THE ROLE AND IMPORTANCE OF AGGREGATE AND SECTORAL SHOCKS IN BUSINESS CYCLES OF AN OIL-EXPORTING ECONOMY

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Abstract: This paper uses a multisectoral business cycle model for identifying the role and importance of aggregate and sectoral shocks in business cycles of manufacturing sectors in an oil exporting economy. Aggregate shocks involve innovations in oil revenues, money supply, government expenditures, and real exchange rate; and according to the RBC theory, productivity shocks are considered as sectoral shocks. Unlike the findings of empirical studies about industrial countries, the results of this paper demonstrate that in the oil resources-based economy, aggregate shocks are the dominant source of sectoral output fluctuations. At the presence of these exogenous impulses, disturbances could threaten the long run economic and industrial growth, even in the oil boom periods.

Keywords: Business Cycles, Aggregate Shocks, Sectoral Shocks, Total Factor Productivity, Oil-Exporting Economy, Economy of Iran

1 Introduction

The nature of business cycles determinants could have an important role in the performance of countercyclical policies for achieving economic stability. Therefore the sources of fluctuations and propagation mechanisms have been the subject of extensive investigation in the business cycle literature. Modern macroeconomics is quitted from the effort for explaining fluctuations as a combination of deterministic cycles with different periods. The primitive efforts have given their place to the one that believes the economy has been influenced by different shocks, in different sizes and stochastic periods then these distortions have been propagated in the whole economy.

Following the business cycle studies of Slutsky (1937) and Frisch (1933), many researchers have studied the sources of shocks and their propagation mechanisms. In this regard the monetary theories of business cycles in framework of the demand side shocks or real business cycle theory (*RBC*) in framework of the supply side shocks can be notified. Before the theory of *RBC*, most of the macroeconomic analysis had concentrated to the impacts of unexpected shocks of macroeconomic policies, such as monetary and fiscal policy, on output. So, sectoral shocks, such as technology shocks which might happen in different economic sectors and might be a source of fluctuations were not important anymore. When *RBC* became important and had an emphasis on technology and productivity changes, sectoral shocks also became a source for economic fluctuations[1].

In this paper I try to explain the role and importance of aggregate and sectoral shocks in business cycles of an oil-exporting economy. In section I, the theoretical basis of business cycles will be briefly reviewed. Section II, presents the results of some empirical works about the impacts of aggregate and sectoral shocks on business cycles. In section III, I develop an industry multisectoral model in which

[1] See, for example, Stockman (1988)

the effects of different shocks on output in manufacturing sectors can be analyzed explicitly. In section IV, the identified model is applied in an analysis of output growth in the economy of Iran, disaggregated by six industrial sectors. Estimates of the model, using the Seemingly Unrelated Regression *(SUR)*, based on the annual data covering the period 1970-2001, will be present in the section V. Aggregate or macroeconomics shocks are considered as innovations in four macro variables: oil exports revenues, money supply, government expenditures, and real exchange rate, and sectoral shocks are known as innovations in total factor productivity *(TFP)* of different manufacturing sectors.

2 Theoretical basis of business cycles

Business cycles are the regular fluctuations of macroeconomic variables such as production, consumption, investment, employment, prices and interest rates, in the boom and recession periods, around the long-run economic trends. Long and Plosser (1983) have identified this behavior with two general rules: (a) If we measure business cycles with deviations from trends, then the upward and downward fluctuations tend to be persistent. (b) Economic activities (e.g. output of different sectors) have comovement.

In the literature of business cycles many exogenous and endogenous factors (technology, preferences, and policies) used to explain these kinds of common features and to identify the nature and causes of business cycles. According to the primary analysis, any kind of cyclical behavior appears in a way to create the next cyclical movement. But in today's thoughts, business cycles are created by the endogenous stochastic distortions (shocks) and are propagated. By this, economy will be stable dynamically and the individual shocks only create a damped oscillation. Therefore, the main core of the business cycle literature is on identifying the shocks that create fluctuations around the stable trend of economic activities (Chatterjee, 2000). Shocks appear with different natures and effects. They can act stochastically with temporary or stable influences. Some of them affect the nominal variables and others the real ones. The difference between the demand and supply shocks is that supply shocks have a long-run effect but the demand shocks are known to have temporary effects.

Different economic thoughts have emphasis on specific shocks. The first view on business cycles, which is based on the economic growth models, can be found in the thoughts of Adam Smith. Economic fluctuations in this view are resulted from adjustment mechanisms towards equilibrium. In this model flexibility of prices, wages and interest rates keep the three main markets (output, labor and financial markets) in full employment and money is the only mean of exchange and unit of account with no effect on the real sector. This understanding leads policymakers to ignore the role and importance of monetary shocks and focusing more on the supply side shocks (Mankiw, 1989).

Existence of involuntary unemployment and the thought that demand side changes cause fluctuations put the classical economics in a crisis. Keynes by regarding to the three concepts of sticky wages and prices, multiplier, and marginal product of capital, considers the role for monetary and fiscal policies in order to

control the crisis and reduction of business cycles fluctuations. The researches of Michel (1913), Robertson and Michel (1915), and Fisher (1923) about the interaction between money changes and bank credits with investment, output and inflation, and also the relation between monetary fluctuations and business cycles, resulted that unlike the classical views, output can be affected by the monetary and fiscal policies, and changes the investors' confidence.

From the view of the monetarists, markets are clear but the delayed information causes the more or less output than full employment. The difference between the expected and actual prices, based on the adaptive expectations, leads to the effective monetary policy in the short-run but neutral in the long-run because of the full adjustment of economic agents' expectations. Friedman and Schwartz (1963), and Friedman (1968), unlike Keynesian views on credit and interest rates, emphasized the role of money as an exogenous determinant of business cycles.

Lucas (1972) described that the rational expectations of future policies affect the current decisions. Sargent and Wallace (1975) represented that stabilization policy has no impact on either real output or unemployment in classical equilibrium models if they embody a supply function relating deviations of output to surprise movements in the price level, and further that (a) both private and public agents have identical information sets and (b) are able to act on these information sets. So the new classical thought relates business cycles to the stochastic factors or unanticipated shocks.

In the new Keynesians' view, stickiness of nominal wages within the long term non-contingent contracts, agents cannot respond to new information by changing their consumption, wage-price decisions, etc. So, as quickly as the public sector can change any of its controls, then scope once again emerges for systematic stabilization policy to have real effects (Fischer, 1977; Phelps and Taylor, 1977). New Keynesians studies about credit market have emphasis on the role of imperfect information in the limits of banking loans and credit rationing. In this theory imperfect competition and menu costs are explanations for nominal stickiness and non neutrality of money. Therefore, in the existence of demand shocks, prices have a procyclical behavior and real sector will be affected. The imperfect competition can also explain Solow residual and the comovement of business cycles (Glasner, 1997).

Ultimately, the theory of real business cycle for understanding of economic fluctuations was represented within a walrasian general equilibrium model (Kydland and Prescott, 1982; Long and Plosser, 1983). In this theory the main sources of economic fluctuations are real shocks (e.g. technology, government expenditures, employment and decisions of saving and consumption). According to *RBC* theory the only causes for fluctuations are the ones which change the walrasian equilibrium (Mankiw, 1989). Labor supply changes are explained in respond of expected real wages and interest rates by bringing the leisure in the individuals' utility functions and using the work-leisure theory. By comparing the current and expected real wages with regards to the present value of utility, labor decide how to choose between work and leisure hours in respond to productivity shocks and real wages changes (Romer, 2001; Plosser, 1989).

3 Effects of aggregate and sectoral shocks

Many researches have presented the relative importance of aggregate and sectoral shocks in industrial countries. Although these studies are different in methodology, under studying countries, and the period of data, but the common result is that aggregate shocks cannot explain all the changes in industrial output alone and confirms the Long and Plosser's (1987) findings that sectoral distortions are sources of business cycles. They showed that aggregate shocks explain 41 percent of manufacturing output variance in average and sectoral shocks in each industry cannot be ignored. Norbinn and Schlagenhauf (1990) also studied about the 14 industrial groups of the USA in the two periods of 1956-71 and 1971-84. They considered technology shocks (Solow residual) as industrial shocks, M1 changes as an aggregate shock, the oil price changes as an international shock, and model residuals as specific shocks in each industry which are often unknown. In the first period, the sectoral and aggregate shocks explain output fluctuations about 25.5 and 68.7 percent respectively. These numbers change to 17.7 and 45.2 percent in the second period. Lee *et al* (1992) described the persistence of shocks in the UK output growth by using a multisectoral model and by dividing the shocks to the aggregate and other shocks which included the specific shocks of each manufacturing sector. The results of their study show that sector–specific shocks are most important in generating persistence effects on sectoral and aggregate output than macroeconomics shocks. Caporale (1997) also analyzes the output fluctuations in 19 industry sub-sectors for England by using a linear real business cycle model. This study shows that part of the variance of output residual which is explained by aggregate shocks is variable from 0.01 percent for oil and mine sector to 80 percent for other manufacturing sectors, and totally, these shocks only explain 55 percent of the variance of total industry output residual. Kang and Orazem (2003) analyzed the data of 12 industrial groups of South Korea for examining the effect of sectoral and aggregate shocks by using multisectoral model of business cycle. The changes of the growth rate of industrial output are divided to three parts: aggregate, industrial group, and specific shocks. The consequences of this research show that although each shock is important, but the sectoral shocks are the main source of the fluctuations. The share of aggregate shocks in the fluctuations of industrial sectors is from 8.5 percent in precision instruments to 49.1 percent in basic metals. The share of sectoral shocks is fluctuating in the range of 44.9 percent for fabricated metal products to 86 percent for paper products.

4 The multisectoral model

According to the studies of Frisch and Slutsky, output movements are explained by the interaction of shocks and internal propagation mechanisms in which ultimately a serial correlation of output fluctuations are generated (Norrbin and Schlagenhauf, 1996). Let Y_t be an m × 1 vector of sectoral output growth rates. Then a general multisectoral model may be written as:

$$Y_t = \alpha + \sum_{k=1}^{K} \pi_k Y_{t-k} + \varepsilon_t$$

where π_k is a (i ×i) matrix of regression coefficients with k time lag and ε_t is the vector of residuals. By using the literature of business cycle, the ε_t can be denoted as the shocks and the π_k as the propagation mechanism. The model presented in this paper is the extended model of multisectoral business cycles of Long and Plosser (1983). In their primary model, capital is depreciated in a production period and capital stock is equal to the new investment. But in the extended model, capital is depreciated by a determined rate. It is considered a constant return to scale Cob-Douglas production function:

$$Y_{i,t+1} = A_{i,t+1} L_{i,t+1}^{b_i} \prod_{j=1}^{n} X_{ij,t}^{a_{ij}} \quad , \qquad i = 1,\ldots,n$$

where $X_{ij,t}$, $j = 1,\ldots,n$ are the inputs which are used in period t for output $Y_{i,t+1}$. $L_{i,t}$ is the labor input for output of sector i, a_{ij} and b_i are production elasticities, and $A_{i,t+1}$ is the total factor productivity. By assuming about a specific depreciation rate for inputs, the production function may be written as:

$$Y_{i,t+1} = A_{i,t+1} L_{i,t+1}^{b_i} \prod_{j=1}^{n} X_{ij,t}^{a_{oij}} \prod_{j=1}^{n} X_{ij,t-1}^{a_{1ij}} \ldots \prod_{j=1}^{n} X_{ij,t-p}^{a_{pij}} \quad , \quad i = 1,..,n$$

where $p+1$ is the maximum period which inputs can be used in production. According to the constant return to scale and positive elasticity of labor assumptions, we can write:

$$\sum_{\tau=o}^{p} \sum_{j=1}^{n} a_{\tau ij} \langle 1 \quad \forall_i \qquad b_i + \sum_{\tau=o}^{p} \sum_{j=1}^{n} a_{\tau ij} = 1 \quad \forall_i$$

The logarithmic form of the production function is as follows:

$$y_{i,t+1} = b_i l_{i,t} + \sum_{\tau=o}^{p} \sum_{j=1}^{n} a_{\tau ij} x_{ij,t-\tau} + \lambda_{i,t+1} \qquad , \quad i = 1,\ldots,n \tag{1}$$

Consumer maximizes the expected value of intertemporal utility function subject to the budget constraints:

$$U = \sum_{t=o}^{\infty} \beta^t \left(\theta_o \ln Z_t + \theta' \ln C\right)$$

$$Z_t + \sum_{i=1}^{n} L_{i,t} \equiv H \quad , \quad C_{j,t} + \sum_{i=1}^{n} X_{ij,t} \equiv Y_{j,t}$$

where Z_t and $C_t = (C_{1,t},\ldots,C_{n,t})$ are leisure and consumption at time t, and H is the total hours available which is allocated to leisure and work. Using equation (1) and by solving the optimization problem we get to these results:

$$Z_t = \frac{\theta_o}{\theta_o + \beta \sum_{j=1}^{n} \gamma_j b_j} H \ , \ C_{j,t} = \frac{\theta_j}{\gamma_j} Y_{j,t} \ , \ L_{j,t} = \frac{\beta \gamma_j b_j}{\theta_o + \beta \sum_{i=1}^{n} \gamma_i b_j} H \ ,$$

$$X_{ij,t} = \frac{\beta \gamma_i a_{ij}}{\gamma_j} Y_{j,t}$$

where $\gamma_j = \theta_j + \beta \sum_{i=1}^{n} \gamma_i a_{ij} \quad , \quad i = 1,\ldots,n$

By taking logarithm from the $X_{ij,t}$'s and substituting in equation (1) we have:

$$y_{t+1} = \alpha + A(L)y_t + \lambda_{t+1} \quad (2)$$

where α represents the constant parameters, $A(L) = A_o + A_1 L + \ldots + A_p L^p$, $A_\tau = (a_{\tau ij})$ $\tau = 0, \ldots, p$, and λ_{t+1} is the changes of productivity. Therefore, based on the literature of real business cycle, the output of each sector is described by its own lag, the lags of output of other sectors, and the innovation factor of productivity. In this model, as Norrbin and Schlagenhauf (1991) have noted, the intersectoral dynamics are considered too. According to empirical studies, the other shocks must be added to the model for more explanation. In general case, by defining Y_t as the vector of output changes of different manufacturing sectors, each row of equation (2) may be written as:

$$y_{i,t} = \alpha_i + \sum_{k}^{K} \sum_{j=1}^{I} \pi^{i}_{j.k} y_{i,t-k} + \varepsilon_{i,t} \quad (3)$$

where $\pi^{i}_{j,k}$ is equal to $[\pi^{i}_{1,k}, \pi^{i}_{2,k}, ..., \pi^{i}_{I,k}]$. Equation (3) shows that the output growth rate of sector i depends on the optimal time lag of its own and output growth rates of other sectors. In this case the number of parameters for estimation is too large. Thus, for reducing the number of parameters, equation (3) may be used in the restricted form (Lee *et al*, 1992), as follows:

$$y_{-i,t-k} = \sum_{j=1, j\neq i}^{I} \alpha_{ij} y_{j,t} \;,\; y_{i,t} = \alpha_i + \sum_{k=1}^{K} (\theta_{ik} y_{i,t-k} + \gamma_{ik} y_{-i,t-k}) + \varepsilon_{i,t} \quad (4)$$

where $y_{i,t}$ is the growth rate of sector i, α_{ij} is the share of sector j from total manufacturing output without sector i, and $y_{-i,t-k}$ is the weighted average of growth rates of all sectors. In this equation the aggregate effects of other manufacturing sectors on sector i is summarized in the term of $y_{-i,t-k}$. By estimating the above equations system, the $\varepsilon_{i,t}$'s, which shows the effects of different shocks with different sources, are obtained. But because the purpose of this study is to appoint the relative importance of aggregate and sectoral shocks in output fluctuations, therefore, these two groups of shocks are considered for determination of $\varepsilon_{i,t}$. In this case the system equations (4) can be written as:

$$y_{i,t} = \alpha_i + \sum_{k=1}^{K} (\theta_{ik} y_{i,t-k} + \gamma_{ik} y_{-i,t-k}) + \sum_{j=1}^{P} \sum_{k=1}^{K} C_{ij} V_{j,t-k} + u_{i,t} \;,\; y_{-i,t-k} = \sum_{j=1, j\neq i}^{I} \alpha_{ij} y_{j,t} \quad (5)$$

where v_j represents the aggregate and sectoral shocks, and $u_{i,t}$ represents the other unknown shocks of each sector. In this study, the unexpected changes (or innovations) of oil exporting revenues, money supply, real exchange rate, and government expenditures are considered as aggregate shocks (V_{oil}, V_m, V_{er}, V_{gex}) and unexpected changes of productivity (V_{pro}) as sectoral shocks. These shocks are derived from the following equations:

$$\Delta m_t = \alpha_m + L\Delta m_t + L\Delta oil_t + L\Delta gex_t + V_{m,t} \quad (6)$$

$$\Delta oil_t = \alpha_{oil} + L\Delta oil_t + V_{oil,t} \quad (7)$$

$$\Delta er_t = \alpha_{er} + L\Delta er_t + L\Delta oil_t + L\Delta m_t + V_{er,t} \quad (8)$$

$$\Delta gex_t = \alpha_{gex} + L\Delta gex_t + L\Delta oil_t + L\Delta m_t + V_{gex,t} \quad (9)$$

$$\Delta pro_t = \alpha_{pro} + L\Delta pro_t + L\Delta oil_t + L\Delta cre_t + V_{pro,t} \quad (10)$$

where L denotes the lag operator, and Δoil_t, Δm_t, Δgex_t, Δer_t, Δpro_t and Δcre_t are changes in oil revenues, money supply, government expenditures, real exchange rate, productivity, and banking credit, respectively. For each of the above equations, the most general specification that was considered included among the explanatory variables values of the dependent variables lagged by up to three periods.

The model was estimated based on aggregate and sectoral (six manufacturing sectors) annual data (1970-2001) of the Iranian economy as an oil exporting country. Following the other empirical studies[2], Solow residuals were used as the representative of productivity changes by estimating the Cob-Douglas production functions for manufacturing sectors using capital, labor, and intermediate goods as inputs. For calculating the aggregate and sectoral shocks, equations (6) to (10) were estimated (Table 1). The results show that the inclusion of the additional behavioral variables, instead of simple AR, is an important exercise because the residuals from these equations do not contain a systematic element. After the stationary test of model variables (Table 2), equations system (5), based on the presented sectoral output growth equations in Table 3, was estimated by using the systematic estimation method of seemingly unrelated regressions (SUR) (Zellner, 1962; Baltagi, 2002). The reason of using this method is that there is correlation between disturbance terms. According to the Akaike information criterion, the appropriate lag length for the sectoral output growth rates is two. The estimation results of the multisectoral model have been reported in Table 4.

5 The role of shocks in the business cycles

To examine the effects of aggregate and sectoral shocks on business cycle of the manufacturing sectors, first by using a base simulation, the trend of output growth rates of different sectors are pointed in the absence of the shocks. Then by imposing one standard error shock, the impulse responses are evaluated.

5.1 The effects of oil exports revenues shock

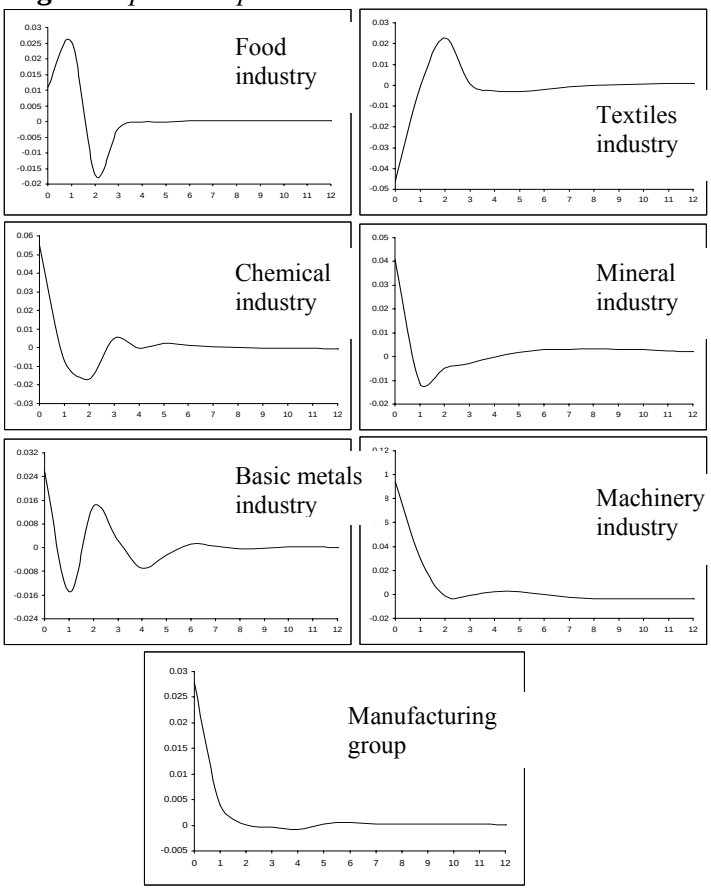
The impulse responses to one *SE* shock in oil exports revenues are illustrated in Fig. 1. The large share of oil exports from total exports in an oil exporting economy, as a main source for financing the capital and intermediate imported goods, is a determinant variable for economic growth by the investment and production channels. In the oil boom periods, imports are higher than its long run trend and it has level effect on output and employment. In the case of dominant government role

[2] See Silva (2002), Malley *et al* (2003), Ireland (2001), Norrbin and Schlagenhauf (1988, 1990, 1991), Lucke (1998)

in industrial production by *SOEs*, the oil revenues have a significant role in government investments.

According to the literature of natural resource curse and Dutch Disease phenomenon, the oil exports boom is accompanied by falling of the price of tradable goods relative to non-tradable goods, or appreciation of the real exchange rate, that causes the undeveloped non-oil exporting sector. The rising of oil exports revenues increase demand for both tradable and non-tradable goods. In these circumstances the real exchange rate is appreciated by government inflexible exchange rate policy and consequently imports increase. Even regarding to low elasticity of domestic supply in the short run, the government may import for fulfilling the excess demand. It is obvious this includes the goods that can be traded. As a result, the price of tradable goods approximately stays fixed but the price of non-tradable goods increases by domestic demand pressure. The rising of the relative price of non-tradable goods increases the profitability and output growth of this sector by changing the resource allocation.

Fig. 1: *Impulse responses to one SE shock in oil revenues*



Oil shock affects the output growth of the non-metallic mineral and machinery industries relatively with a large and significant positive effect in the first period. But the response of textiles industry is negative. Reduction of the output growth of such industries in the shock period or after represents that the effect of import rising

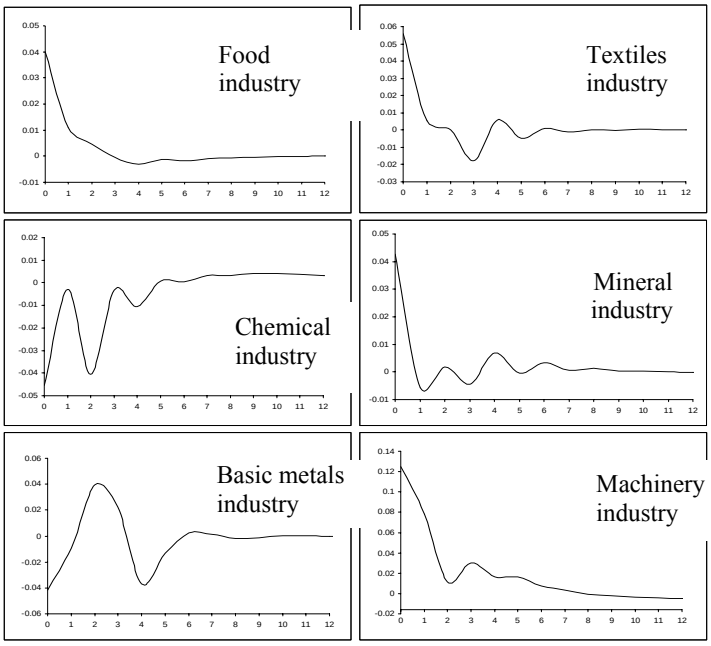
of oil shock is more than the effect of new contingent investments which are financed by oil revenues. The positive effect of oil shock on machinery industry can be explained by high dependency of this sector to the imports and protection policies of the government.

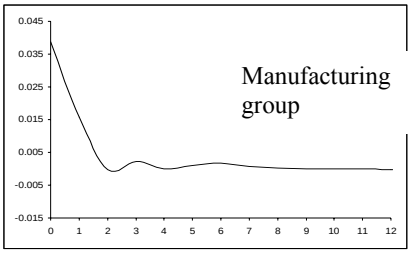
The notable point according to the above results is that in the oil exporting economy oil shocks may increase the output of non-tradable or domestic produced and consumed products (e.g. non-metallic mineral and machinery), but lead to undeveloped tradable sectors (e.g. basic metals and chemical) with low competitiveness.

5.2 The effects of government spending shock

The impacts of government spending shock on output growths are also different (Fig. 2). It has a primary positive effect except in chemical and basic metals sectors. The mechanisms of being effective can be explained in two ways. First, the expansionary shock of government spending tends to raise the prices level, following the rise in the aggregate demand. By assuming the sticky nominal exchange rate the competitiveness of tradable outputs, such as chemical and basic metals products, falls. But the effect of the shock on non-tradable outputs, such as food, textiles, and non-metallic mineral products, is positive. The second mechanism depends on the financing source of government spending. Because in this analysis the shocks are uncorrelated, it is assumed that unexpected changes in government spending are financed by taxation. Thus, the output growth rates of sectors, such as chemical and basic metals, that cannot pass the tax burden to consumers, will reduce. In the case of price controlling of products in these sectors by the government, this mechanism could be more effective.

Fig. 2: *Impulse responses to one SE shock in government spending*

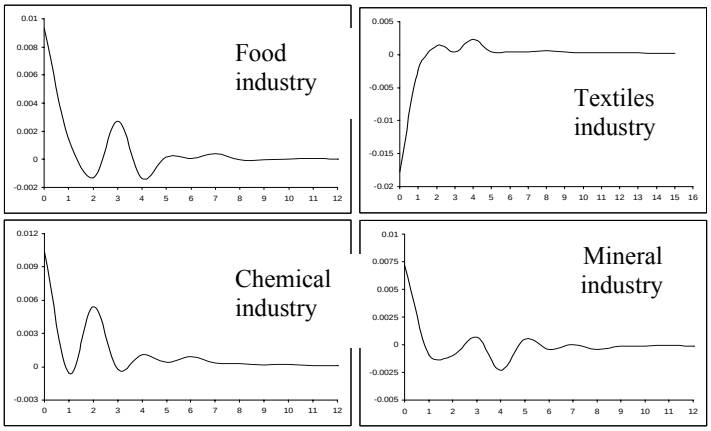


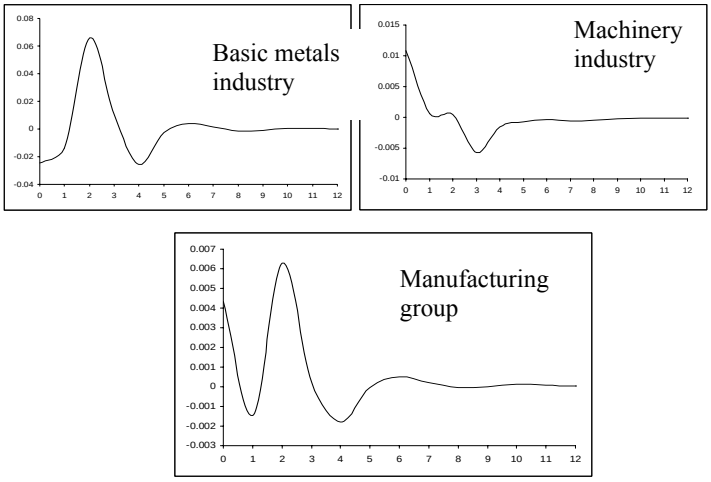


5.3 The effects of money stock shock

The impulse responses to one SE shock in the money stock are illustrated in Fig. 3. The impacts of the monetary shock must be interpreted cautiously because according to the nature and competitiveness level of sectoral outputs, its effects via the credit channel differ in different sectors. The machinery sector has been affected positively during the shock period which shows that credit availability generates a temporary boom in this sector but the negative effect of the shock appears after a short time. In food and mineral sectors, with domestic demand and low competitiveness, the growth rates of output raises in the primary period because of inflation effect of monetary shock. In basic metals sector which has a share in industrial exports, the primary effect of shock is negative. This happens through the inflation effect of the monetary shock that causes the real appreciation of exchange rate and low competitiveness. The negative effect of the monetary shock on textiles products also can be explained by inflation rising and real appreciation of exchange rate that consequently reduce the domestic demand and increase the foreign imported goods. The results indicate that the monetary shock has a partial positive effect on the output of different manufacturing sectors and on the aggregate output of industry which confirm the past empirical researches about the trade off between output and inflation in the Iranian economy.

Fig. 3: *Impulse responses to one SE shock in money stock*

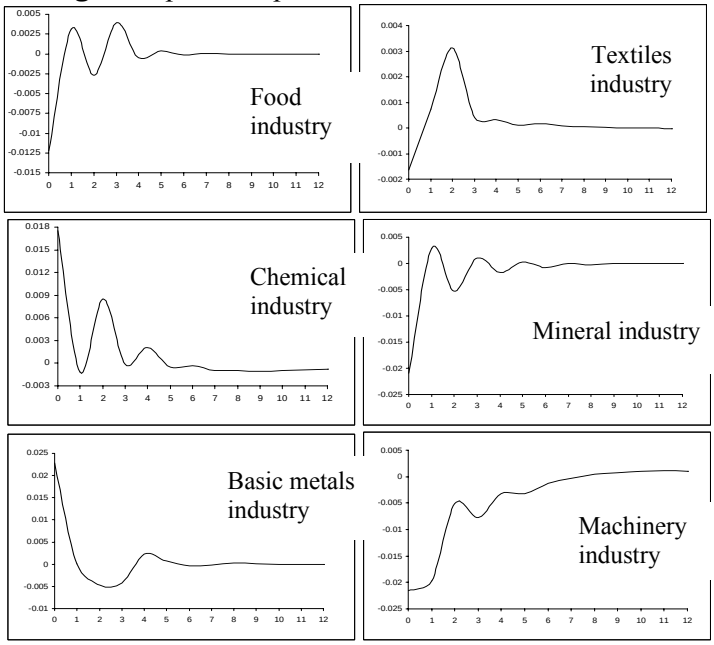


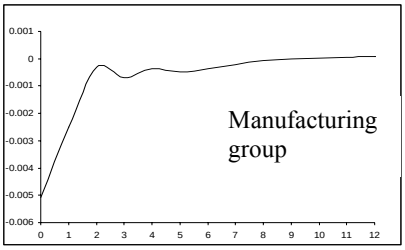


5.3 The effects of real exchange rate (RER) shock

The *RER* shock has impacts on the production process and industrial investment by exports, imports and input prices channels. The response of each sector by being dependent on imported raw materials and capital goods or exported goods, are different. The impulse responses to one *SE* shock in the *RER* are shown in Fig. 4. A positive shock in the *RER* (real depreciation) has a positive effect on output growths of chemical and basic metals sectors, which have an export oriented nature in the oil exporting economy. But in other sectors, especially textiles, non metallic mineral and machinery, it has a negative effect in the first period then a positive during the following periods.

Fig. 4: *Impulse responses to one SE shock in RER*

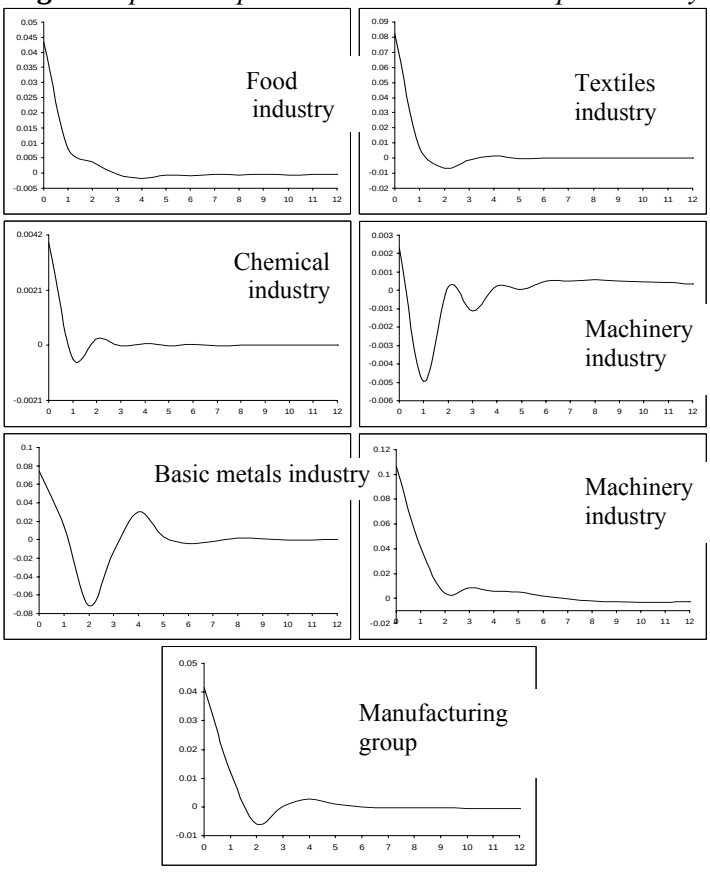




5.6 The effects of productivity shocks

The impulse responses to one *SE* shock in the sectoral productivity are illustrated in Fig. 5. The positive effect of productivity changes on the output growth rates of all manufacturing sectors is significant in the first period. Productivity changes can affect the output growth by better production factors organizing and increasing the marginal product of inputs. These types of shocks lead to raising the output and also the labor income in the current period, and saving and capital stock in the consequent periods. Thus, the persistent productivity shock can boom the industrial activities.

Fig. 5: *Impulse responses to one SE shock in productivity*



6 The importance of shocks in the business cycle

In this section, the variance decomposition approach is used for measuring the relative importance of different shocks in the business cycles. Consider the following system of equations:

$$Y_t = \alpha + \sum_{k=1}^{2} \pi_k Y_{t-k} + F_{gex} GEX_t + F_{oil} OIL_t + F_{m1} M1_t + F_{er} ER_t + F_{pro} PRO_t$$

Where π_k is a (6×6) matrix of lagged coefficients of output growths, $F_{gex}, F_{oil}, F_{m1}, F_{er}, F_{pro}$ are (6×1) vectors with elements of $f_{i,gex}, f_{i,oil}, f_{i,m1}, f_{i,er}, f_{i,pro_i}$ and $GEX_t, OIL_t, M1_t, ER_t$ are representative variables of the shocks. Assume $E(GEX_t)=\circ, E(M1_t)=\circ, E(OIL_t)=\circ, E(ER_t)=\circ$, therefore the expected value of Y_t cab be written as:

$$E(Y_t) = E(\alpha) + E\left(\sum_{k=1}^{2} \pi_k Y_{t-k}\right) + E(F_{gex} GEX_t) + E(F_{oil} OIL_t) + E(F_{m1} M1_t) +$$
$$E(F_{er} ER_t) + E(F_{pro} PRO_t)$$
$$E(Y_t) = E(\alpha) + E\left(\sum_{k=1}^{2} \pi_k Y_{t-k}\right)$$

By assuming that shocks are uncorrelated, the variance of Y_t can be written as:

$$V(Y_t) = E\left[(Y_t - E(Y_t))(Y_t - E(Y_t))'\right]$$
$$V(Y_t) = \sigma^2_{gex} F_{gex} F'_{gex} + \sigma^2_{oil} F_{oil} F'_{oil} + \sigma^2_{m1} F_{m1} F'_{m1} + \sigma^2_{er} F_{er} F'_{er} + \sigma^2_{pro} F_{pro} F'_{pro}$$

The relative importance of the shocks can be found by dividing each element of the above equation to the variance of Y_t. For explaining the total industry's fluctuations, the weighted average of growth rates in different sectors is considered as a proxy for the total industry growth rate. The weights could be equal with shares of each sector in the total output of industry $W_m = [W_{food}, \ldots, W_{machine}]$. Thus, the variance of aggregate output growth of the industry can be defined by:

$$V(Y_{mt}) = W_m V(Y_t) W'_m = \sigma^2_{gex} W_m F_{gex} F'_{gex} W'_m + \sigma^2_{oil} W_m F_{oil} F'_{oil} W'_m + \sigma^2_{m1} W_m F_{m1} F'_{m1} W'_m +$$
$$\sigma^2_{er} W_m F_{er} F'_{er} W'_m + \sigma^2_{pro} W_m F_{pro} F'_{pro} W'_m$$

For calculating the relative importance of shocks (table 5), the variance of each shock must be used and because different shocks may have the same variance in different ranges (e.g. oil shocks with a range higher than 0.5 and productivity shocks with a range lower than 0.5) which cause distortion in the results, therefore, first the shocks are changed to numbers between zero and one by using *Max-Min* approach $[\frac{Shock_i - Min_{Shock}}{Max_{Shock} - Min_{Shock}}]$ then the main model is again estimated with new data.

The results about the relative importance of aggregate and sectoral shocks in the business cycles of the industry may be summarized as the following:

A. The results show that in the manufacturing sectors, the productivity shocks explain a low percent of fluctuations in comparison with aggregate shocks. About

85.4 percent of aggregate output growth fluctuations can be explained by aggregate shocks. This shows that manufacturing sectors in an oil exporting economy may be strongly dominated by the changes in macroeconomic environment where the intersectoral mechanisms, such as productivity growth, have a little role.

B. The most important shocks in explaining fluctuations are oil revenues, government spending, productivity, exchange rate and monetary shocks, respectively. The notable point is that monetary shock has a partial positive effect on the output.

C. The combination of the effects of different shocks in various sectors show that oil shocks have the most important role in output fluctuations of machinery and non-metallic mineral sectors. This means that during the oil boom, the influence of Dutch Disease (low competitiveness) can be significant in non-tradable or domestic produced and consumed products. The importance of government spending shocks in explaining the fluctuations of the food and textiles sectors is notable. On the other hand, the share of productivity shocks in these two sectors is relatively remarkable. Thus, policies toward sustained productivity promotion lead to a higher output growth.

7 Conclusions

In the recent literature of business cycle, the sources of economic fluctuations and its nature of propagation are the most important debate. In this paper the effects and relative importance of aggregate and sectoral shocks on the output growth rates of manufacturing sectors, in an oil exporting economy, are discussed by estimating the multisectoral model of business cycles with the systematic approach of seemingly unrelated regression (SUR). Aggregate shocks include oil exports revenues, government spending, money stock, real exchange rate, and sectoral shocks include productivity shocks. The results can be summarized as follows:

1- In an oil exporting economy the contribution of aggregate shocks in manufacturing output growths, as compared with productivity shocks are large. The results suggest that industrial output is substantially depended on the changes of the macroeconomic environment in which the distortion of macro policies weakens the performance of intersectoral mechanisms which lead to the productivity growth. Thus, considering the macroeconomic policies consistent with the export oriented industrial development is necessary. Inconsistent policies could disturb endogenous growth of the manufacturing sectors via of week total factor productivity. At the presence of these exogenous impulses, while aggregate shocks are significant sources of output fluctuations, it seems disturbances could threaten the long run economic and industrial growth, even in the oil boom periods.

2- The ranking of relative importance of different shocks in explaining the aggregate output growth are oil revenues shock, government spending shock, productivity shock, real exchange rate shock, and money stock shock, respectively.

3- Oil boom shocks are the most important in the development of non-tradable sectors or domestically produced and consumed goods (e.g. non-metallic mineral

and machinery) rather than the tradable sectors (e.g. chemical and basic metals). The results support the Dutch Disease as a phenomenon of natural resource curse.

4- Explaining the effects of the monetary shock through the credit expansion must be with cautiousness in which it has different effects on various manufacturing sectors regards to the competitiveness and nature of the products. The shock causes a positive effect in the machinery sector just in the first period but the negative effect of the shock appears after a short time. In the non-metallic mineral sector because of the low competitiveness and effective domestic demand, the inflationary effect of money expansion raises production and investment; therefore, it has a positive effect in the primary period. About the basic metals sector, which shares a part of industrial exports, the effect of the monetary shock is negative. It is because of real exchange rate appreciation and consequently the reduction of exports. The negative effect of monetary shock on textiles and clothing can be explained by rising the domestic prices level and then real exchange rate appreciation which lead to reducing domestic demand and raising the imports of foreign goods. The result suggests that the monetary shock has a partial positive effect on output and this is for the studies which are about the trade off between inflation and output growth in the Iranian economy. In general, the monetary shock has a negative effect on tradable sectors and a positive effect on non-tradable sectors through inflation and real exchange rate appreciation.

5- The government spending shock raises aggregate demand and the rate of inflation which leads a fall in the output growth of exportable sectors (e.g. chemical and basic metals). On the other hand, these sectors cannot pass the tax burden to consumers when taxes raise, therefore, their output growths will reduce.

6- The real exchange rate shock has a positive effect on output growths of the exportable sectors but a negative effect on sectors which are relied on imported raw materials.

7- The effect of productivity shocks is positive in all sectors, especially in the food and textiles sectors. This type of shocks leads to raising the output and also the labor income in the current period, and saving and capital stock in the consequent periods. Thus, the persistent productivity shock can boom the industrial activities.

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Table 1: *Estimates of the equations used in the derivation of aggregate and sectoral shocks*

Dependent Var.	Estimated Equations	
Oil Exports Revenues	DLOIL = -0.035 -0.194 DLOIL(-1) + 0.46 DLOIL(-2) (-2.04) (-1.2) (3.16)	R^2 =0.28 DW =2.08
Real Exchange Rate	DLER = 0.031+ 0.89 DLER(-1) -0.48 DLER(-2)- 0.22 DLM1 (3.64) (5.27) (-2.64) (-2.83)	R^2 =0.63 DW =1.9
Government Spending	DLGEX = 0.018 - 0.22 DLGEX(-1)+ 0.61DLGEX(-2)+ 0.20 DLOIL+ 0.24 DLOIL(-1)- 0.18 DLM1 (2.64) (-1.82) (3.86) (2.13) (3.94) (-1.79)	R^2 =0.63 DW=1.9
Money Supply	DLM1= 0.019+ 0.68 DLM1(-1)- 0.25 DLGEX- 0.52 DLGEX(-2)+ 0.51DLGEX(-3)+ 0.21DLOIL+ 0.17 DLOIL(-2) (4.65) (10.2) (-1.85) (-2.68) (3.69) (3.55) (2.66)	R^2 =0.74 DW=2.6
TFP of food industry	TFPfo = -0.03 + 0.55 TFPFO(-1)- 0.80 TFPFO(-2) - 0.03 DLCRE+ 0.10 DLOIL- 0.03 DLOIL(-1) (-1.15) (2.56) (-4.01) (-1.84) (2.08) (-1.08)	R^2 =0.56 DW=1.78
TFP of textiles industry	TFPtex = 0.03- 0.66 TFPTEX(-1)+ 0.04 DLOIL(-1) (1.56) (-4.47) (2.25)	R^2 =0.18 DW=1.90
TFP of chemical industry	TFPch = 0.01 - 0.29 TFPCH(-1)- 0.24 TFPCH(-2)+ 0.05 DLCRE+ 0.06 DLCRE(-1)- 0.13 DLOIL- 0.16 DLOIL(-1) (0.91) (-1.79) (-1.50) (1.82) (2.35) (-1.72) (-2.43)	R^2 =0.76 DW=2.06
TFP of non-metallic mineral industry	TFPmin = -0.12 - 0.46 TFPMIN(-1)- 0.14 DLOIL-0.36 DLOIL(-1) (-11.7) (-2.93) (-2.05) (-9.28)	R^2 =0.60 DW=2.08
TFP of basic metals industry	TFPmet =0.001 + 0.30 TFPMET(-1)- 0.28 TFPMET(-2)- 0.06 DLCRE- 0.06 DLCRE(-1)+ 0 .07DLOIL+ 0.11DLOIL(-1) (0.25) (1.16) (-1.13) (-2.23) (-3.15) (2.31) (4.59)	R^2 =0.61 DW=1.84
TFP of machinery industry	TFPmac = 0.002 - 0.36 TFPMAC(-1)- 0.68 TFPMAC(-2) (0.084) (-2.68) (-4.77)	R^2 =0.25 DW=1.61

Notes: D: Difference, L: Logarithm. The residuals of estimated equations are considered as the aggregate and sectoral shocks.

Table 2: *Unit root test for the model variables*

Variable	ADF Test Statistic	5% Critical Value	Integration Order	Variable	ADF Test Statistic	5% Critical Value	Integration Order
LER DLER	-2.95 -2.95	-1.29 -4.39	I(1)	TFPtex	-3.45	-3.06	I(0)
LM1 DLM1	-2.95 -2.95	-2.26 -2.45	I(2)	TFPch	-31.8	-3.06	I(0)
LOIL DLOIL	-2.95 -2.95	-1.97 -4.10	I(1)	TFPmin	-74.1	-3.06	I(0)
LGEX DLGEX	-2.95 -2.95	-2.28 -2.39	I(2)	TFPmet	-300.3	-3.06	I(0)
TFPfo	-46.2	-3.06	I(0)	TFPmac	-4.13	-3.73	I(0)

Note: The ADF test results presented above indicate that the logarithms of the real exchange rate (LER) and the real oil exporting revenues (LOIL) are integrated of order one, I(1), the Solow residuals, as TFP of the manufacturing sectors, are I(0), where the logarithms of the money stock (LM1) and the real government expenditures (LGEX) are I(2). Based on the Perron test, by considering the structural changes for the year 1978, the two recent variables are also I (1).

Table 3: *Equations System of the Multisectoral Model*

DYfood=c(1)+c(2)*DYfood(-1)+c(3)*DYfood(-2)+c(4)*DYexfood(-1)+c(5)*DYexfood(-2)
+c(6)*GEX+c(7)*OIL+c(8)*M1+c(9)*ER+c(10)*TFPfo

DYtextiles=c(11)+c(12)*DYtextiles(-1)+c(13)*DYtextiles(-2)+c(14)*DYextextile(-
1)+c(15)*DYextextile(-2) +c(16)*GEX+c(17)*OIL+c(18)*M1+c(19)*ER+c(20)*TFPtex

DYchemical=c(21)+c(22)*DYchemical(-1)+c(23)*DYchemical(-2)+c(24)*DYexchemical(-1)
+c(25)*DYexchemical(-2) +c(26)*GEX+c(27)*OIL+c(28)*M1+c(29)*ER+c(30)*TFPch

DYmetal=c(31)+c(32)*DYmetal(-1)+c(33)*DYmetal(-2)+c(34)*DYexmetal(-1)
+c(35)*DYexmetal (-2) +c(36)*GEX+c(37)*OIL+c(38)*M1+c(39)*ER+c(40)*TFPmet

DYmachine=c(41)+c(42)*DYmachine(-1)+c(43)*DYmachine(-2)+c(44)*DYexmachine(-1)
+c(45)*DYexmachine(-2)+c(46)*GEX+c(47)*OIL+c(48)*M1+c(49)*ER+c(50)*TFPmac

DYmineral=c(51)+c(52)*DYmineral(-1)+c(53)*DYmineral(-2)+c(54)*DYexmineral(-1)
+c(55)*DYexmineral(-2) +c(56)*GEX+c(57)*OIL+c(58)*M1+c(59)*ER+c(60)*TFPmin

Yfood=Yfood (-1)*(1+DYfood)
Ychemical=Ychemical (-1)*(1+DYchemical)
Ymachine=Ymachine (-1)*(1+DYmachine)
Ymetal=Ymetal (-1)*(1+DYmetal)
Ymineral=Ymineral (-1)*(1+DYmineral)
Ytextiles=Ytextiles (-1)*(1+DYtextiles)
Yexfood=Ychemical+Ymachine+Ymetal+Ymineral+Ytextiles
Yexchemical=Yfood+Ymachine+Ymetal+Ymineral+Ytextiles
Yexmachine=Ychemical+Yfood+Ymetal+Ymineral+Ytextiles
Yexmetal=Ychemical+Ymachine+Yfood+Ymineral+Ytextiles
Yexmineral=ychemical+ymachine+ymetal+yfood+ytextiles
Yextextile=Ychemical+Ymachine+Ymetal+Ymineral+Yfood
DYexfood= (Yexfood-Yexfood (-1))/Yexfood (-1)
DYexchemical= (Yexchemical-Yexchemical (-1))/Yexchemical (-1)
DYexmachine= (Yexmachine-Yexmachine (-1))/Yexmachine (-1)
DYexmetal= (Yexmetal-Yexmetal (-1))/Yexmetal (-1)
DYexmineral= (Yexmineral-Yexmineral (-1))/Yexmineral (-1)
DYextextile= (Yextextile-Yextextile (-1))/Yextextile (-1)

Variables	***Description***	***Variables***	***Description***
DYfood	Output growth of food sector	OIL	Oil exporting revenues shock
DYtextiles	Output growth of textiles sector	ER	Real exchange rate shock
DYchemical	Output growth of chemical sector	M1	Money stock shock
DYmetal	Output growth of metals sector	GEX	Government expenditures shock
DYmachine	Output growth of machinery sector	TFPfo	Productivity shock in food sector
DYmineral	Output growth of mineral sector	TFPtex	Productivity shock in textiles sector
DYexfood	Total output growth excludes food	TFPch	Productivity shock in chemical sector
DYextextile	Total output growth excludes textiles	TFPmin	Productivity shock in metals sector
DYexmetal	Total output growth excludes metals	TFPmet	Productivity shock in machinery sector
DYexchemical	Total output growth excludes chemical	TFPmac	Productivity shock in mineral sector
DYexmachine	Total output growth excludes machinery		
DYexmineral	Total output growth excludes mineral		

Table 4:
Estimated Coefficients of the Multisectoral Model

Estimation Method: Iterative Seemingly Unrelated Regression

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.001365	0.023461	0.058200	0.9536
C(2)	0.064888	0.049921	1.299806	0.1941
C(3)	-0.060089	0.049647	-1.210340	0.2266
C(4)	0.545589	0.105781	5.157718	0.0000
C(5)	-0.319736	0.155844	-2.051638	0.0406
C(6)	0.560396	0.137128	4.086676	0.0000
C(7)	-0.032344	0.039629	-0.816177	0.4147
C(8)	-0.093640	0.144901	-0.646237	0.5184
C(9)	-0.128954	0.112227	-1.149047	0.2510
C(10)	1.376385	0.158502	8.683689	0.0000
C(11)	0.052823	0.014556	3.628809	0.0003
C(12)	0.185719	0.057795	3.213422	0.0014
C(13)	0.057505	0.063198	0.909917	0.3632
C(14)	0.133399	0.073064	1.825783	0.0683
C(15)	0.435851	0.076595	5.690367	0.0000
C(16)	0.612924	0.087107	7.036469	0.0000
C(17)	-0.135469	0.024151	-5.609311	0.0000
C(18)	-0.177196	0.097129	-1.824333	0.0686
C(19)	-0.017285	0.085352	-0.202511	0.8396
C(20)	1.086176	0.177560	6.117217	0.0000
C(21)	0.203789	0.011773	17.31056	0.0000
C(22)	-0.137679	0.036102	-3.813614	0.0001
C(23)	0.250073	0.038572	6.483355	0.0000
C(24)	-0.104691	0.032847	-3.187217	0.0015
C(25)	-0.303785	0.034001	-8.934546	0.0000
C(26)	-0.455225	0.042784	-10.64004	0.0000
C(27)	0.120229	0.013418	8.960094	0.0000
C(28)	0.103973	0.055005	1.890240	0.0592
C(29)	0.184440	0.047083	3.917330	0.0001
C(30)	-0.168787	0.025984	-6.495843	0.0000
C(31)	0.136946	0.022444	6.101594	0.0000
C(32)	0.090808	0.048670	1.865789	0.0625
C(33)	-0.452752	0.047002	-9.632617	0.0000
C(34)	-0.299873	0.132950	-2.255540	0.0244
C(35)	0.794212	0.134424	5.908265	0.0000
C(36)	-0.830860	0.171962	-4.831658	0.0000
C(37)	-0.030228	0.038286	-0.789533	0.4301
C(38)	-1.376040	0.141987	-9.691282	0.0000
C(39)	0.240958	0.126340	1.907224	0.0569
C(40)	1.794163	0.164345	10.91706	0.0000
C(41)	0.220956	0.021656	10.20288	0.0000
C(42)	0.319882	0.048698	6.568653	0.0000
C(43)	-0.093793	0.050804	-1.846178	0.0653
C(44)	-1.203578	0.147210	-8.175941	0.0000
C(45)	-0.147161	0.165536	-0.888994	0.3743
C(46)	1.731279	0.144389	11.99035	0.0000
C(47)	0.555019	0.039843	13.93001	0.0000
C(48)	0.107973	0.160047	0.674633	0.5001
C(49)	-0.227089	0.123989	-1.831527	0.0675
C(50)	1.277154	0.103206	12.37477	0.0000
C(51)	0.147874	0.009322	15.86264	0.0000
C(52)	-0.136846	0.031385	-4.360194	0.0000
C(53)	0.045842	0.029628	1.547226	0.1223
C(54)	0.009277	0.049361	0.187937	0.8510
C(55)	-0.450873	0.054513	-8.270936	0.0000
C(56)	0.428061	0.058844	7.274522	0.0000
C(57)	0.162199	0.016437	9.867952	0.0000
C(58)	0.071920	0.069055	1.041500	0.2980
C(59)	-0.219955	0.058366	-3.768554	0.0002
C(60)	0.000196	0.023559	0.008308	0.9934

Table 5: *Variance Decomposition of the Output Growth Rates Of the Manufacturing Sectors (percent)*

Sector	Oil Revenues shock	Gov. Spending shock	Productivity Shock	Exchange rate shock	Money stock shock
Food	6	43	32	13	6
Textiles, Clothing	25	41	18	6	10
Chemical	36	40	14	8	2
Non-Metallic Mineral	53	31	3	9	4
Basic Metals	40	23	15	16	6
Machinery	43	30	14	8	5
Manufacturing group	39.4	31.4	14.6	7.5	7