The economic benefits of shale gas extraction in the southern Karoo, South Africa

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Abstract

It has been said that the development of a shale gas industry could be a "game changer" for South Africa. However, despite this significant claim independent economic modelling shows that, on the contrary, the benefits to the local economy of the planned development will be quite small and that the major beneficiaries will be the owners (e.g. Shell, Falcon Oil and Gas, Bundu, etc.) of the extraction activities who predominantly reside outside of the development area. Accordingly, this paper provides a number of findings on the estimated economic impact of shale gas extraction—based on the application of an economy-wide impact modelling methodology—which should be of interest to both opponents and proponents of the shale gas industry. By including all possible results, such as the boost in public sector jobs and the analysis of the impact on the exchange rate and jobs in other sectors, this paper attempts to reveal more about the likely impact of shale gas extraction in the southern Karoo of South Africa.

Keywords

Energy Policy; Computable General Equilibrium Models; Shale Gas, Fracking

JEL Codes

Q32; Q43; D58; Q53

WORK-IN-PROGRESS-PLEASE DO NOT QUOTE OR CITE

1. Introduction

Companies are planning to explore and exploit the shale gas reserves of the southern Karoo of South Africa and, as elsewhere with shale gas projects, have encountered substantial local opposition. Various action groups and local communities have initiated lobbying and protest action. Proponents of shale gas emphasize the potential economic benefits, such as job creation and economic growth, associated with the development of this resource. Opponents emphasize the environmental risk associated with hydraulic fracturing (fracking) used to extract shale gas. The main environmental concern is water pollution and water is a particularly scarce resource in the Karoo. The Karoo is estimated to have 485 trillion cubic feet (tcf) in technically recoverable reserves (EIA, 2011). Vermeulen (2012) argues that further exploration is necessary to determine the true scale and commerciality of shale gas reserves. Exploration will provide a better understanding of the Karoo's geological and water configuration and the impact it will have on the fracturing process (Vermeulen, 2012).

The uncertainties surrounding the scale of economic benefits and environmental costs make fracking a contentious issue for public policy. The South African government initially imposed a moratorium on exploration pending a review of the fracking process. This moratorium has now been partially lifted, opening the Karoo for exploration activities, but not yet fracking (Department of Mineral Resources, 2012). If the Karoo's shale gas is to be extracted, efforts will need to go beyond exploration.

Many industry sponsored reports have attempted to quantify the benefits and to a lesser extent the environmental risks of shale gas extraction in the United States (US). Kinnaman (2011) provides an overview and critique of these studies. Regeneris Consulting (2011) prepared a similar industry sponsored report for Lancashire and the United Kingdom (UK). In their research note, Ames et al.

(2012) conducted a Cost Benefit Analysis (CBA) of shale gas for the US. They concluded that the economic benefits of shale gas exceed the costs (Ames et al*.,* 2012).

The only recent academic work (journal publication) on this topic is the study by Weber (2012), which estimated the gains to employment, labour compensation and household income associated with expanding gas production for Colorado, Texas and Wyoming in the US. Weber (2012) compared his employment impact results to the ex-ante predictions for developing the Fayetteville (CBER, 2008) and Marcellus (Considine et al*.,* 2010) shale gas reserves and concluded that the ex-ante predictions may have been overestimated.

No academic articles have yet evaluated the potential economic impact of exploiting the Karoo's shale gas reserves. At this stage, only ex-ante predictions of economic impacts are possible. However, a report entitled '*Karoo shale gas report: A special report on economic considerations surrounding potential shale gas resources in the southern Karoo of South Africa*' has recently been released by Econometrix (Econometrix, 2012). The report acknowledges the environmental concerns over fracking and the analysis is focused on the economic impact side of the debate. The report estimates macro-economic impacts for estimated gas finds, using a macro-economic framework, equating expanding gas production values to an injection of income into the South African economy (Econometrix, 2012).

This paper reviews the potential benefits and costs of developing shale gas resources, estimates the economy-wide impacts of developing the Karoo's shale gas and compares the results to that of the Econometrix Report. The aim of this paper is therefore to inform the policy debate surrounding shale gas and its potential benefits and costs.

2. Benefits and costs of shale gas development

2.1 Arguments for developing the shale gas industry

Logic suggests that the benefits of shale gas should outweigh the cost when pursing the development of shale gas reserves. The economic benefits of an expanding gas industry, enhanced by shale gas production, will depend on the gas/inter-industry linkages with other domains in the economy. Most notably, increased employment, income, government revenue and economic growth are expected. Furthermore, consumers can benefit from using shale gas as a source of energy (Kinnaman, 2011). This can create a positive spill-over effect by reducing the demand for more carbon intensive energy sources such as oil and coal (Kinnaman, 2011). Wang et al. (2011), considering the higher power generation efficiency of shale gas, conclude that over the long run shale gas has a lower carbon footprint than coal. The short run carbon footprint of shale gas can be reduced to a level similar to that of coal by using existing technology to minimise methane emissions (Wang et al., 2011). The environmental impact could be reduced even further by storing CO_2 emissions in depleted shale gas reservoirs (Wang et al., 2011).

The effects of a growing natural resource industry will vary based on the economic setting, the commodity in question and the time horizon being evaluated (Weber, 2012). The impact of gas extraction can occur during two periods, the development stage and the production stage. The development stage entails exploration and infrastructure investments whilst the production stage entails the production and distribution of gas. Depending on the petroleum fiscal system, revenues and taxes may accrue to government from the early stages of exploration or only (excise) once production has started.

Considine et al. (2009) estimated the economic impact of the Marchellus shale gas industry in Pennsylvania for 2008 and 2009. The study used an IMPLAN input-output model to estimate the multiplier impacts of shale gas extraction. The impact estimates for 2008, estimated an addition to value added of US$2.3 billion, the creation of more than 29,000 jobs and US$240 million in state and local taxes (Considine et al., 2009). The estimates for 2009 were US$3.8 billion for economic output, state and local taxes more than US$400 million and job creation in excess of 48,000 (Considine et al., 2009). Overoptimistic assumptions of spending behaviour and drilling activity call into question these results (Kinnaman, 2011). In a follow up study, Considine et al. (2010) estimated the following economic impacts for 2009, the impact on gross output was US$7.17 billion, the addition to value added was US$3.87 billion and the increase in employment was 44,098 jobs. The overoptimistic assumptions of the initial study are still present in the follow up study (Kinnaman, 2011). The CBER (2008) conducted a similar type of study for the extraction of the Fayetteville shale reserves in Arkansas. The estimated impacts for 2007 were an addition to gross output of US$2.6 billion and the creation of 9,533 jobs (CBER, 2008).

In contrast to the above mentioned ex-ante input-output studies, Weber (2012) conducted an ex-post assessment of an expanding gas sector in Colorado, Texas and Wyoming. The study estimates income and employment impacts, and further examines the distribution of these impacts in the local population (Weber, 2012). Increased income and employment impacts do not necessarily translate into reduced poverty rates (Weber, 2012). The distributional impacts depend on the existing level of skills, the existing income distribution, the structure of the local labour market, and the size of the spill-over effects for other sectors in the economy (Weber, 2012). Weber (2012) uses OLS and IV regression analyses to evaluate economic impacts over several years. The results suggest that boom counties, with a growing gas sector, experience higher growth in employment and labour income (Weber, 2012). The Marcellus et al. (2010) employment impact estimate of 44,098 far exceeds the ex-post value of 2,183 estimated by Weber (2012). The same is true when comparing the CBER (2008) study's employment estimates of 9,533 jobs to that of 1,377 jobs estimated in the ex-post analysis

(Weber, 2012). Although the ex-post impact results are smaller than that of the input-output studies, Weber (2012) regards these impacts as modest but still significant.

Regeneris Consulting (2011) estimated the employment impacts from shale gas extraction for Lancashire and the UK using three possible scenarios, a central case, a lower end case and a higher end case. The number of wells drilled and the pace with which drilling is completed are considered important determinants of the scale and nature of employment impacts (Regeneris Consulting, 2011). The analysis spans the period from 2013 to 2032.

Regeneris Consulting (2011) identify four key differences between the US and UK's shale gas industry. Firstly, the scale of the US's gas reserves is much greater than that of the UK. The large US reserves have attracted specialist service providers to specific shale plays whereas the UK may not attract the supply chain to specific plays to the same extent. Secondly are differences in geography, US shale plays like Marcellus in Pennsylvania, span over rural areas with a relatively small populations. For this reason, the commuting of personnel from other regions is hampered and suppliers have to set up a local base. Furthermore, the costs of connecting to the established gas and electricity networks are much higher. Thirdly are differences in drilling techniques. Due to geology, vertical and directional drilling is the norm in the UK whereas horizontal drilling is used in the US. For this reason, there will be differences in the time-scale and costs of drilling. Finally, there is a major difference in the payment of royalties. In the US, landowners own the mineral rights to minerals underneath their land and receive royalty payments, which supplement their income (Regeneris Consulting, 2011). In the UK, as in South Africa, mineral rights and royalties accrue to the government and not the landowners (Regeneris Consulting, 2011).

The estimated employment impacts arise from three processes; the main process (drilling and fracturing), the conversion process (spending to establish infrastructure for the distribution of shale gas or electricity from shale gas) and the maintenance process (costs for the maintenance of wells)

(Regeneris Consulting, 2011). The central case assumes that 190 wells are drilled over a six year period; the lower end case assumes that 400 wells are drilled over a nine year period and the high end case assumes that 810 wells are drilled over a sixteen year period (Regeneris Consulting, 2011). The central case estimated a peak annual employment impact of 5,600 jobs for the UK and 1,700 jobs for Lancashire (Regeneris Consulting, 2011). The lower end impact estimates show an annual peak of 3,400 jobs for the UK and 560 jobs for Lancashire (Regeneris Consulting, 2011). The higher end impact estimates are an annual peak of 6,550 jobs for the UK and 2,500 jobs for Lancashire (Regeneris Consulting, 2011).

Ames et al. (2012) conducted a rudimentary Cost Benefit Analysis (CBA) of shale gas extraction in the USA. Comparing the estimated costs and benefits, they conclude that the benefits exceed the costs to the community by 400-to-1 (Ames et al*.,* 2012). The benefits, in terms of consumer surplus, are estimated by using the price reduction in natural gas prices caused by the expansion of shale gas production. The environmental cost is estimated in terms of the clean-up costs of potential accidents. The result is highly dependent on the assumptions made to derive the benefits and costs. It is questionable whether these measures are an accurate reflection of all the costs and benefits arising from shale gas extraction.

The following section draws from the Econometrix Report (2012), referred to as the report. The report refers to the Marcellus and Lancashire studies and identifies a number of differences that hamper a comparison with the Karoo basin. The studies for the US and UK are based on past experience of developing shale gas whereas South Africa has no prior experience and extraction is still to take place. The US and UK already have the necessary downstream infrastructure in place whilst the South African gas network is fairly limited in terms of the overall energy mix. The US and UK have access to more detailed and publicly available data and an experienced and competitive upstream supplier base. Consumers in the US and UK are more familiar with and confident in gas than South African consumers. The Karoo basin is still to be explored, making specific estimates of production and labour requirements difficult. The report identifies six possible areas of application for natural gas in South Africa. They are: exporting gas, the use of gas as an energy source for domestic, commercial and industrial applications, power generation, creating automotive fuels and as an energy input in the fertiliser sector. The extent to which gas is exported will influence the scale of downstream value adding activities. The exploration phase is likely to use mostly imported capital equipment, with a shift to more local content as the process moves from exploration to production.

The report assumes shale gas production will start by 2020 and estimates the potential economic impact of developing the Karoo basin, over a 25 year period (2020-2045), using two possible scenarios. Scenario **A** assumes a recoverable reserve of 20tcf and scenario **B** assumes 50tcf. The model is calibrated to use constant 2010 prices. Both scenarios use a well head gas price of US$8/mcf, and apply the 2010 Rand/US Dollar exchange rate of R7.303/$ for the conversion to Rand values (Econometrix, 2012). Scenario **A** modelled a combined turnover (upstream and downstream) of R4.031 trillion, a total value added (contribution to GDP) of R2.006 trillion, a R887 billion contribution to government revenue and the maximum employment created is estimated at 355 817 jobs. Scenario **B** modelled a combined turnover (upstream and downstream) of R9.520 trillion, a total value added (contribution to GDP) of R5.015 trillion, a R2.223 trillion contribution to government revenue and the maximum employment created is estimated at 854,757 jobs. The extent to which gas is exported will have a significant effect on the estimated economic impacts. The possible impacts arising from a situation where 0% of gas is exported, where 50% of gas is exported and a 100% of gas is exported, are shown in Table 1 below.

Table 1

Summary of Econometrix Report impact model results.

Source: Econometrix, 2012.

	0% Gas Exports		50% Gas Exports		100% Gas Exports	
Combined upstream and downstream	**Scenario A**	**Scenario B**	**Scenario A**	**Scenario B**	**Scenario A**	**Scenario B**
Project turnover (Rand million)	4,031,773	9,520,268	3,069,827	7,115,402	2,107,881	4,710,537
Project value added (Rand million)	2,006,046	5,015,116	1,587,263	3,968,158	1,168,480	2,921,200
Project government revenue (Rand million)	886,808	2,223,494	705,894	1,771,208	524,979	1,318,922
Maximum employment (Number)	355,817	854,757	258,880	612,415	161,943	370,073

The impact estimates fall significantly as the share of gas exports increase (Econometrix, 2012). The case where 100% of the gas is exported will still be an improvement for the country's energy trade balance over the case of not producing shale gas. The estimated economic impact will vary with changes to the assumptions of resource size and the well head gas price. Fakir (2012) critiques the use a of single value well head price and suggests the use of a range of possible prices incorporating the unique characteristics of South Africa's current gas market. Changing cost conditions will also have a significant effect on the estimated impacts.

2.2 The case against developing the shale gas industry

The main argument against developing shale gas is the possible negative externalities. These include the deterioration of roads associated with the increased traffic of heavy trucks and equipment, possible health problems in the local population and environmental pollution (Weber, 2012). Surprisingly little (and by no means comprehensive) analysis has been undertaken in the Econometrix Report to quantify the success or failure of countries or regions in effectively and safely managing natural gas development. Without such information, it is very difficult for regulators, government officials, and citizens to engage in productive dialogue around natural gas development and the process of hydraulic fracturing (Considine et al., 2012). Whether considering regulatory changes in a province where development is already under way, or debating the permitting of natural gas development where it has not yet occurred, quantifying measurements of success are necessary for building consensus and making sound decisions.

Nor does the Econometrix Report provide any exhaustive analysis of the potential environmental impacts (or associated costs) of shale gas extraction. The only topic of relevance covered is the implications for water resources and its possible constraint on the shale gas extraction activity. Although this is a major concern and also one of the most contentious aspects of hydraulic fracturing (especially in the dryer, semi-dessert areas of South Africa, i.e. the southern Karoo), there are numerous other environmental factors that also need consideration. Some of these (environmental) issues concern air pollution (from methane emissions and production operations), land use, and fracturing fluid composition and reporting (Bluestein et al., 2012).

On the issue of land use, an unavoidable impact of shale gas extraction is a high land occupation due to drilling pads, parking and manoeuvring areas for trucks, equipment, gas processing and transporting facilities as well as access roads (Lechtenböhmer et al., 2011). Other possible impacts include air emissions of pollutants, groundwater contamination due to uncontrolled gas or fluid flows due to blowouts or spills, leaking fracturing fluid, and uncontrolled waste water discharge (Lechtenböhmer et al., 2011). Fracturing fluids contain hazardous substances, and flow-back in addition contains heavy metals and radioactive materials from the deposit (Bluestein et al., 2012).

Experience from the US shows that many accidents happen during extraction, which can be harmful to the environment and to human health. The recorded violations of legal requirements amount to about 1-2 % of all drilling permits. Many of these accidents are due to improper handling or leaking equipment (Lechtenböhmer et al., 2011). Furthermore, groundwater contamination by methane, in extreme cases leading to explosion of residential buildings, and potassium chloride leading to salinization of drinking water has been reported in the vicinity of gas wells. The impacts add up as shale formations are developed with a high well density of up to six well pads per km^2 (Lechtenböhmer et al., 2011).

All these (environmental) issues need to be understood and considered if government bodies are to successfully augment current and draft potential regulations to safely regulate the new industry. In this regard, there are demonstrated measures available to mitigate the potential environmental effects of shale gas extraction (Lechtenböhmer et al., 2011).

Regarding the contamination of groundwater, a recent study by Davies et al. (2012) has found that the technique to extract unconventional gas can be done safely. According to their research, fracking has well below a 1% chance of causing unintended cracks in the ground beyond 600 meters. The study used data from hundreds of both natural fractures and fracking operations in Europe and the United States and shows that if operations are kept at an adequate distance from aquifers that there is virtually no chance of groundwater contamination. The research also found that the chance of unintentional fractures forming 350 meters from the sight was about 1%. However, in South Africa, the depths of the gas bearing shale rock layers range between 4 000 meters and 6 000 meters (Naidoo, 2012). This is much deeper than the depths at which shale gas is extracted in the United States.

This brief discussion attempts to stress the environmentally risky aspects of shale gas extraction and the level of waste products that are generated and point to the significant potential for environmental damage to land along with contamination of groundwater aquifers used by the agriculture sector and rural communities. For a more complete picture a balanced economic analysis should address the costs associated with shale gas extraction and disposal of potentially harmful elements. If these are fully captured then the level of negative benefits generated from shale gas extraction might be significantly higher as they will include significant reductions to agricultural sector capacity from the likely scale of environmental degradation. Perhaps the rising controversy over shale gas extraction is in part due to lax environmental impact assessments, as demonstrated by the Econometrix Report.

3. Broader economic implications

In the preceding sections we discussed the different methodologies and findings of several studies each attempting to quantify the potential impact of fracking on the South African economy. Our approach is to apply an economy-wide modelling methodology in the form of an Applied (Computable) General Equilibrium (CGE) model for South Africa to the shale gas question.

Based on a select literature review, CGE models emerge as the most appropriate tool to perform these types of analyses, and have been shown elsewhere to be particularly suitable for use in modelling energy-related issues. Bhattacharyya (1996) provides an overview of CGE models that have been applied to improve the understanding of energy policy implications in various countries such as Australia, Sweden, Norway, Belgium, the United States, the Philippines and various applications to the global economy over the period 1974 to 1993. Subsequently many more such models have been developed and applied since 1993 on topics ranging from carbon emission tax policies (e.g. Sulamaa and Pohjola, 1995) to analysing the impact of stimulus to energy efficiency on the economy and environment (e.g. Hanley et al., 2006).

In South Africa, CGE models have been used with increasing frequency since first applied in the country by Naudé and Brixen (1993). Initially CGE models in South Africa were mainly used to analyse trade issues (e.g. Coetzee et al., 1997; Naudé and Coetzee, 2004; Naudé and Rossouw, 2008) and later to study labour market issues, environmental impacts, the impact of HIV/AIDS and fiscal issues, amongst others (see e.g. Arndt and Lewis, 2000). Energy issues however, have not yet been a major area of focus in the growing application of CGE's. At the time of writing there have been but few formal studies into energy issues using a CGE model in South Africa namely by Altman et al. (2008), Cameron and Naudé (2008), Van Heerden et al. (2006) and De Wet and Van Heerden (2003). Our search was not exhaustive and we are aware that after the 2008 crisis energy issues have started receiving a lot more focus.

For interpretation and discussion, CGE models have a number of general features that make them suitable for this analysis (Arndt et al., 2008):

- The models simulate the functioning of a market economy, including markets for labour, capital, and commodities, and provide a useful perspective on how changes in economic conditions will likely be mediated through prices and markets.
- The structural nature of CGE models permits consideration of new phenomena, such as fracking.
- They assure that all economy-wide constraints are respected. Fracking is expected to generate significant foreign exchange earnings (savings in the case of fuel import substitution), use large quantities of land, and demand substantial quantities of labour. In this context, it is important to consider the balance of payments, the supply of land, and the supply of labour.
- Because they can be fairly disaggregated, CGE models can provide an economic simulation environment for examining how different factors and channels of impact will affect the performance and structure of the economy, how they will interact, and which are (quantitatively) the most important.
- CGE models provide a theoretically clean framework for welfare and distributional analysis.

According to Arndt et al. (2008) economic decision-making in CGE models is the outcome of decentralised optimising by producers and consumers within a coherent economy-wide framework.

A variety of substitution mechanisms are specified including substitution among labour types, between capital and labour, between imports and domestic goods, and between exports and domestic sales all occurring in response to variations in relative prices. Institutional rigidities and imperfect markets can be captured by the exogenous imposition of features such as immobile sectoral capital stocks, labour market segmentation, and home consumption, which permit the more realistic application of this class of model to developing countries.

Experience with this class of models also highlights some disadvantages. An economy-wide approach is not well suited for the analysis of all issues. In striving to develop a comprehensive picture of the entire economy, some detail is necessarily suppressed. If detail highly relevant to the analytical question at hand has been suppressed, the approach is obviously poorly suited (Arndt et al., 2008). Similarly, some issues can be adequately addressed with economic frameworks that are less comprehensive allowing the analyst to spend more time on analysis and less time on data issues and modelling.

Due to the potential scale of fracking and the upstream and downstream implications across the economy, the CGE approach was adopted.

3.1 Our South African CGE model

The model applied here in the simulations undertaken comprises 32 activities/commodities, 6 household types and 4 ethnic groups. Five factors of production are identified (i.e. three types of labour [unskilled, semi-skilled and skilled], land, and factor capital). This detail captures the structure of the South African economy and substantially influences the model results. Hence, because shale gas extracted through fracking will either be exported or will replace fuel imports, substantial increases in shale gas production will have implications for foreign exchange availability and hence trade. Due to expanded foreign exchange availability, South Africa will have the capacity to import more and to reduce exports of other products (besides shale gas). As a result, one might expect sectors with high trade shares (either a large share of production exported or a high degree of import competition) to be more strongly affected than sectors that are non-traded. Basic structural features of the South African economy as encapsulated in the CGE model applied are presented in Table 2.

The current definition for the shale gas sector as contained in the model equations and database includes the broad SIC[1] division 2 – Other mining and quarrying. Hence, the "*other mining*" sector in Table 2 includes the activity: the extraction of crude petroleum /natural gas, and incidental service activities (SIC22), which captures the value and impact of the fracking activity in the South African economy. For the purposes of analysing the effects of changes to the shale gas sector the ideal would have been to further refine the model and database to isolate the "*extraction of crude petroleum and natural gas, including service activities*" sector (SIC221) from the other sectors. However, due to time and resource constraints this was not attempted for the purposes of this paper. An approximation approach was used based on the Supply and Use tables (StatsSA, 2006) to scale shocks and results with the relative contribution of the products SP12 – other mining and quarrying (containing SIC2210, SIC2511, SIC2512, SIC2519, SIC2520, SIC2531, SIC2532, and SIC2539).

Table 2

Structure of the South African economy in 2006 (based on a 2006 SAM for South Africa).

Source: Conningarth Consultants, 2006.

	Share of total (%)				Export intensity (%)	Import penetration (%)
	GDP	Employment	Exports	Imports		
Total GDP	100.0	100.0	100.0	100.0	17.6	16.7
Agriculture	3.6	2.6	2.8	1.8	2.1	1.0
Mining	6.1	7.1	28.1	22.9	6.4	2.7
Gold mining	*1.9*	*3.2*	*11.0*	*13.2*	*0.0*	*0.0*
Other mining	*4.1*	*3.9*	*17.1*	*9.7*	*6.4*	*2.7*
Manufacturing	34.8	25.0	55.5	67.2	85.0	91.8
Chemicals	*6.6*	*3.5*	*10.5*	*3.7*	*12.3*	*3.3*
Machinery	*1.7*	*1.7*	*5.1*	*6.9*	*15.7*	*15.8*
Other manufacturing	*26.5*	*19.8*	*39.9*	*56.6*	*57.0*	*72.7*
Other industries	31.7	34.7	5.7	6.3	6.3	4.5
Private services	18.5	16.6	5.2	0.7	0.0	0.0
Government services	5.4	14.0	2.7	1.2	0.3	0.1

Note: ‘Export intensity’ is the share of exports in domestic output, and ‘import penetration’ is the share of import in total domestic demand.

Within the existing structure and subject to macro-economic constraints, producers in the South African CGE model maximise profits under constant returns to scale, with the choice between factors governed by a constant elasticity of substitution (CES) function. Factors are then combined with fixed-share intermediates using a Leontief specification. Under profit maximisation, factors receive income where marginal revenue equals marginal cost based on endogenous relative prices (Van Heerden et al., 2006).

Substitution possibilities exist between production for domestic and foreign markets. This decision of producers is governed by a constant elasticity of transformation (CET) function which distinguishes between exported and domestic goods, which then captures any time or quality differences between the two products. Profit maximisation drives producers to sell in those markets where they can achieve the highest returns, which are based on domestic and export prices (Arndt et al., 2008).

Further substitution possibilities exist between imported and domestic goods under a CES Armington specification. Such substitution can take place both in final and intermediates usage. These elasticities vary across sectors, with lower elasticities reflecting greater differences between domestic and imported goods.

The model distinguishes between various institutions, including enterprises, the government, and ten representative household groups. Households are disaggregated across four different race groups and 6 different national income quintiles. Households and enterprises receive income in payment for producers' use of their factors of production. Both institutions pay direct taxes to government (based on fixed tax rates), save (based on marginal propensities to save), and make transfers to the rest of the world. Enterprises pay their remaining income to households in the form of dividends (Arndt et al., 2008). Households, unlike enterprises, use their income to consume commodities under a linear expenditure system (LES) of demand.

In the model government receives income from imposing activity, sales and direct taxes and import tariffs, and then makes transfers to households, enterprises and the rest of the world. The government also purchases commodities in the form of government consumption expenditure, and the remaining income of government is (dis)saved.

The CGE model is calibrated to a 2006 SAM for South Africa (Conningarth Consultants, 2006), which was constructed using information from national accounts, trade and tax data, and household income and expenditure data from the 2006 General Household Survey (GHS). Armington elasticities for the South African manufacturing sector are taken from the Naudé et al. (1999). The model is calibrated so that the initial equilibrium reproduces the base-year values from the SAM.

The CGE model applied in this paper is a basic single-period "static" CGE model for South Africa. Since fracking investment will, even under the most optimistic scenarios, unfold over a dozen years or more, the model must be capable of moving forward and looking at growth trajectories. For this a dynamic model is required. Such a model was not available to the authors at the time of conducting the research and accordingly it should be kept in kind that the model results represent a once-off effect over time and not a period-on period change as with a dynamic model.

3.2 Scenarios: closure rules and assumptions

The concept of 'closure rules' refers to the way in which the number of endogenous variables in a model is set equal to the number of equations of the model in order to ensure that there will be a mathematical solution to the system of equations (or model) (Robinson, 1991; Whalley and Yeung, 1984). Different closures for the same model will change the model's quantitative characteristics, and it is therefore important to apply the correct closure depending on the specific question being analysed (Bandara, 1991:17).

The general closure assumptions for short-run comparative-static simulations conducted are:

- the numeraire is the world average price of all goods;
- capital stock is assumed fixed in each industry;
- no relative change in government consumption expenditure is assumed;
- slack labour markets for all labour categories are assumed;
- average real wages are kept constant – so wage rates adjust with inflation;
- household consumption moves with disposable income for all households; and
- the industrial structure of private investment responds to changes in relative rates of return.

In the short-run closure applied for this analysis, wages do not adjust in the labour market. It is assumed that real wage is fixed and total investment, total consumption and total government demand are also assumed to be fixed. Compared to the standard closure (Horridge *et.al.* 1993), real household consumption 'x3tot' is exogenous instead of total nominal supernumerary household expenditure 'w3lux'. This implies that the aggregate level of household consumption is fixed. Aggregate real investment expenditure 'x2tot_i' is exogenous instead of the economy-wide rate of return 'invslack'. This means that the level of investment is fixed. Aggregate real government demands 'x5tot' is exogenous instead of shift parameter 'f5tot2'. Consequently, net export is the only demand changing endogenously.

As with any attempt to simplify and quantify real world processes and actions with a mathematical representation, one has to make a host of assumptions. This is captured by the well-known broad assumption *ceterus paribus*. Therefore this implies some of the following (non-exhaustive) more detailed assumptions below:

- Assumption of no mitigation: No short-term change in the production technology of mining for these sectors is effected to mitigate the impacts of the lower consumption of electricity.
- Assumption of no international market demand changes as a result of changes in output (especially of commodities such as gold, platinum, etc.)

To attempt to give apply a similar analysis as conducted in the Econometrix Report, similar shocks were calculated and applied using the South African CGE model. The two test scenarios modelled for the purposes of this study include:

- Scenario 1 with an assumed resource size of 20tcf.
- Scenario 2 with an assumed resource size of 50tcf.

The U.S. EIA report (EIA, 2011) on shale gas resources outside of the U.S. estimates South Africa's production at 115Bcf during 2008. This value was used to translate the above two scenarios into percentage change shocks to be applied in the model. This gave annualised percentage increases of 23.8 (20tcf) and 65.6 (50tcf) for the two scenarios respectively.

As mentioned previously, as a work-around to the issue of not having a 'pure' shale gas sector definition in the model, we applied the ratio of the Supply and Use tables of SP12 – other mining and quarrying (containing SIC2210, SIC2511, SIC2512, SIC2519, SIC2520, SIC2531, SIC2532, and SIC2539). In addition, it should also be noted that although the two fracking scenarios are implemented over one year the impact is simulated as a once-off event that plays itself out over a period of about 25 years (i.e. to be comparable with the results from the Econometrix Report). The results are then annualised and the impact can therefore be discounted back to reflect annual adjustments over the one-year period. This was calculated at 31 per cent for shale gas extraction. In order to calculate the relevant shock for the increase in production output of the composite "*other mining*" sector, based on the fact that the model is in linear form, we therefore applied these ratios to the shock.

Consequently, for scenario 1, a 20tcf increase for the shale gas production output share of the composite sector would translate to an overall composite sector shock of **19.2** per cent. For scenario 2, a 50tcf increase for the shale gas production output share of the composite sector would translate to an overall composite sector shock of **52.9** per cent.

4. South Africa-wide macro-economic impacts

For the purpose of this study we model only the impact of the potential increase in shale gas production of 19.2% and 52.9% for the extraction of crude petroleum /natural gas, and incidental service activities sector (SIC22) represented by model sector 3 (Other mining and quarrying).

The national level impacts of the simulations are presented in Table 3. This analysis mainly focuses on two variables, that of overall economic output measured by Gross Domestic Product (GDP) and employment. The results are presented in annualised percentage change format.

Table 3

Macro-economic implications (% change).

Source: Authors' model calculations * Exogenous by assumption.

Annualised % Change	Scenario 1 Resource size of 20tcf	Scenario 2 Resource size of 50tcf
Gross Domestic Product (GDP)	2.01	8.59
Employment	0.65	2.18
Average Real Wage Rate*	0.00	0.00
Domestic Consumption*	0.00	0.00
Consumer Price Index	0.05	0.20
Government Consumption*	0.00	0.00
Exports (Volume Index FOB)	5.67	24.99
Export Price Index	-1.37	-5.42
Imports (Volume Index CIF)	-0.41	-1.32
Import Price Index*	0.00	0.00
Balance of Trade (% of GDP)	0.01	0.06
Terms of Trade	2.01	8.59
Real Exchange Rate (Depr/Appr)	0.44	1.88

The cause-effect logic of the simulation would be that as a result of the fact that the shale gas sector increases its output relative to the base case, other sectors increase sales / production output as a result of the up-and down-stream linkages, as well as consumer demand escalations due to induced employment gains. For sectors such as mining (3), chemicals (14), base metals (18), electricity (24) and transport services (29) the impact is more significant than other sectors, with relatively larger implications for employment in these sectors (refer to Tables 4 and 5). The services sectors are less impacted.

In general the effect is relatively small and for scenario 1 at 2.01 per cent higher GDP and 0.65 per cent higher for employment, compared to the base case in a comparative static fashion (for a review of the interpretation of these types of comparative static results refer to Horridge *et. al.* 1993:77). Similar results are obtained for scenario 2, with the results being much more positive when compared to scenario 1..

For more context, if we translate this in terms of GDP growth and constant 2005 GDP monetary value it would yield approximately R38.1 billion relative to 2011 real GDP[2] for South Africa (R 1,895.7 billion x 2.01/100). In terms of forward looking growth this can be interpreted that if South Africa targets 3 per cent growth for a given year, the impact of this scenario would result in the economy realising 5 per cent growth. In terms of the employment context (non-agricultural sector employment) this would translate into approximately 54,464 employment positions gained for South Africa[3] (8,379,000 x 0.65/100). For scenario 2, using the same reasoning, we get a R162.8 billion increase relative to 2011 real GDP and approximately 182,662 employment positions gained.

The result is that production volumes increase while prices need to adjust downwards to compensate. The price decrease implies an expansion of exports so that the equality between the given world prices and the marginal costs of export supplies is restored in all industries. Domestic supply will also increase because the prices of domestic products relative to the import prices decrease (imported prices assumed constant) and import volumes will decrease as a result. Total production therefore increases and is propagated through the inter-industry input-output linkages. Overall domestic consumption is assumed fixed (but will change on income group level) and the resulting general domestic price increase that needs to take place to achieve equilibrium is approximately 0.05 per cent, while the imported price index stays constant as South Africa is assumed to be a price taker in the international market. Import volumes now decrease at 0.41 per cent as a result of the South African economy's lower import propensity.

Since producers are assumed to maximise profits, employment gain is the result of increased outputs combined with sticky (and even decreasing) wage rates (average real wages assumed fixed). The employment gain in turn leads to a higher wage bill being paid to labour, with the resulting feedback of increasing household income. Similar positive results can be found for scenario 2, however to a much larger extent.

Given the macro-economic results, the impact of fracking seems to be overwhelmingly positive. However, if one delves deeper into the detailed results, especially at the micro-economic level, a different picture comes to light. The micro/industry/sector level results for the two scenarios modelled can are captured in Tables 4 and 5.

Table 4

Sectoral results – Scenario 1.

Source: Authors' model calculations * Exogenous by assumption

		Value Added		Exports		Imports		Employment	
	Sector Annualized % Change	**Volume**	**Price**	**Volume**	**Price (LCU)**	**Volume**	**Price (FCU)**	**Volume**	**Nominal Wage**
1	Agriculture, forestry, fishing and hunting	0.00	0.00	-0.03	0.01	0.00	0.00	-0.02	0.05
2	Mining of gold and uranium ore	-0.05	-0.04	0.20	-0.05	-0.07	0.00	-0.07	0.05
3	Other mining and quarrying	27.14	-7.18	33.43	-6.96	-7.84	0.00	7.80	0.05
4	Food processing & products	-0.02	0.03	-0.16	0.04	0.06	0.00	-0.04	0.05
5	Beverages processing & products	0.01	0.04	-0.18	0.05	0.12	0.00	0.02	0.05
6	Tobacco processing & products	0.01	0.04	-0.16	0.04	0.08	0.00	0.02	0.05
7	Textiles goods	-0.03	0.02	-0.12	0.03	0.04	0.00	-0.03	0.05
8	Clothing goods	-0.06	0.05	-0.22	0.06	0.17	0.00	-0.07	0.05
9	Leather goods	-0.06	0.02	-0.11	0.03	0.05	0.00	-0.10	0.05
10	Footwear goods	-0.02	0.03	-0.15	0.04	0.12	0.00	-0.03	0.05
11	Wood and wood products	-0.01	0.04	-0.21	0.05	0.17	0.00	-0.02	0.05
12	Paper and paper products	0.04	0.02	-0.09	0.02	0.12	0.00	0.09	0.05
13	Printing & publishing	0.02	0.06	-0.30	0.08	0.16	0.00	0.04	0.05
14	Basic chemicals	0.64	-0.27	1.07	-0.27	0.06	0.00	1.64	0.05
15	Rubber products	0.15	0.05	-0.23	0.06	0.50	0.00	0.30	0.05
16	Plastic products	0.18	0.00	-0.07	0.02	0.25	0.00	0.23	0.05
17	Non-metallic minerals	0.33	-0.25	0.98	-0.24	-0.40	0.00	0.66	0.05
18	Base metal products	0.78	-0.26	1.00	-0.25	-0.18	0.00	1.70	0.05
19	Fabricated metal products	0.17	0.00	-0.02	0.01	0.20	0.00	0.28	0.05
20	Machinery and apparatus	0.00	0.02	-0.10	0.02	0.11	0.00	0.00	0.05
21	Electric, electronic, medical & other appliances	0.01	0.00	-0.04	0.01	0.04	0.00	0.02	0.05
22	Transport equipment	-0.08	0.03	-0.16	0.04	0.09	0.00	-0.12	0.05
23	Furniture and other items NEC and recycling	0.12	-0.06	0.18	-0.05	-0.02	0.00	0.41	0.05
24	Electricity, gas, steam and hot water supply	0.27	0.01	0.00	0.00	0.00	0.00	0.90	0.05
25	Construction	0.01	-0.07	0.00	0.00	0.00	0.00	0.02	0.05
26	Construction services, civil engineering	-0.36	-0.19	0.89	-0.22	0.00	0.00	-0.63	0.05
27	Trade services	0.25	0.14	-0.60	0.15	0.00	0.00	0.47	0.05
28	Catering & accommodation	-0.01	0.02	-0.10	0.03	0.15	0.00	-0.05	0.05
29	Transport services	0.73	0.33	-1.30	0.33	0.70	0.00	1.61	0.05
30	Post and telecommunication	0.06	0.11	-0.44	0.11	0.00	0.00	0.15	0.05
31	Finance and insurance services	0.03	0.09	-0.40	0.10	0.00	0.00	0.10	0.05
32	Community services	0.07	0.05	-0.23	0.06	0.25	0.00	0.08	0.05

Table 5

Sectoral results – Scenario 2.

Source: Authors' model calculations * Exogenous by assumption

		Value Added		Exports		Imports		Employment	
	Sector Annualized % Change	Volume	Price	Volume	Price (LCU)	Volume	Price (FCU)	Volume	Nominal Wage
1	Agriculture, forestry, fishing and hunting	-0.02	-0.03	-0.09	0.02	-0.03	0.00	-0.08	0.20
2	Mining of gold and uranium ore	-0.20	-0.19	0.96	-0.24	-0.45	0.00	-0.31	0.20
3	Other mining and quarrying	126.85	-21.98	160.39	-21.28	-24.74	0.00	25.13	0.20
4	Food processing & products	-0.08	0.12	-0.59	0.15	0.21	0.00	-0.15	0.20
5	Beverages processing & products	0.01	0.16	-0.67	0.17	0.42	0.00	0.05	0.20
6	Tobacco processing & products	0.01	0.16	-0.62	0.16	0.30	0.00	0.05	0.20
7	Textiles goods	-0.15	0.09	-0.49	0.12	0.10	0.00	-0.19	0.20
8	Clothing goods	-0.25	0.19	-0.87	0.22	0.63	0.00	-0.29	0.20
9	Leather goods	-0.29	0.08	-0.44	0.11	0.15	0.00	-0.46	0.20
10	Footwear goods	-0.10	0.12	-0.57	0.14	0.39	0.00	-0.17	0.20
11	Wood and wood products	-0.12	0.16	-0.77	0.19	0.54	0.00	-0.15	0.20
12	Paper and paper products	0.11	0.07	-0.41	0.10	0.42	0.00	0.24	0.20
13	Printing & publishing	0.08	0.22	-1.14	0.29	0.60	0.00	0.12	0.20
14	Basic chemicals	2.11	-0.88	3.56	-0.87	0.17	0.00	5.44	0.20
15	Rubber products	0.41	0.16	-0.79	0.20	1.49	0.00	0.84	0.20
16	Plastic products	0.54	0.03	-0.34	0.08	0.78	0.00	0.68	0.20
17	Non-metallic minerals	1.00	-0.84	3.31	-0.81	-1.50	0.00	1.98	0.20
18	Base metal products	2.55	-0.87	3.37	-0.82	-0.70	0.00	5.62	0.20
19	Fabricated metal products	0.46	-0.01	-0.08	0.02	0.54	0.00	0.74	0.20
20	Machinery and apparatus	-0.08	0.07	-0.38	0.10	0.31	0.00	-0.12	0.20
21	Electric, electronic, medical & other appliances	0.00	0.02	-0.18	0.04	0.11	0.00	0.00	0.20
22	Transport equipment	-0.33	0.14	-0.63	0.16	0.33	0.00	-0.49	0.20
23	Furniture and other items NEC and recycling	0.37	-0.18	0.58	-0.14	-0.06	0.00	1.29	0.20
24	Electricity, gas, steam and hot water supply	0.82	-0.07	0.00	0.00	0.00	0.00	2.74	0.20
25	Construction	0.04	-0.23	0.00	0.00	0.00	0.00	0.06	0.20
26	Construction services, civil engineering	-1.75	-0.74	3.66	-0.90	0.00	0.00	-3.10	0.20
27	Trade services	0.95	0.55	-2.26	0.57	0.00	0.00	1.80	0.20
28	Catering & accommodation	-0.06	0.08	-0.33	0.08	0.54	0.00	-0.24	0.20
29	Transport services	2.81	1.27	-4.88	1.26	2.29	0.00	6.22	0.20
30	Post and telecommunication	0.23	0.39	-1.64	0.42	0.00	0.00	0.52	0.20
31	Finance and insurance services	0.10	0.33	-1.43	0.36	0.00	0.00	0.31	0.20
32	Community services	0.16	0.19	-0.86	0.22	0.77	0.00	0.19	0.20

We present some sectoral outcomes in Tables 4 and 5. Although many sectors are positively impacted, several, including the agriculture (1) and mining industries (2), several manufacturing industries (4, 7-11, 20 & 22), civil engineering (26) and catering and accommodation services (28) experience a negative impact across the numerous measures. Employment losses range from 0.08% to 3.1% for these sectors.

Tables 6 to 9 present the distributional results of the two scenarios modelled in terms of changes in real household consumption and the corresponding changes in household-specific consumption-price indices.

Table 6

Scenario 1 – Distributional results – real household consumption.

Source: Authors' model calculations

Real Household Consumption	**Population Group**				
Income Group	**White**	**Coloured**	**Asian**	**Black**	**Average**
q1	0.05	0.05	0.06	0.05	0.05
q2	0.05	0.05	0.06	0.04	0.05
q3	0.05	0.05	0.06	0.04	0.05
q4	0.06	0.05	0.06	0.04	0.06
d9	0.06	0.05	0.06	0.05	0.06
d10	0.06	0.06	0.06	0.06	0.06
Average	0.05	0.05	0.06	0.05	0.05

Table 7

Scenario 1 – Distributional results – household-specific consumption-price indexes.

Source: Authors' model calculations

Household Consumption-price Index	**Population Group**				
Income Group	**White**	**Coloured**	**Asian**	**Black**	**Average**
q1	0.00	-0.24	-0.33	0.09	0.00
q2	0.00	-0.24	-0.32	0.09	0.00
q3	-0.01	-0.24	-0.32	0.09	-0.01
q4	-0.01	-0.24	-0.32	0.09	-0.01
d9	-0.01	-0.24	-0.32	0.09	-0.01
d10	-0.02	-0.24	-0.32	0.08	-0.02
Average	-0.01	-0.24	-0.32	0.09	-0.01

For scenario 1, the benefits from the fracking activity in terms of household consumption seem to be fairly evenly distributed across all income groups as well as all race groups. In terms of prices faced by households, the changes are once again relatively small between the various income groups, but with the greatest benefits being enjoyed by the Coloured and Asian race groups.

Table 8

Scenario 2 – Distributional results – real household consumption.

Source: Authors' model calculations

Real Household Consumption	Population Group				
Income Group	**White**	**Coloured**	**Asian**	**Black**	**Average**
q1	0.17	0.19	0.24	0.19	0.17
q2	0.18	0.20	0.23	0.18	0.18
q3	0.20	0.19	0.22	0.17	0.20
q4	0.22	0.19	0.21	0.17	0.22
d9	0.22	0.20	0.21	0.18	0.22
d10	0.23	0.22	0.22	0.22	0.23
Average	0.20	0.20	0.22	0.19	0.20

Table 9

Scenario 2 – Distributional results – household-specific consumption-price indexes.

Source: Authors' model calculations

Household Consumption-price Index	Population Group				
Income Group	**White**	**Coloured**	**Asian**	**Black**	**Average**
q1	0.03	-0.76	-1.03	0.26	0.03
q2	0.02	-0.77	-1.01	0.27	0.02
q3	0.00	-0.76	-1.00	0.28	0.00
q4	-0.02	-0.76	-1.00	0.28	-0.02
d9	-0.02	-0.77	-1.00	0.27	-0.02
d10	-0.03	-0.79	-1.01	0.23	-0.03
Average	0.00	-0.77	-1.01	0.26	0.00

For scenario 2, the results in terms of household consumption seem to be slightly more differentiated across the various income groups as well as race groups. Similar results to scenario 1 can be seen for price changes, with the exception of Black households now paying more for consumption across all income groups. This is to be expected as employment in the many of the mining and manufacturing sectors are most adversely affected.

These outcomes for GDP and employment compare well with the outcomes obtained in the Econometrix Report. For the Econometrix (2012) **A** scenario (with an assumed resource size of 20tcf) the outcome obtained was an average annual GDP contribution equivalent to 2.8% and 0.98% (equivalent to an employment level of 355,817) for employment. For scenario **B** (with an assumed resource size of 50tcf) the outcome obtained was an average annual GDP contribution equivalent to 9.6% and 6.5% (equivalent to an employment level of 854,757) for employment (Econometrix, 2012:67-68). Although the impact for both scenarios obtained in this analysis was relatively less positive (2.01% and 8.59% annualised increase in real GDP for scenario 1 and 2 respectively; 0.65% and 2.18% respectively for employment) one must keep in mind that we make very different and conservative assumptions. What is interesting from the CGE analyses is that the knock-on effect of the increase in production activities in the shale gas sector has potentially much wider-ranging impacts across the various economic systems as illustrated by the two scenarios modelled.

5. Summary results

The CGE model results would suggest that fracking may provide South Africa with an opportunity to substantially enhance economic growth and poverty reduction. However, if one delves deeper into the results it becomes clear that large scale growth of shale gas production unavoidably imposes adjustments on other sectors due to competition for labour and due to the implications of increased foreign exchange availability for the real exchange rate. In relative terms, traditional exports shrink in both scenarios in order to make space for shale gas. Consumer prices increase slightly with imports decreasing in both scenarios. Overall, while welfare broadly increases due to enhanced purchasing power, certain households may be negatively affected due to the price and quantity adjustments associated with rapid growth in shale gas production.

The results further suggest that careful attention should be paid to the labour intensity of production methods employed for fracking. The model results indicate that the degree of labour intensity has the potential to strongly influence the distribution of income.

Whilst CGE models are ideally suited to answer counterfactual and economy-wide type of questions on the impacts of fracking, we do need to recognise that they also suffer from a number of shortcomings. Besides some topic specific shortcomings, CGE models also have two major generic shortcomings namely that CGE modelling relies on debatable assumptions such as perfectly competitive markets and constant returns to scale, and depends on the quality of data and parameter values, which can be variable (see also Bandara, 1991:29-31).

Some of the shortcomings specific to this study include: first, water usage is not considered explicitly in the model; second, the model does not consider the potential spillovers to other exporting sectors due to the transport and other infrastructure that shale gas production will require (e.g., the potential "crowding in"); finally, other methods for mitigating downside price risk for shale gas, such as generation of electricity and identification of potential substitutes for shale gas, should be considered.

In summary, and based on the results of both the literature review and CGE modelling exercise, the following benefits (pro-fracking) can be listed:

- An alternative source of energy for power generation – estimated using willingness to pay for gas; extrapolating from market data);

- A cleaner form of energy; and
- Possible spillover effects in the form of reduced demand for coal and oil for electricity generation.

On the other hand, some of the costs (anti-fracking) include:

- Considering the timing of extraction (i.e. present or future – future generations)
- Shift of resources (in a fully employed economy) from other sectors to be used as inputs for shale gas production;
- Nuisance, noise and loss of privacy to owners of property in the southern Karoo; and
- Potential irreversible damages to the natural environment.

6. Conclusion

At this stage it is only possible to conduct an ex-ante impact assessment based on estimated reserves and well head prices. The partial removal of the fracking moratorium should produce more detailed data on the actual reserves in the Karoo basin. Once more data is available, a comprehensive Cost Benefit Analysis (CBA) should be conducted to compare the benefits and costs of developing this resource. In the interim, the potential negative externalities of fracking cannot be ignored and any discussion of potential benefits must incorporate these factors.

It has been said that the development of a shale gas industry could be a "game changer" for South Africa. However, any attempt to quantify these "once-in-a-generation economic opportunities" should be subjected to close scrutiny by any and all interested parties. It is hard to overcome the suspicion that privately commissioned reports make a number of systematically generous assumptions with little consideration of likely adverse impacts. Such an approach naturally results in an estimate of strong net benefits when such a study should have perhaps found the opposite, given the number of uncertainties and unquantifiable negative impacts on an economy. The extent of any potential risks to the environment and the industries that rely on it, especially agriculture, cannot be ignored and need to receive just as much attention as the potential economic benefits.

Finally, it is also undeniable that, as both the South African population and economy continue to grow, the nation's energy demands will similarly increase. In the pursuit to find adequate environmentally friendly and sustainable energy sources all benefits and costs need to be weighed and measured before any decision with regards to its use can be made. In the case of fracking, all its advantages are accompanied by some really consequential disadvantages. A substantial amount of research and debate has to go into determining whether fracking is a suitable energy option for South Africa. It is a debate that is far from being decided.

Footnotes

1) Standard Industrial Classification (SIC) of all Economic Activities, Fifth Edition, Statistics South Africa (Stats SA), January 1993 (Report No. 09-90-02).

2) Source of data: South African Reserve Bank online statistics at www.resbank.co.za.

3) Source: Statistics South Africa. P0277 – Quarterly Employment Statistics, March 2012.

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