Research Paper 12/01

Modeling the inflation rate dynamics in Tunisia: An SVAR approach

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Introduction:

The latest popular uprising in Tunisia has very often been described as the result of a distorted labor market that has not been able to absorb the growing flow of young and educated labor force entering the labor market. While this description does provide useful insights into the roots of the Tunisian revolution, one must not overlook the other macroeconomic factors that had, over time, fueled the popular discontent. The increasing cost of living as captured by the surge of inflation rate, although not in a dramatic proportions (according to official figures at least) had aggravated the vulnerability of large segments of the population that felt totally marginalized by the system in place, as they moved every day a bit closer to the periphery of the society. The resulting desperate reaction of this population is now internationally well-known.

In contrast to other countries, very few researchers had attempted to explore the underlying factors that influence the dynamics of the inflation rate movements in Tunisia. In this note, we follow the recent strand of research (Sousa and Zaghini (2005),Almounsor(2010), Berkelmans (2005), Martel (2008), stock and Watson (2001), Aucremanne and Wouters (1999)) by applying a Structural Vector Autoregressive model (SVAR) to shed some light on some of the channels, both contemporaneous and lagged ones, through which shocks to macroeconomic variables influence the inflation rate dynamics in Tunisia. This methodology, as Sousa and Zaghnin(2005,p3) argue is "a more powerful methodology to investigate this link, as it controls for the interactions between the variables, allowing us to provide more appropriate assessment of the contribution of monetary shocks to global output and inflation". We will unfold the influence of three main shocks, that's the monetary shock, the supply shock and the external shock, by constructing a simple model to capture short and long run interactions amongst macroeconomic variables. The impulse response functions generated by the structural model are given a particular attention in this study to better understand the transmission mechanisms through which the inflation rate in Tunisia is interacting with other variables.

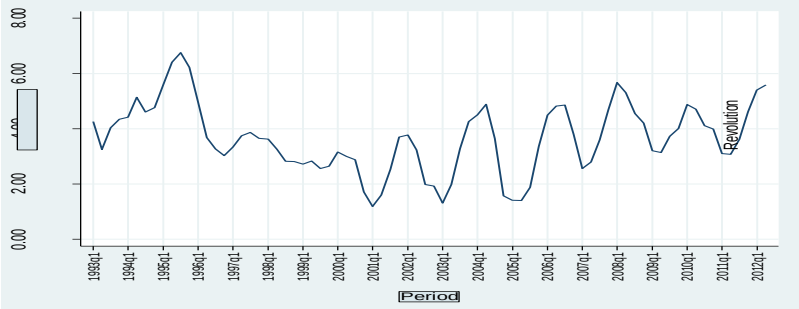
The main findings of this paper confirm that the recent instability of the inflation rate in Tunisia is not only influenced by external shocks generated by the sporadic interventions of the monetary authorities to allow marginal depreciation of the exchange rate or as result of shocks on the supply side. The major force factor of the inflation movement in Tunisia remains the core shocks (dynamics) to the

price level itself. Those shocks appear, according to present model, to account for more than 70% of the inflation variance over a period of 2 years.

General trend of inflation since 1993

In order to get some insights into the evolution of the inflation rate in Tunisia, figure 1 plots of the annual inflation rate from 1993 through 2012.

Firgure 1: Inflation rate movement in Tunisia



At first glance it seems that the inflation rate in Tunisia has constantly moved during the period under investigation within a range of 2 to 6 % with a pick during the year 1995 when the government adopted a series of economic policies to ensure greater openness of the Tunisian economy to the global market along with gradual liberalization of the domestic financial markets. Although this financial liberalization era which has caused a growing inflationary pressure in the country was followed by relatively stable economic conditions where price levels were kept under control (not exceeding a reasonable level of 3 %), starting from 2001 the inflation rate began once again trending upward albeit in a cyclical fashion. This high volatility in the price levels introduces, according to the economic theory, an additional uncertainty element into the economic environment of the country and thus reduces the ability of the domestic and international actors to formulate accurate expectations about future trends of macroeconomic variables. Investors tend to be extremely reluctant, in this kind of unpredictable environment, to finance long-term projects, limiting the country's long run development perspectives.

Overall, like any other small and open economies, the Tunisian economy remains highly vulnerable to external and internal shocks that could aggravate the instability of the price levels. To better understand the dynamics that regulate the evolution of the inflation

rate, we propose to construct a simple model where short and long shocks (both internal and external) are generated and their respective impacts on price levels analyzed.

Model construction

The model we test in this paper relies on a set of dynamic equations used to investigate the impacts of structural shocks. We choose to construct a simple SVAR model that accounts for certain number of structural characteristics of the Tunisian economy, namely; (a) it's a small and relatively open economy subject to recurrent internal and external shocks; (b) the Tunisian Central Bank(TCB)tends to intervene aggressively and regularly in the financial markets by adjusting its monetary policy instruments to ensure more stability in the economy.

The model is structured as follows;

$$M_t = b_{10} + b_{11}M_{t-1} + lagsAllVariables + \varepsilon_{1t}$$
$$Y_t = b_{20} + b_{21}M_t + b_{22}Y_{t-1} + LagsAllVariables + \varepsilon_{2t}$$
$$\Pi_t = b_{30} + b_{31}M_t + b_{32}Y_t + b_{33}\Pi_{t-1} + LagsAllVariables + \varepsilon_{3t}$$
$$EX_t = b_{40} + b_{41}M_t + 0 + b_{43}\Pi_t + b_{44}Ex_{t-1} + LagsAllVariables + \varepsilon_{4t}$$
$$R_t = b_{50} + b_{51}M_t + 0 + b_{53}\Pi_t + 0 + b_{55}R_{t-1} + LagsAllVariables + \varepsilon_{4t}$$

Let y_t denotes the log of industrial production index, r_t denotes the nominal money market rate as the main instrument of the Central Bank's monetary policy, Ex_t is the nominal effective exchange rate (calculated as the trade-weighted average of the nominal exchange rate), Π_t is the log of the inflation rate and M_t is the log of the total amount of money and quasi-money(M2) in the economy. ε_{it} are the orthogonal structural shocks with normalized variances. An additional exogenous variable, log of the crude Oil price, is added to the model to capture the influence of an external shock on the dynamics of the domestic price levels in Tunisia. We use quarterly data from the first quarter of 1993 through the first quarter of 2012. We deliberately expand the period under review to cover the latest social uprising event in order to account for the impact this external shock might have had on the long run dynamics of the inflation in Tunisia. All variables were tested for the presence of unit roots and first differences were generated to ensure their stationarity. We choose a lag length of 4 periods for this model as suggested by the AIC, HQ and SIC information criterion and in accordance with the literature analyzing the quarterly data.

We adopt a recursive SVAR model which summarizes the model above into the triangular Matrix B^0 for the contemporaneous variables and matrix B^1 for the lagged variables (Berkelmans (2005), stock and Watson (2001)). To simplify the model, we don't impose in this paper any restrictions on the lagged variables (i.e., no long run effect restrictions), that's we assume that each variable influences all other variables in the model with certain lag. Restrictions are only placed on the contemporaneous relationships of certain variables as explained below. These restrictions are represented by the O in the lower triangle of the matrix B^0. In the matrix representation below, the

$$\mathbf{B}^0 = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ b^0 21 & 1 & 0 & 0 & 0 \\ b^0 31 & b^0 32 & 1 & 0 & 0 \\ b^0 41 & 0 & b^0 43 & 1 & 0 \\ b^0 51 & 0 & b^0 53 & 0 & 1 \end{bmatrix} \begin{bmatrix} M \\ Y \\ \Pi \\ Ex \\ R \end{bmatrix} \qquad \mathbf{B}^1 = \begin{bmatrix} b^1 11 & b^1 12 & b^1 13 & b^1 14 & b^1 15 \\ b^1 21 & b^1 22 & b^1 23 & b^1 24 & b^1 24 \\ b^1 31 & b^1 32 & b^1 33 & b^1 34 & b^1 35 \\ b^1 41 & b^1 42 & b^1 43 & b^1 44 & b^1 45 \\ b^1 51 & b^1 52 & b^1 53 & b^1 54 & b^1 55 \end{bmatrix}$$

coefficient b^0_{ij} describes the instantaneous effect of the variable j on variable i.

Overall, the above recursive structure of the model consists of five dynamics equations. In the first equation, we assume that the money supply is conditioned by its historical trend as one might extpect given the current intermediary objective of the Tunisian Central bank to stabilize its money supply growth rate over the short run.

The Tunisian industrial production is modeled in the second equation as a function of the contemporaneous money supply rate and past values of all variables included in the model. This construction is motivated by the strong and relatively stable relationship between the growth rates of the M2 and GDP in Tunisia.

In a small and open economy like Tunisia, the inflation rate is often assumed to be influenced by multiple channels. First, inflationary pressures tend to instantly react to any adjustment made to the monetary policy by the central bank. According to the economic theory, the decision to ease the monetary policy through an accelerating growth of the money supply or a cut in the money market rate will cause, *ceteris paribus*, a surge in the domestic demand and thus additional pressures on the price level. A rise in the domestic inflation can also be triggered through the balance of payments channel with a devaluation of the exchange rate causing a surge in the prices of imported goods and services. Such an increase will ineluctably fuel domestic prices (particularly in countries like Tunisia where most imported goods are intermediate goods (raw and auxiliary materials with a low elasticity) that are used in the production process of final

local products. To capture all domestic and international transmission effects on the inflation rate, all variables enter the equation 3 with their lagged values in addition to the contemporaneous effects of the money and the supply shocks. The lagged inflation rate is included in this equation in accordance with the theoretical assumption that the inflation process is a self-sustained process whereby tomorrow's price surge is strongly correlated with today's core shock.

One short run restriction is imposed to equation 4. Since the Tunisian Dinar is anchored to the Euro, its short term dynamics is assumed to be influenced only by the contemporaneous monetary shocks and the inflation rate differential between the domestic and commercial partners' rates given the importance for the local authorities to maintain the competitiveness of the national industries. Other variables are assumed to impact the value of the Tunisian Dinar with some lags. Equation 5 captures the reaction function of the Tunisian Central Bank. The latter is assumed to implement its monetary policy by setting the money market rate gradually taking into account its historical levels, the money growth rate and the deviation of the inflation rate from its long run level. Since the monetary authority is expected to observe the level of output growth only with a certain lag, we impose a restriction on the contemporaneous impact of the industrial production variance over the money market rate. This modeling accounts for the latest law provisions introduced in 2006 to regulate the mandate and the functioning of this institution. This law established the price stability as the main objective of the monetary policy.

The model we develop in this paper while appears to reflect some of the conclusions of the economic theory and to capture certain obvious characteristics of the transmission channels within the Tunisian economy, its scope must not however be overstated. Rather, it should be considered, as was the intention of its author, as an additional theoretical contribution to better understand the dynamics of some key macroeconomic variables of the Tunisian economy. In this respect, we fully adopt the views of numerous authors such as Berkelmans (2005, p1) who points out that: "While a SVAR model is compatible with many different economic theories, the estimates can be sensitive to the set up of the model".

Empirical Results

We only focus in this study on the impulse response functions of the Tunisian inflation rate to shocks generated by the other macroeconomic variables (Figure 2). This approach as stock and Watson (2001, p106) describes "traces out the response of current and future values of each of the variables to a one unit increase in the current value of one of

the VAR errors, assuming that this error returns to zero in subsequent periods and that all other errors are equal to zero".

The supply shock appears to have an immediate negative impact on the inflation as the increase in the productivity tends (in a situation of sticky wages) to cause a decrease in the real marginal cost and thus a gradual decrease of the domestic price levels. The trend is reversed after three quarters as domestic wages and prices start to adjust to the productivity shock and the domestic firms' profitability increases the aggregate demand (Aucremanne and Wouters, 1999). The long run equilibrium (the steady state path) is reached in two-year period. This relatively quick adjustment as Martel (2008) points out suggests that the supply shocks (e.g., productivity shock) are often not very important to the inflation dynamics in the country.

An exchange rate shock leads to an instantaneous, albeit marginal, variation of the inflation rate in the first year before it gets muted thereafter. This instantaneous impact of external shock should come with no surprise since the tradable goods represent an important component of the country's import basket. The impact of the exchange rate shock on the price level is assumed to be offset over time by the variance of the aggregate demand as real wages in the economy start to adjust to the resulting inflation variance after two quarters from its occurrence. We interpret the persistent variance of the inflation rate following the exchange rate shock reflects as the result of a continuous intervention of the monetary authority to offset the impact on the price level by calibrating various parameters of the economy. The long run equilibrium is only reached after 18 months.

An initial monetary innovation (generated by a variation in the money supply) causes a temporary slight increase in the inflation rate before this effect dies out rapidly starting from the 5th quarter following the shock. This minor impact of an innovation in the base money is explained by some authors as a result of the limited role the monetary policy has in the context of anchored exchange rate regime.

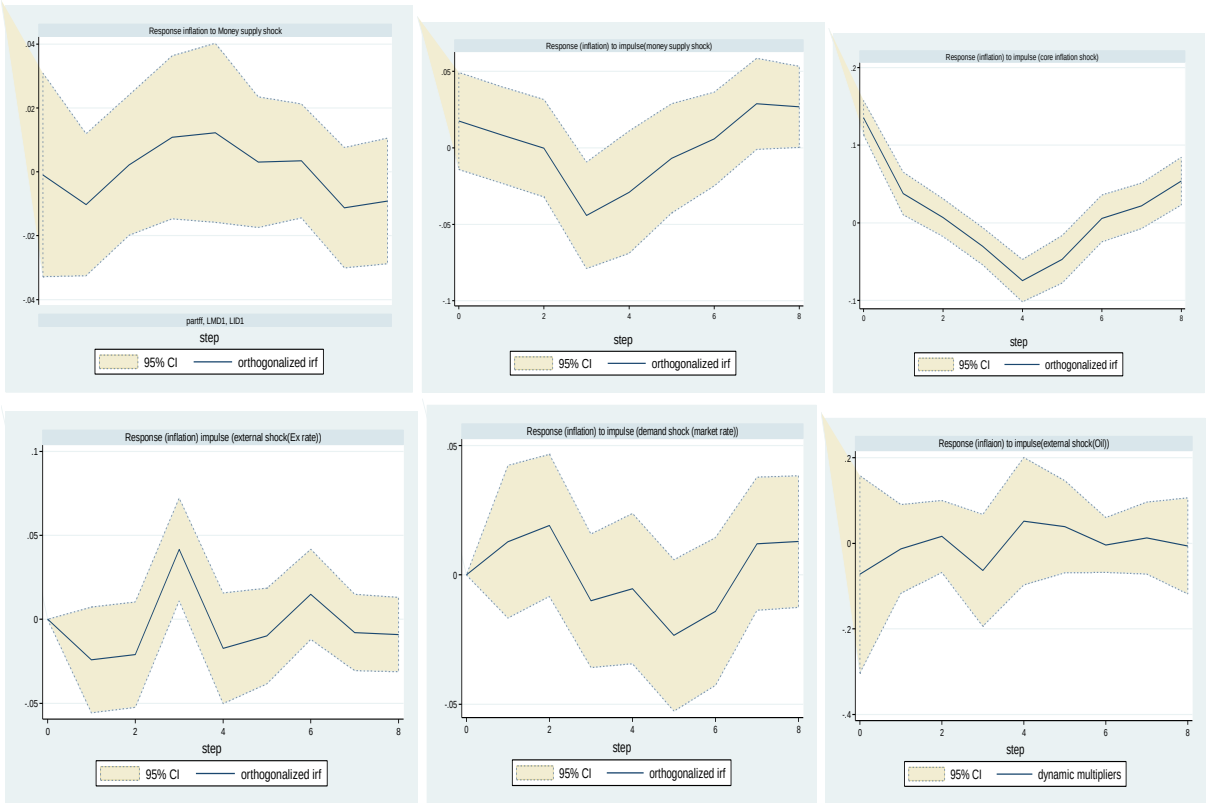
A weak reaction of the inflation over the long-run is found in response to a monetary policy shock. Although such a reaction is in the expected direction, the downward adjustment of the price levels does not start until the second quarter and reach its lowest level around the 5^{th} quarter before it starts picking up(interesting to note that the theoretically well-known phenomenon of "price puzzle" is observed at early stage). This finding that monetary policy shock does not have a persistent effect confirms some analysts' views that the interest rate in Tunisia is mainly administered within a narrow range by the TCB for the purpose of supporting the exchange rate and ensuring the stability

of the financial markets and not necessarily based on economic fluctuations.

The core shock seems to rapidly and significantly impact the price levels. After inflation hits its pick, the price levels seems to decrease substantially in the year following the shock as a result of policy actions taken by the government to cope with the inflationary pressures. The upward trend in the inflation response begins to gain strength once again starting from the 5th quarter.

The domestic price levels tend to positively and instantly react to an energy price shock particularly in the first 6 months. This quick reaction is due, as we explained above, to the dominance of two main pass-through channels, that's; (a) the hike of the marginal production cost as oil price increases the cost of intermediate goods; (b) the increase of the price of final consumption goods (e.g. energy prices, transportation..). This reaction is rapidly reversed by the end of the second quarter following the counter-inflationary measures government officials often take in these circumstances and also as a result of the decline of aggregate demand (Aucremanne and Wouters, 1999). The new domestic equilibrium generates a stable price level starting from the second year following the shock.

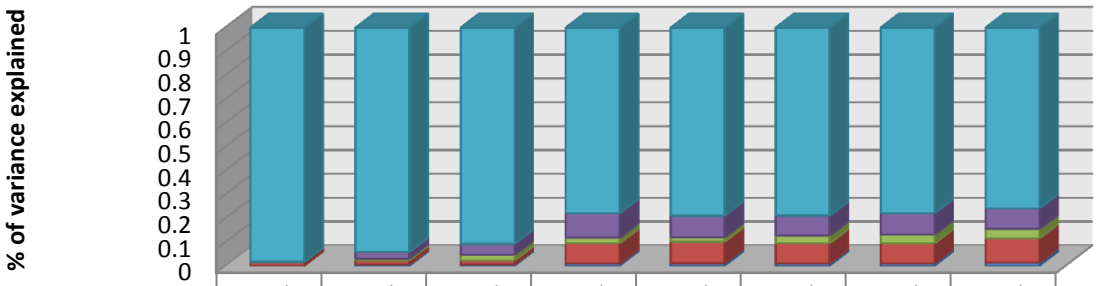
Figure 2: Response functions of inflation rate to internal and external shocks



We also test for the stability of the model's coefficients over the whole period to capture any potential parameter inconstancy that might have occurred as a result of the latest social and economic turmoil starting from the first quarter 2011. While the period under investigation seems quite short to formulate a crystal clear conclusion on the stability of the inflation rate coefficient before and after the revolution, the result of the Elliott-Müller qLL test statistic for time varying coefficients remains quite useful in confirming the stability of this coefficient at various critical levels (1%, 5% and 10%).

Another approach to analyze the findings of the present SVAR model is to look at the forecast-error variance decomposition (figure 3). This decomposition allows for the analysis of the percentage of forecast variation that is attributable to each shock in the system for a period of two years (Vimolsiri and Hirunraengchok, 2004). As expected, in the short run, the core shock to is the main driving force of price level dynamics. The core shock explains more than 70% of the inflation variance over a period of two years. This finding is consistent with the results of similar studies (Berkelmans 2005, Martel 2008, Aucremanne and Wouters 1999). Imported inflation resulting from an exchange rate shock, accounts for about 10 % of the variance of inflation after 4 quarters. While shock to the supply side appears to be insignificant in explaining the Tunisian inflation rate over the short run, its effect climbs to little less than 10 per cent one year after the shock is generated. The monetary shocks seems not to have a significant influence over the variance of the inflation in the short and the long run suggesting that past interventions of the Tunisian Central Bank might have been ineffective in terms of controlling the inflation rate.

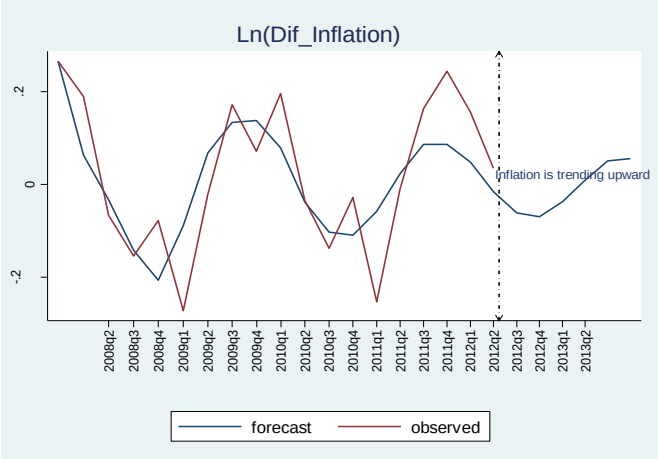
Figure 3: Inflation rate variance decomposition



	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 7	Period 8
Inflation rate	0.982588	0.940568	0.906117	0.778623	0.788502	0.788132	0.778777	0.757691
Ex rate	0	0.027545	0.046378	0.102129	0.089933	0.084327	0.089136	0.08668
Market rate	0	0.007743	0.023947	0.023307	0.019351	0.032202	0.037062	0.03906
Production	0.016833	0.017966	0.017312	0.085739	0.089514	0.083374	0.082972	0.101089
M2	0.000579	0.006178	0.006245	0.010202	0.012699	0.011965	0.012052	0.015479

Figure 4 depicts the predicted trend of inflation variance over the next few quarters. The fitted curve of the estimated model seems to closely follow the actual variance of the inflation rate despite some diversion observed in the recent period following the latest social upheaval in the country. During this period, where the recorded inflation appeared to be accelerating at much faster pace than predicted by the model based on past trend. According to the forecast model, the upward trend is expected to prolong and probably accelerate starting from the 4th quarter of 2012 as the effects of some of the studied shocks that occurred in the recent period (i.e., easing of monetary policy and slight devaluation of the Tunisian Dinar) will kick-in.

Figure 4: Actual vs predicted inflation variances



Conclusion

This paper uses a structural vector autoregressive (SVAR) model to estimate the short and long term endogenous relationships between the inflation rate and macroeconomic variables in Tunisia. The analysis indicates that inflation rate seems to be influenced in the short run by the core shock. As we extend the horizon, other shocks such as to the supply shock and external shock are found to gain influence in determining the variance of the inflation. Moreover, the model suggest that with the exception of the price level own shocks, all other shocks appears to be absorbed by the end of the second year following the occurrence of the shocks. Overall, the main challenge of the monetary authority in Tunisia like any other small and open economies is to be forward looking when deciding about their intervention in the financial markets to accurately anticipate potential external and internal shocks that could aggravate the instability of the price levels. Formulating a set of intervention tools before the occurrence of the shock by implementing a proactive and prudent monetary policy rather than reactive one (which according to the model seems to be ineffective in coping with future shocks) will help lessen the volatility of the inflation rate in the country.

As an initial paper issued in this series of working papers dealing with some of the macroeconomic challenges facing the Tunisian economy, this model remain subject to multiple improvements to try to better capture all short and long run dynamics that affect the price levels. One of the improvements we propose to introduce in future papers is the use of some forward looking elements as potential explanatory variables in the SVAR model. Such an approach will allow us to account for the rational expectation dimension in the inflation dynamic. This dimension, in a country like Tunisia which has witnessed over the recent period a steady upward trend of the inflation rate, is expected to substantially weigh in on the long run equilibrium as local population continues to adjust their forecasts of future inflation. Those forecats, as past experiences around the world have shown, tend very often to be an inverse function of the central bank’s credibility as an efficient inflation fighting actor.

Reference

Almousor, Abdullah (2010), " Inflation Dynamics in Yemen, An Empirical Analysis", IMF Working paper WP/10/144.

Berkelmans, Leon (2005), "Credit and Monetary Policy: An Australian SVAR", Research Discussion Paper 2005-06.

Martel, Sylvain, (2008),"A structural VAR Approach to Core Inflation in Canada", Bank of Canada, Discussion paper/Document d'analyse 2008/10.

Loi n° 2006-26 du 15 mai 2006, modifiant et complétant la loi n° 58-90 du 19 septembre 1958, portant création et organisation de la banque centrale de Tunisie, http://www.bct.gov.tn/bct/ siteprod/documents/loi200626.pdf.

Stock, James, and Watson, Mark, (2001),"Vector Autoregressions", Journal of Economics Perspectives, Vol (15) 4.

Soussa, Joao Miguel, and Zaghini, Andrea, (2005), " Global Monetary Policy in the G5: a SVAR Approach", XIX European Economic Association Congress.

Vimolsiri, Porametee, and Hirunraengchok, Athipong, (2004), " Structural Vector Autoregressions: The case of Thailand", paper prepared for the Interntaional Symposium on forcasting, Sydney, July 4-7, 2004.

Aucremanne, Luc and Wouters, Raf, (1999) :" A Structural VAR Approach to core inflation and its Relevance for Monetary Policy", Proceeding of the Workshop of Central Bank model builders, held at the BIS , 1999.