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THE IMPACT OF INTERNATIONAL OIL PRICE INCREASE ON THE ECONOMY OF FREE STATEPROVINCE OF SOUTH AFRICA

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Abstract

This article researches quantitatively the impact of an increase in the international oil price on economy of the Free State provincial economy using a Computable General Equilibrium model. The result of an increase international oil price shows that, the percentage in labour demand of transport, other services, agriculture, and manufacturing sector decrease. The GDP of the overall economy decrease by 0.01%, the highest decrease observed in transport sector followed by other services, agriculture and manufacturing sector. It also reflects that from the household income analysis the lower income households are more affected compared to the rest of household categories.Considering poverty (measured in terms of Equivalent Variation) the results also suggest that the lowest welfare gain observed in poor households. The results suggest that it is inevitable that there will always be some external shocks outside the control of economic policies. Hence it is necessary to strengthen the effectiveness of economic growth by incorporating target available resources and ensuring coherence in policy design.

Key words: *Oil price; Households, GDP, Equivalent Variation, Free State Province, CGE*

1. Introduction

The Free State Province is one of nine provinces in South Africa. It has a population of 2.8 million people, which is approximately 5.7 % of the South African population according to the 2007 community survey produced by Statistics South Africa. The Free State is centrally situated among the remaining eight provinces. It is bordered by six provinces (the Eastern Cape, Northern Cape, Gauteng, Kwazulu-Natal, North West and Mpumalanga). The only two provinces not bordering it are Limpopo and the Western Cape. It also forms a border with Lesotho (Maisonnave*et al.*, 2010; STATSSA, 2006).

The Free State has a surface area of 129 480 km^2, which makes it the fourth largest province in South Africa, covering 10.6 % of the total area of the whole country. The Free State is subdivided into five district council municipalities, i.e. Xhariep, Motheo, Lejweleputswa, Thabo Mofutsanyane and Northern Free State. These district councils comprise 20 municipalities (STATSSA, 2006).

With regards to oil price shocks, the November Monthly Bulletinof the European Central Bank (ECB) (2004) points out that direct, indirect and second-round price effects can be distinguished. Direct price effects via energy items in the consumer basket are unavoidable following oil price shocks, as energy is part of the households' consumer basket. Indirect effects may emerge on account of higher input costs being passed on to consumer prices via the domestic production chain. Second-round effects originate from wage reactions or, more generally, from inflation expectations to oil price increases. The full impact of oil price changes on prices largely depends on the actual reaction of wages as well as fiscal and monetary policy (ECB, 2004; National Institute of Economic and Social Research (NIESR),

2004). Moreover, a temporary oil price shock will have less impact on inflation through its effect on expectations that will a permanent shock (NIESR, 2004). According to a European Central Bank Monthly Bulletin (2004), the impact of oil price shocks also depends on the flexibility of the economy and the way in which product and labour markets function.

Developing countries generally suffer more than the OECD countries from oil-price increases, because their economies are more dependent on imported oil, energy-intensive manufacturing generally accounts for a larger share of their GDP and energy is used less efficiently (International Energy Agency, 2003).

The South African Reserve Bank's Monetary PolicyReviewof March 2001 points out that it may be expected that factors such as changes in oil prices will have a larger effect on production prices than on consumer prices due to the fact that imported goods have a weight of 27 % in the production price index, as opposed to an estimated weight of around 6 % in the overall consumer price index (CPIX), excluding interest rates on mortgage bonds (Swanepoel, 2006).

Following recent international oil price increases, there has been increasing concern about their macroeconomic implications, both abroad and in South Africa. Indeed, the South African Reserve Bank (SARB) considers oil price movements to be one of the major threats to the continued attainment of its inflation target, as evidenced by numerous recent statements by its Monetary Policy Committee. Furthermore, rising energy prices have the potential to undermine the government's Accelerated and Shared Growth Initiative for South Africa (AsgiSA) to halve unemployment and poverty by 2014 (Wakeford, 2007).

As a consequence, there has been considerable interest in how this increase in oil price can affect the South African economy, including the Free State province's economy. For instance, industrial agriculture (or 'agri-business') depends heavily on oil for the production of fertilisers, herbicides and pesticides. The main motivation of the study is to analysis the oil price increase and providing policy guidance to development strategies.

The objective of this study is to assess the impact of international oil price on the economy of the Free State province, designing policy scenarios and simulation of scenarios in a CGE; and identification of the likely effect and impact of different scenarios on the economy of the Free State (i.e. GDP, employment, etc.).

2. Methodology, Data Used and Policy Scenarios

2.1. Methodology and Data Used

To evaluate the impact of international oil price increase on the economy of the Free State was applied a computable general equilibrium (CGE). A CGE model is economy wide in the sense that it includes all sectors. Such models have gained increasingly wide acknowledgement in terms of policy evaluation. This model permits a systematic analysis at provincial level of external price shocks and shifts in other exogenous variables, tracking the effects of such changes on various actors in the economy. It is possible to distinguish the implications of various policy and external price regimes with respect to their effect on several variables of interest: macroeconomic variables; sectoral output, employment, household income and welfare (Nielsen, 2002; Bahta, 2007). The underpinning database to be used for the model is a social accounting matrix (SAM) of base year 2004, developed in 2006 by the Free State provincial government, the Development Bank of South Africa (DBSA) and the Free State provincial treasury. The model is initially set up to replicate the base year SAM by appropriately calibrating the parameters of the model. Most of the parameters of the model can be and are calibrated from the SAM; however, the Armington elasticities are obtained from Gibson (2003).

The production elasticities were set at 1.2 and 0.6; the household income elasticities were set at 0.20 and 0.48 and export demand elasticities were set at 0.9 and 2.

A social accounting matrix (SAM) provides a comprehensive and consistent description of the transactions taking place in an economy in a given year; between production sectors, factors, households, government institutions and the rest of the world. Each macro account in the SAM is represented by a column and a row, with columns tracking expenditures and rows tracking incomes. The SAM follows the principles of double-entry accounting. This has two implications: (1) any purchase, expenditure or financial outlay by one account is sale, income or financial inflow to one or more other accounts, and (2) for each account total income must be equal to total expenditure (Nielsen, 2002).

The Free State province's SAM incorporates six major accounts, each of which can be sub-divided into numerous sub-accounts. These major trade accounts are: activity (production) accounts, commodity accounts, factor accounts (labour and capital – gross operating surplus), institutional accounts, capital accounts and trade accounts (rest of the world). The factor account, households' account and trade account are discussed in the next paragraphs.

Factor account – Income flows to factors of production from their employment in domestic activities. These may also include payment to foreign factors of production used in the production process. Typically, households own all labour services. Consequently, payments to domestically based labour are distributed across the different types of household as labour income and distributed profits. In terms of the remuneration of labour that is reflected in the labour account for the Free State, four population groups (i.e. Blacks/Africans, coloureds, Indians and whites) have been specified in the SAM for the Free State, along with eleven occupational groups. This classification is the reflection of different skills levels employed in the provincial economy: legislature, professionals, technicians, clerks, service workers, skilled agricultural workers, craft workers, plant and machine operators, elementary occupations, domestic workers and occupation unspecified. In this particular study, labour categories are used as an aggregate of all labour groups as (FLAB).

The households' account has been sub-divided into 48 different household types, corresponding to the four–population groups and 12 income categories per group.The households were disaggregated into four population groups: Africans/Blacks; Coloured; Indian/Asians and Whites. Further sub divided into 48 different household types corresponding to the 4 population groups and 12 income categories per group (Percentile 1 to Percentile 12). The household divided into 5 household expenditure categories for each population group. Low–income households (P1 and P2), low–middle–income households (P3 to P5), middle–income households (P6 to P8), high–middle–income households (P9 and P10) and high –income or expenditure household groups (P11 and P12). Low–income households comprise all households with an income/expenditure per year from 1 to 10602 Rand, low middle income households from 10603 to 24172 Rand, middle-income households from 24173 to 49394 Rand, high middle households 49395 to 107537 and high–income households group from 107538 to 141063 and above (Free State Provincial Treasury, 2006). In this particular study, 48 household categories are aggregate in to 5 household income groups (low–income households; low–middle–income households; middle–income households, high–middle–income households and high–income households) for easier presentation of results.

Trade account with the rest of the world – Trade accounts recorded trade transactions with the rest of the world, and are important for trade policy analysis. These include current and capital accounts, as well as visible and invisible trade. Imports are reflected as an income, i.e. a row entry, because they represent an income to foreign countries that is associated with expenditure by domestic agents. Exports are reflected as expenditure by foreign countries and, hence, represent an income to the domestic account. The rest of the

world account is divided between the rest of South Africa and the rest of the world. In other words, the rest of the world (trade account) included exports from the Free State to the rest of South Africa and the rest of the world, factor payments from the Free State to the rest of South Africa and the rest of the world, transfers from households in the Free State to households in the rest of South Africa and the rest of the world, and transfers from the provincial Free State government to the rest of South Africa and the rest of the world.

The Free State's SAM does not include specific accounting for crude oil. Crude oil is included in the 'other mining' account. In order to conduct an analysis of crude oil price movements, it is necessary to separate them from the aggregated 'other mining' account. Based on the study by PROVIDE (2005) and Fofana *et al*. (2008) and trade data from customs data supplied by the South African Revenue Service (SARS), the share of aggregate commodity imports that related to crude oil is 75 % to 84 % of other mining. South Africa (i.e. the Free State province) does not export crude oil, so that in the modification of SAM it is assumed that then local price of crude oil is the same as that of imported oil. There is no product tax on crude oil imports. As a result of all these included data discrepancies the SAM is unbalanced, and the cross-entropy method is used to balance the SAM (Bahta, *et al*., 2014).

Balancing a SAM using the cross-entropy (CE) method has become a standard procedure in most SAM-based modelling. Robinson, Cattaneo and El-Said (2000) have explained that the CE method is built on information theory, as developed by Shannon (1948) and brought into economics by Theil (1967). The main idea is that the expected information value of additional data can be expressed as a Kullback-Leibler (1951) cross-entropy distance I (p:q)between the prior (q) and posterior (p) probability distributions of a set of n events.

$$-I(p:q)=\sum_{i=0}^{n} p_i ln\frac{p_i}{q_i} \qquad (1)$$

The objective of the CE problem is to find the set of *pi* that minimises (1), using information on the prior and the data. With regards to SAM estimation or updating, the problem is to find a new SAM coefficient matrix A***** that minimises the CE distance between itself and the prior (or initial and probably unbalanced) coefficient matrix A. Let *aij** and *aij*be the respective elements of A***** and A, the minimisation problem can be written as follows:

$$\text{Subject to: } \sum_j a_{ij} y^*_j = y^*_i ; \sum_j a_{ji} = 1 \text{ and } 0 \le a_{ji} \le 1 \qquad (2)$$

Problem (2) does not have a closed form solution, and needs to be solved numerically, after setting up the Langrangian multiplier. It is, however, possible to express the optimal solution *a*ij*as a function of both the Lagrange multipliers iassociated with the row and column sums, and the initial coefficient *aij*:

$$a^*_{ij} = \frac{a_{ij} exp(\lambda_i y^*_j)}{\sum_{i,j} a_{ij} exp(\lambda_i y^*_j)} \qquad (3)$$

Robinson, Cattaneo and El-Said (2000) discuss the comparability of (3) to Bayes' rule, in which 'the posterior distribution is equal to the product of the prior distribution and the likelihood function, dividing by a normalisation factor to convert relative probabilities to

absolute ones'. Thus, Equation (3) may be seen as an efficient information processing rule that satisfies the information conservation principle of Zellner (1962). That is, it does not ignore any of the input information and neither does it produce any false information. The authors also draw on Golan *et al*. (1996) to argue that the CE estimator is consistent and has maximum likelihood properties under some distributional assumptions.

The basic minimisation problem in (2) can be made richer by incorporating aggregation constraints and measurement errors. For *k* restrictions, a typical aggregation constraint may be expressed as follows:

$$\sum_i \sum_j g_{ij}^{(k)} t_{ij} = y^{(k)} \tag{4}$$

Where "*gij"* define an n-by-n aggregator matrix which has ones for cells in the aggregate and zeros otherwise. Assume that there are k such aggregation constraints. Similarly, measurement errors are incorporated as follows:

$$y = x + e \tag{5}$$

Where *y* is a vector of row sums and *x*, measured with error *e*, is the vector of known column sums. The error is expressed as a weighted average of known constants *viw*:

$$e_i = \sum_w w_{i,w} . v_{i,w}$$
$$\sum_w w_{i,w} = 1 \text{ and } 0 \le w_{i,w} \le 1 \tag{6}$$

The weights are treated as probabilities, which are estimated together with the elements of the matrix A*. The estimation procedure used in this study is based on five weights that are symmetric about zero. The minimisation problem (2) is solved, subject to Equations (4), (5) and (6).

2.2. Policy Scenarios

The scenarios are based on an increase on international oil price. The Free State province's CGE model was implemented using computer codes provided by the International Food Policy Research Institute (IFPRI), as documented in Lofgren *et al*. (2002). Model implementation consists of applying the theoretical model to behavioural parameters. The FSP CGE model was solved numerically with General Algebraic Modelling Systems (GAMS) software.

The reasoning behind the selection of the particular scenarios used for the analyses is supplied in the subsequent paragraphs.

The steep upward trend in the price of crude oil in recent years, reaching a record nominal high, has led to increasing concern about its macroeconomic implications, both abroad and in South Africa. Furthermore, rising energy prices have the potential to undermine the government's accelerated and shared growth initiative for South Africa to halve unemployment and poverty by 2014 (RSA, 2006). The world demand-driven oil price shock has affected the way emerging countries pursue macroeconomic policy. South Africa has also been concerned about the impact of the oil price increases on economic growth and on poor people (Fofana *et al*., 2008).

South Africa's economy is relatively energy-intensive, with resource-based industries such as mining (especially gold mining), chemicals, iron and steelbeing particularly heavy users of energy (DMERI, 2002). Crude oil accounts for a further 17 % of raw energy supply (PROVIDE, 2005).

Oil shocks are usually defined in terms of price fluctuations, but these may in turn emanate from changes in either the supply of or the demand for oil. Price shocks may of course be negative (a fall) or positive (a rise). South Africa's historical experience with oil shocks showed that four oil shocks could be identified in the post-war era, having occurred in 1973–1974, 1979–1980, 1990 and the period from 2003 to 2006.

2.2.1. The first oil shock (1973–1974)

The first oil shock was catalysed by the Arab-Israeli war, which resulted in various Arab oil producing nations placing an embargo on oil exports to the United States and the Netherlands, which were seen as strongly pro-Israel. The oil price rose by a factor of nearly four, from about $3 per barrel prior to the war to around $11.50 per barrel in 1974.

2.2.2. The second oil shock (1979–1980)

The second oil shock occurred in the wake of the Iranian Revolution in 1978/79 and the subsequent war between Iraq and Iran in 1980, which caused Iranian oil exports to dry up altogether.

2.2.3. The third oil shock (1990)

The third oil price shock was triggered by the Iraqi invasion of Kuwait in August 1990. As a consequence of fear-driven stockpiling and the elimination of Iraq and Kuwait's approximately 7 per cent share of daily world oil production following the imposition of United Nations sanctions, the price of oil climbed by a factor of about two from $17 per barrel in July 1990 to an average of $35 per barrel in October (Van der Merwe and Meijer, 1990).

2.2.4. A fourth oil shock (2003–2006?)

The balance between supply and demand in the oil market has gradually been tightening over the past few years. This is partly attributable to steeply rising demand on the back of robust economic growth, especially in major emerging economies such as China, but also in the USA. On the other hand, supply has expanded less rapidly than demand. Moreover, there have been temporary or recurrent disruptions to the flow of oil in some areas as a result of various factors, such as the ongoing conflict in Iraq; sporadic conflict and sabotage in Nigeria; the devastation wrought by hurricanes Katrina and Rita in the Gulf of Mexico; and a leaking pipeline leading to a temporary closure of the Prudhoe Bay field in Alaska in August 2006. Speculation in the oil market has amplified the price effects of these relatively minor supply disruptions. In addition, fears amongst oil traders were exacerbated by the conflict between Israel and Hezbollah in July/August 2006.

As a consequence, the price of crude oil rose from around US$25 per barrel in 2003 to a high of US$78 per barrel in July 2006. This represents a trebling of oil prices over three years, which – according to the earlier definition – may be defined as a 'trend' oil price shock. Since this shock has been drawn out over a number of years, its effects have been slow to manifest. In addition, the impact has to some extent been masked or offset by other factors such as declining prices of (particularly Asian) manufactured goods, low interest rates

and cost-reducing technological innovations. South Africa has been buffered from the oil price trend by these factors as well as by a relatively strong currency from 2003 till around the middle of 2006 (on the back of robust commodity prices). As a result of these conditions, domestic consumers have been engaged in a credit–driven consumption boom. An increase in the prices of crude oil (21.2 %) will be simulated in the model.

3. Closure Rule

The macro-economic closure rules selected for the purpose of the simulations in the FSP model or the economic environment under which the simulations are carried out is characterised by:

- The numeraire –the consumer price index (CPI) is the numeraire and it is fixed while domestic producer index (DPI) is flexible.
- Savings-investment – Investment driven savings – uniform marginal propensity to save (MPS) rate for selected institutions
- Government – Flexible government savings with fixed direct tax
- External or Rest of World – Flexible exchange rate with fixed savings
- Factor account/markets – Capital market – capital is activity-specific and fully employed; Labour market – labour is mobile and unemployed (fixed wages)

4. CGE Model Implementation and Results

As already indicated, this study analyses the impact of international oil price on the economy of FSP. Such an inquiry requires the quantification of the direction and magnitude of price and policy shocks associated withan increase in international oil price.

A simulation of an external price shock to the Free State economy has been prepared. An increase in the international oil price is simulated. The effects on labour, GDP and household are quantified.

4.1. Impact on Employment

As Table 1shows that the agriculture shares in total output is 4.51 % while other services (like electricity and water, construction, trade and accommodation; and community and social services) are 51.92 %. Manufacturing sector does not loss more jobs compared to other services.

Table 1. Relative impacts on employment of an increase of international oil price (21.2%)

Economic sector	% employment share in total production	% increase in labour demand after increase oil price
Agriculture	4.51	−1.2
Mining	0.27	7.49
Manufacturing	30.1	−6.25
Transport & communication	10.96	−0.15
Financial & business services	2.24	0.17
Other services	51.92	−0.89

Source: CGE simulation result

As a result of this external shock the percentage increase in labour observed in mining and financial service sector. The remaining sectors like transport, other services, agriculture, and manufacturing decrease, this implies that a tendency of losing job observed.

4.2. Impact on GDP

As a result of an increase of international oil price, the GDP of the overall economy decrease by 0.01%. The highest decrease observed in transport sector followed by other services, agriculture and manufacturing sector.

Table 2. Percentage of real GDP at factor cost by activity as a result of an increase of international oil price (21.2%)

Sectors	%
Agriculture	−0.89
Mining	4.03
Manufacturing	−2.84
Transport & communication	−0.06
Financial & business services	0.13
Other services	−0.47
TOTAL	−0.01

Source: CGE simulation result

4.3. Impact on Households

As Table 3 shows, the low-income households are more affected compared to the rest of household categories.

According to Gohin (2003), one of the main tasks of applied economists is the computation and explanation of the welfare effects of policy reform or other shocks to the economy that may be of interest. The effects of the simulated results on household welfare in the Free State can further be measured by the concept of Equivalent Variation (EV). EV is a welfare measure indicating the money equivalent the households are better (worse) off as a result of the shock/simulation.The lowest welfare gain observed in poor households.

Table 3. Impact on households' real income and welfare (EV) as a result of an increase of international oil price (21.2%)

Household Categories	Household income	EV
Low-income households	−0.41	2574.92
Low middle-income households	−0.62	10320.35
Middle-income households	−0.78	15690.39
High middle-income households	−0.88	13178.62
High-income households	−0.79	11936.93

Note: EV is in value terms R – (South African currency – Rand)
Source: CGE simulation result

5. Summary, Recommendations and Conclusion

This article has analysed the impact of international oil price increase on the economy of the Free State province using a general equilibrium model framework.

As a result of an increase in international oil price the percentage in labour demand of transport, other services, agriculture, and manufacturing sector decrease.

The GDP of the overall economy decrease by 0.01%, the highest decrease observed in transport sector followed by other services, agriculture and manufacturing sector. It also reflects that from the household income analysis the lower income households are more affected compared to the rest of household categories. Considering poverty (measured in terms of Equivalent Variation) the results also suggest that the lowest welfare gain observed in poor households.

Based on the results of this study the following recommendations are put forward. It is inevitable that there will always be some external shocks (an increase in international oil price) outside the control of economic policies. Hence it is necessary to strengthen the effectiveness of economic growth by incorporating target available resources and ensuring coherence in policy design. There is no one-size-fits-all approach and an appropriate policy mix should be found.

In conclusion, a CGE model is a useful tool for policy analysis. A CGE model has some limitations, in particular, a number of assumptions, including production technologies, product and factor market. Usually the model results are sensitive to various parameters. For this specific study, the critical parameters were obtained from literature. Then, if all the resources are available, it is advisable to calculate the exact parameters using different econometric methods.

CGE modelling, which requires extensive data in order to capture broad economic interdependency, still has a somewhat limited scope. Future research should include more advanced estimation techniques for the response parameters of the CGE model relying on historical data series and incorporating all CGE constraints at the outset and further research using a dynamic CGE model.

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