How Can Monetary Policy Affect the Economic Activity?

by

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Presented at the Annual Review Seminar, Research Department
Central Bank of Barbados
July 28-31, 1998

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July 1998

Lead Working Paper

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Abstract

The aim of this paper is to measure the persistence of monetary shocks on sectoral and aggregate output. Our study is in line with Pesaran, Pierce and Lee's (1993) multisectoral model. After presenting this approach, we will analyze the consequences of sectoral and aggregate shocks on the GDP through a restricted VAR and a Bayesian VAR.

Introduction

Studies done by Nelson and Plosser have shown that most maroecronomic variables tend to be stochastic, today however, there is a new wave of business cycle analysis. Indeed, within a Keynesian framework, one could manage to eliminate macroeconomic fluctuations through more defined stabilisation policies such as monetary policy. Many reflections and analyses question this view since shocks on GDP, because of their permanent effect are only due to supply shocks, for the Keynesian model in its simplest form shows only a temporary impact of demand.

Persistence has become the framework analysis. This paper attempts to explain that the equilibrium is structurally modified after repeated transitory shocks on the economy. This phenomenon generated a variety of studies focussing primarily on aggregate time series. Blanchard and Quah (1989) specified a small VAR (output and unemployment) of macro that achieves identification. They assume that supply shocks can have permanent effect on the level of output while demand shocks can have only temporary effects. These assumptions are consistent with theoretical paradigms. One problem with the Blanchard and Quah model is that it allows only two underlying shocks to the economy. Based on this reasoning Shapiro and Watson (1988) used a system that comprised real output, total labour hours, inflation and real interest rate. This set of variables allowed them to account for four different disturbances, two to aggregate supply which they identified as shocks to labour supply and technology and two to aggregate demand which they refered to as *IS* and *LM* shocks. These authors found that aggregate demand shocks had a smaller impact on real GDP than Blanchard and Quah did.

The aim of this paper is to measure the persistence of shocks on the output within the framework of multi-based sector model. This work is similar to that of Pesaran, Pierse and Lee's (1993). The theoretical framework is based on an economy possessing n sectors, noted s_1, s_2, s_n, the shocks generated by the sector s_i $(i = 1,...,n)$ can affect in the long run sector S_j either directly or indirectly through possible links with other sectors. Firstly, it is important however to find some indicators that allows us measurement of persistence.

This paper is organised as follows. In section 1 we present the framework of Pesaran, Pierce and Lee (1993) for the measurement of persistence in a sectoral model. We then carry out empirical investigations using a constrained VAR model and a Bayesian VAR models that avoid overindentification of sim's VAR models. For example the existence of a cointegration relation between two sectors shows that when a shock affects these variables permanently, its effects are transitory. This gives the answer of the consequences of sectoral cointegration on aggregate GDP.

1. A sector-based model of persistence

1.1 Sector-based shocks index

Considering the aggregation constraints, to which the use of macroeconomics data could lead, Pesaran Pierce and Lee (1993) offered a disaggegrated approach of persistence, which can be written as follows :

$$\Delta y_t = \beta + \Phi(L)\varepsilon_t$$
$$\text{with} \quad \Phi(L) = \sum_{i=0}^{\infty} \psi_i L^i \qquad (1)$$

We can notice that the equation is valid even when a stationary trend is present in the sectoral output. We can thus keep these well known hypotheses:

$$E(\varepsilon_t) = 0 \text{ and } E(\varepsilon_t \varepsilon_t^{'}) = \sum = (\sigma_{ij}) \qquad (2)$$

Δy_t is a vector of the sectoral output $(n,1)$, β denotes an $(n,1)$ vector of constants, and ε_t is an $(n,1)$ vector of white noise innovations. The ψ_i are the squared matrices of order n such that $\psi_0 = I_n$ is the identity matrix.

According to Pesaran Pierce and Lee (1993), the measure of persistence P_{ij}, which represents the effects of a shock of the sector j on the sector i, is represented as follows[3] :

$$P_{ij} = \frac{e_i^{'}\Phi(1)\sum\Phi(1)^{'}e_j}{e_j^{'}\sum e_j} \qquad (3)$$

e_k is the k^{th} column of the identity matrix I_n. Under such conditions, P_{ij} measures the cumulive effect of a shock initiated in the sector j on GDP in the sector i. This indicator could be assimilated to a long run response of the variable i level. The output level will be the sum of sectoral output balanced with the relative weighted vector :

$$y_t = \sum_{i=1}^{n} w_i y_{it} = w^{'} y_t \qquad (4)$$

In a univariate perspective, we can also write :

$$\Delta y_t = w^{'}\beta + w^{'}\Phi(L)\varepsilon_t \qquad (5)$$

According to (5), this specification can be directly compared to an *ARIMA* process within a univariate context, and whose use is frequent when measuring persistence at an aggregate level. Given the importance generally granted to the order of the ARIMA model, which often lead to questionable measures of persistence when this latter is not high enough (Christiano and Eichenbaum 1989), it is necessary to ponder the characteristics of the ARIMA (*n*, *n-1*) process developed in equation (5) above. Yet, the equation (5) seems to indicate that it might tend to an ARIMA model, even though sectoral output is defined by an autoregressive process of order 1. Therefore, this seems more appropriate to measure persistence at an aggregate level than the expression itself (1). Pesaran, Pierse and Lee (1993) considered the persistence measure as follows :

$$P^2 = \frac{w^{'}\Phi(1)\sum\Phi(1)^{'}w}{w^{'}\sum w} \qquad (6)$$

To be more precise, let's rewrite this formula by assuming that only output in the i sector is stationary. Equation (6) is then represented as follows :

$$P^2 = \frac{\sigma_{ii} w_i^2}{w^{'}\sum w} P_i^2 \qquad (7)$$

If the innovations are not correlated, we then have :

$$P^2 = \frac{w_1^2 P_{11}\sigma_{11}}{w_1^2\sigma_{11}} \qquad (8)$$

Or

$$P = P_i \qquad (9)$$

The relation between P and P_i implies that if $P_i = 0\ \forall i,\ i = 1,\ldots,n\ \ P = 0$. Nevertheless, the nullity of persistence at an aggregate level does not necessarily mean that $P_i = 0$. Indeed, we just have to keep the cointegration hypothesis between the sectors and set out that the weight w is proportional to one of the cointegrating vectors.

From (3), we obtain:

$$e_j^{'}\sum e_j P_{ij} = e_j^{'}\Phi(1)\sum\Phi(1)^{'}e_j \qquad (10)$$

by taking into account (6) and the cointegration relation $\alpha^{'}P = 0$, we have then :

$$\left(w^{'}\sum w\right)P^2 = \sum_{i=1}^{n}\sum_{j=1}^{n} w_i w_j \sigma_{ij} P_{ij} \qquad (11)$$

One particular case of importance arises when there are only two cointegrated sectors. Considering that they are the model's sole sectors and that the cointegrating vector is :

$$\begin{pmatrix}\alpha_1\\ \alpha_2\end{pmatrix} = \alpha$$

by taking into account the previous relation resulting from this hypothesis we have :

$$\sigma_{ij} P_{ij} = \sigma_{jj} P_{ij} \qquad (12)$$

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[3] In an univariated perspective, is the index of persistence proposed by Campbell and Mankiw (1987).

We can then write :

$$\sigma_{11}P_{21} = \sigma_{22}P_{12} \tag{13}$$

But also:

$$\begin{aligned} \alpha_1 P_{11} + \alpha_2 P_{21} = 0 \\ \alpha_2 P_{12} + \alpha_2 P_{22} = 0 \end{aligned} \tag{14}$$

We obtain the following expression if α_1 and α_2 have equal sign

$$\left(w'\sum w\right)^{\frac{1}{2}} P = \left|w_1\sqrt{\sigma_{11}}P_1 - w_2\sqrt{\sigma_{22}}P_{22}\right| \tag{15}$$

alternatively, if α_1 and α_2 have contrary sign

$$\left(w'\sum w\right)^{\frac{1}{2}} P = w_1\sqrt{\sigma_{11}}P_1 + w_2\sqrt{\sigma_{22}}P_{22} \tag{16}$$

The previous formulae have relevant conclusions about the value of the persistence index at an aggregate level as the latter is greatly dependent upon the signs of the cointegrating vector components. Let's analyze the frequent case in which $\frac{\alpha_1}{\alpha_2} < 0$. From the latest equation we obtain :

$$P = \left(\frac{w_1^2\sigma_{11}}{w'\sum w}\right)^{\frac{1}{2}} P_1 + \left(\frac{w_2^2\sigma_{22}}{w'\sum w}\right)^{\frac{1}{2}} P_2 \tag{17}$$

Then, by setting $\lambda_i = \left(\frac{w_i^2\sigma_{ii}}{w'\sum w}\right)^{\frac{1}{2}}$, the previous formula can be written as the weighted sum of the sector-based indicators

$$P = \lambda_1 P_1 + \lambda_2 P_2 \tag{18}$$

Proceeding as previously, we can demonstrate that if the sectoral output are cointegrated and positively correlated, at an aggregate level, persistence can be expressed as a linear combination of persistence measures at a disaggregated level, which is :

$$P = \sum_{i=1}^{n} \lambda_i P_i \tag{19}$$

Where P_i is a sector-based index of persistence defined by

$$P_i = P_{ij}^{\frac{1}{2}} \tag{20}$$

and where P_{ij} is a specific measure of persistence of shocks in sector j on the level of output in the sector i.

1.2 Macroeconomics shocks effects

The previous expression will be limited if the variables considered were affected by specific shocks on the sectors. This model is a simplified representation so that dismissing the macroeconomics effects, does not give adequate opportunity to analyze the effects of an aggregate shock to the different sectors j. To considered such a possibility let's consider the following model :

$$\Delta y_t = \mu + C(L)v_t + \Phi(L)\varepsilon_t \tag{21}$$

with $E(v_t) = 0$, $E(v_t^2) = \sigma_v^2$ $C(L) = c_0 + c_1 L + c_2 L^2 + \ldots$

$$c_j = \begin{pmatrix} c_{1j} \\ \cdot \\ \cdot \\ \cdot \\ c_{jn} \end{pmatrix}$$

One would observe that this model has rather interesting meaning since it gives us indications of the consequences on the different sectors of macroeconomics shocks, where v_t represents the innovations of money supply which can be written as follows :

$$\Delta x_t = \beta' z_t + v_t \tag{22}$$

Where z_t represents a vector of the exogenous variables. We suppose that $Cov(\varepsilon_t, v_t) = 0$.

We can easily verify that persistence can be broken into two components as ;

$$P^2 = \lambda P_\varepsilon^2 + (1-\lambda) P_x^2 \tag{23}$$

Where P_ε is the persistence component as a result of shocks, whereas P_x is being caused by variable x. We can easily verify :

$$P_\varepsilon = \left[\frac{w'\Phi(1)\sum\Phi(1)'w}{w'\sum w}\right]^{\frac{1}{2}} \tag{24}$$

and

$$P_x = \left[\frac{w'C(1)}{w'c_0}\right] \tag{25}$$

but also

$$\lambda = \frac{\sigma_v^2 (w' c_0)^2}{\sigma_v^2 (w' c_0)^2 + w' \sum w} \qquad (26)$$

Based on this formula, we can obviously measure the sector-based persistence. We can verify that the formula (24) leads to P_i^2 if we replace w by e_i.

2. Results

2.1 Data and methodology

We first test for unit roots in sectoral output. The data used are real GDP series for Barbados over the period 1974:1-1995:4. The tests results (Table 1) suggest that the real GDP series for Barbados show a random walk. We consider five sectors : sugar, non-sugar agriculture and fishing, construction, wholesale, retail and tourism.

Table 1 : unit root test
sample : 1975:1-1995:4

	Comments
Sugar	I(1)
Tourism	I(1)
Construction	I(1)
Nsaf*	I(1)
Wholesale & Retail	I(1)

* Non-sugar agriculture and fishing.

Here one might consider 2 models. The first one is a constrained VAR model including 3 lags whose formulation is given by equation (27). One of the important problems of VAR modeling comes mainly from overparametrisation. The difficulty with overparameterisation arises even when considering reduced size systems given the need to account for too many parameters which after applying the hypothesis tests often prove to be insignificant.

Given the above, the following constrained VAR was specified :

$$\Delta y_{it} = \beta_i + \sum_{s=1}^{k} \varphi_{s,it} \Delta y_{i,t-s} + \sum_{s=1}^{k} \phi_{s,i} \Delta y_{-i,t-s} + \varepsilon_{it} \qquad (27)$$

with $\Delta y_{-i,t-s} = \sum_{\substack{j=1 \\ j \neq i}} \Delta y_{jt}$

The advantage of this specification is that it greatly reduces the number of parameters to be estimated since in order to determine the evolution of the output-growing rate in a determined sector, only 5 coefficients must be estimated.

By comparison, the same equation taken from a traditional VAR model requires 21 coefficients. However, with 2 lags and 10 sectors, where a non-constrained VAR attempt integrates 210 coefficients, the constrained model only has 50. This model takes into account externalities linked to the development of other sectors of the economy. Lucas (1988) has demonstrated the importance of these externalities.

We might also consider a Bayesian VAR model. The idea behind this approach is to consider that coefficients relative to high order lags can be significant. However, it is advisable to distinguish the fact that they have the same importance as those relative to weak order lags. What makes this method original is the fact that it appears like a necessary compromise between overparametrisation and underparametrisation. Indeed, the overparametrisation integrates too many non significant coefficients accompanied with high (standard error), whereas the underparametrisation omits completely some variables and/or some lags when forcing coefficients to take the zero value.

2.2 Specific shocks effect

Having performed the test for non-stationary we can proceed to identify long run relations between sectoral output levels. Discovery of such relations amounts to testing the existence of linear combinations between sectoral output. For this reason, we have applied Johensen and Juselius procedure (1989). Most of the sectors are not cointegrated in a pairwise manner.

Table 2 and 3 summarize the persistence index according the two models. Comparisons are difficult to make because the aggregate persistence measures are sensitive to the VAR specification. However, if one consider the values of persistence in non-traded sectors one would realise that it is lower.

Table 2 : persistence index (constrained VAR)
sample : 1975:1-1995:4

	P_i
Sugar	0.90
Tourism	0.39
Construction	0.22
Nsaf	1.19
Wholesale & Retail	0.85
P	0.41

Table 3 : persistence index
(B-VAR)
sample : 1975:1-1995:4

	P_i
Sugar	0.32
Tourism	0.41
Construction	0.65
Nsaf	1.11
Wholesale & Retail	2.02
P	1.28

For the constrained VAR, if we compare the aggregate persistence measure P (0.41) estimated by (6) and the aggregate measure P (1.25) obtained by (19), we observe that these values are very different. It's not surprising as the sectors are not cointegrated pairwise.

2.3 Monetary growth equation and shocks effects

Tests of the implications of the monetary policy require measures of expected and unexpected money growth to be constructed for subsequent use in the output equation as proxies for monetary shock. Previous empirical studies have typically used the predicted values and residuals from money growth models of the type estimated by Barro (1977). Recently some studies have showed the instability of money growth models and their inability to explain the behaviour of money during the two last decades. For instance Baba, Hendry and starr (1992) have proposed another model which, they claim, is a stable and explains these behaviours. Our specification is similar to theirs. Equation 21 intuitively suggests the procedure to follow in order to measure the importance of monetary shocks on output. Indeed, if we take into account the residual of (28) concerning 2 periods, we see that the monetary shock effect on GDP will be very weak in the long (short) run if $c_0 + c_1 = 0$ ($c_0 = c_1 = 0$). The first hypothesis of the classical school that claims that money supply has little effect on the real output in the long run is accepted. To consider the significance of these coefficients, we have used the *Wald test*, which allows us to conclude the following results.

Among the 5 sectors retained, only two of them are affected in the short and long run by monetary supply shocks: they are the tourism and the wholesale and retail sector. As a consequence, it is natural to set that ($c_0 = c_1 = 0$) for these sectors.

$$\Delta\left(\frac{m}{y}\right)_t = \underset{(0.82)}{0.011} - \underset{(-2.11)}{0.295}\Delta\left(\frac{m}{y}\right)_{t-1} - \underset{(-0.91)}{0.352}\Delta\pi_{t-1} - \underset{(-1.30)}{0.045}\Delta i_t - \underset{(-2.14)}{0.087}\Delta i_{t-1} - \underset{(-1.07)}{0.046}\Delta i_{t-2} - \underset{(-0.82)}{0.0314}\Delta i_{t-3} \quad (28)$$

$$+ \underset{(0.79)}{0.037}\Delta g_t + \underset{(1.01)}{0.056}\Delta g_{t-1} + \underset{(0.06)}{0.036}\Delta g_{t-2} - \underset{(-1.01)}{0.040}\Delta g_{t-3} - \underset{(-4.36)}{0.908} z_{t-1} + v_t$$

$$R^2 = 0.59 \qquad DW = 1.87 \qquad See = 0.035$$

$$z_t = \left(\frac{m}{y}\right)_t - \underset{(-4.85)}{2.24} - \underset{(-4.30)}{0.239}\pi_t + \underset{(2.20)}{0.031} i_t - \underset{(-1.63)}{0.059} g_t \quad (28')$$

$$R^2 = 0.82 \quad DW = 1.16 \quad See = 0.045$$

In this equation, $m_t, i_t, \pi_t, g_t, y_t$ respectively represent the real growth rates of money supply, interest rate and the consumer price index the, government expenditure and the real GDP. z_t is the error correction mecanism.

Table 4 : monetary shocks effects
(Constrained VAR)
sample : 1975:1-1995:4

	P_x	P_x	P
Sugar	0.22	0.00	0.18
Tourism	1.18	0.18	0.82
Construction	1.04	0.00	1.03
Nsaf	0.82	0.00	0.77
Wholesale & Retail	1.65	2.46	2.30
P	0.81	0.87	0.79

Our major finding is that the aggregate persistence is not very different from one due to the other shocks (the first and the third column of the table depicts this very clearly). In spite of a rather high monetary persistence, the effect of a monetary shock on output is negligible. P_x value (0.811) can be misleading. To further clearl the results we focus on the different values of the λ given by (26). Starting from (23) one notices that the part of P_x in total persistence is all the more important as λ becomes high. If λ equals 1, we obtain the equality between monetary persistence and total persistence. In the same way, a zero value of λ means the money is neutral on GDP.

It is remarkable that the construction and tourism sectors are those in which sectoral persistence is the highest when considering the results in table 3 or table 4. This proves monetary shocks complexities on the commodity market. The fact of omitting correlated variables to money supply in the specification retained leads to a bias which could certainly be reduced by integrating into equation (28) other variables such as unemployment, exchange rate.

Conclusion

We have tried to investigate if it was possible to establish a link between persistence at the aggregate level, and sectoral persistence. We started by calculating their values based on Pesaran, Pierse and Lee (1993) approach. In order to have a better view, we focused on the consequences of shocks generated not only by a single sector, but also by shocks common to all sectors on the original sector. This study, also brings to light complexities of output fluctuations.

In the first case, when we found that the sectors are pairwise co-integrated, the aggregated persistence is presented as a weighted measure of sectoral persistence. Apart from this hypothesis, which is not very probable, it was not possible for us to give prominence to any relation.

In the second case, with regards to macroeconomics shocks, only monetary shocks were considered. However, only two sectors are affected by money. The consequences of money shocks are impact differently on GDP. Some sectors are sensitive others are not.

In summary, the gap between total persistence and that relative to other shocks, is relatively reduced. So, the effects of money on total output are generally very weak, but these are not negligible in every sector. In conclusion, more disaggregate decomposition of shocks which takes into consideration greater account of aggregation constraints, would certainly improve the results which seem substantial enough for persistence analysis.

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