An Empirical Analysis of the Impact of the Credit Default Swap Index Market on Large Complex Financial Institutions

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Abstract

This paper contributes to the primarily empirical literature by conducting the first extensive empirical analysis of the impact of the degree of co-movement in the main standardized credit default swap (CDS) indices on the group of systemically relevant large complex financial institutions (LCFIs). We attempt to account for the dynamics between banks' equity returns and most liquid CDS market indices, the investment grade 5-year CDX North America and the investment grade 5-year iTraxx Europe, through conditioning our analysis on the historical correlation between the variables. Our most important findings are threefold. First, equity returns for all the LCFIs are negatively correlated to both the CDX and the iTraxx indices. Second, the CDX index is the dominant factor driving shocks across all the LCFIs and its influence varies substantially across the institutions included in this study. Third, we find that the impact of CDS market volatility on the equity return volatility of LCFIs appears very pronounced, suggesting a transmission mechanism which results in the destabilisation of banks and a subsequent increase in their default risk.

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1 Introduction

A major structural innovation in the financial system has been the development of a market for credit risk transfer (CRT). This market offers a rapidly increasing number of instruments to deal with different aspects of credit risk. Besides providing default protection for individual firms through CDSs, the credit risk in entire credit portfolios can now be traded by means of collateralized debt obligations (CDOs). Essentially, a CDO represents a set of claims or tranches of varying exposure to the cash flows from a portfolio of credit instruments.

The overall market for over-the-counter derivatives shot up to $455 trillion at the end of 2007. Some $62 trillion of that were CDSs, whose supercharged growth continued despite of the credit crunch. Conceived in the 1990s as a hedging tool, CDSs soon took off as a way to speculate on the likelihood of a firm going bust without having to trade its underlying bonds. For much of this decade, they have been celebrated as a means of spreading risk around the financial system.

The subprime crisis that unfolded in 2007 has morphed into a credit crisis that has caused major disruption to financial institutions in the United States (US) and Europe. A number of internationally-active banking groups, with large credit related exposure, have been severely affected by the current market turmoil, particularly those with US mortgage-related asset-backed securities (ABSs) and CDOs exposure. The more volatile trading environment has severely impaired the performance of every single global bank. Consequently, the intensifying solvency concerns about a number of the largest US-based and European financial institutions have pushed the global financial system to the brink of systemic meltdown.

In this study we focus on the global CDS index market and its implications for systemic risk in financial markets. Today, the index tranche market is very much the “on-the-run” market for synthetic CDOs. Many billions of dollars in notional risk are traded each week through benchmark products in the US, Europe, and Asia, spanning investment grade and high yield markets. The index tranche market has introduced valuation transparency to a point where a standardized correlation model has emerged. Liquidity in off-the-run index tranches has broadened the index tranche market quite substantially. The index tranche market itself has evolved quite a bit, with today's products centered around the *CDX* and *iTraxx* family of indices, with healthy activity across the term structure and even within off-the-run indices.

The main reason we focus on this topic is that the stability of the banking sector and the financial system at large is of the utmost importance for a sustainable and stable growth of the global economy. The extent to which the increasing marketability of credit risk can influence credit and economic cycles is of particular macroeconomic importance.

We address a number of global financial institutions of the US and European banking industry that could undergo distress on a systemic scale.

Specifically, this paper focuses on the group of *Large Complex Financial Institutions* (LCFIs) as defined by the *Bank of England* (2001)[1]. LCFIs include the world's largest banks, securities houses and other financial intermediaries that carry out a diverse and complex range of activities in major financial centres[2]. These financial institutions are *ABN Amro*[3], *Bank of America*, *Barclays*, *BNP Paribas*, *Citigroup*, *Credit Suisse*, *Deutsche Bank*, *Goldman Sachs*, *HSBC Holdings*, *JPMorgan Chase*, *Lehman Brothers*, *Merrill Lynch*, *Morgan Stanley*, *Société Générale* and *UBS.*

LCFIs play a pivotal role in the international financial system as intermediators of risk and as providers of liquidity to capital markets. LCFIs can be considered as institutions whose size and nature of business is such that their failure and inability to operate would most likely spread and have adverse implications for the smooth functioning of financial markets or other financial institutions operating within the system. If the disturbance were large enough to threaten financial system

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[1] The Bank of England, (December 2001), *Financial Stability Review*, No. 11, London, describes the criteria used to determine an LCFI peer group. The financial institutions selected are ranked in the top ten in at least two of the following six categories: (i) equity book runners, (ii) bond book runners, (iii) syndicated loans book runners, (iv) interest rate derivatives outstanding, (v) foreign exchange revenues, and (vi) holders of custody assets.

[2] For the purposes of financial system stability assessment, it is important to identify and monitor the activities of banking groups whose size and nature of business is such that their failure and inability to operate would most likely have adverse implications for financial intermediation, the smooth functioning of financial markets or other financial institutions operating within the system.

[3] We omit from the sample Abn Amro since in 2007 it was taken over by a consortium of European banks led by Royal Bank of Scotland (RBS) Group. Accordingly, we deem more appropriate to include RBS in the banking sample.

stability it could be transmitted through various channels – including payment systems and markets – but would most likely originate from an institution being unable to meet its payment and settlement obligations [ECB, 2006].

Movements in banking stock prices provide a market-based measure of investors' assessment of corporate credit risk. Changes in and perceptions of credit quality have indeed the potential for creating losses resulting in stress to systematically important LCFIs. The potential for instability in pricing credit risk in the tranches index market could result in broad spillovers and/or mark- to market losses. Hence, an indicator attempting to capture the extent of CDS index market sensitivity of LCFIs returns provides an indirect measure of institutional susceptibility to price changes. Broader credit deterioration and falling credit prices could combine into a substantial hit to the equity capital of systematically important LCFIs.

This paper extends the approach used in recent research by *Chan Lau* and *Ong* (2006)[4]. Employing a VAR model, the authors show that the use of CDs by the major UK financial intermediaries does not pose a substantial threat for the *stability* of the UK financial system. In fact, exposures across major financial institutions appear sufficiently diversified to limit the impact of any shock to the market, while major insurance companies turn out to be largely exposed to the "*safer*" senior tranches.

In this study we adopt an empirical approach to perform tests on the global banking system. To our knowledge this paper is the first to investigate the dynamics between banks' equity returns and major tranched CDSs indices. Unlike most existing works on links between the CDs market and the fragility of the banking system, an indirect measure of banks' fragility – the variability of banking stock returns – is employed. We apply a parsimonious vector autoregression (VAR) model. The advantage of the VAR is that it estimates how banks' prices change following adverse CDSs shocks implying that the stress test is conditional on the historical correlation among the variables in the multivariate model.

This paper makes two major contributions to the literature.

At first, from a methodological standpoint, it complements existing work on the implications of structured credit products volatility for financial sector stability. We do this by applying an innovative modelling approach which handles the VAR methodology to readily available financial market data. The second contribution, from

[4] Chan-Lau J. A., Ong L. L., (2006), *The Credit Risk Transfer Market and Stability Implications for U.K. Financial Institutions*, IMF Working Paper No. 06/139.

an empirical perspective, is to provide evidence of the impact of the evolution of the co-movements – i.e. correlation - between the standardized CDSs indices prices on the global banking sector, by assessing the extent to which LCFIs asset prices are driven by the evolution of volatility in the CDS index market.

No conventional theoretical economic model describes the relationship from CDSs variables to bank returns and vice versa (for example by affecting CDSs spreads levels and thus the magnitude of credit risk).

Our paper is also closely related to the study of *Bystrom* (2005)[5]. This author provides indeed the first attempt to investigate the relationship between the CDS index market and the stock market. For a sample of European sectoral iTraxx CDS indices, a correlation analysis reveals a close link between the two markets. CDS spreads have a strong tendency to widen when stock prices fall and vice versa. Stock price volatility is also found to be significantly correlated with CDS spreads and the spreads are found to increase (decrease) with increasing (decreasing) stock price volatilities.

In this study, we focus on the two most liquid corporate CDs indices: the DJ CDX North American Investment Grade Index (based on a liquid basket of CDS contracts for 125 US firms with investment grade corporate debt) and the iTraxx Europe Main Index (composed of the most liquid 125 CDS referencing equally weighted investment grade entities).

A good understanding of the interactions between developments in the CDS index market and measures of *financial stability* is of crucial importance to the wide academic community as well as to practitioners and policy makers. Simultaneous large capital losses in several banks can affect a banking system's financial stability, and so the likelihood of such an event needs to be monitored and measured.

The paper is structured as follows. Section II provides a review of the related literature that discusses the implications of fluctuations in CDs markets on risk borne by the banking sector and its consequences on financial stability.

Section III discusses the institutional framework of the CDS index market. Additionally, it contains primers on the two main CDS tranched indices, the US CDX and the Europe iTraxx. Section IV describes the econometric methodology that is employed in the empirical analysis. The following section, V describes the main

[5] Bystrom H., (2005), *Credit Default Swaps and Equity Prices: The iTraxx CDs Index Market*, Working Paper, Lund University.

sources of CDS data. Section VI contains the main results from the estimation. Finally Section VII offers some concluding remarks.

2. Related Literature

It is too early and there is, so far, insufficient information to reach firm conclusions on the impact of CDs on *financial stability*. This is partly because of the currently incomplete statistical coverage of CDs; it is also because many CDs markets are still young and are evolving rapidly.

To our knowledge, there are only few papers that address the issue of the potential impact of CDs on the financial system. Furthermore, given the short history of the CDs market[6] and limited data availability, there has so far been little empirical work in this area.

Most of the literature on CDs concentrates on pricing issues as if they are instruments traded in standardized markets – see *Das* (1998) and *Kiff*, *Michaud* and *Mitchell* (2003) for a survey or *Schonbucher* (2000), *Brunnel* (2001), *Houwelling* and *Vorst* (2003) and *Hull*, *Predescu* and *White* (2003), among others. On the other hand, there is a large body of literature on financial innovation and security design – see *Harris* and *Raviv* (1992), *Allen* and *Winton* (1996) for a survey. Most of this literature deals only with debt and equity and does not consider derivatives.

There is a parallel stream of literature that analyzes the impact of default on financial contracts and the potential uses of credit derivative products (e.g., *Kim*, *Ramaswamy* and *Sundaresan* (1993), *Nielson* and *Ronn* (1995), *Hull* and *White* (1995)).

Several studies – see, for example, *Pennacchi* (1988) and *Jones* (1998) – argue that credit derivative transactions are motivated by the desire of banks to economize on their regulatory capital.

Perraudin and *Psillaki* (1999) show that transactions, involving either loan sales or CDs, which lead to the transferral of loans into the hands of less risk-averse lenders, are likely to increase efficiency.

[6] Two articles by Rule D. (2001) provide excellent institutional backgrounds on the credit derivatives market.

Beattie (2000) finds that use of CDs is an effective hedge against default risk during periods of international financial crises[7]. Furthermore, the author advocates that the increased use of CDs may protect against future debt crises as well as increase corporate returns in Argentina and Brazil when used as hedges in conjunction with reference assets.

Another strand of the literature considers the impact of CRT on the allocation of resources when there is asymmetric information.

Starting from the observation that the bank's information advantage changes over the time and, in particular, it is greater near the maturity date of the loan issued, *Duffee* and *Zhou* (2001) demonstrate that the problem of adverse selection may be overcome by the stipulation of CDs with maturity inferior to that of the underlying assets.

Nicolò and *Pelizzon* (2005) have investigated the problem faced by banks that may not have enough capital to satisfy capital requirement for issuing new loans when outside investors do not know the true type of the protection buyer and therefore faces an adverse selection problem. They argue that CDs contracts can be designed in order to solve the adverse selection problem; for it to happen banks should use first-to-default basket contracts in which the underlying assets have different maturities.

Morrison (2005) shows that a market for CDs can destroy the signalling role of bank debt and lead to an overall reduction in welfare as a result. He suggests that disclosure requirements for CDs can help offset this effect.

The *Deutsche Bundesbank* (2004) argues that on the one hand, developed and liquid CRT markets would allow for a broader diversification and more efficient price-setting which would improve the allocation of credit risk and therefore would foster *financial stability*. However, on the other hand, there would be risks involved in CRT, which could have a negative impact on *financial stability*.

Drawing on wide ranging discussions in London and the United States with intermediaries, end-users, rating agencies and others, *Rule* (2001) describes the CDs market and its use as a basic building block in synthetic securitisations of loan and bond portfolios. *Rule* discusses a range of questions that market participants might usefully consider. These cover, for example, counterparty credit risk and 'willingness

[7] It is possible that inadequate understanding of the relationship between market and credit risks in derivative markets is one reason for why Argentina and Brazil did not manage to avoid Asian and Russian contagion more successfully.

to pay' under stressed conditions; whether the incentives of banks to monitor their loan books might be changed; whether, for portfolio trades, sellers of protection understand the characteristics of the underlying portfolios; and whether CDs might affect corporate and sovereign debt restructuring negotiations. While none of these issues will be unfamiliar to market experts, their significance perhaps needs to be more widely appreciated. Credit events tend to be bunched. The prospective weakening in global economic demand and consequent rise in credit risk, described in the 'conjuncture and outlook' piece, might therefore present a significant test for participants in the CDs market.

In the literature, there is no unambiguous consensus to the question of whether these derivatives have a positive or negative effect on *financial stability*. For a variety of assessments of the impact of CRT on bank risk see, among others: *Arping* (2004), *Verdier* (2004), *Wagner* and *Marsh* (2004), *Instefjord* (2005), *Wagner* (2005), *Partnoy* and *Skeel* (2006), *Wagner* (2007).

Duffie (2008) discusses the costs and benefits of CRT instruments for the efficiency and the stability of the financial system. The argument is that if CRT leads to a more efficient use of lender capital, then the cost of credit is lowered, presumably leading to general macroeconomic benefits such as greater long-run economic growth. On the other hand, CRT activity can engender greater retention by banks of “toxic waste,” assets that are particularly illiquid and vulnerable to macroeconomic performance. As a result, CRT could raise the total amount of credit risk in the financial system, and could lead to inefficient economic activities by borrowers.

With regard to the 2007 US subprime-mortgage crisis, new research by *Mian* and *Sufi* (2008) provides hard evidence that securitisation fostered “moral hazard” amongst mortgage originators, which led them to issue loans to uncreditworthy borrowers. By examining local variations in housing and mortgage data, the authors were able to identify a causal link running from securitisation to increased credit supply, faster house-price growth and rising default rates. Their findings confirm what many suspected: poor screening by mortgage originators intent on selling on loans was a significant factor in the housing boom and bust.

A recent study by *Hu* and *Black* (2008) concludes that, thanks to the explosive growth in CDs, debt-holders such as banks and hedge funds have often more to gain if companies fail than if they survive. The study warns that the breakdown in the relationship between creditors and debtors, which traditionally worked together to keep solvent companies out of bankruptcy, lowers the system's ability to deal with a credit crunch[8]. This development hence could endanger the stability of the financial system.

The consequences for *financial stability* of CRT between the banking sector and the insurance sector have been analyzed by *Allen* and *Gale* (2006) and in *Allen* and *Carletti* (2006), for example.

Allen and *Gale* (2006) develop a model of banking and insurance and show that, with complete markets and contracts, inter-sectoral transfers are desirable. However, with incomplete markets and contracts, CRT can occur as the result of regulatory arbitrage and this can increase *systemic risk*.

Using a model with banking and insurance sectors, *Allen* and *Carletti* (2006) document that the transfer between the banking sector and the insurance sector can lead to damaging contagion of *systemic risk* from the insurance to the banking sector as the CRT induces insurance companies to hold the same assets as banks. If there is a crisis in the insurance sector, insurance companies will have to sell these assets forcing down the price which implies the possibility of contagion of *systemic risk* to the banking sector since banks use these assets to hedge their idiosyncratic liquidity risk.

Baur and *Joossens* (2006) demonstrate under which conditions loan securitization - CDOs of banks - can increase the *systemic risks* in the banking sector. They use a simple model to show how securitization can reduce the individual banks' economic capital requirements by transferring risks to other market participants and demonstrate that *systemic risk* do not decrease due to the securitization. *Systemic risk* can increase and impact *financial stability* in two ways. First, if the risks are transferred to unregulated market participants there is less capital in the economy to cover these risks. And second, if the risks are transferred to other banks interbank linkages increase and therefore augment *systemic risk*.

Heyde and *Neyer* (2007) analyze the consequences of CDs contracts in which both the protection buyer and the protection seller is a bank for the *stability* of the banking sector. Overall, they prove that in a macroeconomic downturn, CDs reduce the *stability* of the banking sector, and in a macroeconomic upturn, they may reduce this *stability*.

[8] "Spread across the economy, the 'freezing' of debtor-creditor relationships can increase systemic financial risk," says the paper. "[It] can also increase the economy's exposure to liquidity shocks".

3. Credit Default Swap Indices

While the market for outstanding synthetic CDOs is vast and quite diverse with respect to structural complexity, it remains fragmented.

The emergence of standardized, tradable, and relatively diverse default swap indices in 2003 provided the opportunity for an on-the-run market for tranches to develop shortly thereafter. Today, the tranched index instruments are by far the largest liquidity point in the structured credit market, serve as an entry point for many investors and have been responsible for making the business mainstream.

Within the context of today's synthetic CDOs, the tranched indices are relatively simple instruments, and are effectively standardized static synthetic CDOs. Credit default swap indices are simply portfolios of single name default swaps, serving both as trading vehicles and as barometers of the market activity. While intuitively very simple, the indices are responsible for increased liquidity and popularity of tranching of credit risk.

By buying protection on an index, an investor is protected against defaults in the underlying portfolio. In return, the buyer makes quarterly premium payments to the protection seller. If there is a default, the protection seller pays par in exchange for the reference obligation to the protection buyer.

Indices for CDSs were properly introduced in 2003, when investment banks JP Morgan and Morgan Stanley launched the market's first index, known as *Trac-X*.

Afterwards, in June 2004, a harmonised global family of CDS indices was launched, namely *iTraxx* in Europe and Asia and *CDX* in North America and emerging markets. The introduction of this credit index family has revolutionized the trading of credit risk due to their liquidity, flexibility and standardization.

A *Credit Default Swap Index* is a CD used to hedge credit risk or to take a position on a basket of credit entities. Unlike a CDS, which is an over the counter CD, a CDS index is a completely standardised credit security and may therefore be more liquid and trade at a smaller bid-offer spread. This means that it can be cheaper to hedge a portfolio of CDSs or bonds with a CDS index than it would be to buy many CDSs to achieve a similar effect.

The indices are constructed on a rules basis with the overriding criteria being that of liquidity of the underlying CDS. The indices have a predetermined "*Deal Spread*", which is paid on a quarterly basis. Consequently, if the index is currently trading away from the deal spread, an upfront payment is required to reflect the difference between the current market spread level and the deal spread. Conceptually, it is equal to the present value of the difference between the two, adjusted for default probabilities.

It is also important to note that all the underlying single name contracts also have the same deal spread as the index. Just as a portfolio of bonds with different coupons has better convexity than a corresponding portfolio with the same coupon for each of the bonds (assuming both portfolios have the same average coupon and maturity), the convexity characteristics of the index are somewhat different from that of an equal-weighted portfolio of the underlying single name default swaps.

CDX is the brand-name for the family of CDS index products of a portfolio of 125 5-year default swaps, covering equal principal amounts of debt of each of 125 named North American investment-grade issuers. They form a large sector of the overall CDs market.

iTraxx contains 125 equally weighted default swaps, composed of both investment grade CDSs and speculative, high-yield CDSs. CDSs are chosen to be part of the index based on their liquidity (the higher their liquidity, the more likely they are to be included in the index), credit quality (a sufficient number of both investment and noninvestment grade CDSs has to be included), and lack of counterparty conflict (CDS issuers that are also large issuers of the index should not be included in the index, if possible).

The most widely traded of the indices is the *iTraxx Europe Main index* composed of the most liquid 125 CDSs referencing European investment grade credits, subject to certain sector rules as determined by the International Investment Company. The index trades with three credit events ("*Failure to Pay*", "*Bankruptcy*" and "*Modified-Modified Restructuring*"). Similar to other index benchmarks, the *iTraxx Europe* is further segmented into sub-indices, defined by industry groups (*Sector Baskets*) and trading levels (*HiVol Index*).

Given the CDS index composition, the corresponding CDO comprises instruments with varying degrees of exposure to the joint loss distribution of the 125 firms. These tranches therefore provide claims to the cash flows of the CDS portfolio, and in parallel serve as protection for a certain range of defaults in the portfolio. The equity tranche serves as the first level of protection against any defaults among the firms in the index and is therefore also called the "*first loss piece*".

The subsequent levels of default protection are provided by mezzanine and senior tranches, where investors' exposure to default risk in the portfolio is quite small[9]. The *tranches* and carry different credit ratings. Specifically, the six *iTraxx Main* index tranches are *Equity* (ranging from 0% to 3% of the joint loss distribution), *Low Mezzanine* (3-6%), *Mid Mezzanine* (6-9%), *High Mezzanine* (9-12%), *Super Senior* (12-22%) and *High Super Senior* (22-100%)[10].

The attachment point determines the subordination of a tranche. For example, a 3-7% tranche's attachment point of 3% implies that the tranche will incur losses only after the first 3% of the notional has been lost due to defaults over the term of the index. The detachment point determines the point beyond which the tranche has lost its complete notional. In other words, the 3-7% tranche is completely wiped out if portfolio losses exceed 7% of the index. The difference between the attachment and detachment points is referred to as "thickness" of tranche.

4. The Empirical Model

From a *financial stability* assessment perspective, it is useful to ask how the credit market figure out the impact of the change in the risk profile of a financial institution's net worth. The risk profile of the financial institution is determined by the value and volatility of equity. Decreasing equity values and increasing volatility contribute to the institution's fragility. When developments occur simultaneously for a number of institutions following the same 'credit market' shock, systemic risk rises leading to a marked deterioration of financial stability.

Banks' exposures to CDs markets provide a nexus between credit and market risks, as these instruments introduce elements of credit risk into their trading book holdings. Since CDs are increasingly being used to gain exposures to loans that are originated by other banks, the possibility of unexpected losses emerging from such

[9] According to market terminology, the buyer of a tranche, i.e. the buyer of credit portfolio risk, is selling protection to the counterparty.

[10] In addition to the standardised synthetic CDOs discussed here, banks frequently use other types of CDO structures to transfer credit risk from their own loan books, for example in their loans to small and medium-sized enterprises (SMEs).

positions has dramatically increased since banks had not been fully aware of the credit quality of the underlying loan asset pools which are monitored by the originating banks [Chan Lau and Ong (2006)].

Following Chan Lau and Ong (2006), we estimate the exposure of the major global financial institutions to the CDs market by examining the extent to which developments in the CDS index market contribute to the variability of the firm's equity returns.

4.1 The Impact of CDS Indices on the Value of Bank Equity

To test the possible influence of fluctuations of the indices on the banks' equity returns we have adopted a SVAR (see *Hasbrouck* (1991a[11], 1991b[12]). SVARS constitutes a convenient manner that allows capturing the interrelationships within a system of variables when the imposition of strong a-priori restrictive assumptions cannot be derived by economic theory.

Assume that the interconnections between the variables of interest can be depicted by the structural linear system that relates the vector of variables Y in the system:

$$A_0 Y_t = A_1(L) Y_{t-1} + \varepsilon_t \qquad \text{t=1,...,T (1)}$$

The vector of structural disturbances (n x 1) ε_t consists of independent with zero mean stochastic elements with diagonal covariance matrix $E(\varepsilon_t \varepsilon_t^{'}) = \Sigma$. The contemporaneous relationship between the variables is depicted by A_0, whose diagonal elements are normalised to the value of unity and $A_1(L)$ is a matrix polynomial in the lag operator.

Associated with the structural form, the 'observed' reduced form of the model given by (1) can be represented by a VAR model of the form:

$$Y_t = B(L) Y_{t-1} + e_t \qquad (2)$$

[11] Hasbrouck J., (1991a), *Measuring the Information Content of Stock Trades*, Journal of Finance, Vol. 46, pp. 179–207.

[12] Hasbrouck J., (1991b), *The Summary Informativeness of Stock Trades: An Econometric Analysis*, Review of Financial Studies, Vol. 4, pp. 571–95.

The covariance matrix of the reduced form disturbances (e) is given by: $E(e_t e_t^{'}) = \Omega$. From (1) and (2) is obvious that the structural errors and the reduced form disturbances are related by the following equation:

$$\varepsilon_t = A_o^{-1} e_t \qquad (3)$$

To recover the parameters of interest A_0 and Σ from the estimation of (2) the imposition of parameter restrictions on Ω is required. This matrix is symmetric with $(n^2+1)/2$ distinct elements requiring the imposition of restrictions. The necessary condition for exact identification of the structural parameters is that the number of parameters in A_0 and Σ is the same as the number of non-zero elements in Ω. The main advantage of employing the SVAR methodology is the evaluation of the system responses to structural shocks using the reduced form VAR model and a relatively small number of exclusion restrictions. Writing model (2) in its equivalent moving-average form we obtain:

$$Y_t = C(L)e_t = \mathrm{C}_o \mathrm{e}_t + \mathrm{C}_1 \mathrm{e}_{t-1} + ... \qquad (4)$$

The MA coefficients are related to the reduced form parameters via the recursion:

$$C_0 = I, C_1 = B_1, C_2 = B_1 C_1 + B_2 \quad (5)$$

and their sum is given by:

$$C^* = \sum_{i=0}^{\infty} C_i = \left[I - \sum_{i=1}^{p} B_i \right]^{-1} \quad (6)$$

Simple exclusion restrictions can be imposed that guarantee exact identification. The most common assumption is that Σ is a diagonal matrix, the covariance of the structural shocks is zero. Further exclusion restrictions can be imposed on A_0, and subsequently on the structure of Ω that allow to identify the estimated system. The use of such restrictions has been questioned by Chari, Kehoe and McGrattan (2005) who argue that restrictions should originate from the underlying behavioural model that generates the VAR, and they are not to be used for empirical convenience. Sims (1980) suggested that simple short run exclusion restrictions can be imposed in the presence of a natural timing sequence in the manner the shocks that affect the system. Long-run restrictions motivated by the description of equilibrium derived from economic theory can be used to provide identifying restrictions. By postulating A_0 as a lower triangular the system assumes a recursive structure and this along with the restricted nature of Σ provides for the exact identification of the unrestricted VAR.

Under such conditions a well defined two-step procedure can be used to extract estimates of the structural parameters from the estimation of the reduced form.

The algorithm requires that the estimate $\hat{\Omega}$ is obtained from (2) and the structural model coefficients are obtained from maximizing the likelihood function that obtains consistent and efficient estimates of the parameters of interest.

$$l(A_0,\Sigma) = -\frac{Tn}{2}\log(2\pi) + \frac{T}{2}\log|A_0|^2 - \frac{T}{2}\log|\Sigma| - \frac{T}{2}tr[(A_0'\Sigma^{-1}A_0)\hat{\Omega}] \quad (6)$$

The variance of each element of Y_t can be decomposed into components due to each element of ε_t for various horizons.

$$Var_t(Y_{t+j}) = \sum_{i=0}^{j-1}\{(C_i A_0^{-1})\Sigma(C_i A_0^{-1})'\} \quad (7)$$

In addition the dynamic response of each element to a shock is traced via the computation of the impulse response function:

$$\frac{\partial Y_{t+j}}{\partial \varepsilon_{p,t}} = \frac{E_t Y_{t+j}}{\partial \varepsilon_{p,t}} = \hat{C}_j(i,p) \quad (8)$$

Where $\hat{C}_j(i,p)$ is a function of the structural parameters and the MA coefficients that can be obtained as functions from the unrestricted reduced form VAR. When positive shocks to either or both of the indices impact negatively on equity returns, the value of the equity declines resulting in increased institutional fragility due to the progressive reduction to the value of equity capital.

We estimate 15 three-equations VAR systems of the form: $\{d\log(cdx)_t, d\log(itrx)_t, r_{i,t}\}_{t=1}^{T}$ where dlog(.) denotes the continuously compounded returns of CDX and iTraxx indices whilst $r_{i,t}$ is the returns of bank (i). In the absence of a fully specified behavioural model the adoption of this methodology allows to establish the existence and the nature of a statistical causal relationship between the evolutions of the indices of the CD markets and the equity returns of LCFIs. Our interest is the exploration for such impact rather than the acquisition of estimates of the behavioural structural parameters. What is of importance in this case is the identification of shocks as 'structural'.

4.2 The Transmission of Volatility from the CDS Indices on Bank Equity Volatility

We then proceed to estimate the influence of the conditional volatility of assets traded in the CD markets on the conditional volatility of the banks' equity. We follow a two stage procedure. In the first stage we estimate a VAR-MV(GARCH) system that consists of the two major indices, CDX and iTraxx. From this we retrieve the estimates of the conditional second moments and employing them as regressors in the conditional volatility equation from each bank that is estimated by a univariate GARCH model:

$$\begin{aligned} r_{i,t} &= \Lambda Z_{t-j} + u_{i,t} \\ u_{i,t} &\sim (0, h_{i,t}) \qquad\qquad (9) \\ h_{i,t} &= \alpha_0 + \sum_{l}^{L} \alpha_l (u_{i,t-l})^2 + \sum_{k}^{K} \beta_k h_{i,t-k} + \gamma_1 h_t^{cdx} + \gamma_2 h_t^{itrx} \end{aligned}$$

Where Z_t denotes the determinants of bank equity returns and the time varying conditional variances of the two indices are h_t^{cdx} and h_t^{itrx}.

If the conditional volatilities from the CDs market enter the equity variance equation with a positive sign, the conclusion is that increases in the conditional volatility of the indices undermine significantly the financial stability of the institutions.

Combining the results from the two procedures outlined above we can establish whether shocks and their volatility in the CRT market lead to a reduction of the valuation of banks' equity and an increase in risk due to increased equity volatility. Reduction in the value of equity and the possible increase to the its volatility resulting from developments in the CDS markets imply significant deterioration in the banks' Sharpe ratios (see Appendix B). Such reduction, in turn, will trigger increases in the required rate of return putting further downward pressure on equity prices.

The system's financial stability is threatened when there is a uniform reaction of the institutions' risk profile, following a common credit market shock across systemically important global banks.

5. DATA

5.1 Dataset of CDSs Prices

Traditionally, traders quote prices, credit spreads, and trading volume of individual CDSs. On an aggregate, indices track the development of prices and volumes for parts or all of the CDS market. Such CDS indices work like all financial indices. Their statistics reflect the combined value of a number of components.

We use price data for the traded *DJ CDX North America* index and the *iTraxx Europe Main* index, respectively. The analysis in this paper is restricted to the 5–year indices maturities, since these contracts are reportedly most actively traded.

The indices CDS prices and the bid–ask spreads are extracted from an extensive proprietary database obtained from one of the major global investment banks (*Morgan Stanley*)[13]. The dataset consist of several thousand one-way quotes and the at-issue pricing - the bid-ask spreads – of the single tranches. The prices of the

[13] Although the dataset we were given access to is proprietary, data for standardized CDS indices tranches are now available on the Bloomberg system and other commercial sources.

indices are denoted in basis points per annum. In this study, we focus on the realized trades.

This dataset covers virtually the entire history of the CDX and iTraxx indices through 2005. Data is missing for some days during the earlier part of the sample. We omit these days from the sample, leaving us with a total of 912 usable daily observations for the 4-year sample period. For the primarily descriptive purposes of this section, we report summary statistics based on the continuous series of the on-the-run CDX index and iTraxx index, respectively (rather than reporting statistics separately for the individual CDSs series).

The start date for the sample is determined by the requirement of matching the initial dates of trading of the two indices. Indeed, data for the iTraxx 5 year becomes only available from later dates.

5.2 Dataset of Equity Prices

The dataset consist of individual institutions data drawn from the group of LCFIs as defined by the *Bank of England* (2001).

Equity prices, denominated in US dollars for the LCFI group, are extracted from *Datastream* and cover the period from 4 January 2005 to 13 November 2008. We have daily observations for 15 global financial institutions, 14 LCFIs plus Royal Bank of Scotland. We exclude Abn Amro since in 2007 it was taken over by a consortium of European banks led by Royal Bank of Scotland (RBS) Group.[14] Accordingly, we deem more appropriate to include RBS[15] in the banking sample.

6. Results

The system's recursive nature provides for the exact identification that allows for the computation of the impact of the shocks in the CDs markets as represented by the stochastic components of the relevant indices on the equity valuation of the global financial institutions.

[14] The consortium includes also Banco Santander (Spain's largest bank) and Belgo-Dutch bank Fortis.
[15] RBS has grown to become one of the world's top 10 financial services groups.

We began by establishing the causal hierarchy of the two major market indices used in this study. In a two equation VECM system, using daily data over the period 06.01.05-13.11.08 (912 observations), we find that the hypothesis of "iTraxx does not Granger cause CDX" is not rejected, whilst the opposite causality hypothesis is strongly rejected. The results are presented in table 1.

TABLE 1

Granger Causality Test

Null Hypothesis:	F-Statistic	Probability
iTraxx_return does not Granger cause CDX_return	1.50788	0.22194
CDX_return does not Granger cause iTraxx_return	454.334	3.E-137

The issue of the presence of weak exogeneity between the indices was examined within a VECM system that consists of the market quotations of the two indices.

We establish that the indices are cointegrated and that CDX is weakly exogenous with respect to the iTraxx. Imposing the following two restrictions: a) both parameters associated with the series normalised to unity and b) weak exogeneity exclusion on the VECM , we obtain the p-value of the resulting test statistic that does not reject the null. The value of the test-statistic and its associated p-value are shown in table 2.

TABLE 2

Test for Weak Exogeneity

Chi-square(2)	1.647126
Probability	0.438865

These hypotheses can justify the imposition of the recursive nature of the two indices.

Although our empirical analysis is somehow limited, we think this result to be of remarkable magnitude. It essentially captures the core empirical relationship between the two markets and basically confirms the leading role of the CDX index tranche market for price discovery in the iTraxx Europe market.

Having established a hierarchical relationship between the two indices we proceed to estimate the three equations VAR by adding the returns of the banks.

The addition of the banks' return equation to the last position in the system is based on the rationale that each of these institutions although makes a contribution to the index, its share is vanishing small given that the index composition consists of 125 investment grade reference entities (albeit with changing weights every 3 months). The lag structure of the VAR was chosen using the AIC criterion. For most of the estimated VARs considered in this paper the AIC criterion suggested a VAR of order 6.

In the Appendix A, we report the impulse response functions of the equity returns of the 15 financial institutions from the estimated VAR to one s.d. shocks to the indices' returns. Higher returns imply raised 'insurance' premia and therefore are indicative of increased default risk. We expect that such increases will be detrimental to the banks' valuation, thus exercising downward pressure on equity returns[16].

Equity returns for all the institutions considered in this study were shown to react negatively to increases in both indices. As a robustness check, different orderings of the variables were considered and the impulse responses computed using the 'generalised impulse' function described in Pesaran and Shin (1998). The latter method constructs an orthogonal set of shocks that does not depend on the variable ordering.

The table below (Table 3) shows the impact of shock to the indices on equity returns.

[16] The results and misspecification statistics for all VARs are available on request from the authors.

TABLE 3

Impact Effect (Generalised Impulse Response Functions)

Bank	CDX	iTraxx
Goldman Sachs	-.0018**	-.0019**
Morgan Stanley	-.0018**	-.0017**
Merrill Lynch	-.0024**	-.0020**
Lehman Brothers	-.0031**	-.0028**
Citigroup	-.0007*	-.0008*
Bank of America	-.001**	-.0008**
JP Morgan	-.0013**	-.0010**
Deutsche Bank	-.0042**	-.0037**
UBS	-.0042**	-.0038**
Credit Suisse	-.0040**	-.0036**
HSBC	-.0038**	-.0028**
Royal Bank of Scotland	-.0055**	-.0053**
Barclays	-.0060**	-.0050**
BNP Paribas	-.0058**	-.0050**
Societe Generale	-.0060**	-.0050**

(** indicate statistically significant impact at 5%, * at 10%)

The effect of shocks to CDX is always more pronounced than the equivalent shocks to the iTraxx. What is of interest is the differential response of equity returns depicting the market's perception of the bank's vulnerability to increases in default risk. By and large, in our sample, European banks 'suffer' greater returns reduction compared to their American counterparts. The effect of the shock is very short lived in all cases with only the first period being statistically significant.

The estimated VARs show, for each LCFIs, a significant relation between changes in CDS indices spreads and the institutions share prices returns. Over the period January 2005-November 2008, the impact of a given-sized CDX index shock on each LCFIs is found to be highly significant. The model detects a statistically significant impact of a negative shock to the CDX on the European LCFIs sample. The sequential shocks to these institutions (Deutsche Bank, UBS, Credit Suisse, HSBC, Royal Bank of Scotland, Barclays, BNP Paribas, Societe Generale) bring on average stock returns down 0.004 per cent on a daily basis. Barclays and Societe Generale show the strongest response to the CDX, as evidenced by its negative coefficient and p-value, followed by Royal Bank of Scotland. This reveals that the CDS market has a significant impact on the banking sector, a pre-requisite for assessing spillover effects to the banking sector.

These data illustrate the strong link that exists between the CDX and European LCFIs. They underscore the importance of the long-run impact of the North American investment-grade credit index on the banks equity performance. However, under this scenario, somewhat surprisingly, the potential stability impact on the major US banks appears to be less pronounced.

The results from this simulation, thus, give us a first helpful insight into the interplay between the CDS market and the equity market. As an initial conclusion, these results suggest that there is a clear evidence of "contagion" from the CDS index market to the banking sector as a whole.

Table 4 gives the proportion of equity returns variance contributed by the CDX and the iTraxx, respectively after 10 periods: (t-stat).

TABLE 4

Variance Decompositions

Bank	CDX	iTraxx
Goldman Sachs	8.44 (2.14)	0.94 (0.81)
Morgan Stanley	6.32 (1.92)	1.54 (0.89)
Merrill Lynch	7.30 (2.18)	0.81 (0.71)
Lehman Brothers	5.91 (2.18)	1.07 (0.82)
Citigroup	8.92 (2.14)	0.45 (0.50)
Bank of America	7.48 (1.94)	0.89 (0.67)
JP Morgan	6.41 (1.90)	1.81 (0.92)
Deutsche Bank	13.30 (2.07)	2.30 (0.95)
UBS	12.79 (2.21)	1.93 (0.95)
Credit Suisse	12.82 (2.49)	4.12 (1.17)
HSBC	13.03 (2.19)	2.02 (1.16)
Royal Bank of Scotland	10.78 (2.29)	2.37 (1.12)
Barclays	14.81 (2.35)	1.73 (0.89)
BNP Paribas	13.82 (2.17)	2.96 (1.07)
Societe Generale	13.26 (2.27)	2.14 (0.96)

A key point to note is the marked asymmetry in the LCFIs equity variance contribution of CDX and iTraxx. The iTraxx influence is essentially close to zero for all the banks within the peer group. On the whole, the explanatory power of the CDX appears to be low for institutions based in US. The CDX market factor is only marginally significant, explaining in each case, 6.32-8.92% of the variation (Citigroup has the highest CDX variance contribution, 8.92%)[17].

By contrast, the CDX contribution is relatively more important for all the European LCFIs (Deutsche Bank, UBS, Credit Suisse, HSBC, Royal Bank of Scotland, Barclays, BNP Paribas, Societe Generale) where over 10% of their variation is explained by the CDX factor (it ranges from 10.78% (RBS) to 14.81% (Barclays).

The impact of the structured credit market volatility on banking systemic risk is analysed using the univariate GARCH model outlined in section 4. Estimates of the

[17] As expected, the explained variation estimates are higher than the original data series variance. This is mainly due to the dramatic jump in market volatility occurred throughout the 2008. The initial data series results are available on request.

conditional volatilities of the two indices were obtained from a multivariate GARCH(1,1) model using Diagonal BEEK specification[18].

The following table (Table 5) presents the estimated coefficients and their associated t-statistics from the conditional volatility equations of equity returns as depicted in equation system 9[19].

TABLE 5

Impact of CDX Index Volatility on the Volatility of Bank Equity (T-stat)

Bank	CDX-Index Volatility
Goldman Sachs	.0035**
Morgan Stanley	.0005**
Merrill Lynch	.0006
Lehman Brothers	.0112 **
Citigroup	.0008 *
Bank of America	.0007**
JP Morgan	.0009*
Deutsche Bank	.0031**
UBS	.00002
Credit Suisse	.0000
HSBC	.00041**
Royal Bank of Scotland	.0007**
Barclays	.0037**
BNP Paribas	.0011*
Societe Generale	.0024**

(** indicates significance at 5%, * at 10%)

As expected, generally the measures of the volatility of the returns in the CD markets have a large impact on the variation of all LCFIs stock market volatilities.

The coefficients from the GARCH estimates imply that, in the long run, increases in CDS market volatility are associated with a substantial increase in equity risk. Consequently, all else being equal, this would amplify the potential impact of the

[18] The results are available on request.
[19] All univariate models volatility models are of the form GARCH (1,1). The 'mean' equation consists of a single lag of the dependent variable and the returns of the two indices.

key vulnerabilities and disturbances relative to the CDS index market, thereby lessening the resilience of the financial system[20].

Overall, we find evidence that the transmission impact of the CDX is significantly larger for banks domiciled in continental Europe and UK as opposed to the US. Therefore, LCFIs domiciled in a bank-based financial system are shown to be prone to larger systemic risk. This implies an increase in the transmission of the shock to the European banking system and, thus, of the size of the shock that is borne by banking shareholders.

The analysis, therefore, underlines the potential instability effects of the CDS market as a whole, since, theoretically, substantial declines in the equity prices of LCFIs may directly impair the regulatory capital ratios[21] for these institutions and shut off the equity market as a source of new *Tier 1 capital*[22].

We can conclude that independently of whether we look at the CDX or the iTraxx indicators considered in this paper, a shock in these markets represented by such indices would weaken a bank's market performance and thus threaten its stability.

7. Conclusions and Implications

The paper contributes to the empirical literature on CDs and systemic risk by conducting one of the first multivariate analyses of how CDSs developments affect the aggregate dimension of banking stability.

Authorities are actively pursuing policies intended to stabilize financial conditions and maintain the smooth functioning of the banking system. Therefore, it is extremely important to study the systematic effects of CDs on the international banking system.

To the best of our knowledge, this study is the first to examine the financial stability implications of standardized CDS indices. We focus our analysis on the 5-

[20] Shocks that increase the mean and volatility of the indices reduce the banks Sharpe ratio as they reduce equity returns and increase risk.
[21] Risk-based capital ratios are, in principle, superior measures of capital adequacy, but their accuracy relies heavily on a proper risk valuation of assets.
[22] *Tier 1 capital* is the core measure of a bank's financial strength from a regulator's point of view. It is composed of core capital, which consists primarily of equity capital and cash reserves, but may also include irredeemable non-cumulative preferred stock and retained earnings.

year North American CDX and on the equivalent European series, namely the 5-year main iTraxx Europe, both referencing investment grade corporate entities.

We demonstrate that the augmented interconnectivity between the CDS index market and the equity market has theoretically two distinct and potentially destabilising effects on the resilience of the banking system. Equity returns for all the LCFIs are negatively correlated to both the CDX and the iTraxx indices movements. Moreover, the measures of the volatility of the returns in the CD markets have a large impact on the variation of all LCFIs stock market volatilities.

The results also illustrate, very surprisingly, that the transmission impact of the CDX is significantly larger for banks domiciled in continental Europe and UK as opposed to the US.

Overall, changes in the CDS index market have the potential for creating equity losses resulting in stress to systematically important LCFIs. The potential for instability in pricing credit risk in the tranches index market thus could result in broad spillovers and/or mark-to-market losses. Broader credit deterioration and rising CDs spreads could combine into a substantial hit to the equity capital of systematically important LCFIs.

Taken as a whole, these results prove consistent and coherent with the anecdotal evidence. It confirms that CDS indices in Europe and US are important in explaining the movement in LCFIs equity prices, as are credit fundamentals.

Additionally, we find robust shot-run evidence of an overall increase in correlations across these two markets since the middle of 2007. This lays out that the CDS indices implied co-variation within the LCFIs assets become far more turbulent since July 2007, suggesting that there is a volatility transmission mechanism, which results in the destabilisation of bank assets and a subsequent increase in default risk.

In particular, the analysis confirms that those institutions having large exposures to securitized or problem assets tend to be adversely affected by the widening of credit spreads in both sides of the Atlantic.

Consequently the most significant finding is the exceptional intensification of the adverse feedback loop between CDS indices shocks and financial institutions' share prices. Such critical effect has important stability implications for the banking system as a whole, since a collapse in the equity prices for most banks would make it difficult for them to raise common equity thus materially undermining the overall capital adequacy and solvency of the system.

The results, therefore, could help regulators shed more light on the CDS index market and its interaction with other markets and inform on policy implications. They allow to bettering comprehending the direction in which the financial system is heading towards.

Very little research has been done on the financial stability implications of CRT markets. In particular there is a paucity of work considering the interactions between the various CRT markets or instruments. Regarding CDSs, the small number of existing studies can be explained by a lack of quantitative data and by the brief history of the market. Most of the academic research in this area, therefore, has necessarily been prospective.

This study leaves several avenues open to further analysis. We have only analysed investment-grade corporate reference entities, without considering speculative-grade corporate entities. The issue of differences between stress and tranquil periods is worth investigating in future work as well as incorporating, if possible, structural changes in the pricing of the single CDS index tranches. In addition, we have not explored the question of the existence of non-linear dependence between the indices themselves and their relation with equity returns.

Only further research, beyond the scope of this study, can shed light on this and other related issues.

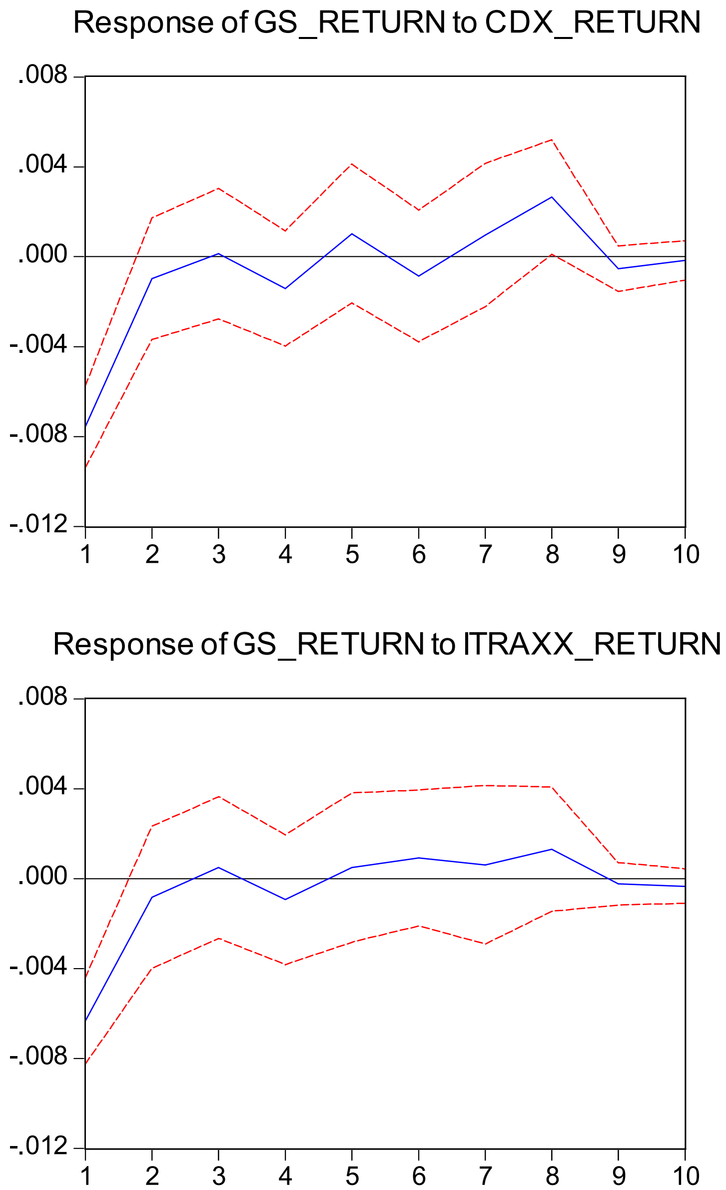
Nevertheless, we believe, that the adopted structural VAR approach, complemented by a GARCH model, is a useful addition to the suite of models used to assess the fragility of the banking system to adverse credit markets shocks.

APPENDIX A

Impulse Response Functions for the LCFIs

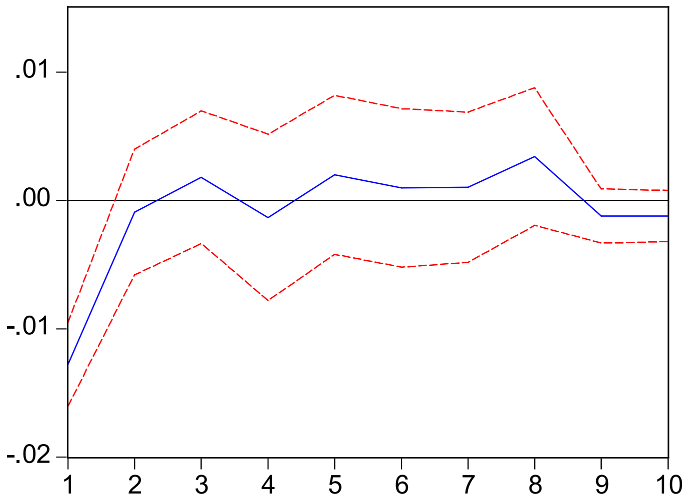
GOLDMAN SACHS

Response to Generalized One S.D. Innovations ± 2 S.E.

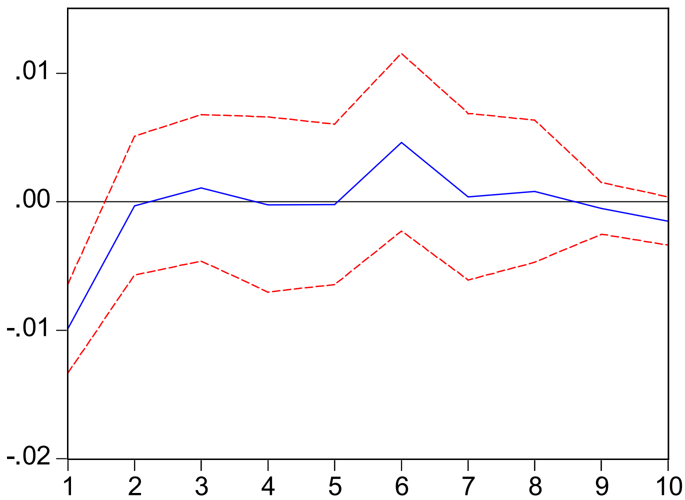


Response to Generalized One S.D. Innovations ± 2 S.E.

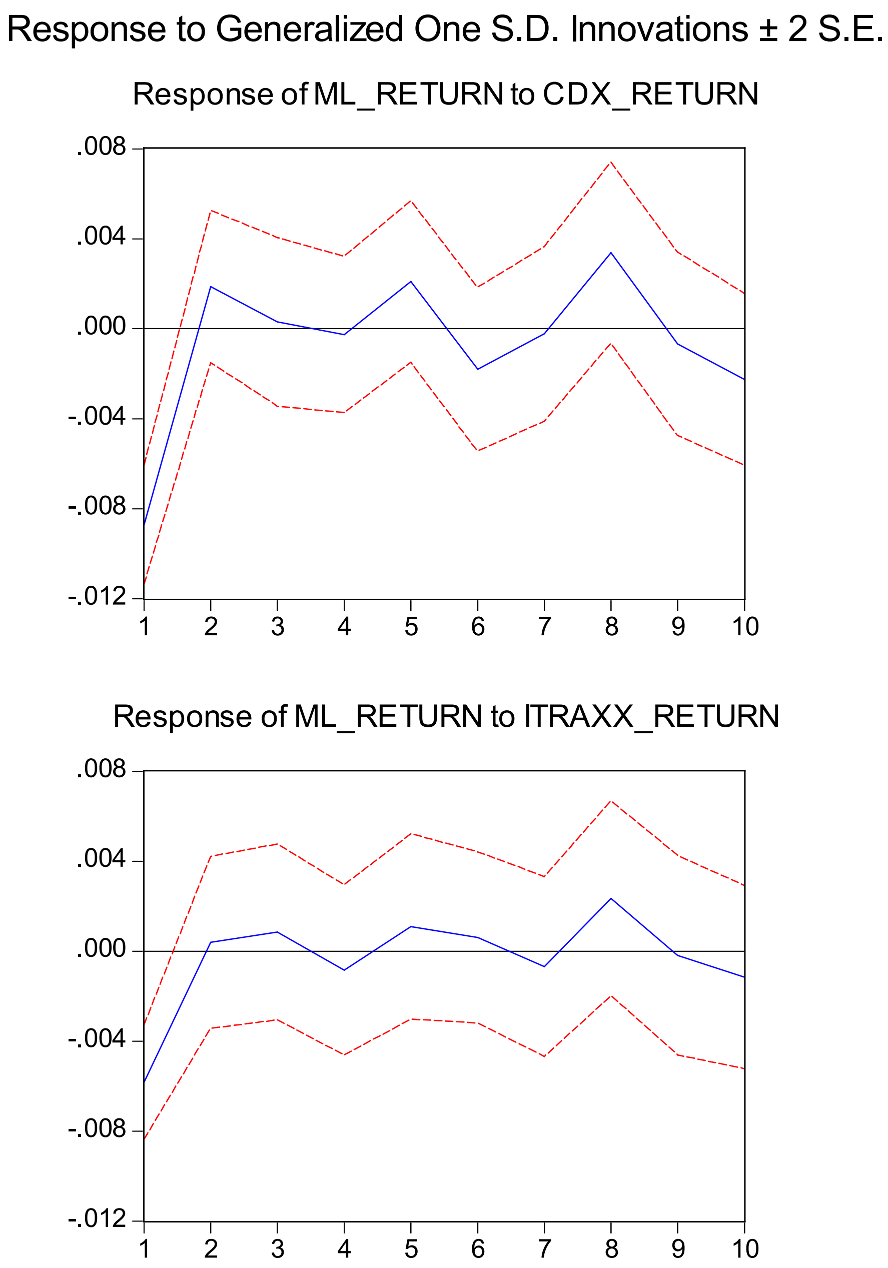
Response of MS_RETURN to CDX_RETURN



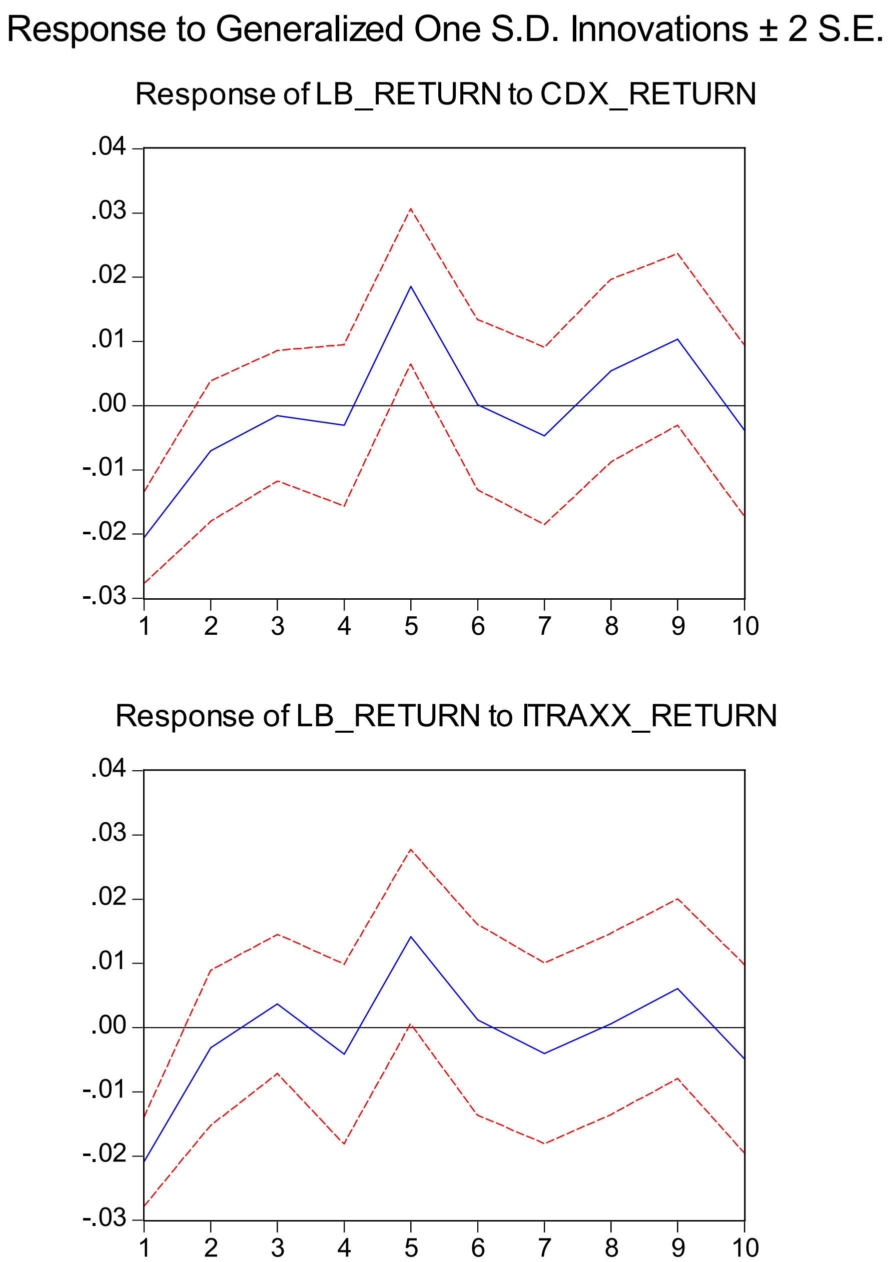
Response of MS_RETURN to ITRAXX_RETURN



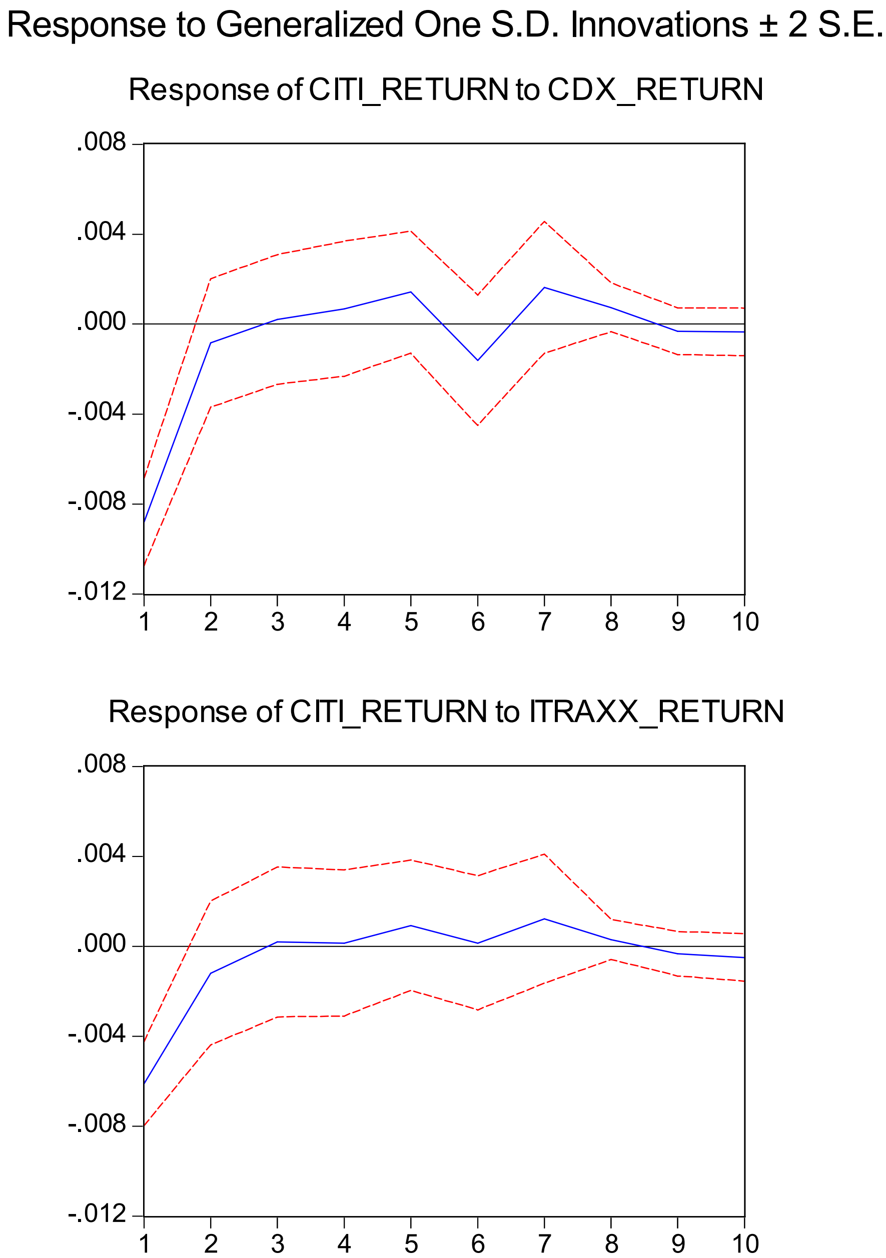
MERRILL LYNCH



LEHMAN BROTHERS



CITIGROUP


Response to Generalized One S.D. Innovations ± 2 S.E.
Response of CITI_RETURN to CDX_RETURN
.008
.004
.000
-.004
-.008
-.012
1
2
3
4
5
6
7
8
9
10
Response of CITI_RETURN to ITRAXX_RETURN
.008
.004
.000
-.004
-.008
-.012
1
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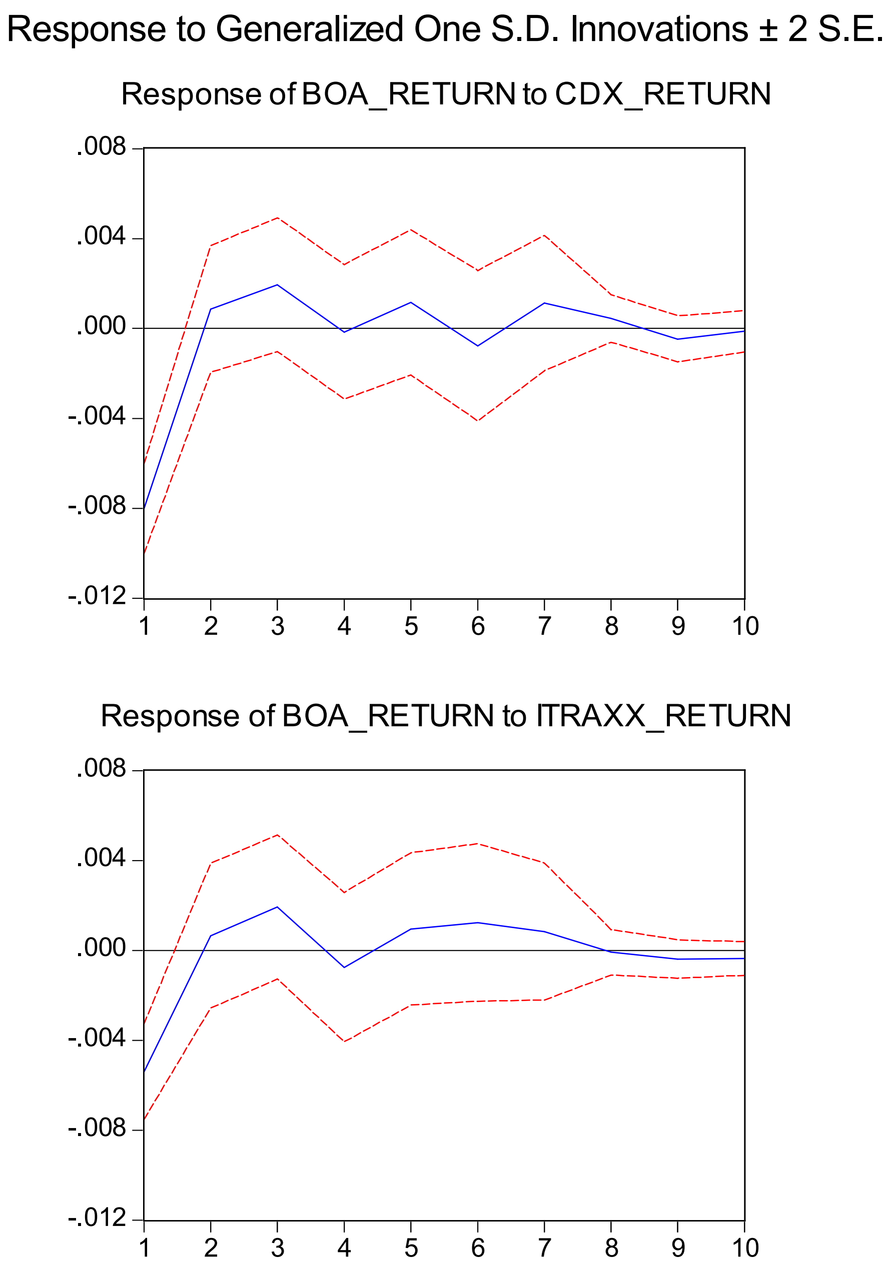
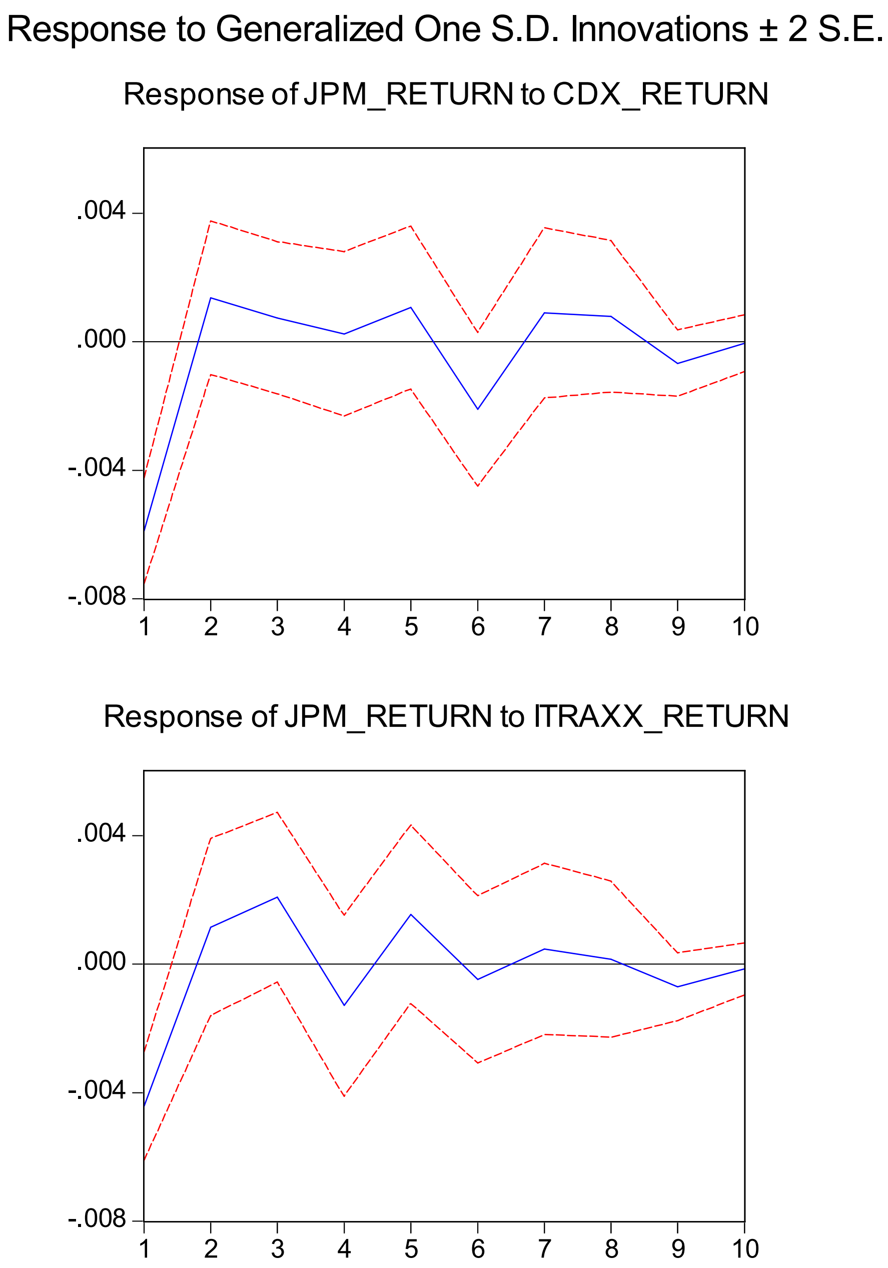
9
10

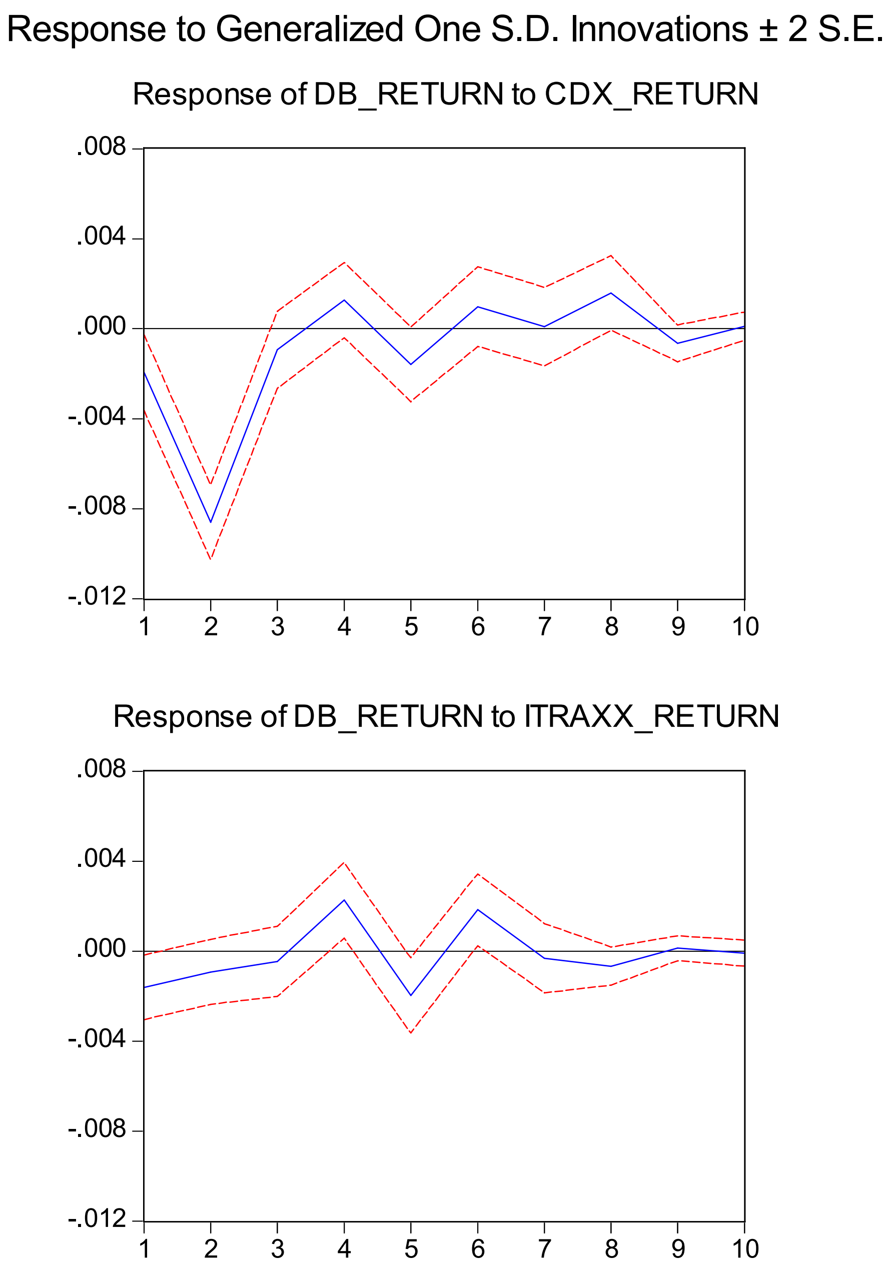
BANK OF AMERICA



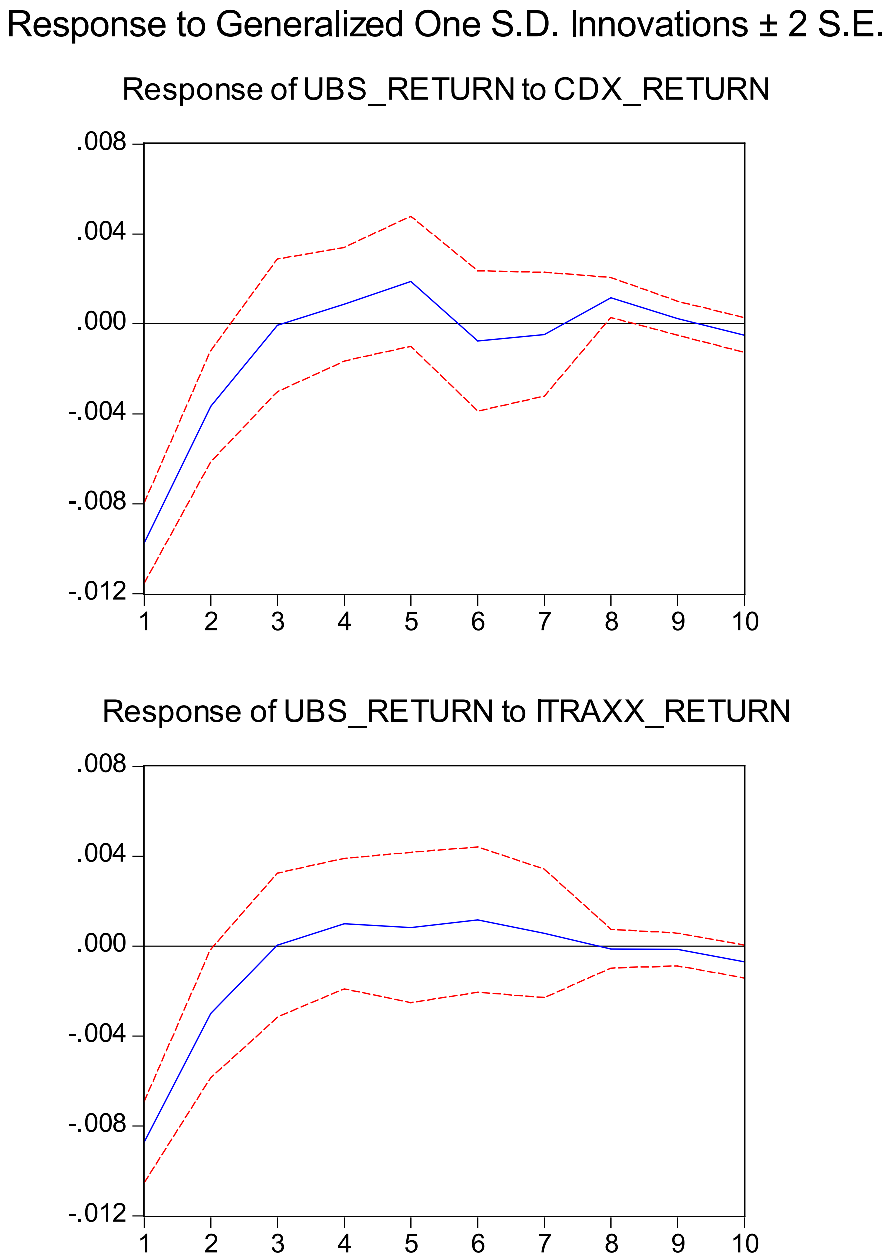
JP MORGAN


Response to Generalized One S.D. Innovations ± 2 S.E.
Response of JPM_RETURN to CDX_RETURN
.004
.000
-.004
-.008
1 2 3 4 5 6 7 8 9 10
Response of JPM_RETURN to ITRAXX_RETURN
.004
.000
-.004
-.008
1 2 3 4 5 6 7 8 9 10

DEUTSCHE BANK



UBS


Response to Generalized One S.D. Innovations ± 2 S.E.
Response of UBS_RETURN to CDX_RETURN
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.004
.000
-.004
-.008
-.012
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2
3
4
5
6
7
8
9
10
Response of UBS_RETURN to ITRAXX_RETURN
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.004
.000
-.004
-.008
-.012
1
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5
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7
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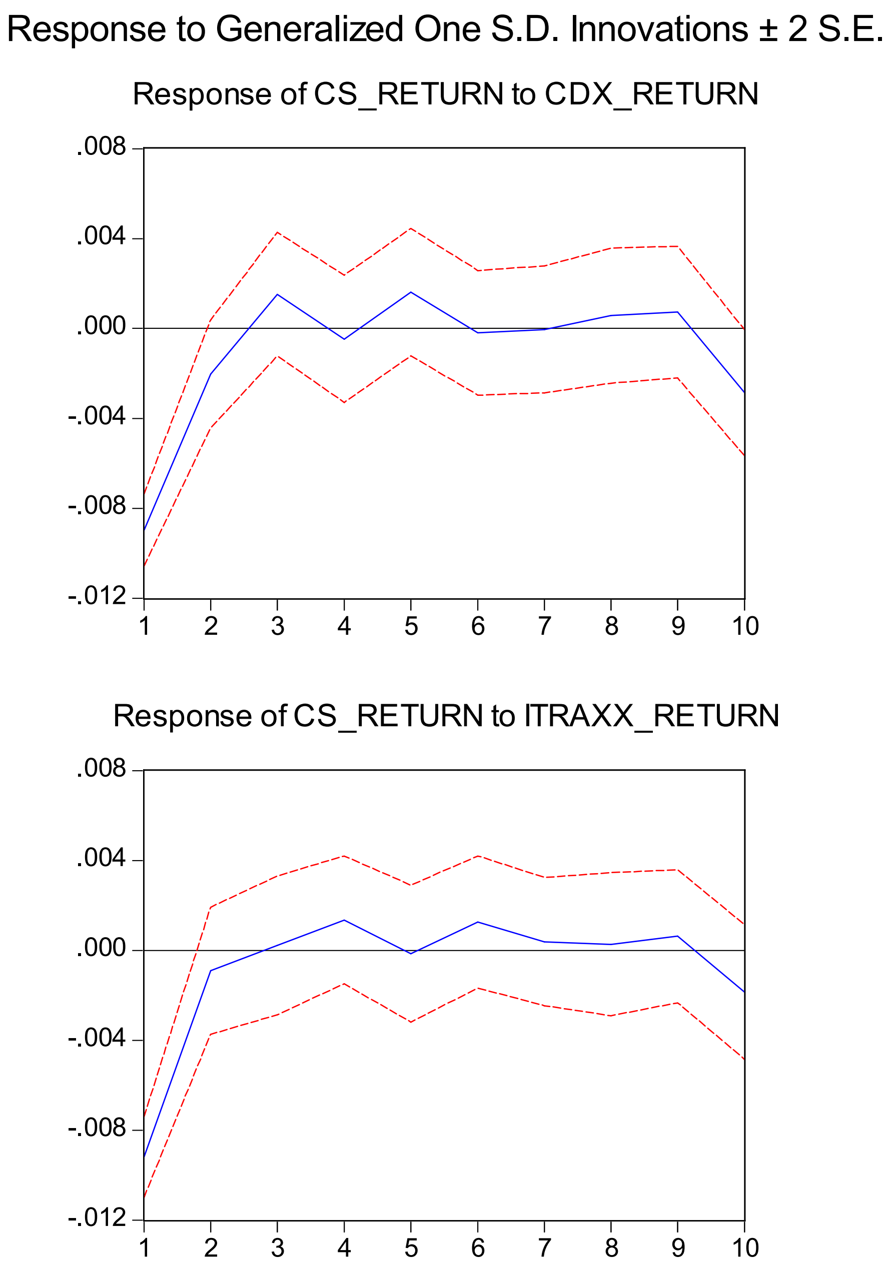
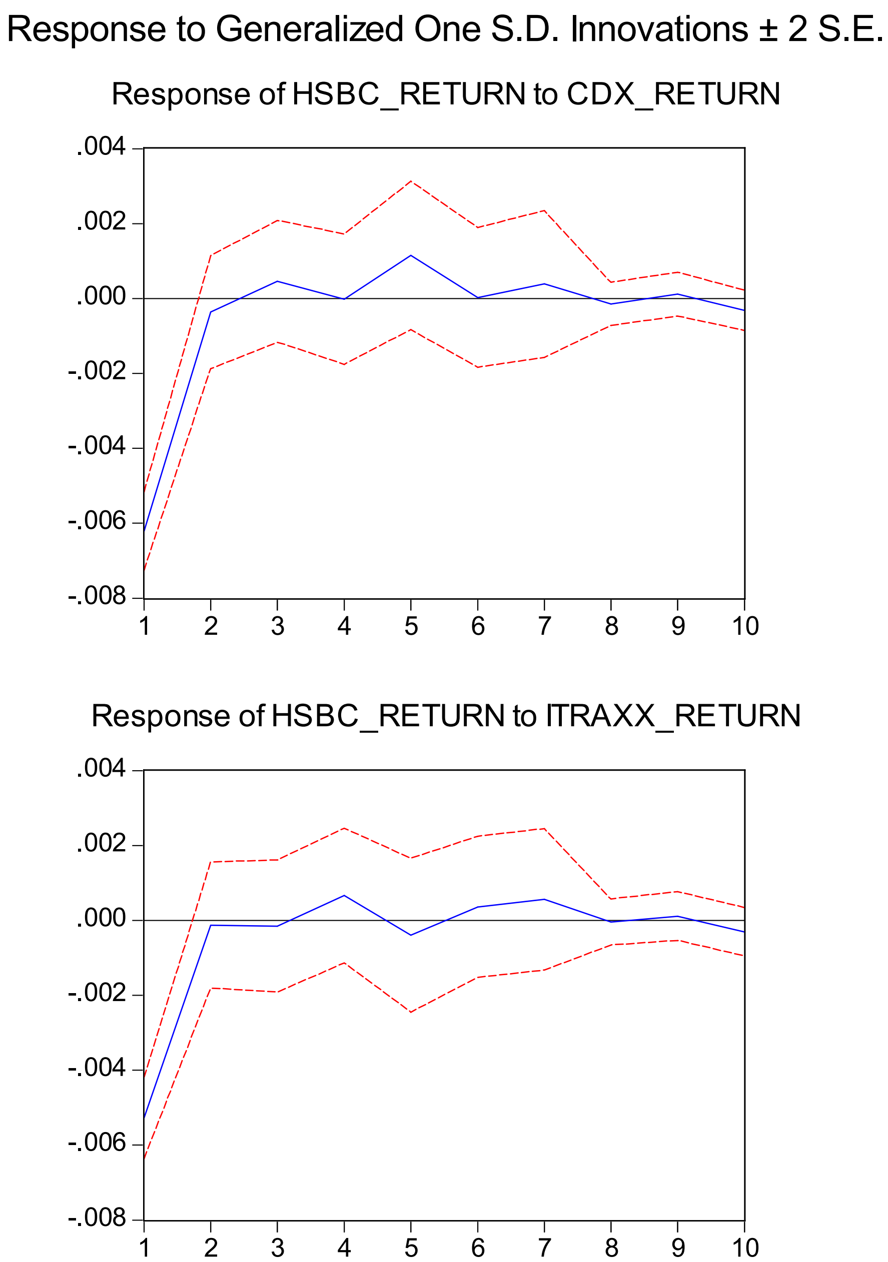
9
10

CREDIT SUISSE



HSBC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Response of HSBC_RETURN to CDX_RETURN
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.000
-.002
-.004
-.006
-.008
1 2 3 4 5 6 7 8 9 10
Response of HSBC_RETURN to ITRAXX_RETURN
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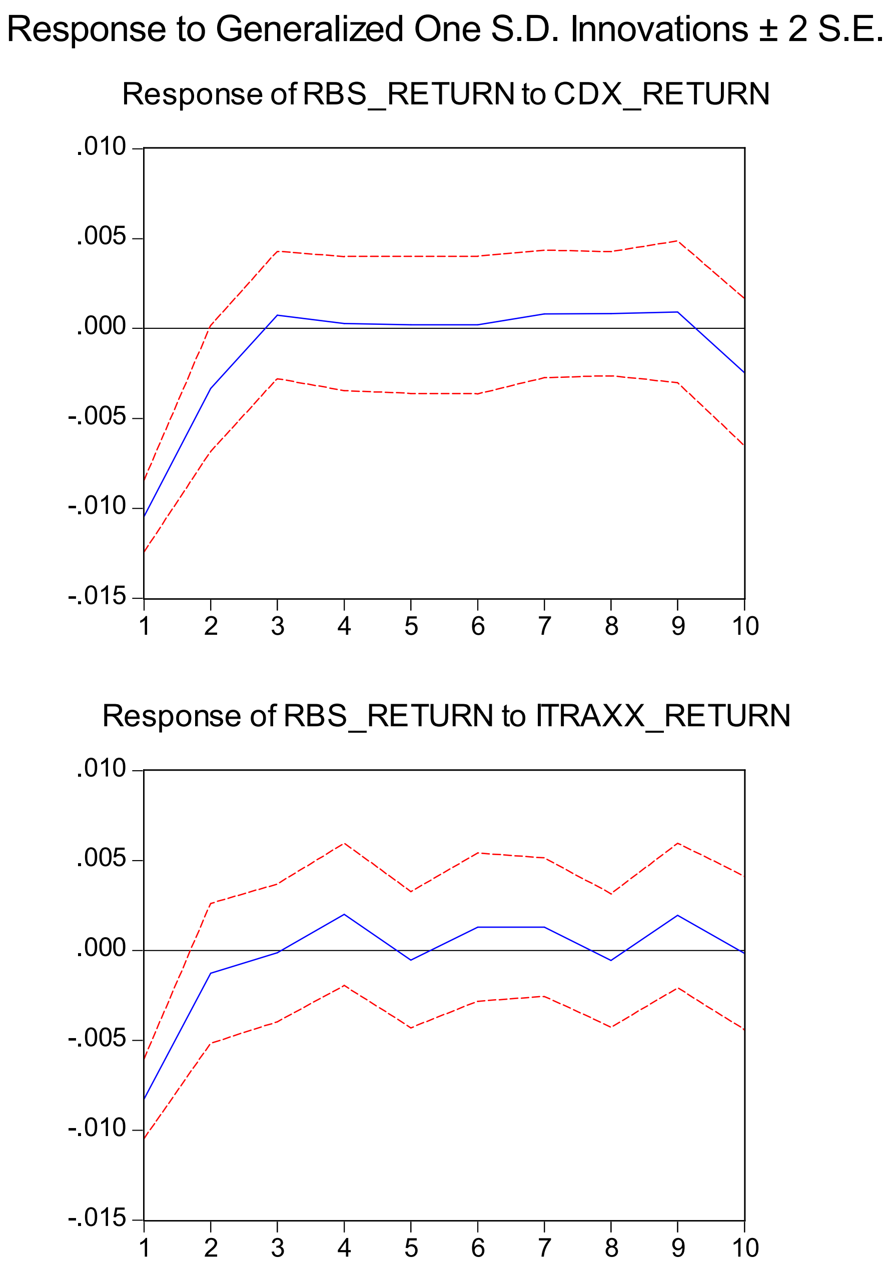
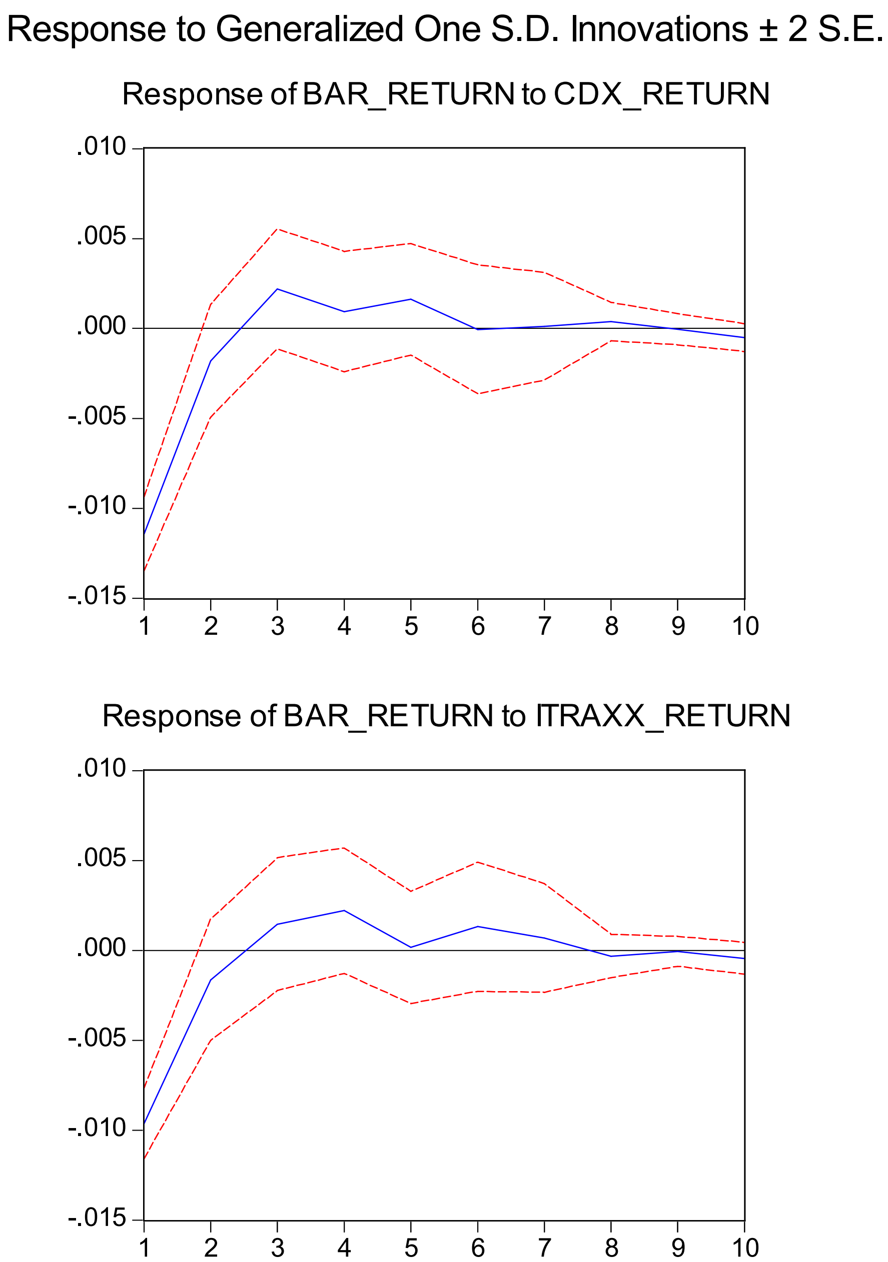
.002
.000
-.002
-.004
-.006
-.008
1 2 3 4 5 6 7 8 9 10

ROYAL BANK OF SCOTLAND



BARCLAYS



Response to Generalized One S.D. Innovations ± 2 S.E.
Response of BAR_RETURN to CDX_RETURN
.010
.005
.000
-.005
-.010
-.015
1 2 3 4 5 6 7 8 9 10
Response of BAR_RETURN to ITRAXX_RETURN
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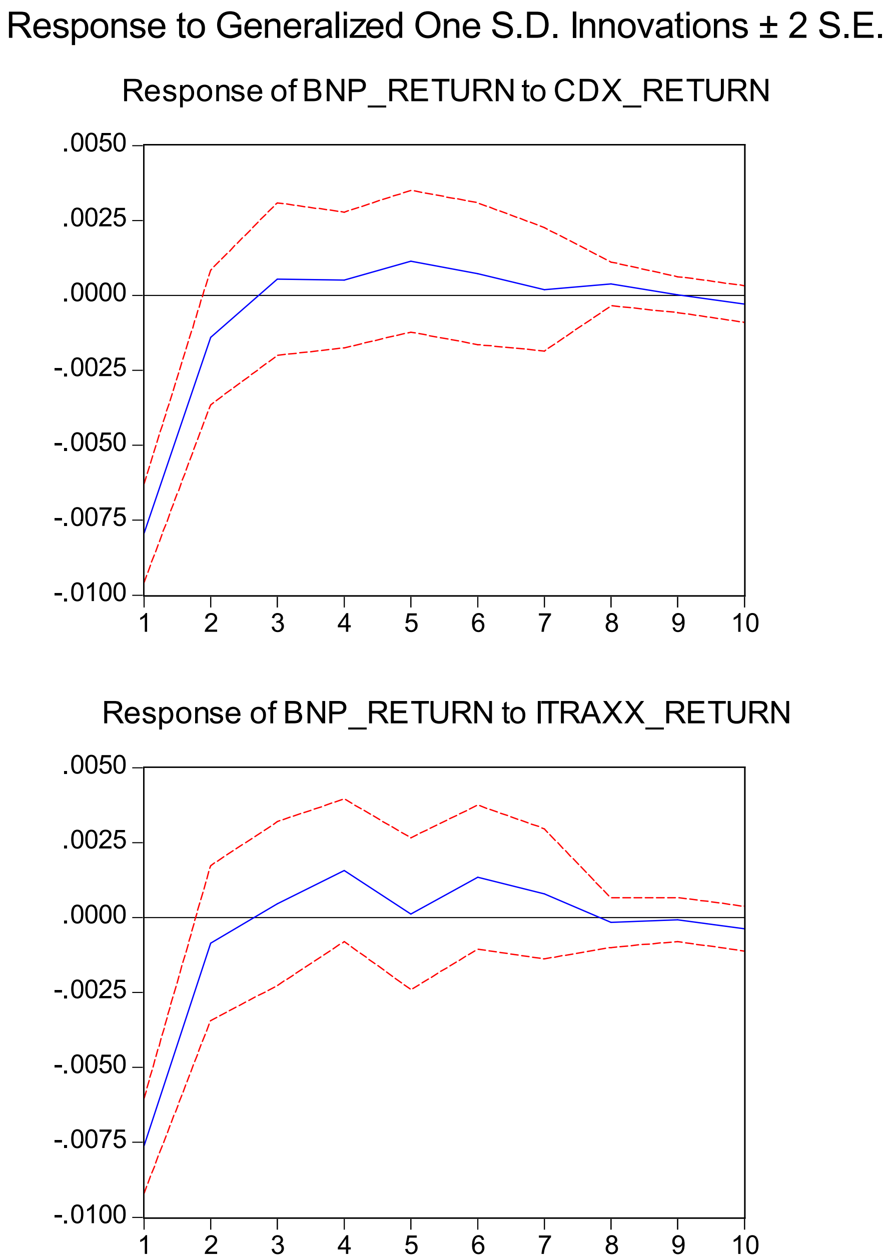
.005
.000
-.005
-.010
-.015
1 2 3 4 5 6 7 8 9 10

BNP PARIBAS


Response to Generalized One S.D. Innovations ± 2 S.E.
Response of BNP_RETURN to CDX_RETURN
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Response of BNP_RETURN to ITRAXX_RETURN
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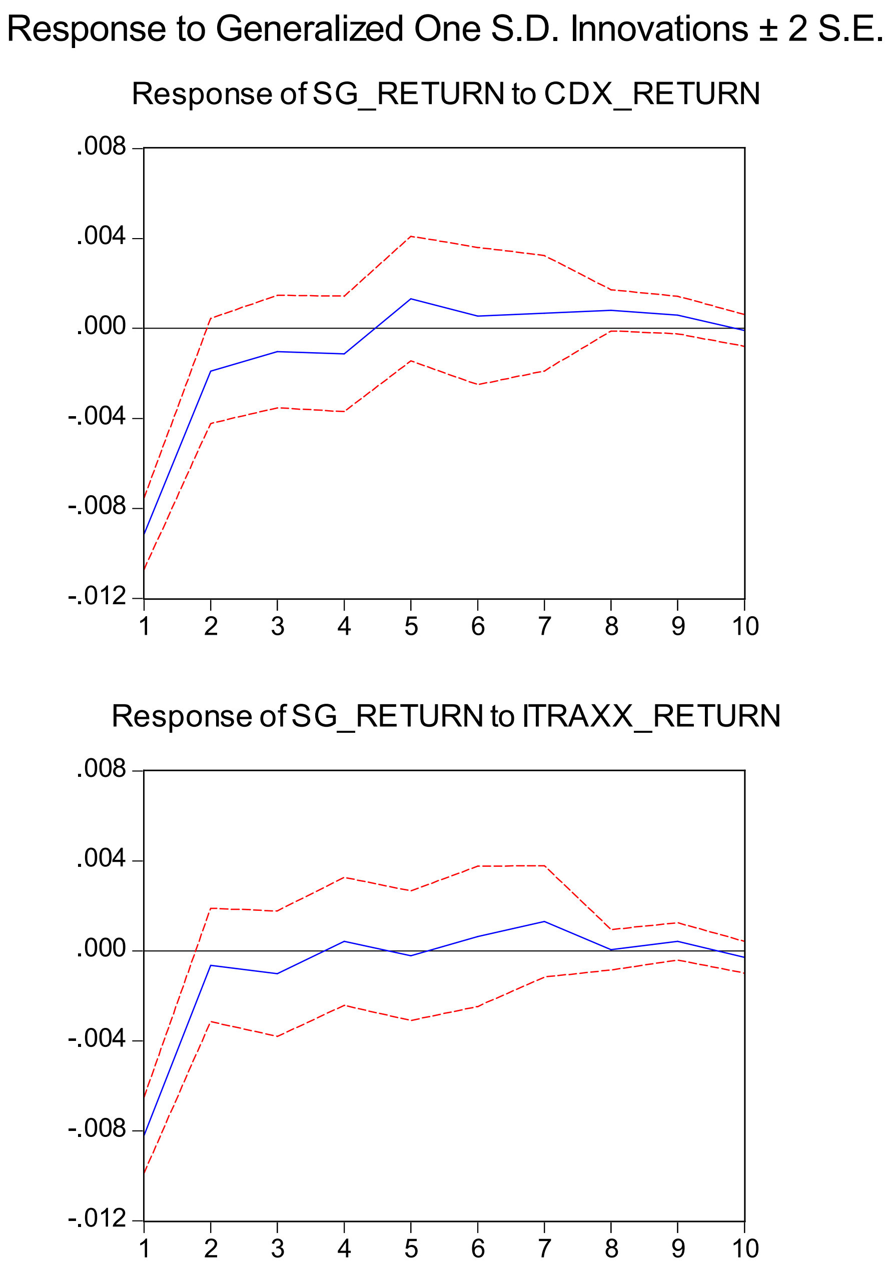
SOCIETE GENERALE



APPENDIX B

Covariance Matrix of Sharpe Ratios for the LCFIs

GS	*MS*	*ML*	*LB*	*CITI*	*BoA*	*JPM*	*DB*	*UBS*	*CS*	*HSBC*	*RBS*	*BAR*	*BNP*	*SG*
1.0215094	0.7812698	0.7332595	0.4696152	0.6276926	0.6003473	0.6446254	0.4855979	0.4129396	0.3864623	0.3053788	0.3104643	0.3408812	0.3229067	0.3207704
	0.999514	0.7230891	0.4112439	0.650134	0.6237899	0.6153762	0.4704218	0.3907258	0.3696417	0.3232926	0.3234331	0.3554833	0.3154505	0.2995501
		1.0102423	0.4385221	0.6622707	0.6457476	0.6819051	0.4739874	0.4085402	0.369581	0.3332645	0.2995147	0.3223422	0.3454597	0.3450524
			0.6124861	0.3877362	0.3936325	0.3865258	0.3105525	0.2855682	0.244546	0.2275965	0.2334163	0.2383748	0.2459806	0.2512812
				1.0050049	0.7416874	0.7372439	0.4260865	0.3830932	0.3359849	0.3090445	0.3090281	0.3195449	0.3162479	0.2978856
					1.0077945	0.7694406	0.4151357	0.3551756	0.3062421	0.2961923	0.2877218	0.2995606	0.3135628	0.3038116
						1.0146782	0.4318913	0.3586349	0.3003073	0.2598556	0.2580648	0.2805145	0.3044486	0.3019942
							1.0961065	0.7012298	0.7552615	0.6469761	0.6079253	0.6729817	0.7841802	0.7548436
								1.0788274	0.8014839	0.5867866	0.5939507	0.6257425	0.7280776	0.7127013
									1.1112337	0.6539037	0.6223784	0.688428	0.7406883	0.7293699
										1.1111111	0.6427351	0.7097055	0.6743403	0.6787164
											1.0838955	0.784165	0.6777084	0.6420824
												1.0860182	0.7088286	0.6917744
													1.1097471	0.8872845
														1.10701

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