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Input–output analysis in an oil-rich economy: The case of Azerbaijan

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ABSTRACT

This paper aims to provide empirical research to identify the linkages between final demand–total output, final demand–total supply, value-added ratios and prices, and also to analyze total factor productivity growth using input–output framework for 25 sectors. Studying the input–output tables for 2001 and 2006, the research estimates impact and response multipliers of non-oil sectors, as well as non-oil trading sectors. The results are important from the view of development of non-oil trading sectors and diversification of the economy in order to avoid the "resource curse".

Introduction

The last economic downturn in Azerbaijan started in 1989 when the country was part of the Soviet planned economy, and experiencing deep recession. The contraction of the economy continued during the first years of independence, and positive GDP growth was observed again only in 1996. Azerbaijan surpassed its Soviet period peak level (1988) GDP in 2006, and then doubled it in 2010. The jump in the GDP growth in the recent years (26.4% in 2005, 34.5% in 2006, 25.0% in 2007, and 10.8% in 2008) was achieved due to the sharp increase in hydrocarbon extraction after 2005 and fiscal stimulation as the result of skyrocketing oil prices for the same period. The Azerbaijan economy also demonstrated quite high total GDP growth (9.3%) in 2009 during the global recession.

However, hydrocarbon reserves can constitute the source of economic growth in Azerbaijan only for the midterm, since oil and gas production are close to their peak level and there will soon be a sharp decline in oil extraction. Approximately 50% of natural gas and 65% of oil reserves will be extracted during the years 2010–2024. Therefore, the possibility of diversification of the economy and avoidance of the "resource curse" by the end of the above mentioned period is the main question.

Several studies, including by Gelb (1988) and Auty (1993), have found a significant linkage between natural resource abundance and poor economic growth, which also known as "resource curse" or "paradox of plenty". As Mikesell (1997) stated, "*the resource curse hypothesis is closely related to the problem of sustainability for resource-exporting countries since periods of high growth are frequently followed by long periods of stagnation*".

The issue is also topical for Azerbaijan and some aspects of the problem, such as fiscal sustainability (Bandiera et al., 2008), policy strategies for Azerbaijan to deal with the dual challenge of transition and oil boom (Rosenberg and Saavalainen, 1998; IMF, 2003), the impact of government expenditure on growth (Koeda and Kramarenko, 2008), and the impact of real oil prices on the real effective exchange rate (Hasanov, 2010) have been studied in the named papers. At the same time, research analyzing other natural resource-abundant countries (Auty, 1998; Kalyuzhnova and Nygaard, 2008; Esanov et al., 2004; Kutan and Wyzan, 2005) has touched on relevant issues pertaining to Azerbaijan. This paper also studies the impact of the oil and gas sector on the Azerbaijan economy, and uses the input–output analysis to investigate oil boom impact on various sectors.

Leontief (1986, p. 19) defined input–output analysis as "*a method of systematically quantifying the mutual interrelationships among the various sectors of a complex economic system*". It derives

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from the Soviet Union's "Balance of the National Economy" for 1923–1924, which was released in book form in 1926 by Soviet Central Statistical Administration (Spulber and Dadkhah, 1975). Subsequently, the input–output framework, especially the material supply plan became an important element in construction of short-term Soviet planning; particularly the annual economic plan. In a different way the annual plan was a particular aspect in the Soviet schema for achieving long-term economic growth (Levine, 1962; Manove, 1971). There were also studies using input–output analysis in regional economic planning in the Soviet Union (Ellman, 1968) and for comparison of the economic structures of the U.S. and the U.S.S.R (Long, 1970).

During the Soviet period the intersectoral balance of the Azerbaijan economy had been constructed periodically by the Economics Institute of the State Planning Committee. The last intersectoral balance of the planned economy was for 1987, while the first intersectoral balance of the market oriented Azerbaijan economy was constructed by the State Statistical Committee (The State Statistical Committee of the Republic of Azerbaijan, 2004) for the year 2001 and released in 2004. The balance had been prepared in accordance with the methodology recommended by the United Nations and included about 14,000 pieces of data on 26 sectors of the economy and 107 groups of goods and services (Orucov et al., 2009, pp. 97–98).

This paper aims to provide empirical research to identify the linkages between final demand–total output, final demand–total supply, value-added ratios and prices, and also to analyze total factor productivity growth using the input–output framework for 25 sectors. Studying input–output tables for the years 2001 and 2006, the research defines developments in intersectoral relations between 2001 and 2006.

The second section provides the methodology for calculation of total factor productivity and multiplier approach to define the above mentioned linkages. The third section analyzes the results and interprets the findings. The conclusions are made in the fourth section.

The research results are of great importance for the comprehension of the relationship between different sectors of a natural resource-rich economy, with a booming sector, non-oil tradable and non-tradable sectors. The findings are also significant from the point of view of development of the policies towards diversification of the economy.

Finally, it is important to note that there are some limitations of input–output techniques. First, GDP estimates, whether derived from input–output techniques or from expenditure analysis, do not account for natural resource depletion. Consequently, GDP tends to exaggerate the wealth of economies, such as Azerbaijan, in which resource extraction plays a large part. Second, GDP measures may understate the value of production in economies with large informal sectors. Despite these problems, virtually all developed countries, as well as many developing countries, use input–output techniques for national income accounting (Stilwell et al., 2000).

Methodology

The multiplier approach: the relationship between final demand and total output

Some symbols used for these models are given below:

X_i=output of ith sector (row vector);
X_j=input of jth sector (column vector);
x_{ij}=flow of input from sector i to sector j (intermediate consumption matrix);
Y_i=final demand of ith sector for the output;
Z_j=value-added of jth sector for the input.

In input–output table $X_i=\sum_{j=1}^n x_{ij}+Y_i$ and $X_j=\sum_{i=1}^n x_{ij}+Z_j$.

Thus, $\sum_{i=1}^n X_i=\sum_{i=1}^n\sum_{j=1}^n x_{ij}+\sum_{i=1}^n Y_i$ and $\sum_{j=1}^n X_j=\sum_{i=1}^n\sum_{j=1}^n x_{ij}+\sum_{j=1}^n Z_j$.

Since $X_i=X_j$, then $\sum_{i=1}^n X_i=\sum_{j=1}^n X_j$.

Where, $\sum_{i=1}^n X_i$ is total output, $\sum_{j=1}^n X_j$ is total input, and $\sum_{i=1}^n\sum_{j=1}^n x_{ij}$ is total intermediate consumption.

Finally, $\sum_{i=1}^n Y_i=\sum_{j=1}^n Z_j=GDP$.

That is, $\sum_{i=1}^n Y_i=GDP$ (Expenditure Approach) and $\sum_{j=1}^n Z_j=GDP$ (Income Approach).

In addition, we have input coefficients $a_{ij}=x_{ij}/X_j$ (Leontief, 1986, p. 22).

We can rewrite these identities in the form of $x_{ij}=a_{ij}X_j$ and by putting this in the equation given above we get $X_i=\sum_{j=1}^n a_{ij}X_j+Y_i$.

Using matrix and vector form we can define $\mathbf{A}=((a_{ij}))$ and $\mathbf{X}=\mathbf{AX}+\mathbf{Y}$.

Then $\mathbf{Y}=(1-\mathbf{A})\mathbf{X}$, where $\mathbf{A}$ is direct requirements matrix and $(1-\mathbf{A})$ is Leontief's matrix.

On the other hand we receive $\mathbf{X}=(1-\mathbf{A})^{-1}\mathbf{Y}$ (Leontief, 1986, pp. 45–46).

$(\mathbf{I}-\mathbf{A})^{-1}=\mathbf{B}$, where $\mathbf{B}$ is total requirements matrix (Leontief's inverse matrix):

$$\mathbf{X}=\mathbf{BY} \text{ and } \mathbf{B}=((b_{ij}))$$

Also we are interested in sum of columns ($\sum_{i=1}^n b_{ij}$) and sum of rows ($\sum_{j=1}^n b_{ij}$). These multipliers give us relationships between final demand and total output. The maximum value among sum of columns $Max(\sum_{i=1}^n b_{ij})$ shows that, the final demand which belongs to this sector makes more impact on intersectoral structure, in other words on total output in comparing with other sectors. The maximum value among sum of rows $Max(\sum_{j=1}^n b_{ij})$ indicates that an output of this sector is most affected by the change in final demand (Oney, 1987, pp. 136–137).

The multiplier approach: the relationship between final demand and total supply

The new equilibrium $X_i+M_i=\sum_{j=1}^n x_{ij}+C_i+I_i+G_i+E_i$ is obtained by considering $Y_i=C_i+I_i+G_i+(E_i-M_i)$ in equation $X_i=\sum_{j=1}^n x_{ij}+Y_i$. Where C_i is consumption, I_i is investment, G_i is government expenditures, E_i is export, and M_i is import of i th sector.

If we define final demand (without import-substitution) as D, and use the equation

$$D_i=C_i+I_i+G_i+E_i$$

we derive $X_i+M_i=\sum_{j=1}^n x_{ij}+D_i$,
then $\sum_{i=1}^n(X_i+M_i)=\sum_{i=1}^n\sum_{j=1}^n x_{ij}+\sum_{i=1}^n D_i$.

Where $\sum_{i=1}^n(X_i+M_i)$ is total supply, and $\sum_{i=1}^n\sum_{j=1}^n x_{ij}+\sum_{i=1}^n D_i$ is total demand.

According to supply we can obtain next coefficients: $a'_{ij}=x_{ij}/(X_i+M_i)$.

So $x_{ij}=a'_{ij}(X_i+M_i)$.

In matrix and vector terms $\mathbf{A}'=((a'_{ij}))$.

From the above mentioned identities this is just $\mathbf{X}+\mathbf{M}=\mathbf{A}'(\mathbf{X}+\mathbf{M})+\mathbf{D}$.

Then, $\mathbf{D}=(\mathbf{I}-\mathbf{A}')(\mathbf{X}+\mathbf{M})$ and $\mathbf{X}+\mathbf{M}=(\mathbf{I}-\mathbf{A}')^{-1}\mathbf{D}$.

After substitution $(\mathbf{I}-\mathbf{A}')^{-1}=\mathbf{B}'$ and $\mathbf{B}'=((b'_{ij}))$, we can write $\mathbf{X}+\mathbf{M}=\mathbf{B}'\mathbf{D}$.

We obtain next multipliers from sum of columns ($\sum_{i=1}^n b'_{ij}$) and sum of rows ($\sum_{j=1}^n b'_{ij}$), which give us relationships between final demand (without import-substitution) and total supply. The highest value among the sum of columns $Max(\sum_{i=1}^n b'_{ij})$ indicates that, the demand (D) for this sector comparing to the other sectors is more effective on total supply. The highest value among