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Measuring China's Core Inflation: A Common Trends Approach

Samuel Albert Andriamiarintsaina RANDRIANTSOAVINA

PhD in Economics at the University of Antananarivo (Madagascar), Faculty of Economics, Management and Sociology, Assistant Professor, Speciality : Money- Banking - Finance, Tel: (+261)32 40 891 66 / (+261) 34 92 710 58; E-mail: albertrandriantsoavina@gmail.com

Abstract – In this study, we estimate core inflation in China using a common trends model over the period from July 2017 to July 2021. In this framework, core inflation is estimated from the information contained in the following variables: the Consumer Price Index (CPI), the Money Supply (M2), and the Industrial Production Index (IPI). Unlike other commonly used measures such as the structural VAR model, the core inflation obtained by the common trends method has a strong correlation with monetary growth and less volatile than headline inflation. It provides an estimate of underlying inflation based on broader information, integrating macro-economic variables which play an important role in determining the long-term inflation rate. It thus makes it possible to identify the strategies of monetary and budgetary policies making it possible to achieve the inflation target and an economic growth objective.

Keywords – Core inflation, Common trends model, Structural VAR, Monetary policy.

1. Introduction

In order to achieve price stability, the monetary authorities need an inflation indicator that only measures the inflation created by money, i.e. the core inflation. As argued by Cecchetti (1997), transitory phenomena should not affect the action of policy makers and the observed short-term changes in the rate of inflation must be carefully analyzed in order to extract long-term inflation.

The trend component of inflation commonly referred to as the "underlying inflation rate or core inflation". Consequently, the empirical study of inflation has become a crucial issue in the analysis of monetary policy, in order to distinguish between persistent sources of inflationary pressures and temporary price fluctuations.

Several measures of the core inflation rate have been proposed and used in practice to conduct monetary policy well. One approach relies on the use of estimators with limited influence, such as trimmed means or the (weighted) median, instead of the classical weighted mean calculated over the complete cross-sectional distribution of individual price elements (Bryan and Cecchetti, 1994). Various techniques have been applied to the set of price series variations to measure the underlying inflation component. For example, the technique of simple moving averages calculated over various time periods (from 3 to 6 months up to 36 months, the simple exponential smoothing) where more sophisticated methods (for example, the model of unobservable components, the dynamic factor index), are used to eliminate noise the inflation fluctuation component.

Other measures are used on econometric methods which aim at the economic decomposition of time series into permanent and transient components. In particular, Quah and Vahey (1995) applied a bivariate vector structural (VAR) model to the UK to estimate core inflation. This method is based on the assumption of long-term neutrality of permanent shocks of the inflation rate on production.

This document extends the two-dimensional analysis, production and inflation advanced by Quah and Vahey (1995) in a multivariate framework applied to China inflation from July 2017 to July 2021. In this context, we interpret core inflation in China as the long-term inflation forecast obtained from a small-scale model of common trends. Stock and Watson (1988); King et al. (1991), built around a (suitably tested) long-run equilibrium relationship between the rate of inflation and what is believed to be its main long-run determinant, the nominal growth rate of the money. In doing so, we follow the approach of Bryan and Cecchetti (1994), who define core inflation as the persistent component of the observed inflation rate, and "that is related in some way to money growth".

Also Quah and Vahey (1995) argue that it would be interesting to allow the monetary variable in the VAR system used to estimate core inflation. Bagliano and Morana (2000)[1] have already provided evidence of a strong long-term relationship between growth in M2 and inflation rate in the US since the beginning of the sixties (60), we interpret and test this relationship in terms of cointegration into a system. In this framework, the identification of permanent shocks is obtained and a measure of inflation is constructed, which only reflects the effect of these permanent disturbances.

2. Expected results

Stable and low inflation in the interest of maintaining balanced and sustainable economic growth is among the main macroeconomic policy objectives in China. Through this study we will identify the following points:

- Should the People's Bank of China (PBOC) target observed inflation or core inflation?
- Is it the interest rate instrument or the fiscal instrument that has more effect on inflation?
- What are the level of economic growth, money supply growth and inflation rate compatible with any core inflation target?

3. Econometrics Methodology: Common Trends Model

The general idea of this measure is to extract the core inflation with a model with common macroeconomic trends of reduced dimension. In this framework, core inflation is interpreted as the long-term forecast of inflation, obtained from the information contained in the variables of the system which are modeled on the basis of their cointegrating properties. The existence of cointegrated relationships between these variables implies that there are long-term equilibrium relationships between them, and that these variables are influenced by a set of common structural shocks. The latter give permanent effects on the cointegrated variables and therefore lead these variables to evolve according to the same stochastic trends. The variables oscillate around their common equilibrium trends and cannot permanently deviate from these trends. When they become of their equilibrium trends, rebalancing mechanisms are put in place to establish the equilibrium situation. Therefore, each variable in the system can be considered as the resultant of two components: one captures its permanent trends which are like with the other variables, and the other gathers its own transitory movements which are conditioned only by the temporary shocks to the system.

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[1] **Bagliano, F. C., &Morana, C. (2003b).**Measuring US core inflation: A common trends approach. Journal of Macroeconomics, 25, pp.197–212.

In the case of inflation, the common trends of this variable, which can be derived from the common trends model, is considered as the core inflation because it is only conditioned by the permanent shocks of the system. It therefore clearly expresses the underlying movements of this variable. It is from this that Bagliano and Morana developed their approach for a measure of core inflation in the United States, United Kingdom and Italy.

Compared to the usual statistical approaches, this method has many advantages. First, it makes it possible to identify and capture the factors that have an impact on the long-term evolution of inflation-something that is completely impossible with purely statistical approaches of the exclusion type (excluding food and energy), weighted average or trimmed mean. Second, this model contains a greater source of information about inflation by including other macroeconomic variables like money supply, in addition to inflation and output.

4. Estimation

According to the quantity theory of money or money demand, we consider a system with three variables, the logarithm of industrial production index (y), the logarithm of money supply M2 (m), and the logarithm of consumer price index (p). The price index series is seasonally adjusted (i.e. seasonally adjusted). Data on the money supply (m), the consumer price index (p), and real production (y) were obtained from Federal Reserve Economic Data. The unit root test presented in Table 1 showed that all the variables are integrated of order 1, i.e. I(1). We used a cointegration test according to the maximum likelihood method of Johansen (1991).

We chose one lag in the long-term specification of the model as suggested by the information from AIC (Akaike Information Criterion). The results of the cointegration tests are shown in Table 2. As expected, the data suggest the existence of a cointegration vector at the 5% significance level. For the normalized eigenvector coefficients, a long-term relationship between output, money supply, and inflation becomes clear. Real production has a very low coefficient (close to zero). As shown in Table 2, a formal test cannot reject the hypothesis that the cointegrating vector captures the real money constancy (m-p) in the long run. This restriction was therefore imposed in the rest of the analysis.

Within the framework of a model with common trends described in the previous section, the existence of one cointegration relationship between the three variables implies the presence of two different sources of shocks having permanent effects at least on part of the variable. We make the following assumption about the nature of the two permanent shocks in the system: we consider a real supply shock (φ_y) driven by movements in the real domestic shock throughout the period studied, and a monetary shock (φ_m) that the source of this latter shock has no long-term effect on output (a long-term neutrality assumption).

Table1 : Unit root test

Variables	Trend significance	Augmented Dickey-Fuller statistics	Critical values			Existence of unit root
			1%	5%	10%	
Log(GDP)=y	With trend	-1.02	-3.57	-2.92	-2.59	Yes
Log(M3)=m	With trend	0.17	-3.50	-2.89	-2.58	Yes
Log(CPI)=p	With trend	-1.40	-3.50	-2.89	-2.58	Yes

Table2 : Cointegration analysis

Hypothesis	λ trace	Trace in 90%	Trace in 95%
r=1	27.52	35.76	29.80
r=2	7.37	8.23	15.41
r =3	0.85	0.85	3.84
Unretricted cointegrating vector :			
	y	m	p
	0.031	1	-1.07
Restricted cointegration vector :			
	y	m	p
	0	1	-1
χ^2 (p-value)		6.214(0,11)	

The permanent part of the common trends representation is then the following bivariate random walk:

$$\begin{pmatrix}\tau_y\\ \tau_m\end{pmatrix}_t = \begin{pmatrix}\mu_y\\ \mu_m\end{pmatrix} + \begin{pmatrix}\tau_y\\ \tau_m\end{pmatrix}_{t-1} + \begin{pmatrix}\varphi_y\\ \varphi_m\end{pmatrix}$$

Whereμ_t is a vector of constant drift terms; φ_y and φ_m are respectively a domestic real shock and nominal disturbance (two permanent shocks)

The common trends representation of the variables in levels is therefore the following:

$$\begin{pmatrix}y\\ m\\ p\end{pmatrix}_t = \begin{pmatrix}y\\ m\\ p\end{pmatrix}_0 + \begin{pmatrix}c_{11} & c_{12}\\ c_{21} & c_{22}\\ c_{31} & c_{32}\end{pmatrix}\begin{pmatrix}\tau_y\\ \tau_m\end{pmatrix}_t + C(L)\begin{pmatrix}\tau_y\\ \tau_m\\ \gamma\end{pmatrix}_t$$

The estimated core inflation series from common trends model is then computed as:

$$p_t^{CORE} = p_o + c_{31}\tau_{y,t} + c_{32}\tau_{m,t}$$

This estimate takes into account the long-term effects on inflation by a set of identified permanent shocks and allows interpretation of long-term inflation, when all transitory inflation shocks have disappeared.

The procedure of Quah and Vahey (1995), applied to a non-cointegrated bivariate system, including production and inflation, would only allow the identification of two permanent shocks and no disturbance of a purely transitory shock was not determined. Core inflation shocks would be identified by imposing a zero restriction on their long-term effect on output and the core inflation series would then be constructed using only this type of disturbance. This identification scheme does not make it possible to estimate long-term inflation attributable to movements in real shocks (which affect production in the long term) and does not exploit the direct long-term link between the money supply and inflation (one of the main features of our study).

Table3 : The estimated common trends model

Long-run effects of permanent shocks

Variable	Supply shock	Monetary shock
Production(y)	0.031	0.000
Money(m)	-0.004	0.007
Inflation(p)	-0.004	0.007

Long-run forecast error variance decomposition

Variable	Supply shock	Monetary shock
Production(y)	1.000	0.000
Money(m)	0.001	0.999
Inflation(p)	0.001	0.999

The main results of the estimation of the common trends model are presented in Table3 above with the estimated values of the long-term impact matrix and the decomposition of the variance of the variable forecast errors. While examining this table, we noticed certain characteristics on the estimated values of the model. First of all, the supply shock has a positive effect on this variable and does not have a permanent effect on the money supply. And also, its effect on the price level is small and negative (about 0.4 %).Finally, the last two variables (money supply and price) show their positive relationship following a monetary shock verifying the constancy of real money.

Regarding the decomposition of the variance of the long-term forecast errors, the table3 explains that 99% of the variance of the money supply and inflation can be attributed to the monetary shock. This means that in the long term inflation is always a monetary phenomenon.

Following a money supply shock, prices quickly converge to their long-term levels, which explains the very short-term effect of money supply shocks on the level of production (the assumption of the neutrality of the money was always verified).

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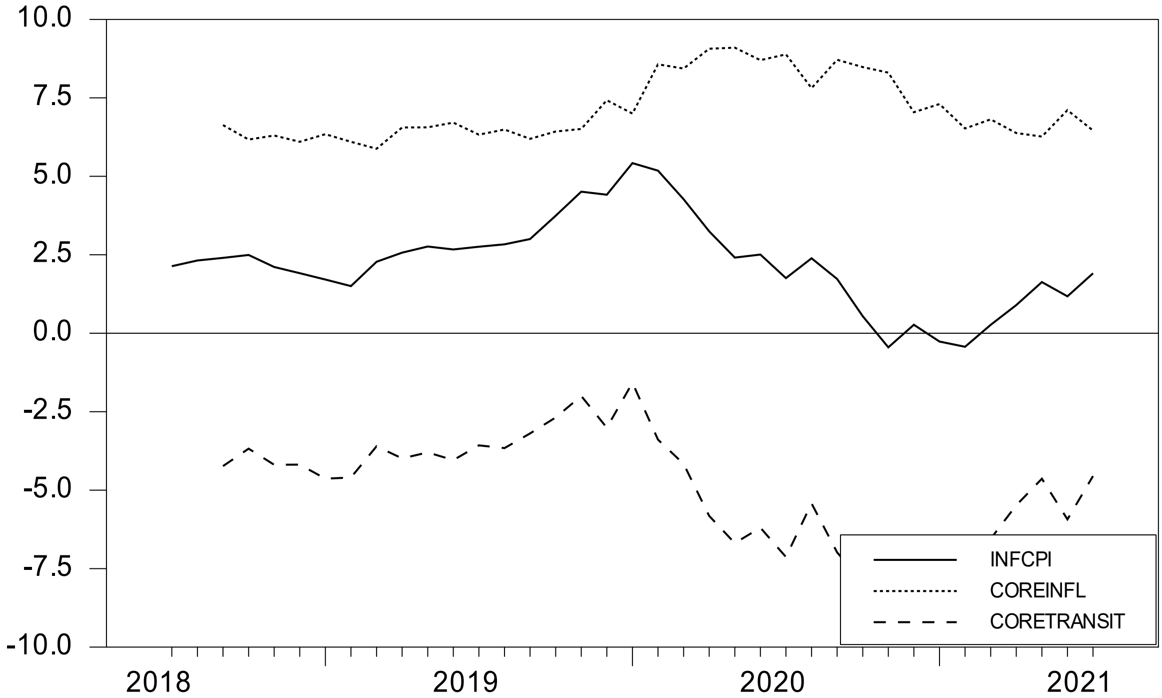
5. Graphic analysis

Below graphs 1 and 2 that we obtained during our estimation (in percent)

GRAPH1: OBSERVED INFLATION (INFCPI), COREINFLATION (COREINFL) AND CORETRANSIT (transitory inflation interpreted as additional demand) (year –on-year)



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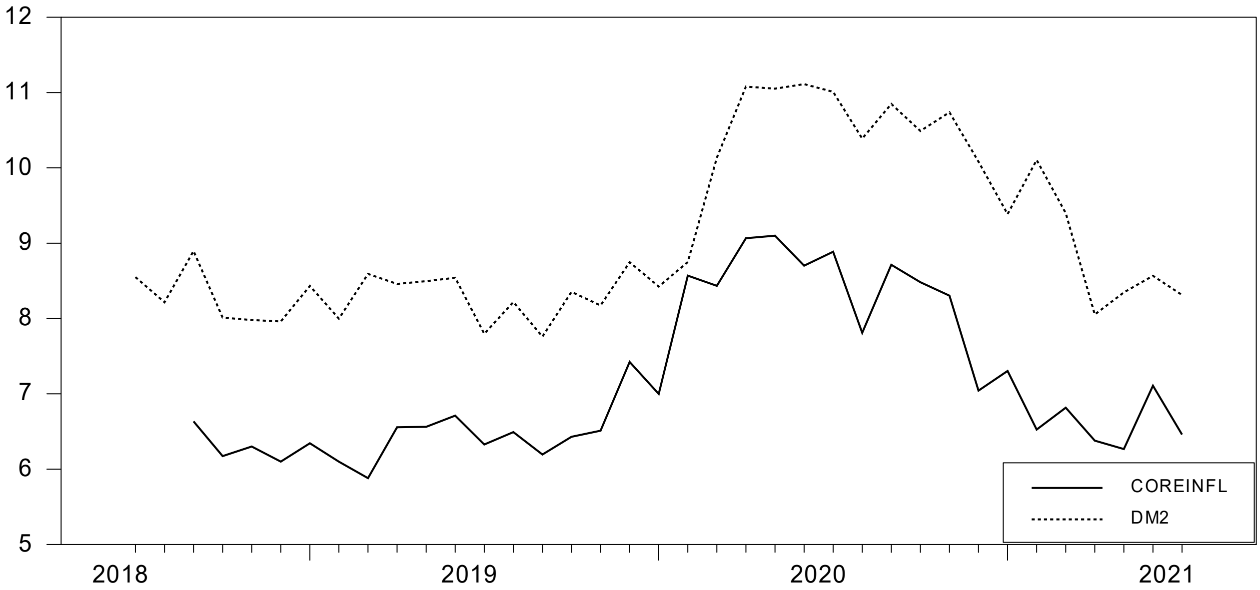
GRAPH2: COREINFLATION (CORETREND) AND MONEY SUPPLY M2 (DM2)

(Year –on-Year)



Graph1 shows us that core inflation remains still above observed inflation during the periods of our estimation. This result can also be justified theoretically by the fact that core inflation is expected to exceed observed inflation in periods of weak growth or recession.

According to the quantity theory of money or according to the simple monetarist model, any monetary increase greater than that in volume activity would result in an upward adjustment in trend inflation (or core inflation). For the case of the China, empirical analyze (Graph 2) show us that changes in the money supply is well and well correlated with changes in the core inflation(correlation coefficient equal to 0,90).

One possible explanation would be to say that excess money in circulation would be allocated more to the consumption of goods and services (consumer loans) than to financial investments (stocks, real estate, bonds). Consequently, increase in the money supply would generate high core inflation in highly financialized economy like the China.

Since october2019, the money supply growth M2 had always remained above 8%.In this context, Chinese politicians have already announced the shift from a restrictive monetary policy to a accommodating monetary policy. The People's Bank of China (PBOC) decided to cut the Reserve Requirement Rate (RRR) by 50basis points for more financial institutions. This measure aims to increase support for the real economy, freeing up 1.2 trillion RMB (about 190billionUSD) for the banking system. This was just the first act in a more comprehensive round of easing measures, for example, most recently the PBOC cut the one-year loan prime rate by 5basis points.

6. Empirical criterion

To ensure the reliability of the measures of the common trends model, a more scientific evaluation is necessary to understand if the estimated measures are compatible with the inflationary trend to come. Before assessing the predictive accuracy, we also examine

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some basic characteristics of underlying inflation using several criteria proposed in the literature. First, we examine unbiasedness, volatility, and how basic measures relate to variables such as the rate of money growth.

In this regard, we present the standard deviation, and the correlation between core inflation

and the change in the M2 money supply shown in Table4. One of the important basic criteria is that underlying inflation must be unbiased to headline inflation. This implies that in the long run, the difference between average headline inflation and core inflation must be zero.

Looking at Table4, we noticed some following points.

First, the volatility analysis (based on standard deviation comparison) shows that the measure of underlying inflation based on a structural VAR is more volatile than headline inflation with the exception of the measure of underlying inflation based on a common trends model. This means that the volatility of core inflation based on a theoretical model is statistically significantly lower than that of headline inflation. Second, the correlation coefficients indicate that the measure based on the structural VAR is weakly correlated with money growth, but the correlation between core inflation based on a common trends model and money growth happens to be the largest with a high level of statistical significance. In short, the statistics in Table4 show that the core inflation based on a common trends model still meets the basic criteria of the study.

Table4: descriptive statistics of inflation

Variables	Standard deviation	Correlation with money growth M2
Observed inflation(ACTINFL)	1.43	-0.27
SVAR inflation(CORESVAR)	1.93	0.11
Trend inflation(CORETREND)	1.26	0.90

7. Conclusion and recommendation

We are trying to build a benchmark that can serve as an indicator of the upcoming inflationary trend. For this, we use monthly historical data for the period from July 2017 to July 2021, and we obtain two measures of underlying inflation from two different methods: the structural VAR method and a common trends model. Core inflation measures are subjected to empirical evaluation to serve as a predictor of future inflationary trends. In this regard, we examine whether core inflation satisfies the following empirical criteria such as unbiasedness, volatility, and high correlation with money supply.

Of these two measures, the estimates calculated from a common trends model appear to have met the empirical criteria used to substantiate core inflation as a predictor of future inflation. Moreover, the model-based measure of underlying inflation outperforms the structural VAR technique if we observe the characteristics of underlying inflation. However, the successful application of the model for monetary authorities is highly dependent on the availability and reliability of data. On the other hand, the central bank can potentially use core inflation based on a theoretical model for internal policy decisions.

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Finally, it would be important to prohibit the subscription of new loans to households which already devote more than 50% of their monthly income to repayments and it's necessary to use the monetary instrument instead of using the interest rate instrument according to the Poole model.

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APPENDIX

1. COMMON TRENDS MODEL:

The representation with common trends makes it possible to make an a priori distinction between so-called persistent and transitory shocks. Permanent shocks are associated with long-term dynamic multipliers that are not all equal to zero. They contribute to the common trends of the system, the latter being specified as linear combinations of the random walks defined from the only permanent shocks. The transient shocks complete the set of shocks to constitute a base of n shocks in a system of dimension n. First, we explain the transition from the Wold representation to the so-called "common trends" representation. In a second step, it will be a question of specifying the identification of the matrix A of the long-term responses to permanent shocks.

The passage from the Wold representation to the representation with common trends

King, Plosser, Stock and Watson (1991) demonstrate the existence of the representation with common trends (C.T.) for an integrated X_t process of order 1 and cointegrated of order (1,1), which admits the Wold representation. A vector X_t integrated of order 1 and cointegrated of order (1,1) with β, a matrix (n*r) of rank r, such that $\beta' X_t$ is stationary, admits the following "moving average" representation:

$$\Delta X_t = \mu + C(L)\varepsilon_t \qquad (1)$$

Where C(L) is a matrix of polynomials of dimension (n*n) such that $C(L) = I_n + \sum_{J=1}^{\infty} C_j L^j$

Let $\varepsilon_t \sim BB(0, \sigma^2)$

If we apply the cycle-trend decomposition according to the principles of Beveridge and Nelson (1981) to the multivariate case, we obtain:

$$\Delta X_t = \mu + C(L)\varepsilon_t - D(L)\varepsilon_t \qquad (2)$$

Or

$$D(L) = C(1) - C(L)$$

$$= (1-L)\,[C_1 + C_2(1-L) + C_3(1+L+L^2) + \ldots]$$

With $[C_1 + C_2(1-L) + C_3(1+L+L^2) + \ldots] = K(L)$

$\Leftrightarrow (1-L)X_t = \mu + C(1)\varepsilon_t + (1-L)K(L)\varepsilon_t$

After the arrangement, we get:

$$X_t = X_0 + \frac{1}{(1-L)} C(1)\varepsilon_t + K(L)\varepsilon_t \qquad (3)$$

With $\frac{1}{(1-L)} C(1)\varepsilon_t$ = permanent shock and K(L) = transient shock

Where $K(L) = \frac{C(L)-C(1)}{1-L}$ is a finite polynomial matrix for all $\|L\|<1$.

We can rewrite the permanent component in the following form: $C(1)\sum_{i=0}^{t} \varepsilon_{t-i}$

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With C(1) the long-term multiplier of a shock observed at t. The level of results from a trend component which depends on the sum of all the contingencies since the initial data(1) and a transitory component given by (2). The cointegration property [β 'X~ I (0)] implies that C(1) has rank n -r = k and that β 'C(1) = 0.

Let β⊥ of dimension (n*k) be a basis of k vectors orthogonal to β such that β β'⊥ = 0.

The cointegration property implies that: $\beta(\beta\beta')^{-1}\beta' C(1) = 0$, so we can rewrite equation (1) as:

$$X_t = X + \beta\perp(\beta'\perp\beta\perp)'\beta'\perp[\frac{1}{1-L}C(1)\varepsilon_t + K(L)\varepsilon_t] \quad (4)$$

By denoting $A=(\beta'\perp\beta\perp)'$,a matrix of dimension(n*k) and $A^{+}=\beta'\perp$ a matrix of dimension

(k *n) where A^{+} is the “pseudo” inverse of A, it is possible to rewrite:

$$\tau_t = \beta'\perp[\frac{1}{1-L}C(1)\varepsilon_t] \quad (5)$$

KPSW (1991) then propose the following representation with common trends of X_t:

$$X_t = X_0 + A\tau + K(L)\varepsilon_t \quad (6)$$

$$\tau_t = \mu + \tau_{t-1} + \varphi_t$$

With $\varphi_t \sim BB(0,\sigma^2)$ et $\varphi_t = \beta'\perp C(1)\varepsilon_t$

$$E(\varphi_t\varphi_t') = \Phi = \beta'\perp C(1)\sum C(1)'\beta\perp \quad (7)$$

The transient component of X_t is always given by (2) which is stationary in the broad sense. The trend component of X_t is described by Aτ where the matrix of common trends denoted A of dimension (n $*$k) is of rank k and where φ_t is a vector of k random walks of drift and innovation, defined from permanent shocks alone.

The common trends to the different series are therefore expressed as linear combinations of these k random walks. φ_t is a vector of independent structural shocks whose effects are permanent. We assume that the shocks associated with these k random walks have zero mean and are independent, i.e. they have a variance-covariance matrix denoted Φ diagonal. This constraint will determine the choice of β⊥ and therefore of the matrix A.

Identification of representation with common trends

The goal is to identify the nk elements of the matrix A(n*k) . Warne (1993) rewrites this matrix A in the form: $A = A_0\pi$

A_0 is a matrix (n*k) of rank k of supposedly known coefficients, such that $\beta' A_0 = 0$.

The free coefficients are gathered in the matrix π of dimension (k*k).

Φ being assumed to be diagonal, we set: $\pi^{*} = \pi^{1/2}$. According to the expression of the matrix Φ given by (7), we obtain: $\pi^{*}\pi^{*\prime} = A_0^{+}C(1)\sum C(1)' A_0^{+\prime}$

The right-hand side corresponds to a matrix (k*k) symmetric, positive definite and known: therefore, the matrix is also known. However, only matrix $\pi^{*}\pi^{*\prime}$ elements are uniquely determined.

If we pose the hypothesis $\Phi = I_k$ and if we choose a Choleski decomposition of the matrix $\pi^{*}\pi^{*\prime}$ is perfectly identified. π then takes a lower triangular structure, which corresponds to a simple normalization of the structural shocks.

Knowledge of the matrix π therefore makes it possible to uniquely determine the elements of A. The cointegration property of X_t implies β' A= 0, hence , the r cointegration relations therefore impose rk restrictions on the matrix A_0.

The exact identification of the matrix A requires imposing nk – $\frac{k(K+1)}{2}$ – rk = $\frac{k(k-1)}{2}$ additional restrictions on the matrix. These additional constraints will be theoretical in nature since they cannot be tested.

In order to identify the permanent shocks of the system, theoretical restrictions must be imposed on the long-term impacts of the shocks, i.e. on the matrixA_0.

These theoretical restrictions must be consistent with the cointegration properties and they must be the least arbitrary possible since the estimation of the model is conditional on them.

2. STRUCTURAL VAR:

The p-order structural VAR model is applied to the vector $X_t = (\Delta y_t, \Delta p_t, \Delta m_t)'$ where Δy_t is the real GDP growth rate, Δp_t is the price growth rate and Δm_t is the change in the money supply.

$\Phi(L)X_t = \varepsilon_t$ (1)

With : V ar(ε_t) =$\sum_\varepsilon$et $\sum_{j=1}^{p} \phi(L) = \phi_j L_j$

The autoregressive form (1) admits the following Wold representation:

$X_t = A(0)\, \varepsilon_t + A(1)\varepsilon_{t-1} + \dots = \sum_{s=1}^{p} A_j \varepsilon_{t-s}$ (2)

That is :

$X_t = A(L)\varepsilon_t$ (3)

With $A(L) = \sum A_j L_j$

It is then the observations of these three variables that will allow us to distinguish the three types of shocks mentioned above. The logarithm of gross domestic production (y_t), the logarithm of inflation (p_t) and the logarithm of the money supply (m_t) are stationary in first difference and not cointegrated (in this study we follow the approach of Quah and Vahey).

This allows us to write the VAR in difference of order p with $X_t = (\Delta y_t, \Delta p_t, \Delta m_t)'$, t=1..T. The Tri-varied moving average (TMA) form can therefore be written as follows:

$$\begin{bmatrix} \Delta y_t \\ \Delta p_t \\ \Delta m_t \end{bmatrix} = \begin{bmatrix} \sum a11\,(j) L_j & \sum a12\,(j) L_j & \sum a13\,(j) L_j \\ \sum a21\,(j)\, L_j & \sum a22\,(j)\, L_j & \sum a23\,(j) L_j \\ \sum a31\,(j)\, L_j & \sum a32\,(j)\, L_j & \sum a33\,(j) L_j \end{bmatrix} \begin{bmatrix} \varepsilon_t^{o} \\ \varepsilon_t^{d} \\ \varepsilon_t^{m} \end{bmatrix}$$

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ε_t^o, ε_t^d, ε_t^m represent respectively the supply shock, the demand shock and the monetary shock. After defining our structural VAR model, we need to look for structural errors from the innovations of the reduced form of the VAR, because its errors are not directly observable.

The reduced form of the VAR model can be written as follows:

$$X_t = B(L)\, X_t + v_t \text{ avec } \quad Var(v) = \Omega, B(L) = \sum B_j L_j \text{ et } X_t = \begin{bmatrix} \Delta y_t \\ \Delta p_t \\ \Delta m_t \end{bmatrix} \quad (4)$$

The moving average representation will then be:

$$X_t = v_t + C(1)v_{t-1} + \ldots = \sum C(j) v_{t-j} \quad (5)$$

$$X_t = v_t + C(1)v_{t-1} + \ldots = \sum C(j) v_{t-j} \quad (6)$$

Thats is :

$$X_t = C(L)v_t \quad (7)$$

Where :

$Var(v) = \Omega$, $C(L) = \sum C_j L_j$ et $C_0 = I$

If we assume that this representation is obtained by inversion of the stationary autoregressive form of X_t, then this moving average form is unique.

Comparing equations (2) and (6) we have:

$$v_t = A(0)\varepsilon_t \quad (8)$$

And :

$$\Omega = A(0) \textstyle\sum_\varepsilon A'(0) \quad (9)$$

It is therefore the knowledge of A(0) that will allow us to find ε(t), since v(t) can be obtained from the standard VAR.

Considering the relations (3), (7) and (8), we determine A(L) and we therefore have:

$$A(L) = C(L)\, A(0) \quad (10)$$

Knowing C(L) from the standard VAR and A(0) will allow us to identify A(L).

2.1 The identification problem:

In general, the equations of the Structural VAR cannot be directly estimated because the errors are correlated with the variables while the estimation techniques require an absence of correlations between the regressors and the error terms. This type of problem does not exist for the standard form of the VAR, and ordinary least squares can be used to estimate the variance-covariance matrix. The question that arises is whether it is possible to identify all the elements of the structural VAR. The number of parameters of the Structural VAR model is equal to $n^2 + n(np+1) + \frac{n(n+1)}{2}$ parameters, while the Standard VAR only contains $(np+1) + \frac{n(n+1)}{2}$.

The Structural VAR model is therefore under-identified because the n^2 parameters cannot be directly identified from the estimated VAR. It is therefore necessary to look for n^2 identifying constraints. By normalization, the elements of the matrix A(0) are equal to 1. Therefore, only $(n^2 - n)$ parameters remain to be identified.

The technique of identifying a Structural VAR requires the application of orthogonalization constraints of the variance-covariance matrix of shocks, and also constraints based on economic theory on the coefficients of the matrix A(0) and on the long-term multipliers. For the case of the variance-covariance matrix(Ω), we assume that it is diagonal. The only unknowns are then the parameters of its diagonal. Therefore, only $\frac{n(n-1)}{2}$ unidentified parameters remain. We must therefore find $\frac{n(n-1)}{2}$ additional constraints. These additional constraints will be obtained from economic theory. In our case, with a trivariate VAR we have: $\frac{n(n-1)}{2}$=3. We therefore only need to impose three restrictions on its parameters, so that the model is identified. From the previous theoretical model, we assume that the two shocks (the demand shock and the monetary shock) have no long-term effects on GDP growth while prices and money suffer the same effects of the monetary shock according to the quantity theory of money.

2.2 The long-term restrictions technique

According to the previous restrictions, the long-term impact matrix can be written as follows:

$$A(1) = \begin{bmatrix} A_{11} & 0 & 0 \\ A_{21} & A_{22} & A_{23} \\ A_{31} & A_{32} & A_{33} \end{bmatrix} \quad (11)$$

With A_{23}=A_{33}.

To solve this identification problem, we will use the approach technique of Mariano Matilla Garcia et al. (2002). This technique consists in identifying the matrix A(0) as a lower triangular matrix by the following method:

Let T be a lower triangular matrix such that: T = FA(1) (12)

$$\text{With } F = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & -1 \\ 0 & 0 & 1 \end{bmatrix}$$

According to relations (9) and (10), we have:

$$C(1)\,\Omega C(1)' = A(1)\,A(1)' \quad (13)$$

Using relation (12), which gives us:

$$FC(1)\,\Omega C(1)'F' = TT' \quad (14)$$

T is an upper triangular matrix, in order to solve the elements of the matrix T, we apply the cholesky decomposition of equation (14) containing known elements. So, the long-term impact matrix is finally obtained by: $A(1) = F^{-1}\,T$ while A(0) is solved by:

$$A(0) = C(1)^{-1}\,A(1)$$

Our calculation method consists of eliminating the component correlated with real production to obtain the core inflation.

The Structural VAR (1) in its reduced form can be written as follows:

$$\begin{bmatrix} \Delta y_t \\ \Delta p_t \\ \Delta m_t \end{bmatrix} = \begin{bmatrix} \sum a11\,(j) L_j & \sum a12\,(j) L_j & \sum a13\,(j) L_j \\ \sum a21\,(j)\,L_j & \sum a22\,(j)\,L_j & \sum a23\,(j) L_j \\ \sum a31\,(j)\,L_j & \sum a32\,(j)\,L_j & \sum a33\,(j) L_j \end{bmatrix} \begin{bmatrix} \varepsilon_t^o \\ \varepsilon_t^d \\ \varepsilon_t^m \end{bmatrix}$$

Where

Δy_t is the first logarithmic difference of Real Output.

Δp_t is the first logarithmic difference of Inflation.

Δm_t is the first logarithmic difference of the money supply.

ε_t^o expresses the supply shock.

ε_t^d expresses the demand shock.

ε_t^m expresses the monetary shock.

The increase in inflation is then transformed as follows:

$$\Delta P_{ct} = A_{31}(L)\varepsilon_t^o + A_{32}(L)\varepsilon_t^d + A_{33}(L)\varepsilon_t^m \quad (15)$$

After eliminating the component $A_{31}(L)\varepsilon_t^o$, the core inflation is then composed as follows:

$$\Delta P_{ct} = A_{32}(L)\varepsilon_t^d + A_{33}(L)\varepsilon_t^m$$

From which:

$$\Delta P_{ct} = \sum_{s=0}^{\infty} A_{32,s}\,\varepsilon_{t-s}\,\varepsilon_t^d + \sum_{s=0}^{\infty} A_{33,s}\,\varepsilon_{t-s}\,\varepsilon_t^m \quad (16)$$

This last equation shows that the core inflation is obtained by the two components of inflation which have no long-term effects on the level of production (it is assimilated here as expected inflation).