Macroeconomic fluctuations and forward yield curve

First draft, June 2013

Abstract

This paper evaluates how macroeconomics fluctuations (aggregate supply and demand shock) affect dynamics of forward yield curve in domestic and foreign debt market. We build a SVAR that includes output growth, inflation rate and interpretable economic variables extracted from forward yield curve (i.e. long term yield, forward interest rates spread and yield curve volatility) using Venezuelan monthly data from 2004 to 2011. We find that long term yield and spread are dominated by inflationary pressures while bond volatility majority responds to fluctuations in real sector after a goods market shock. The theoretical variables computed are more informative and economic powerful compared to traditional Nelson Siegel factors ($\beta_0, \beta_1, \beta_2$). Finally, there are not qualitative differences across debt markets when aggregate supply or demand innovation occurs. This is not satisfied under a negative financial shock, where international valuation of credit conditions alters foreign investors' decisions.

Keywords: Forward yield curve, macroeconomic shocks, supply shock, demand shock, negative financial shock, interest rates, yield curve volatility, Venezuelan bond market, Nelson-Siegel model.

JEL classification code: C13, C21, E00, E04, G12, N26

Introduction

Depending on the side of the literature considered (macroeconomics or finance), the approach used to model the yield curve and the term structure of interest rates is diverse. From a finance perspective, yield curve modeling aims to get the best fit to observed yield rates across different maturities to make financial decisions (modeling interest rates, pricing fixed income derivatives, design of hedging strategies and risk management). There are two main financial models: 1) Parametric or parsimonious models (Nelson and Siegel, 1987 and Svensson, 1994), which use a few unobservable factors (called by Litterman and Scheinkman 1991, as level, slope and curvature) to characterize yield curve. 2) *Affine* term structure models[1] (Vasicek, 1977; Cox, Ingersol and Ross, 1985a; Longstan and Schwartz, 1992a; Duffie and Khan, 1996; among

[1] According to Bolder (2001), mathematically speaking affine means a linear plus a constant. Since this type of models, defines the interest rate using a stochastic differential equations, the coefficients associated to the drift and the diffusion term will have an affine form.

others), where interest rates depend on a state variable that follows a diffusion process under the absence of arbitrage opportunities. This financial literature uses cross sectional information and statistically characterizes the term structure pretty well, but it does not provide any macroeconomic insight of the forces that drive movements of these factors.

On the other hand, from a macroeconomic side, the role of the yield curve has been relegated, in many cases, to the simple definition of spread of interest rates associated to specific terms. Following the works by Estrella and Hardouvelis (1991) and Estrella and Mishkin (1996), this macroeconomic research literature has focused only on the predictive power of yield curve for the economy, but it does not elaborate on the links that support such relationships.

It seems that each of these theoretical frameworks was developed separately to address distinct issues. Nevertheless, recent efforts have been made to build a bridge between financial and macroeconomic literature. Diebold, Rudebusch and Auroba (2006) characterize the dynamics between the macroeconomy and the fixed income market through a set of variables (GDP, CPI and federal fund rate). However, in this research the shocks to the system are limited to the individual changes in this group of variables due to the identification scheme employed (Cholesky decomposition). Rudebusch and Wu (2008), and Alfonso and Martins (2012), incorporate macro variables into a macro– finance system to determine the effects that monetary policy and fiscal shocks exert on the yield curve. This analysis, even though provides a macroeconomic interpretation for movements in the yield curve factors, it restricts the definition of shocks to specific ones. In other words, a general vision on how macroeconomic shocks generate yield curve movements has not been addressed.

The main objective of this research is to evaluate how the main sources of macroeconomic fluctuations affect the dynamics of the yield curve. However, these macroeconomic fluctuations (monetary policy, fiscal, productivity and other shocks) are summarized by their impact on the goods market, i.e. in supply and demand shocks. Indeed, these two shocks replicate the final results produced in the economy by a variety of specific shocks. This is a simple way to capture the key sources of yield curve time variations.

In order to do so, we estimate a SVAR that combines output growth, inflation rate, and three financial indicators for the Venezuelan case during a recent period of time (2004-2011). We elaborate two main setups. In the first one we built the SVAR with variables from the goods sector and the typical unobservable yield curve factors from Nelson and Siegel (1987), i.e. $\beta_0, \beta_1, \beta_2$. In the second setup we substitute traditional yield curve factors by a set of interpretable variables. These last indicators are extracted from the theoretical representation of the yield curve. Chirinos and Maita (2012) estimate yield curve for Venezuela under Nelson Siegel (NS) approach. We use the coefficients of their estimated parameters to compute the following measures: a theoretical long term yield (a comparable variable to the level of yield curve), a spread between long and short forward rates (a comparable variable to slope factor) and the volatility of the term structure, measured as the average of squared deviations respect to different forward interest rates. In the second setup, we use these particular measures instead of the original NS parameters, since they are smoother in their time behavior and more interpretable from an economic point of view. Following Chirinos and Maita (2012) the analysis is applied to domestic and external debt market. Additionally, for the identification of shocks, we use a mixed of sign restrictions on impulse-responses (Canova and De Nicolo 2002) and zero restrictions on coefficients as in Mumtaz and Surico (2009).

To the best of our knowledge, this is the first research that evaluates yield curve volatility responses due to goods market shocks, and provides, at the same time, a macroeconomic meaning to term structure discriminating according to the market where debt instruments are issued.

The paper is divided into five sections: First section discuses methodological issues regarding estimation approach. Second section describes the data used and the empirical application of the methodology. Third section summarizes main results. Fourth section shows an additional exercise that relates economic interpretable variables and real exchange market. Finally, fifth section shows our concluding remarks.

1. Methodological issues

Modeling the yield curve dynamics aims to extract information embedded in its movements, which are intensely related with variations in its shape. A fraction of such movements is usually generated in a macroeconomic environment, and not exclusively by financial variations, as the financial literature tends to emphasize.
By construction macroeconomic effects are wide, in some cases complex and of multiple origins. One possibility is to measure main macro effects through shocks generated in the goods market; it means supply and demand shock. These two shocks have the ability of replicating final effects produced by more specifics shock: monetary, fiscal, oil, exchange rate shocks, among others. For instance, unexpected variations in monetary and fiscal variables are translated into positive movements in prices and output -demand shock-, a productivity shock causes a permanent expansion in output accompanied with negative variations in prices, while an oil shock is considered either demand or supply shock[2]. In few words, with the evaluation of these two variables we can summarize in a simple way the main macro effects that one economy is continuously exposed. Consequently, an alternative to generalize macroeconomics consequences on dynamics of forward yield curve is to uniquely observe shocks associated to goods market. By definition a positive supply shock leads to a raise in output and a decrease in prices, while a positive demand shock generates a joint boost in output and prices

Econometrically speaking and following our two setups, we build a SVAR for each scenario in order to determine how macroeconomics movements exert

[2] Oil innovations are often classified by literature as demand shock. However, for the Venezuelan recent history, and due to the exchange regime that it has implied high levels of imports, an oil shock behaves as supply shock (Barraez, Chirinos and Pagliacci , 2011 and Barcenas, Chirinos and Pagliacci, 2011).

particular effects on the yield curve through a supply and demand shock. SVAR contains variables from goods market (output growth and inflation rate), representing the macro side of the model, and a set of financial variables. In first case such variables come from NS factors and in the second, they are extracted from the yield curve through forward interest rates[3]. Interpretable financial information is actually obtained from traditional yield curve factors ($\beta_0, \beta_1, \beta_2$). According to Diebold and Lee (2004), latent factors of NS model can be denominated as level, slope and curvature, and they represent 99% of possible shifts and changes in the shape of the yield curve (Litterman and Scheikman, 1991).

To identify the shocks, we implement a version of sign restriction scheme (Canova and De Nicoló 2002) with the introduction of a block diagonal strategy as in Mumtaz and Surico (2009). This identification approach implies a mixture of sign and zeros restriction methodology. We are assuming that macro variables affect simultaneously yield curve factors. Certainly, we impose a block diagonal of zeros on coefficients of financial variables. Doing so, we guarantee the isolation of contemporaneous correlations among unrestricted variables. Intuition behind this supports the idea the unrestricted variables can introduce distortions in the identification procedure when sign restriction is employed as identification methodology.

We use traditional yield curve factors estimated in Chirinos and Maita (2012). These authors compute unobservable factors depending on the market in which government bonds are issued; domestic or foreign debt market. The advantage of analyzing these two types of markets separately, but in comparative way, is to provide insights regarding effects that macro variations causes on bond holders investment decisions depending on the currency at with financial instruments are traded. Macro finance models tends to introduce the analysis of NS factors just considering internal debt market, without any role for macro influences on foreign fixed income instruments and their possible effects on investor's expectation. For Venezuelan case, such distinction is not negligible. Vast majority of bonds in foreign debt market have the peculiarity of being denominated in foreign currency but buyers can get them in exchange of domestic currency, then foreign and national investors can access to this market. Due to the presence of exchange rate control in Venezuela, is not trivial to pay attention to potential movements' exhibit by this debt market. Bond holders' incentives, might, at a first stage, differ to those conceived in markets without such kind of restrictions.

According to the theoretical arguments mentioned previously, definitions of the shocks from goods market will imply the imposition of the restriction on variables involved, which are by theoretical construction just output growth and inflation rate. Financial variables are, initially, not subject to restrictions since we attempt to evaluate how main macro movements modifies yield curve through them.

[3] Forward interest rates under parametric estimations, leads to divide yield curve into short, medium and long term components. See Svenson (1997) for a more detailed discussed about forward interest rates.

2. DATA and SVAR

2.1 Unobservable factors of NS model

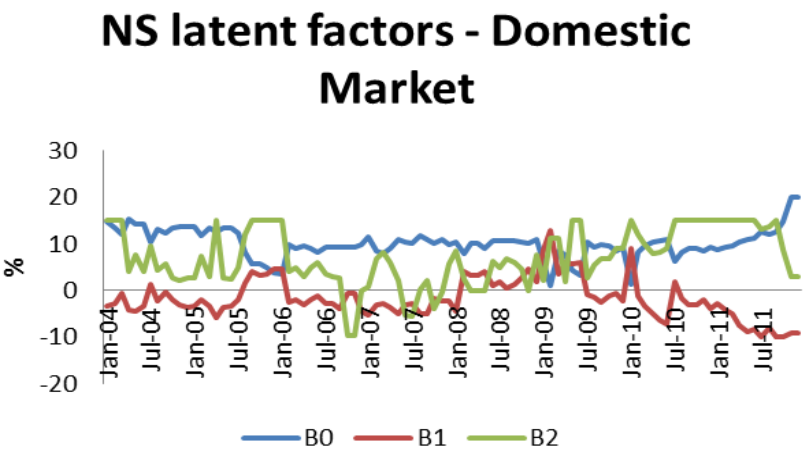
In this subsection, we present and describe the time behavior of the NS factors used in the setup 1.

Consistent with literature, level component shows, in average, the highest trend across markets (with differences in magnitudes), and the lowest fluctuations (figure 1 and figure 2). This is not surprising, because long term components are associated with long term expectations, which in general, tend to be less volatile than short term expectations. In fact, its inclusion in parametric forward computations ensures less noisy patterns along forward yield curve. So, it is understandable why in the construction of forward interest rate, β_0 explains around 80% of it. On the other hand, in domestic market, level and slope are quite correlated but in negative direction. Financially speaking it means the yield curve displays a parallel shift (level factor increases) but with changes in the steepness of the curve in the slope (slope factor decreases). Alternatively, in foreign market, either β_1 or β_2 (figure 2) are potentially more volatile relative to level factor (table 1). One can conjecture that particular conditions of negotiation and issuing, as mentioned in previous section, can induce such erratic performance for certain periods of time. However, at the end, the aggregation of these separate movements, according to the parametric formula of NS[4], will finally determine the shape of forward curve[5].

Figure 1.

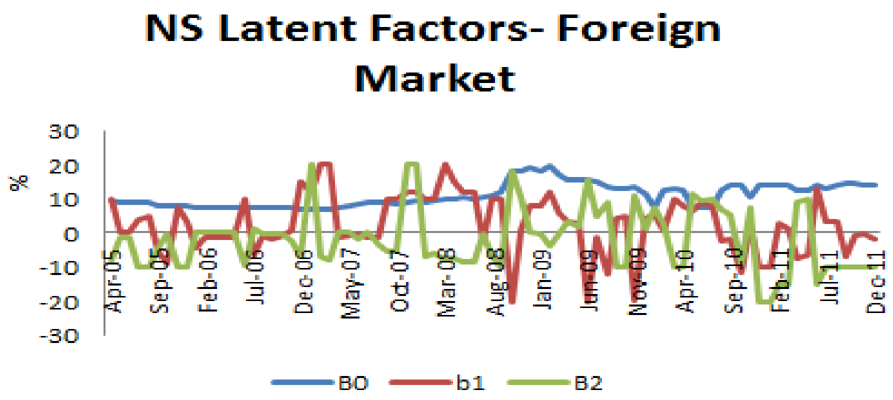
[4] According to Nelson and Siegel (1987), instantaneous forward interest rates is the solution to a second order differential equation given by: $f(t,T) = \beta_0 + \beta_1 \exp\left(-\frac{T}{\lambda}\right) + \beta_2 \frac{T}{\lambda} \exp\left(-\frac{T}{\lambda}\right)$. Where T denotes maturity, *f(t,T)* is forward rate for period [t,T], and $\beta_0, \beta_1, \beta_2, \lambda$ are the coefficients estimated.

[5] For a more detailed explanation of the characteristics of shape of forward yield curve (upward, downward or flat) exhibited by data employed, see Chirinos and Maita (2012).



Source: Chirinos and Maita (2012)

Figure 2.



Source: Chirinos and Maita (2012)

2.2. Interpretable economic variables

In the second setup, we include a group of variables that even when they are computed using the parametric specification of NS, they are substantially informative from an economic perspective.

Our variables compile the following three main features: 1) *they are comparable to NS factors*. We compute three variables that can represent, in some way, the similar patterns shown by $\beta_0, \beta_1, \beta_2$. For the case of β_0, and since this component contains a long term component, we used historical estimated betas related to the longest maturity in data (5 years domestic market and 30 years external market) and plugged into the NS formula of forward interest rates. In this way, we obtain a theoretical long term yield highly correlated across markets, around 90 %, with β_0. For β_1, we compute a theoretical spread that comes from subtraction between theoretical long term yield and theoretical short term yield . Computation procedure of short term yield is exactly the same as the one employed to get theoretical long term yield but just considering shortest maturity horizon exhibited by data (0,5 years in domestic market and 8 years in external debt market). From the theoretical long and short term yield we deduce a theoretical spread, that differs from the one often used by macroeconomic literature, since it comes from forward interest rates instead yield to maturities. So, expectations component associated to short and long transactions are included in a more accurate way.

As pointed out by Litterman and Scheinkman (1991), source of variations in curvature can be related to changes in volatility rates. So, as proxy of curvature we calculate a volatility rate of bond yields, measured as the average of squared deviations of different theoretical yields[6] respect to theoretical long term yield (proxy of β_0). Assumption behind this is the presence of a mean reversion process in forward interest rates along multi-period horizons.

Recently and after financial crises, volatility of term structure has been employed to analyze second moment of yield curve. Intuition runs as follows: Yield curve is fully embedded with information regarding future interest rates; the uncertainty about their movements is also there. In consequence, its second moment can detect sources of their movements. Nevertheless, the type of analysis is mainly relegated to a cross section perspective in financial contexts and evolution across time does not exist. Introduction of this variable in a macro finance context (i.e. a time series) is one of the main contributions of this research.

2) _They are more economic meaningful:_ *2.1)* According to Fama and Bliss (1987) long maturity forward interest rates are powerful predictor 2 to 4 years ahead. In our case, the theoretical long term rate, tied at specific long maturity, can be useful to forecast, being appropriate as a potential indicator for policy recommendations. *2.2)* Theoretical spread, computed from forward interest rates, contains information about real interest rate (Mishkin, 1990) and inflation expectations (Fama, 1990). 2.3) Volatility rate becomes in a dynamic indicator of fluctuations in bond prices across time. Inclusion of temporality leads to compare this rate, in the same terms, with any macroeconomic or financial time series. Even when its computation is pretty simply than stochastic volatility models, it eliminates the static vision often assigns, especially in financial contexts, to such kind of volatility analysis.

3) _They are substantially less noisy than original NS factors,_ especially compared to β_1 and β_2.

In the rest of this research and by simplicity we call long term yield as long yield, theoretical spread as spread and volatility rate as yield curve volatility or bonds volatility.

Table 1. Summary statistics for NS factors

[6] Time to maturities covers a range between 0,5 years and 5 years (domestic debt market) and between 8 years and 30 years (external debt market) .

	Domestic Market		Foreign Market	
	Mean	**S. Dev**	**Mean**	**S. Dev**
β_0	10,08	3,12	11,03	3,44
β_1	-1,65	4,32	2,52	8,45
β_2	7,12	6,15	-1,82	8,99

2.3 SVAR

We set two specific setups depending on financial variables considered. These setups are also subdivided in terms of debt market evaluated. In both cases, we estimate a SVAR where data runs from 2004 to 2011, for domestic debt market. At the same time, we compute a SVAR using foreign or external debt market from 2005 to 2011. Sample used is expressed in monthly basis. Variables included for SVAR are: annualized variation of a monthly index of real activity -seasonally adjusted- (Y), annualized variation of consumer price index (P), and financial variables (level, slope and curvature ($\beta_0, \beta_1, \beta_2$) or long yield, spread and bonds volatility). All the variables are expressed in percentages basis and ordered considering first variables from goods market (Y and P) and then financial ones.

Lag length structure was selected using Hannan-Quinn information criterion, which indicates that the best specification corresponded to a SVAR (2) in both cases. All residuals are stationary and the system estimation is dynamically stable.
For the sign restriction identification we evaluate positive shocks generated in goods market. Restriction scheme imposed is shown in the following table:

Table 2

Shock	Variables restricted	
Supply	Y ↑	P ↓
Demand	Y ↑	P ↑

Besides, restrictions on impulse responses (IR) are set for six periods (months) along a time horizon of 24 months. We decide to maintain persistency of restrictions, in order to pronounce the effects of macro variables into financial ones. Next section explains the main results obtained from the identification of supply and demand shock on traditional unobservable factors of NS model and on the theoretical variables.

3. Empirical Results

3.1 First Setup: Macroeconomic effects on shape of yield curve

Our main purpose in this section is to determine the mechanism that operates between variables coming from goods market and financial indicators when a supply or demand shock occurs. This section covers effects of these shocks, for each debt market, on NS factors. We obtain them through 100000 replications, where 4792 draws were finally accepted[7]. Respective impulse responses are shown from figure 3 to figure 7. Solid line represents the median, while the red dashed and green dotted line refer to lower and upper bounds respectively, which means 16^{th} and 84^{th} percentile of the impulse responses that satisfy the restrictions imposed according to table 2.

Different from literature, positive supply and demand shock, in each market, produce significant contemporaneous responses for all the unobservable factors. Impulse responses associated to traditional yield curve factors, generally, are quite similar across market. However, their effects show, in low or high intensity, responses of first and second effects. Next paragraphs address these issues.

3.1.1 Supply shock effects on traditional NS factors

When a supply shock occurs, level factor decreases, where deepest and longest contraction is displayed in external debt market. In fact, for this market the contemporaneous effect is positive (first effect). Instead for domestic transactions, at the same stage, the contemporaneous response is mainly contractive (first 7 months) with a small expansion for the rest of the periods (second effect). Slope increases as immediate response, during the first two months after the shock, to then decreases. Additionally, and even when contemporaneous response is positive, the final effect of supply shock on curvature factor is majority negative for both markets.

Since the literature has not dealt with effects of supply shock (neither general version nor a specific one), there does not exist way of comparing our results, in analogous conditions (i.e. variations in output growth and inflation rate simultaneously), since most of them implies partial analysis from individual changes in variables, being incomparable to our identification approach. However, results in figures 3 and 4 lead to conjecture a possible linked among aggregate prices and level and slope factor. Wu (2003) points out that movements in inflation rates explains around 66% of variability in level factor. Additionally, what we know for sure is that contraction in short and long term components imply high bond prices and a rise in the level of demand for bonds at these maturities.
In this analysis, it is still not addressed the performance of curvature (medium term component). Indeed, different from previous macro finance models where curvature usually does not display any significant response (Alfonso Martins, 2012 and Diebold and Li, 1997), we find a significant and not negligible reaction for the second derivative of yield curve. Financially speaking we can say bond holders implement a butterfly portfolio. They buy the body of butterfly, which means medium term bonds (go long) and sell (go short) short and long

[7] In order to preserve orthogonality condition, shocks described in table 2 are identified simultaneously.

term bonds [8]. Finally, Venezuelan bond holders implement a negative butterfly strategy; selling more medium term instruments than short and long term bonds as soon as β_0 and β_1 reach their maximum fall.

However, depart from this type of financial interpretation; the concept of curvature is far away of being economic meaningful.

Figure 3. Expansionary supply shock –Domestic debt market

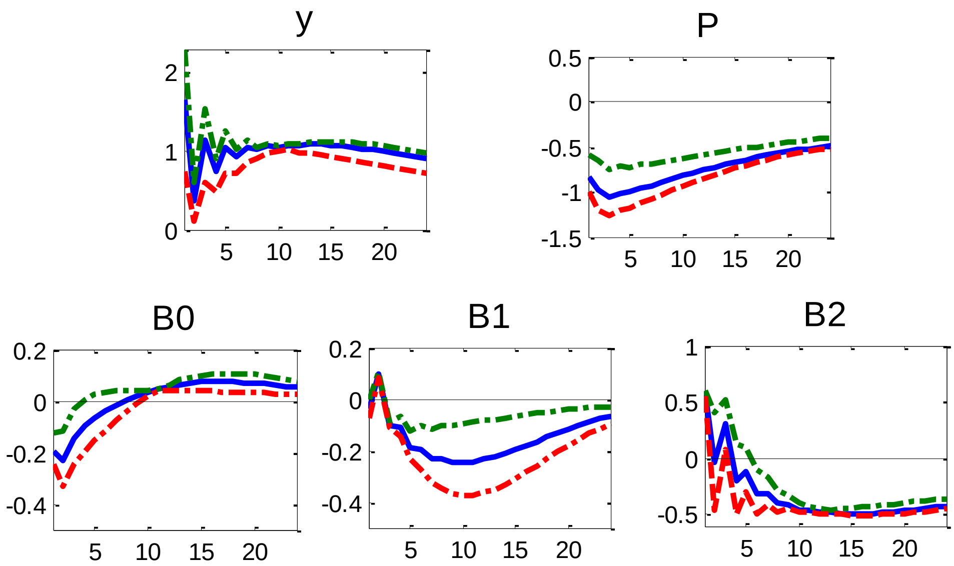
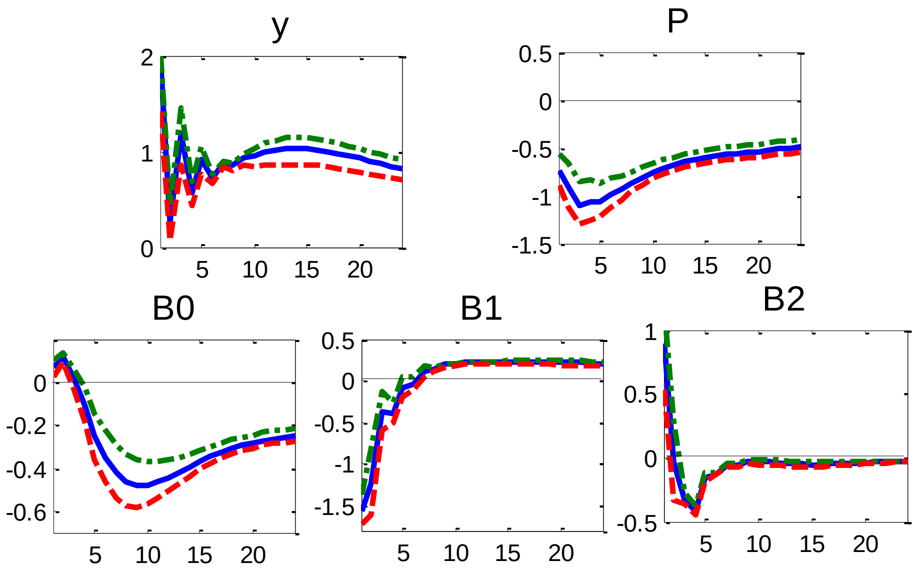


Figure 4. Expansionary supply shock –Foreign debt market

[8] Butterfly portfolio is a common fixed income strategy, created as a combination of holding instruments along the whole maturity spectrum of yield curve for hedging purposes. It combines instruments of short and long term bonds (called the "wings" of the butterfly) and medium term bonds (called body of the butterfly). For a more detailed explanation of butterfly portfolio, see Martellini *et al.* (2002)



3.1.2 Demand shock with traditional NS factors

Expansionary demand shock effects on $\beta_0, \beta_1, \beta_2$ are qualitative opposite to those in supply shock, except for curvature element. Level component increases persistently in foreign market, while initially exhibits an expansion (first effect) and posterior contraction (second effect) in the domestic case (figure 5). β_1 is affected positively by demand shock for both markets, but this pattern is reversed, after a year of shock in local market. Instead β_2 drops due to the shock. The contraction is reversed in both markets, at different period of times, but such reversion is not sufficiently strong to generate a positive final reaction in this factor. Curvature reacts in a similar manner to a positive supply or demand shock in domestic or external debt market, the possible hedging strategy against risk caused by trading with butterflies portfolios might be the answer.

Our demand results are marginally different from those discussed in Alfonso and Martins (2012). They use a VAR to evaluate responses of NS factors to expansionary fiscal shocks, i.e. an annual positive change of debt to GDP ratio in US. This type of shock, replicates the final effects driven by a demand shock; so comparisons turn out to be suitable. In that research, level reacts positively, unless lagged, to fiscal innovation. Besides, a lagged negative reaction in slope is found as well, mainly associated to fluctuations in FED funds rate. A tightening monetary policy, as a response to the initial inflationary pressures, must be responsible for such contraction. We do not include monetary policy variable in our study, since it departs from our original purposes. However, under the absence of monetary policy actions β_1 would tend to be dominated by fluctuations in prices[9]. Finally, authors do not obtain any significant reaction in curvature when an unexpected boost in debt/GDP ratio impacts their system.

[9] Once IR related to slope factor in Alonso and Martins (2012) reaches its baseline level, after a couple of months, tends to increase once the decay in Fed fund rates disappears.

Figure 5. Expansionary demand shock- Domestic debt market

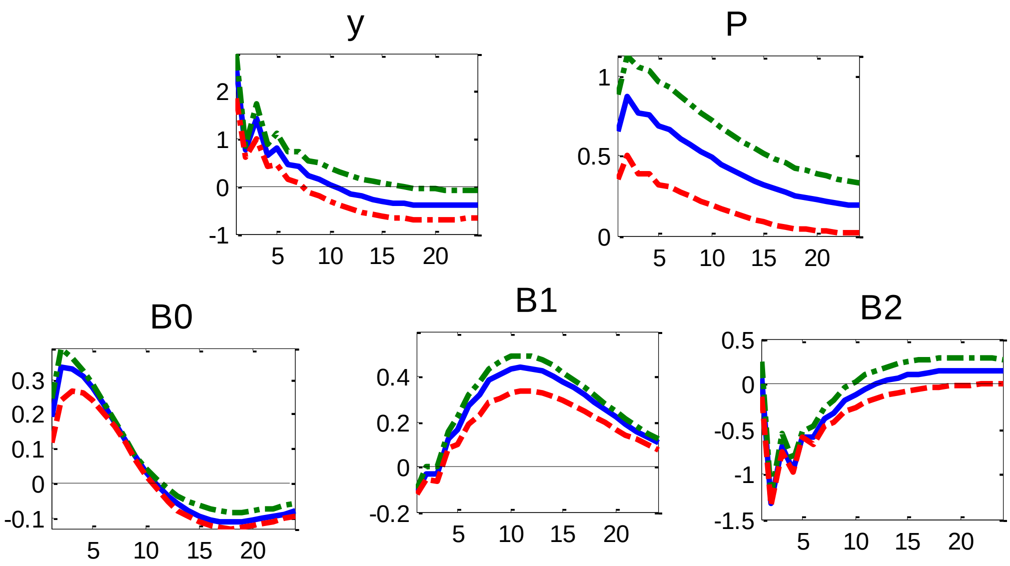
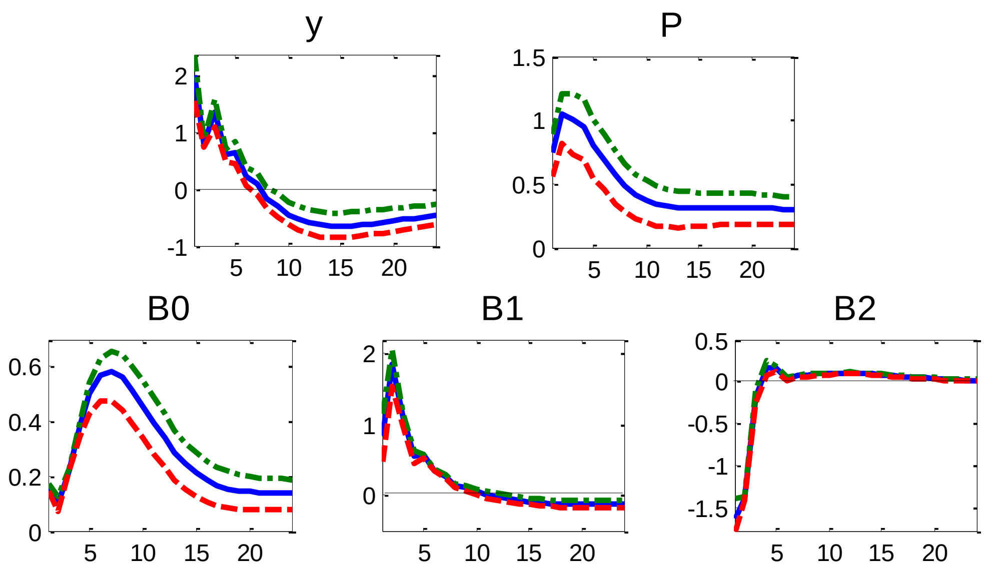


Figure 6. Expansionary demand shock – Foreign debt market



At this point, we can just employ $\beta_0, \beta_1, \beta_2$ movements to detect changes in shape of yield curve. In consequence, with the purpose of giving a more intuitive analysis, we compute a baseline forward yield curve, i.e. median estimated from NS factors series and substitute them in parametric forward interest rate equation, according to certain theoretical time to maturities[10]. We also calculate forward yield curves immediately and one year after each shock.

[10] Theoretical maturities are built considered the observed maturity horizon showed by historical data.

Doing so, a supply shock shifts down yield curve, which means reductions in all bond yields along the whole maturity spectrum. But this reduction is actually perceived 1 year after a shock. First effect on β_0 causes a temporary upward shift of yield curve as immediate impact (figure 8). Parallel contraction in yields is replicated in domestic market at one year after shock; initial impact of shock is almost imperceptible in terms of yield curve movements. In contraposition, a demand innovation is translated into an upward shift of yield curve. Biggest move is achieved in foreign transactions, implying an average growth of 0,28 basis points in yields across different maturities, one year after shock (figure 10). From this graphical analysis is pretty clear that foreign debt market turns out being more affected, in terms of changes in shape of yield curve, than local market when goods shocks take place.

Figure 7. Change shape of domestic yield curve - Supply shock

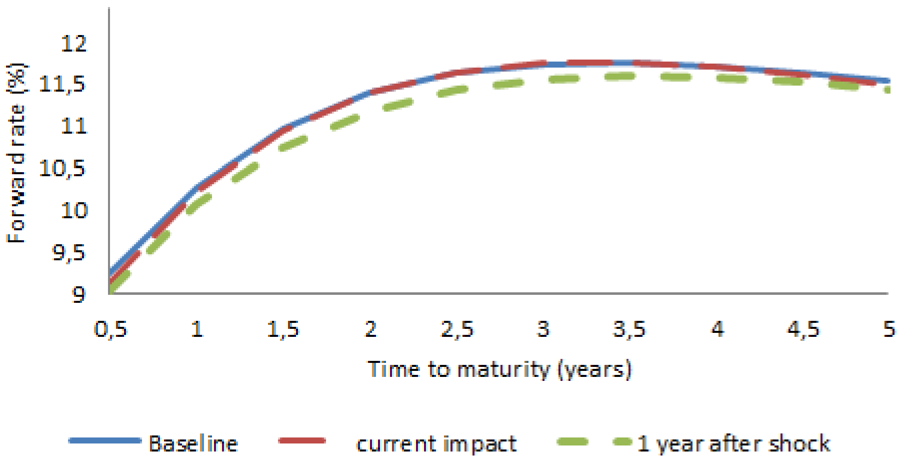


Figure 8. Change shape of foreign yield curve– Supply shock.

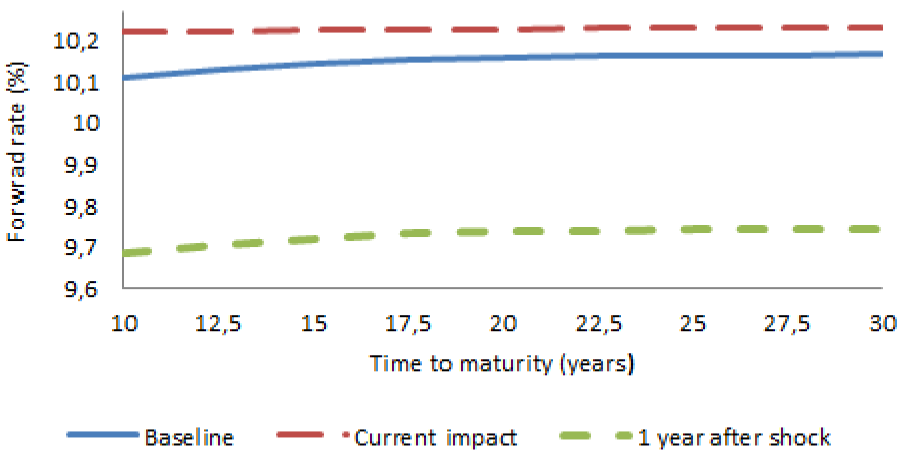


Figure 9. Change shape of domestic yield curve - Demand shock

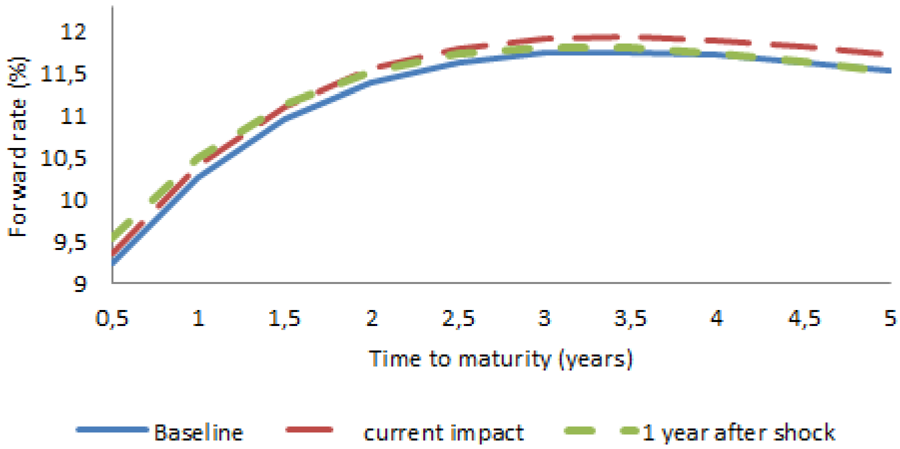
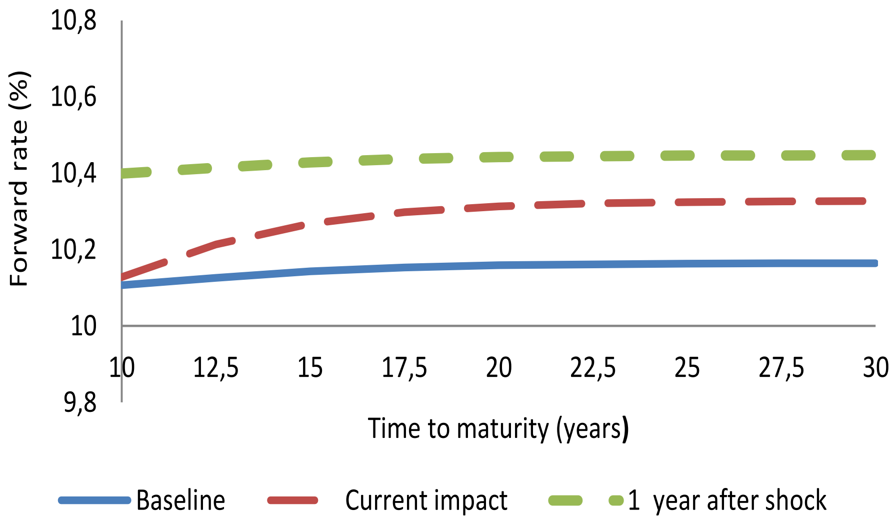


Figure 10. Change shape of foreign yield curve - Demand shock



From the end of the eighties, financial literature assigned a prominent role to yield curve factors to deal with yield curve computations, fixed income analysis and risk management choices. Unfortunately, yield factors generated by parametric estimations lack of economic meaning. Their conception was built considering few economic promises, so their analysis and understanding is not straight forward; instead it becomes complicated and confused in some occasions. Possibly, this is the reason why researchers and financial practitioners associate them to specific maturity set (short, medium and long term) in a particular segment of yield curve, just to give them a bit of economic flavor. Not coincidentally, macroeconomists tend speak in terms of yield curve just referring to its slope (long minus short term yields) and yields related to medium term turns out being irrelevant in some analysis.

To test macroeconomic consequences on theoretical financial variables computed, we reproduce shocks identified in section 3.1.1 and 3.1. 2. SVARs maintain specification, variables ordering, lag structure, and preserve stability conditions. Next section addresses the inclusion of this group of variables in our macro-finance system.

3.2. Second setup: Macroeconomic effects on theoretical financial variables

Following restriction scheme showed in table 2, identification of goods market shocks are summarized in impulse responses from figure 11 to figure 14. These IRs are built using 4802 draws, which fulfill restrictions imposed, from a set of 100000 replications. As previous IRs, bounds showed represent: median (blue solid line), 84th percentile (upper bound-green dotted line) and 16th percentile (lower bound - red dashed line). All the responses of unrestricted variables, in this case of interpretable financial series, are contemporaneously significant. Due to the smooth behavior of such variables, directions of their IRs are more pronounced and less erratic than IRs using NS factors. In consequence, the first and second effects are less intense or tend to disappear in some cases (external debt market).

3.2.1 Supply shock effects on interpretable variables

An aggregate supply shock produces a decay in long term yield. Although the immediate response is a marginal expansion in foreign debt market, a negative reaction along the impulse responses is observed in both debt markets. Even when IR for this variable is qualitative analogous across markets, long yield contraction is more persistent (domestic debt market) and intense (foreign debt market) than reaction observed in β_0. Spreads grows, in net terms, for both markets. The highest expansion is related to foreign debt trading. However, domestic spread increases during the first year after a supply shock, and second negative effect occurs for the rest of impulse response horizon. Since theoretical spread summarizes movements in long and short term yields simultaneously, knowing direction in long bond yields, we can implicitly obtain information regarding short term yields. In consequence, when this variable increases, and given the simultaneously reduction in long term yield, short term yield, linked to specific maturity, are contracting more than proportional long term reductions. In that sense, even when this implicit shrinkage coincides with the fall of β_1 in 3.1.1, magnitudes of the fall are stronger in this case.

In term of the mechanism that operates in dynamics of long yield and slope, the inflation expectations hypothesis coming from Fisher identity, which links market interest rates and inflation expectations, could be applied here. Reduction in inflation is incorporated into investor's decision; they would expect lower short and long interest rates. Slope concept used leads to introduce expectations regarding real short interest rate as well. So, current demand for nominal interest rates must decline once the adjustment caused by deceleration in prices finally happens and expectations are modified. Moreover, since long term nominal interest rates are the sum of inflation expectations and long term real interest rate, current long term yield decreases as well. However, if agents consider a supply shock as a temporal change, especial for the recent Venezuelan history where these types of shocks are attributable to oil shocks, long term expectations shrink but with less intensity than short term. That is the motive why practitioners used to expect a steeper yield curve as a result of a temporal supply shock. It seems that for a supply shock inflationary impact dominates reactions in long yield and spread.

As a result of movements in short and long yields, spread ends up rising. In spite of, IR does not provide any asseveration in terms of causalities; its positive variation verifies the hypothesis that correlates spread of yield curve as a predictor and leading indicators of output growth (Estrella and Hardouvelis 1991, Estrella and Mishkin, 1996).

Our results are quite similar to those found by Smets and Tsatsaronis (1997) and Evans and Marshal (2002). In this last research, authors ask how macroeconomics impulses affect the nominal yield curve. Actually, they identify three types of shocks (supply, marginal rate of substitution (MRS), monetary and fiscal shock) using two approaches for identification. Once coming from Galí (1991) methodology and the second identification strategy is based on imposition of restriction on covariance coefficients according to dynamic general equilibrium models; Basu *et al.* (2001) for the technology shock , Blanchard and Peroti (2000) and Ramsey and Shapiro (1998) for the fiscal shock identification. Authors, find that expected inflation response dominates interest rates for all maturities (short, medium and long) in the supply shock identification. Additionally, Smets and Tsatsaronis (1997) using a SVAR identify aggregate supply, demand, monetary and inflation scare shocks employing a mixture of short and long run zero restrictions. Data belongs to US and Germany from 1960 to 1995. Results show that for German case, short and long term rate fall, where decay in short term rate exceeds reductions in the long term yields. This leads a positive variation in spread of interest rates and a steeper yield curve as a result of positive supply shock.

In terms of volatility analysis, this rate immediately increases after an aggregate supply shock, but its direction is reverted 4 months after the disturbance occurs. Pattern is similar for both markets. Main conjecture is that initial effect perceived by inflationary response, increases the agents' uncertainty. Since a rise in volatility signals macroeconomic uncertainty, the inventors' first reaction aims to rearrange their portfolio. As a consequence, an upward shift in bond demand happens and bonds start to be traded faster (arguing possible arbitrage opportunities), generating an expansion in yield curve volatility. However, given that real response lasts at least two years after shock, agents expectation about economic fundamentals improves and uncertainty regarding fluctuations in bond prices decreases. Bonds prices tend to be stabilized under situations of lower uncertainty. In fact, according to Gerlach *et al.* (2006), bond returns are linked to macroeconomic conditions, and they tend to vary over time due to economic and political turbulence.

Figure 11. Expansionary supply shock –Domestic debt market

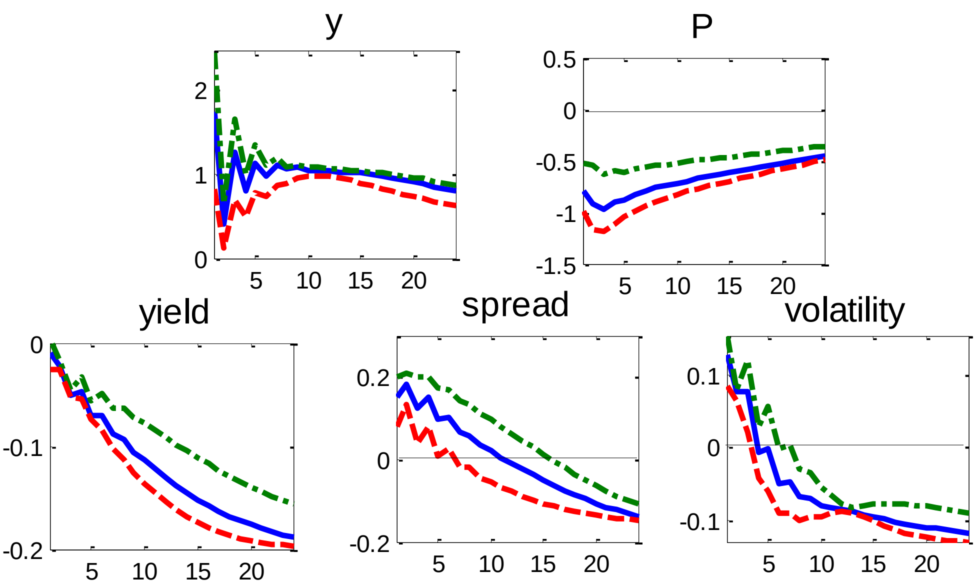
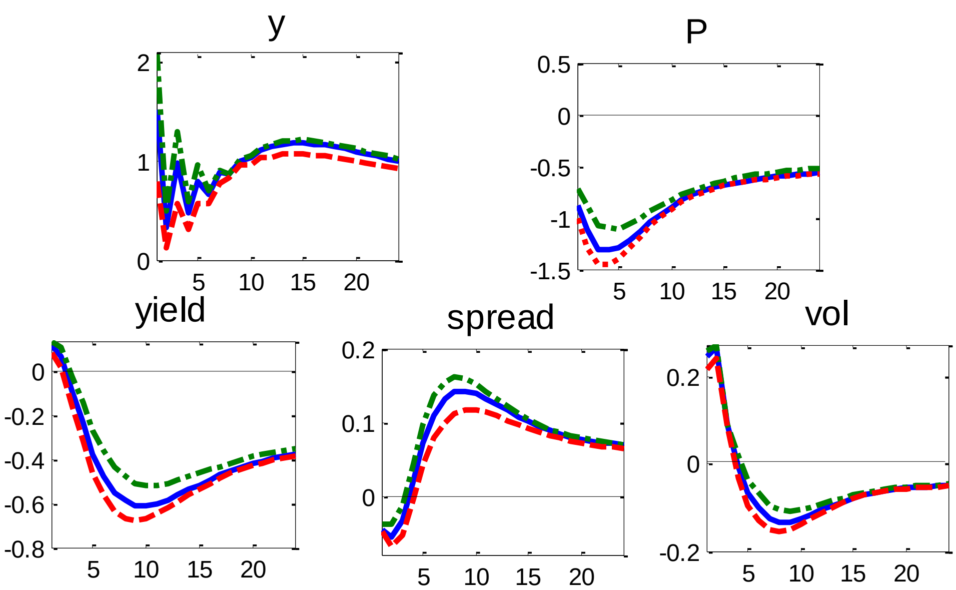


Figure 12 . Expansionary supply shock –Foreign debt market



3.2.2. Demand shock effects on interpretable variables

Effects of positive aggregate demand shock generate expansions in long term yield, which are stronger in foreign debt market but magnitudes of responses are lower than the one obtained across markets using β_0. Spread of interest rates shrinks in both markets, and considering contemporaneous expansion in long yields, this means that short term forward rates must be responding positively but at higher levels. Figure 13 and 14 summarize these issues.

Since financial investments are purely based on expected real returns, investors tend to consider a bunch of macroeconomics scenarios to make decisions. In the short run, given that expected short term rate tends to rise, bond holders adjust current demand for nominal interest rates to maintain unaffected real returns. Nominal interest rates are not just affected by inflation response, since output growth pushes real interest rate as well. As a result, short term interest rates are driven simultaneously by the two forces that characterize aggregate demand shock. In the long run, the better economic performance and inflationary pressures generate an upward force on long term expectations and finally higher nominal long rates. For the case of long bond yield, positive expected inflation generates an upward shift in liquidity premium demand. Agents demand a premium for holding bonds that could potentially be more riskier after the aggregate demand shock shakes the system (i.e. there exists the theoretical and empirical conviction that long term bonds are affected not only by future expectations, the level uncertainty about expected financial and economic conditions modify their pricing mechanism). Expansion in such premium might be not excessively high, once the wealth effect, caused by upward shift in real sector, compensates agent's reaction.

Reasons why positive variations in long yields do not exceed short rates are found in the temporality of shocks and the feedback received by short term rates. Expected variations in short term rate actually affect current long term rates. In fact, channel of transmission of the shock might be diverse. Nevertheless, it is seems short term rate triggers the amplifier effect of the shock.

Our results are similar to those found in Smets and Tsatsaronis (1997). These authors identify an aggregate demand shock, they obtain an analogous responses related to ours results, but a slightly lagged. They argue long term rates anticipate the temporary reaction in short term interest rates linked to short term, which flattens the yield curve. In contraposition, Marshall and Evans (2006), using neither Blanchard and Peroti (2000) nor Ramey and Shapiro identification (1998), do not surprisingly find any significant response in terms of yield curve under a shift in aggregate demand due to an expansionary fiscal policy shock. However, in this research a positive movement in the IS and change in MRS between consumption and leisure, conduces a rise in yields for all maturities. Consequently, level of the yield curve increases accompanied with variations in the slope.

Different from a supply shock, where bonds volatility falls, a variation in aggregate demand of goods and services increases this rate but this effect is more transitory than under a supply shock. Actually, yield curve volatility tends to reach its baseline levels in foreign debt market. Once more time, the first reaction of investors is to trade quickly their positions. Higher level of yields involves higher level of uncertainty about future payoff and prices, i.e. agents are sufficiently risk adverse. As it happens in supply shock, uncertainty related to bond prices is based on the performance of real output growth. Because, for the demand shock, expansionary response in real sector shows lower persistency (inferior than one year), we can argue that incentives to quickly reallocate positions disappear as soon as the rise in real sector is reverted, and bond holders detect that shock has expired.

Figure 13. Expansionary demand shock- Domestic debt market

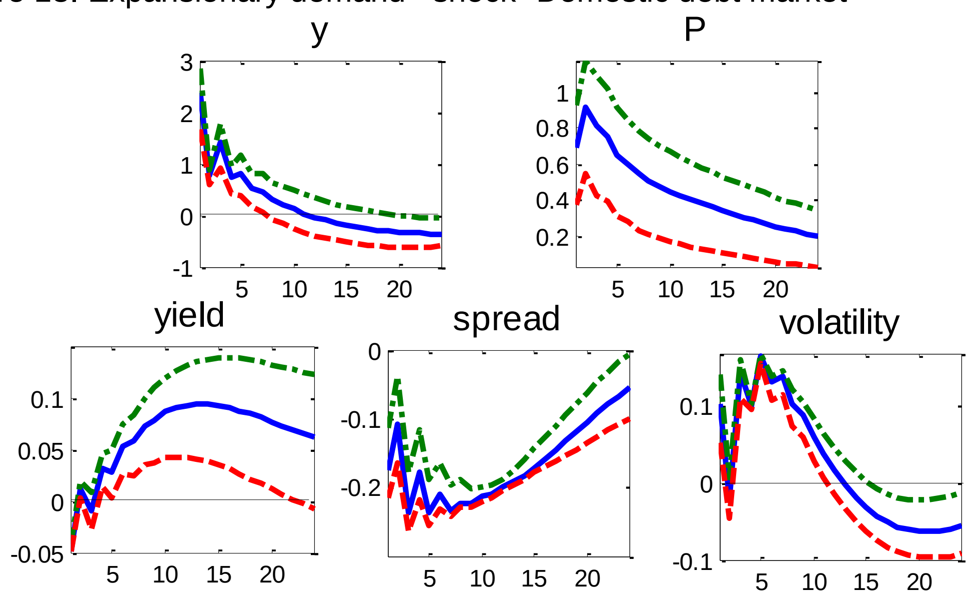
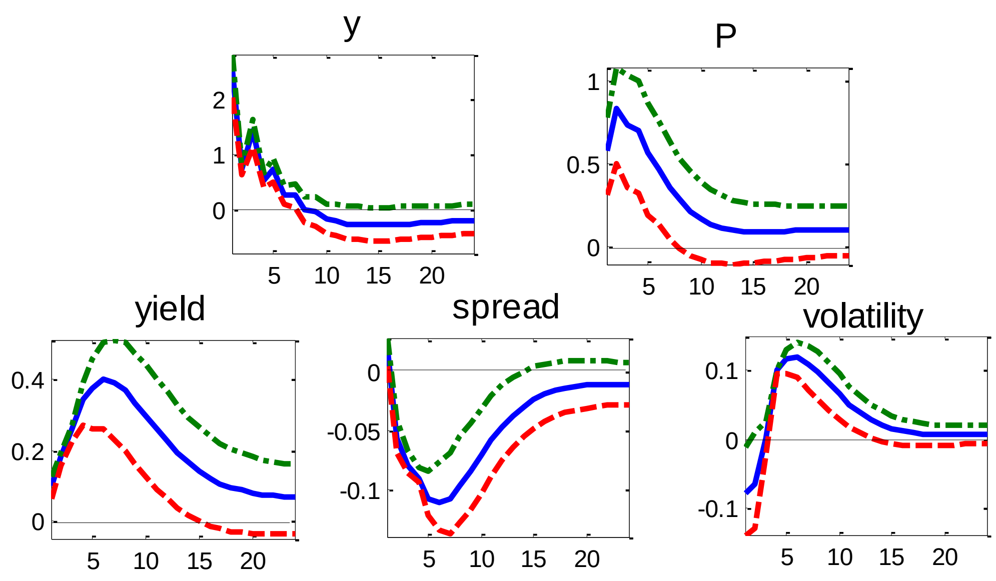


Figure 14. Expansionary demand shock- Foreign debt market



3.3 A financial shock using theoretical yield curve variables

To this point, our main concern has been to evaluate how macroeconomic shocks shifts forward interest rate curve, and the respective implications on yield curve variables. Benefits of the interpretable variables (analytic tractability, smooth behavior and clean response), lead to we ask whether such variables affect the general performance of the economy.

After the recent financial crises, modeling financial shocks have been widely discussed and incorporated into many models to provide policy makers recommendations. Arguments are varied, depending on the goal pursued by each model, where distinctions come from the definition of the shock. According to literature, a financial distortion can involve frictions in the contractual conditions between borrowers and lenders (Nolan and Thoenissen, 2009), change in the external finance premium (Gilchrist *et al.,* 2009), variations in financial stock price index (Fornari and Stracca, 2013), distortions in leverage associated to financial system, among other definitions. What it seems to be a sort of consensus is that during financial distress uncertainty regarding fundamentals and flight to quality (preferences for liquid assets) change simultaneously. When agents perceive that financial distortion modifies economic system, uncertainty about economic future performance affects expected valuation of key real indicators and financial conditions. Asset pricing patterns and its volatility are similarly perturbed. Since, agents want to preserve their wealth during a financial turmoil; willingness of holding risky assets reduces, while coefficient of risk aversion and preferences for liquidity increase. Indeed, short term investments are preferred than the long term positions; they are more liquid assets associated to lower risk. Consequently, long term assets are less demanded, and their related payoffs push up. Having said that and considering our set of interpretable financial variables, we can define a negative financial shock as a rise in bonds volatility with expansions in long term yield. For the particular case of external debt market, this last variable is strongly correlated with credit default swap (CDS) at 5 years (figure 16). So, for this market, variations in long term yield, implies fluctuations in probability of default of bonds tied at the specific maturity considered. In short, negative shock from financial sector, contemplates higher level of volatility, riskier bonds, and additionally, pressures in credit risk.

Econometrically speaking, due to identification scheme applied, with a block diagonal of zeros on financial coefficients, identification of a financial shock is relegated to exert lagged variations on macro variables instead of a contemporaneous effect[11]. Impulse responses are shown in figure 17 and 18, where the interpretation of bounds displayed remains unaltered.

We find a significant response in economic growth, but surprisingly in positive direction around 10 months after shock, when financial disturbance impacts domestic debt market. Since, domestic debt is mainly hold by national investors and given the expansion in long bond yield; we can infer that agents do not initially discriminate this kind of shock from an expansionary demand innovation. Our conjecture is based on trajectory exhibited by median of inflation and output growth variations around a year after shock (figure 17). On the other hand, a negative financial disturbance generates a contraction in aggregate demand side in external debt market. Taking into account, that in this market converges foreign and domestic bond investors, and given the similar behavior between long yields and CDS, positive changes in long yield are signaling to the market that perception of credit risk is varying. Consequently, foreign decisions end up affecting domestic sector through changes in future

[11] As previous exercises, this shock is set for a horizon of six periods, and it is simultaneously identified with demand and supply shock, in order to preserve orthogonality conditions among shocks.

credit conditions and finally in expectations. Hedging credit risk is the incentive to shift CDS demand, which turns out raising the sovereign debt risk. Under this situation, expectations about negative future economic begin to dominate domestic agents' decisions, which are finally translated into a reduction in real sector. Modifications in credit conditions in international markets trigger variation in output growth.

Negative financial shock behaves as a contractionary demand innovation. However, the identification of this shock is not contaminated with aggregate demand shock from section 3.2.2. These responses are different from the specular image of demand shock identified in section 3.2.2; long bond yields are raising (by construction) and spread of forward rates are decreasing. So, both shocks are completely differentiable and they do not overlap each other. In that sense, their origins make them dissimilar. Whether a financial shock is a supply or demand innovation is not quite clear. As argued by Fornari and Stracca (2013), the degree in which credit is granted between consumption or the productive side of the economy determines if a demand or supply effect prevails after a financial shock.

Figure 16. Long yield and CDS (5 years) performance

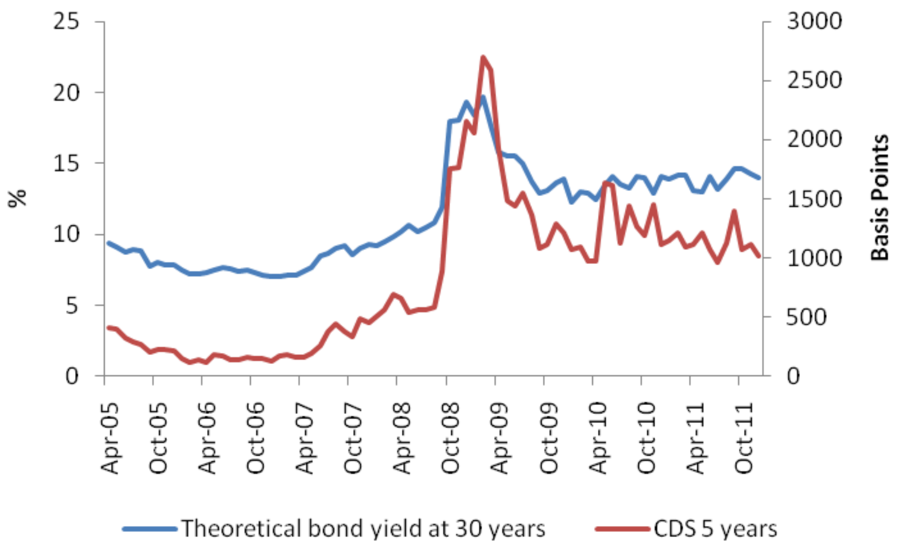


Figure 17. Financial shock- Domestic debt market

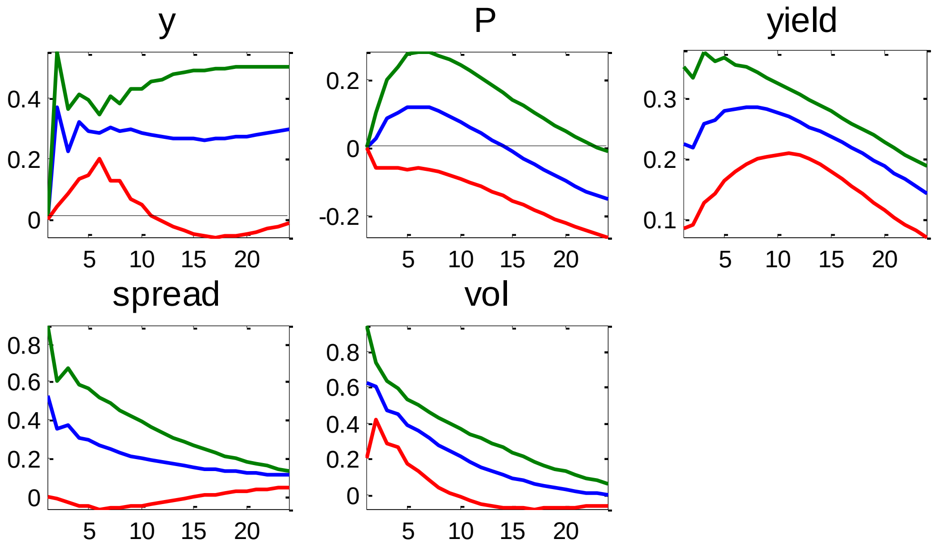
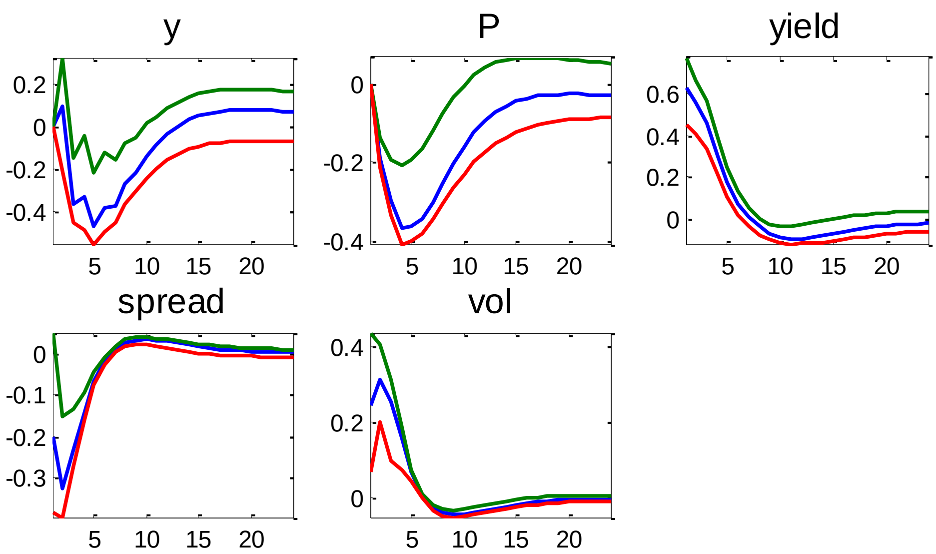


Figure 18. Financial shock- Foreign debt market



3.4 Variance decomposition analysis

Another possibility of interpreting the IR is to evaluate how each shock explains fluctuations of variables included into SVAR along the impulse response horizon; which means a variance decomposition analysis. For domestic debt market, around an 80% of fluctuations in financial indicators are attributable to financial shocks. In a second place of relevance, supply shocks explain movements in long yield, fluctuations in spread are driven by demand innovations, while variations in yield volatility rate is second best explained due to shocks in the goods market in general (table 3). Indeed, main sources of changes in foreign spread and foreign volatility are found in the intrinsic movements in financial sector. At the end, those variables are primarily explained across markets by the same type of shock. What is relevant in external scenario, one year after shock, is that about 60% of variations in long yield are mainly triggered by aggregate supply innovations. In fact, even when financial disturbance is the first cause to characterize fluctuations in spread and volatility in this market, posterior to one year of shock, supply distortion explains around 40%, especially for yield curve volatility, which seems to be almost explained by these two types of shocks (table 4).

Aggregate supply tends to modify financial indicators in external transactions more than what is observed in local market. Composition of the participants, conditions of negotiation of instruments traded, and the direct influences of international valuations, can be a first approximation of a possible reason.

Table 3. Variance decomposition- Domestic debt market

		Structural Shocks		
Variable	**Periods (months)**	**Supply**	**Demand**	**Financial**
Long yield	6	4%	2%	95%
	12	9%	5%	86%
	24	22%	7%	71%
Spread	6	10%	20%	70%
	12	7%	30%	62%
	24	10%	33%	57%
Bond volatility	6	2%	5%	93%
	12	3%	6%	91%
	24	9%	7%	84%

Table 4. Variance decomposition- Foreign debt market

		Structural Shocks		
Variable	**Periods (months)**	**Supply**	**Demand**	**Financial**
Long yield	6	22%	26%	51%
	12	54%	24%	23%
	24	68%	17%	15%
Spread	6	8%	14%	78%
	12	30%	18%	52%
	24	41%	16%	43%
Bond volatility	6	34%	11%	55%
	12	42%	14%	44%
	24	46%	13%	40%

4. An additional exercise: Theoretical yield curve variables and exchange rate

Yield curve is often linked as a good predictor of real output growth, inflation, a leading indicator, a marker of stance of monetary policy, to mention some of the benefits of extracting its embedded information. Under the conditions of Venezuelan exchange rate market (i.e. exchange control from 2003 onwards) with the particular regime imposed, that incentives level of imports, and given

the analysis of yield curve depending on where bonds are issued (local or external debt market), we succinctly evaluate how much information from the theoretical forward curve variables is useful to characterize non official exchange rates variations.
Regarding transactions related to non official exchange rate, recent Venezuelan history can be divided into two main periods, from 2004 to 2010 where non official exchange rate negotiations were strongly affected by brokerage deals, and from 2011 ahead in which such transactions were not permitted by law. Using monthly data linked to the first period, we apply a GARCH (1) specification to regress the variance of non official exchange rate and the variables computed from yield curve. Doing so, we find that theoretical variables are powerful enough to explain movements in non official exchange rate (i.e. almost 70 % of volatility of non official exchange rate is explained by the variables included in the regression). Particularly, one could expect that indicators coming from external sector, due their natural conditions, would exert a higher weight on non official exchange rate. Surprisingly, highest coefficients in the regression are associated to domestic variables, see table 5.

On the other hand, when this regression is exactly replicated for 2004 to 2011, its explicative power is reduced, but it is still not irrelevant (around 52 %), see table 6. This naïve exercise reveals the powerful content in the interpretable financial variables, but also shows the possible structural change, in terms of predictability of stochastic volatility of exchange rate, occurred after 2011.

Table 5. Regression from 2004 to 2010

Dependent Variable: Non official exchange rate
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 06/21/13 Time: 09:08
Sample (adjusted): 2005M06 2010M12
Included observations: 67 after adjustments
Convergence achieved after 30 iterations
Presample variance: backcast (parameter = 0.7)
GARCH = C(7) + C(8)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.618507	0.174464	3.545176	0.0004
Domestic Long yield (-1)	-0.082034	0.017900	-4.582882	0.0000
Domestic Spread(-1)	0.072512	0.011399	6.361342	0.0000
Domestic volatility (-6)	0.102307	0.019557	5.231233	0.0000
Foreign Long yield (-2)	0.007522	0.010177	0.739119	0.4598
Foreign spread (-2)	-0.080686	0.029419	-2.742663	0.0061
Variance Equation				
C	0.006379	0.032622	0.195532	0.8450
GARCH(-1)	0.654566	1.756136	0.372731	0.7093

R-squared	0.702172	Mean dependent var	0.190546
Adjusted R-squared	0.677759	S.D. dependent var	0.254793
S.E. of regression	0.144636	Akaike info criterion	-0.890522
Sum squared resid	1.276103	Schwarz criterion	-0.627276
Log likelihood	37.83250	Hannan-Quinn criter.	-0.786355
Durbin-Watson stat	1.109192		

Table 6. Regression from 2004 to 2011

Dependent Variable: Non Official Exchange Rate
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 06/21/13 Time: 09:13
Sample (adjusted): 2005M06 2011M12
Included observations: 79 after adjustments
Convergence achieved after 42 iterations
Presample variance: backcast (parameter = 0.7)
GARCH = C(7) + C(8)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	1.253643	0.181139	6.920873	0.0000
Domestic Long yield (-1)	-0.136975	0.021076	-6.499251	0.0000
Domestic Spread(-1)	0.042033	0.010611	3.961097	0.0001
Domestic volatilty (-6)	0.060212	0.017656	3.410238	0.0006
Foreign Long yield (-2)	0.014426	0.010993	1.312280	0.1894
Foreign spread (-2)	-0.112617	0.030273	-3.720017	0.0002
Variance Equation				
C	0.006539	0.009006	0.726105	0.4678
GARCH(-1)	0.702365	0.400007	1.755882	0.0791

R-squared	0.557988	Mean dependent var	0.179100
Adjusted R-squared	0.527713	S.D. dependent var	0.239394
S.E. of regression	0.164519	Akaike info criterion	-0.703210
Sum squared resid	1.975851	Schwarz criterion	-0.463266
Log likelihood	35.77678	Hannan-Quinn criter.	-0.607081
Durbin-Watson stat	0.525868		

5. Concluding remarks

Along this whole journey of determining the macroeconomic effects on forward yield curve, we find the computations of our set of theoretical yield variables (long yield, spread and yield curve volatility), compared to traditional NS yield factors, substantially more informative, useful in terms of economic interpretations and powerful as possible indicators of policy recommendations.

At this point, the natural question arises: what is the mechanism that operates in the reaction of such interpretable variables? Inflationary pressure is the common element that drives the directions in long term yield and spread Besides, changes in real sector tend to affect them, especially during an aggregate demand innovation, but it is the direction of aggregate prices which basically determines such fluctuations. Fisher argument seems to dominate here; the adjustment in inflation rate is completely extrapolated to all forward rates in order to preserve real returns. Inflation transferences is more intense in short term interest rates, claiming that effects of shocks are not considered so persistent to influence with similar intensity long term interest rates.

On the other hand, volatility is highly determined by uncertainty about macro conditions, which affects asset pricing mechanisms. Better economic performance reduce transactions that incentives fluctuations in bonds prices, since agents' confidence is enhanced. As pointed out by literature, financial volatility (i.e. volatility related to asset stock, bonds), and output growth are related in negative way. This explains why volatility decreases in supply shock, after the positive real effects attenuates macroeconomic uncertainty.

Finally, debt markets are constituted by a group of different investors (national and foreign bond holders), they react qualitative in the same way, independently the type of market in which instruments are issued; there are not huge differences in responses of theoretical financial variables across markets as result of innovations coming from goods sector. Story is slightly different, under a negative financial disturbance, since markets react in dissimilar fashion. External perceptions regarding national credit conditions and changes in sovereign debt risk are firstly distinguished by not resident bond holders than domestic investors. A sort of asymmetry of information potentially emerges during a financial shock.

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