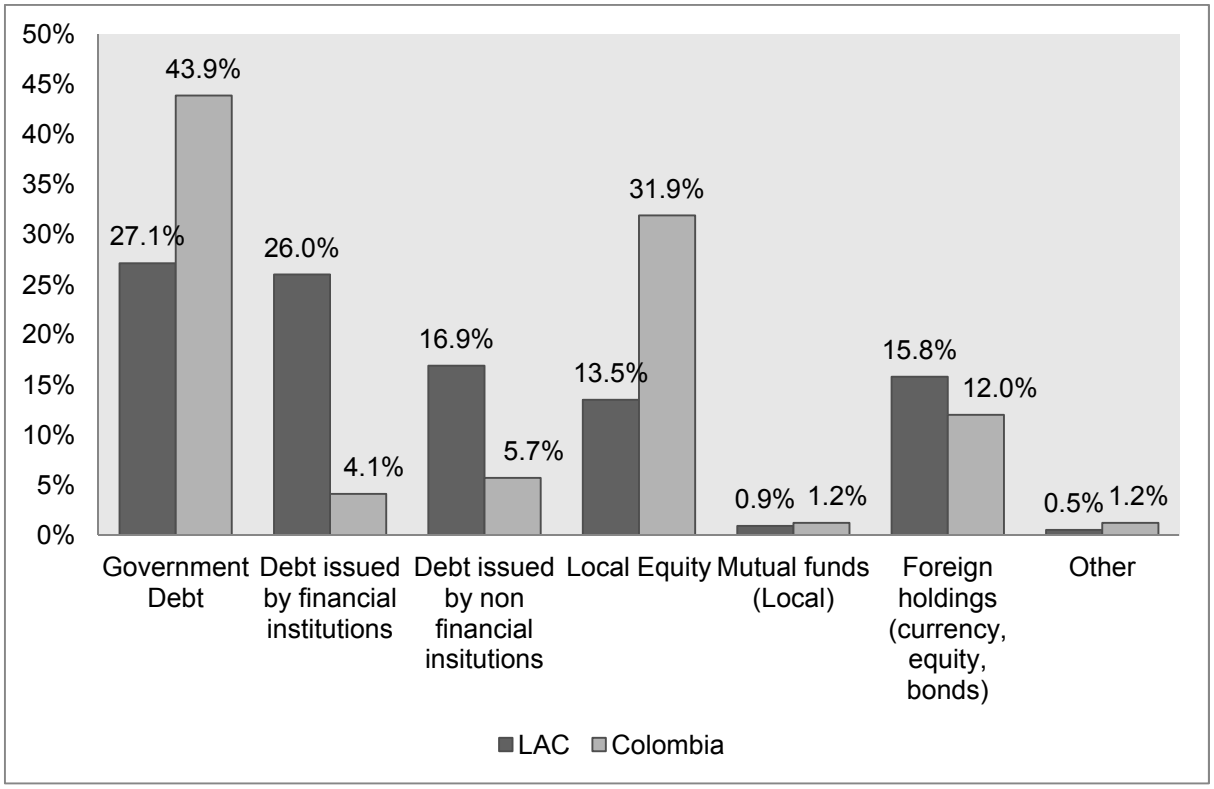
Table reports tests for contagion from the Emerging market bond index return (EMBI) and European Bond index returns (EFFA) to Colombian Pension fund returns (*AGGREGATE*) over three crisis phases. The LHS of the table reports coefficient estimates obtained from regressing the proportion of conditional variance of *AGGREGATE* returns due to each bond index shock on a constant and indicators for crisis phases, $u_{sys,i,t} = \varphi_0 + \varphi_1 u_{sys,t-1} + \varphi_2 I_{subprime,t} + \varphi_3 I_{CCC,t} + \varphi_4 I_{ESD,t} + e_{i,t}$. The RHS of the table reports coefficient estimates obtained from regressing the single index beta (index return shocks) on a constant and indicators for crisis phases,
$\beta_{i,t} = \gamma_0 + \gamma_1 \beta_{i,t-1} + \gamma_2 I_{subprime,t} + \gamma_3 I_{CCC,t} + \gamma_4 I_{ESD,t} + \epsilon_{i,t}$. Significant coefficients indicate contagion at the *90%, **95%, ***99% confidence level.

Table 5: Tests for contagion by quantile: US stock market to Colombian Pension Fund, LAC stocks and Colombian Peso\USD exchange rate.

	$u_{sys,i,t}$			
	Quantile	***AGGREGATE***	***MXLA***	***COPFX***
$\varphi_{2\,Subprime}$	1%	0.002	-0.030	-0.001
	2%	-0.001	-0.031	0.000
	5%	-0.005	-0.006	-0.002
	10%	-0.003	-0.011	-0.001
	25%	-0.001	-0.006**	-0.003***
	50%	0.000	0.000	-0.002***
	75%	0.000	0.002**	0.000
	90%	0.006	0.004***	-0.001
	95%	0.014	0.006**	0.000
	98%	0.013	0.002	0.004
	99%	0.015	0.003	0.007
	Quantile	***AGGREGATE***	***MXLA***	***COPFX***
$\varphi_{3\,CCC}$	1%	0.006***	0.015	-0.001
	2%	0.003	0.002	0.002
	5%	0.001	-0.007	0.000
	10%	-0.001	-0.001	0.000
	25%	-0.003***	-0.003	-0.002***
	50%	0.000	0.004***	-0.001*
	75%	0.000	0.004***	0.001**
	90%	0.002	0.004***	0.004
	95%	0.013	0.003	0.007
	98%	0.008	-0.002	0.019***
	99%	0.026	-0.005	0.011
	Quantile	***AGGREGATE***	***MXLA***	***COPFX***
$\varphi_{4\,ESD}$	1%	-0.008***	0.020	0.000
	2%	0.004**	0.013	0.003
	5%	0.000	0.009	0.001
	10%	0.001	0.009	0.001
	25%	0.002**	0.002	-0.001
	50%	0.002***	0.001	0.000
	75%	0.003***	0.000	0.001
	90%	0.007**	0.000	0.002
	95%	0.014	-0.002	0.006
	98%	0.042***	-0.007*	0.010**
	99%	0.050***	-0.007	0.031**

Table reports tests for contagion from US stock market returns to Colombian Pension fund returns (*AGGREGATE*), Latin American stock index returns (*MXLA*) and the Colombian Peso\USD exchange rate (*COPFX*) over three crisis phases by quantile. Coefficient estimates are obtained from regressing the proportion of conditional variance of returns to each local index due to US stock market shocks on a constant and indicators for crisis phases, $F^{-1}(\tau|u_{sys,i,t}) = \varphi_0(\tau) + \varphi_1(\tau)F^{-1}(\tau|u_{sys,i,t-1}) + \varphi_2(\tau)I_{subp,t} + \varphi_3(\tau)I_{CCC,t} + \varphi_4(\tau)I_{ESD,t} + e_{i,t}$ where τ indicates the quantile. Significant coefficients indicate contagion at the *90%, **95%, ***99% confidence level.

Figure 1-Average investment limits by asset class in private pension funds in Latin America Countries (LAC) and Colombia, 2010.



Source: Data retrieved from the Asociacion Internacional de Organismos de Supervison de Fondos de Pensiones (AIOS)

Figure 2. Conditional variance decomposition, Colombian Pension Fund returns.

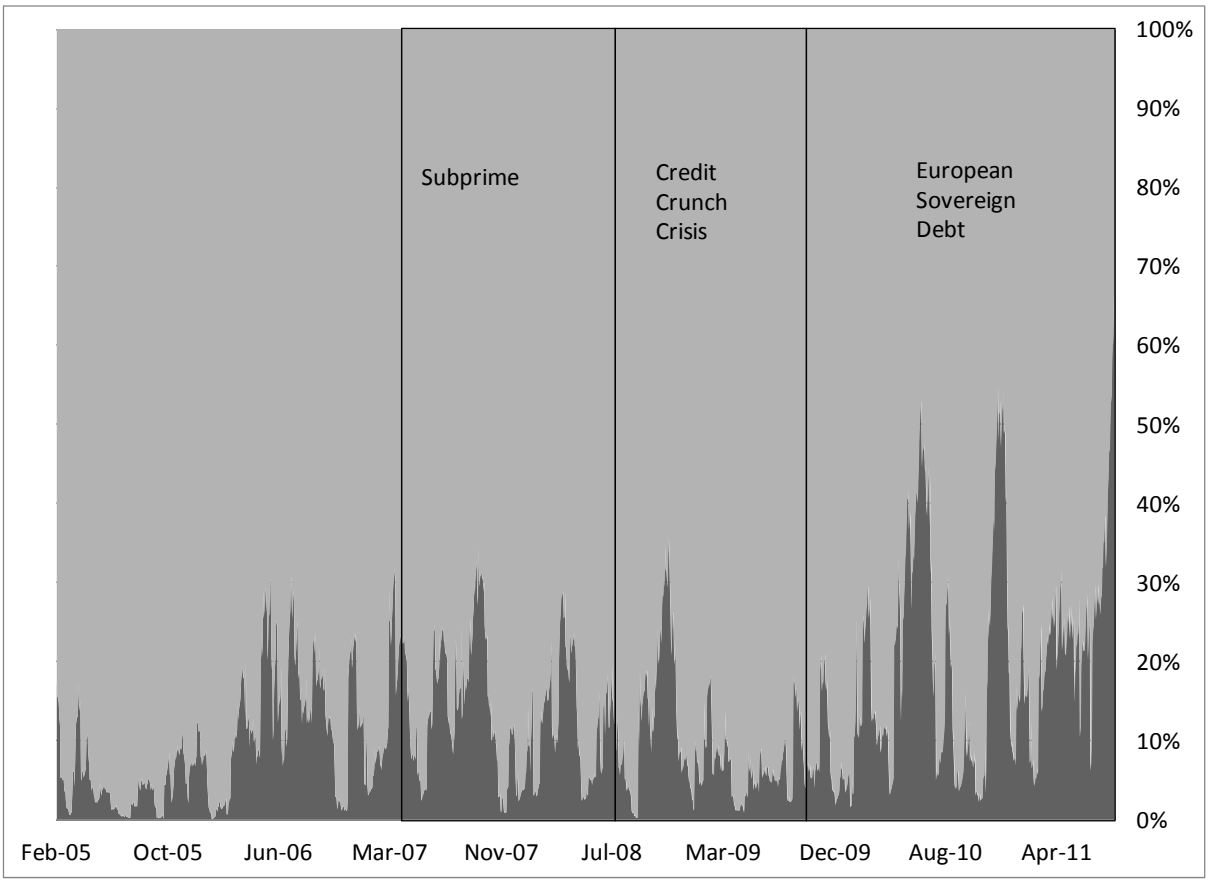


Figure graphs proportion of conditional volatility of returns to Colombian Pension funds due to systematic volatility shocks from US S&P500 (dark gray).

Figure 3. Conditional variance decomposition, Latin American stock market returns.

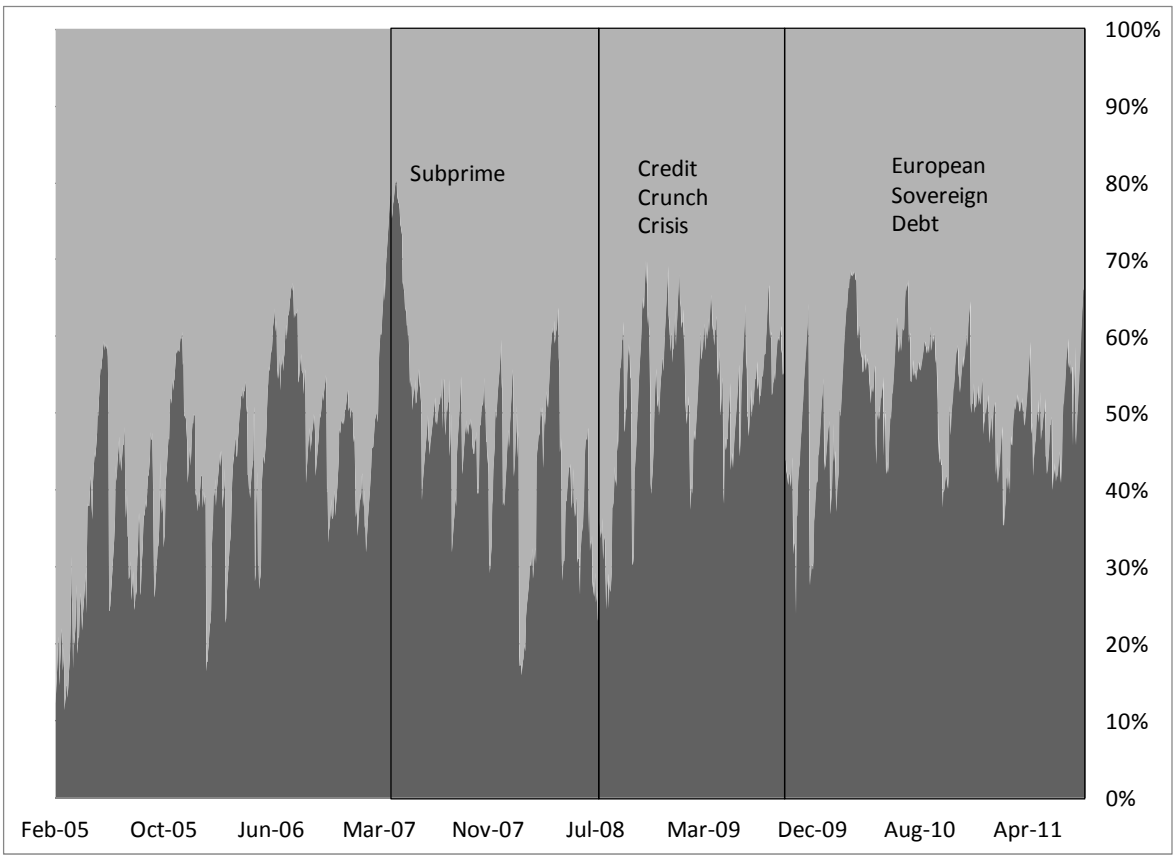


Figure graphs proportion of conditional volatility of returns to the Latin American regional stock index due to systematic volatility shocks from US S&P500 (dark gray).

Figure 4. Conditional variance decomposition, Colombian Peso/USD exchange rate returns.

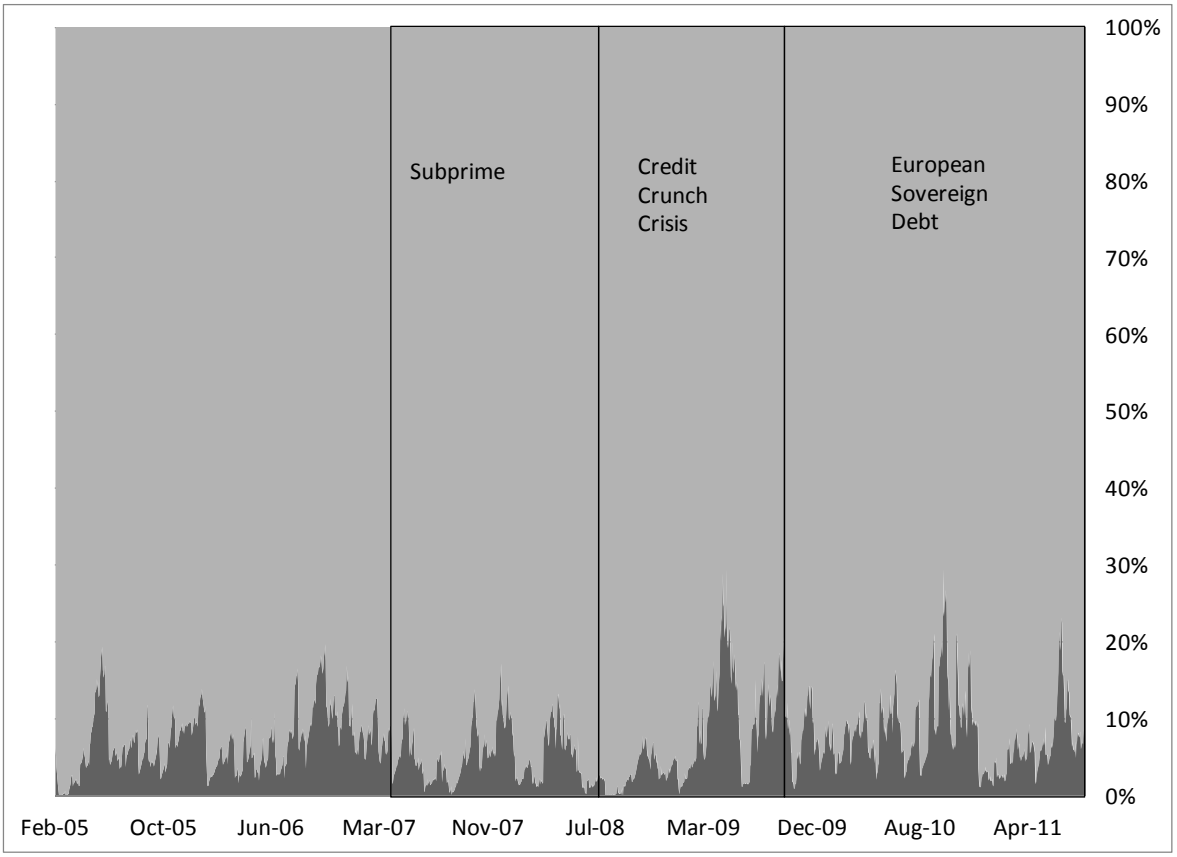


Figure graphs proportion of conditional volatility of returns to the Colombian Peso\USD exchange rate due to systematic volatility shocks from US S&P500 (dark gray).