The effects of licensing and tax policy on the development of the upstream oil and gas sector: the case of South Africa

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1. Introduction

Developing regions such as Africa rely on Foreign Direct Investment (FDI) and knowledge to successfully develop their upstream oil and gas sectors. The upstream sector consists of the exploration for and production of oil and gas. Host governments are in competition to attract the necessary upstream investment (Tordo, 2007:1). Host countries must now consider the range of new technologies that have an impact on potential reserves, the commerciality of extracting these reserves and ultimately a higher level of competition (AIP, 2010). The licensing of exploration acreage, and the specific petroleum fiscal system, are two crucial policy elements that impact on the development and sustainability of a country‘s upstream sector. Licensing controls the allocation of exploration and development rights for a specific area to the investing oil company. The effective management of licensing and marketing upstream acreage is an important aspect of attracting upstream investment. Furthermore, the petroleum fiscal system is an aspect that host governments can directly control, as opposed to the level and type (quality) of oil reserves that the country holds. The design of a country‘s petroleum fiscal system can play a significant role in shaping how investors perceive the competitiveness of a potential hydrocarbon region, thus either attracting or deterring upstream investment. A number of studies has attempted to compare and evaluate the competitiveness of petroleum fiscal systems between countries by using some variant measure of government take (the government’s share of oil revenues expressed as a percentage).

The aim of this study is to evaluate South Africa’s current upstream licensing and tax policy by using the industry literature and the policies of competing oil producers in Africa. Rather than using the standard approach of model oil fields to directly compare different measures of government take, an economy-wide impact modelling methodology (computable general equilibrium or CGE) is used to estimate and compare the economic impact of using the current South African fiscal system as opposed to the systems used by competitor countries such as Namibia, Mozambique, Uganda and Tanzania. The majority of South Africa’s upstream sector is still focused on exploration activity to find commercially viable reserves. Recent years have seen significant developments in offshore exploration activities along the South African coastline. In terms of onshore development, there is also the possibility of significant shale gas reserves from the Karoo basin. The South African economy could greatly benefit from further developing the upstream sector to a stage where significant production can be achieved. However, the proposed Mineral Resource Amendment Bill in South Africa may create significant distortions and divert exploration investment to regions with more attractive fiscal and licensing regimes.

The first section of the study presents the literature on licensing and petroleum fiscal systems, as well as previous studies that compare fiscal systems between countries. The second section provides a brief overview of the petroleum fiscal systems in South Africa and the

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competitor countries included in the empirical analysis. The third section identifies the theory underlying CGE modelling and presents the empirical results. The final section includes the research conclusions and policy recommendations.

2. Licensing, petroleum taxation and the 'comparative' literature

2.1. Licensing

Tordo (2007:3-4) identifies the following stages in the life cycle of an upstream oil project: licensing, exploration, development, appraisal, production and finally abandonment. Licensing is the granting of exploration and development rights for a specific area to an oil company; the host government retains the ownership of the mineral resource. The process of exploration, development and production can only begin once the relevant rights have been allocated to competent operators. Considering the crucial role of oil in the global economy, the presence of significant oil reserves can hold numerous economic and developmental opportunities for a country (Tordo, Johnston and Johnston, 2010:2-3). For this reason, information on a country's possible reserves holds value to society. Host governments should aim to maximise the efficiency of exploration and production and accordingly the associated economic rent and benefit to society. This is a major factor to consider when designing the policy framework for allocating exploration and production rights. An efficient allocation system will favour the selection of efficient operators while ensuring low compliance and administrative costs.

The various systems used to assign exploration and development rights can be grouped into two categories, namely open-door systems (negotiations) or licensing rounds (administrative procedures or auctions) (Tordo, Johnston and Johnston, 2010:12). An open-door system can assign these rights through an informal process of first-come-first-serve, while licensing rounds use either auctions or a formal process such as beauty contests, where companies compete by submitting exploration and development plans (Crampton, 2007:114; Crampton, 2010:289; Inkpen and Moffett, 2011:102).

Internationally, the use of an independent licensing agency is regarded as the best practice for attracting and marketing upstream acreage (Clark 2013; Van Gessel 2012). Countries that use independent licensing agencies include Mozambique, Sao Tome, Principe, Mali, Algeria, Brazil, Colombia and currently South Africa (Clark, 2013). The Petroleum Agency of South Africa (PASA) is currently tasked with licensing South Africa's upstream acreage. Should the proposed Mineral and Petroleum Resources Amendment Act (MPRDA) Amendment Bill be passed in its current form, PASA will be abolished and South Africa will no longer have independent licensing. The functions of PASA will be delegated to regional managers within the Department of Mineral Resources. PASA currently provides a single point of entry to potential investors interested in upstream exploration. Under a system of regional managers, investors interested in acreage spanning multiple regions will have to submit multiple licence applications to the relevant regional managers, increasing the administrative burden.

2.2. Petroleum taxation

The use of a separate fiscal system for the oil industry is largely based upon the special role of economic rent in the production of oil (Baunsgaard, 2001:5). The basic premise of petroleum taxation is to retrieve for the host government, as owner of the resource, a fair share of the economic rent generated by the extraction of oil resources (Nakhle, 2008:5). Johnston (1994:6) defines economic rent in the oil industry as the difference between the value of production and extraction costs. The costs of extraction include factor costs as well as their opportunity costs (Nakhle, 2008:16-17). Accordingly, economic rent is the surplus return above the value of factor inputs used to produce the resource. Inputs accounted for include capital, labour, entrepreneurial profit and risk taking. The exploitation of oil resources involves high investment costs with the potential for very large rewards or losses (Daniel, Keen, and McPherson, 2010a). Host governments need to attract investment (capital) to transform oil resources into productive capacity (Goldsworthy & Zakharova, 2010:6). To achieve this goal, the host government should ensure that investors receive a return on investment that is in line with the associated risk. The distribution of rewards between the host governments that control access to oil resources and the investors who discover and exploit these resources is determined by petroleum taxation (Daniel, Keen, and McPherson, 2010a).

The different combinations of taxation and non-taxation instruments used to capture economic rent are controlled or organised by a country‘s petroleum fiscal system. A petroleum fiscal system is the legal tax structure for a country, including royalty payments (Johnston, 1994: 302). This term encompasses all contractual and fiscal elements that define the relationship between a host government and foreign oil company. There are two main types of petroleum fiscal systems, namely royalty/tax (concessionary) systems and contractual based systems. The main distinction between the two systems is the question of ownership (Johnston, 2003:10-11). A royalty/tax (concessionary) system assigns the title of the crude oil that is produced to the oil company, which has to pay royalties and taxes on production. Contractual systems assign ownership of the oil to the host government. A contractual system will either be a production sharing contract/agreement (PSCs / PSAs) or a service contract (Mazeel, 2010:8-9). The difference between these two arrangements is how the International Oil Company (IOC) is compensated, which could be in cash or in kind (oil). A PSC gives the IOC a share of production (compensation in oil) and a service agreement gives the IOC a share of the profits (compensation in cash).

All exploration and production agreements, regardless of being concessionary or contractual systems, include certain additional components such as signature bonuses, market obligations’ investment uplifts, and stabilisation clauses (Inkpen & Moffett, 2011:228). IOCs commonly make upfront payments, known as signature bonuses, to the host government as part of the fiscal agreement. These bonuses are intended to motivate investors to speed up the exploration, development and production processes in order to recoup their capital expenditure on bonuses.

The fiscal terms of a concessionary system can be replicated by a PSC and vice versa, hence there is no fundamental reason to prefer the one system to the other (Sunley, Baunsgaard, and Simard, 2002:9). The two systems are compared in Table 1 below.

Table 1: Comparing concessionary and PSC systems

Concessionary (royalty/tax) systems	Production Sharing
Royalty	There may be an explicit royalty, or there may be a limit on cost oil[1] that functions as an implicit royalty
Income tax	Income tax, which may be paid out of the government's share of production
Resource rent tax	The determination of the amount of profit oil[2] can mimic a resource rent tax

Source: Adapted from Sunley, Baunsgaard, & Simard (2002:9)

There is not a one-size fits all fiscal system that is suitable for all countries or projects because countries differ in terms of upstream costs, the size and quality of reserves and the perceptions of commercial and political risk held by potential investors (Sunley, Baunsgaard, & Simard, 2002:18). However, there are certain desirable features to pursue when designing a petroleum fiscal system. A country's petroleum fiscal system can attract investment by using a framework that is clear and not subject to retroactive changes (Tordo, 2007:1). An efficient system will promote the development of a country's upstream sector by inducing efficient exploration and development by IOCs, while ensuring a fair share for the host government. Johnston (2003:149-150) provides a number of criteria for an effective petroleum fiscal system. Such a system should provide a stable business environment, deter undue speculation, minimise sovereign risk, provide a balance between risk and reward to provide potential for a fair return to both the host government and investors, minimise complexity and administrative burdens, incorporate flexibility for changing economic conditions and finally promote competition and market efficiency. Land (1995) identifies a number of criteria to appraise fiscal systems for governments who want to maximise their revenue over the long term. These criteria include economic efficiency, the minimisation of both investor risk and government revenue risk and finally the ease of implementing the system. Demirmen (2010) identifies four characteristics of a so-called win-win petroleum fiscal system. Such a system will promote exploration activities, encourage the development of both small and large oil reserves, provide incentives for areas that are difficult to explore and difficult to develop and finally provide an equitable distribution of economic benefits between the host government and IOC. Goldsworthy and Zakharova (2010:6-7) highlight a number of fiscal objectives attributed to a desirable fiscal system. These objectives include neutrality, rent capture, stability and timing of revenue, progressivity and adaptability, administrative simplicity and enforceability and finally international competitiveness. The IMF (2012) suggests a combination of a modest ad valorem royalty, Corporate Income Tax (CIT) and a Resource Rent Tax (RRT) as an appealing option for Lower Income Countries (LICs). The royalty will generate revenue upon production, CIT will tax the normal return to equity and the RRT will capture the distinct revenue potential of the sector.

In addition to the above-mentioned instruments, host governments may prefer to be more directly involved in upstream projects by taking state equity in a project (Baunsgaard, 2001:13). The main motivation would be to share in the possible up-side of projects but there could be non-economic reasons such as attaining skills and knowledge transfers, to increase the sense of ownership or to simply gain more direct control of project development.

2.3. Comparative petroleum fiscal system studies

The division of profit between the host government and the investor is measured by the contractor and government take respectively (Johnston, 1994:9). These measures are expressed as percentages and can be a useful measure to compare one fiscal system to another. Various studies have attempted to compare the use of different petroleum fiscal systems within and between countries, using different measures of government take to deduce the comparative competitiveness or attractiveness of these systems.

Isehunwa and Ifeoma (2011) evaluated the impact on government take from using a sliding scale royalty rather than a fixed royalty for both JVA and PSC systems in Nigeria. The government take under a sliding royalty compared favourably with that of a fixed royalty. Zahidi (2010) compares petroleum fiscal systems across Pakistan, Thailand, Turkey, Cameroon and the DRC using government take statistics. Dongkun and Na (2010) analyse and rank fiscal systems using government take, discounted government take, a Front-Loading Index (FLI), and a Composite Score (CS) index which combines the government take and FLI mausures using a linear weighting method. Front-loading refers to the extent of early payments to government, before any profits have been generated. Mmakwe and Ajienka (2009) compare JVA and PSC frameworks in Nigeria. They conclude that the JVA arrangement is more facourable for the host government, while IOCs would prefer the PSC. Van Meurs (2008) evaluates the impact of fiscal systems on government take and concludes that the type of petroleum fiscal system is not as important as the detailed design and structure of the system. Employing optimal fiscal design could maximise the government share using either concessions or PSCs. Blake and Roberts (2006) compare the petroleum fiscal systems for five regions under conditions of oil price uncertainty. The regions compared are: Alberta Canada (tax/royalty), Papua New Guinea (pre-2003 Rate of Return or ROR system), Sao Tome and Principe/Nigerian Joint Development Zone (SNJDZ) (PSC), Tanzania (PSC/ROR hybrid) and finally Trinidad and Tobago (PSC). They use contingent claims analysis to value the governments' tax claims under uncertainty using Monte Carlo simulation. The systems are ranked based on the after-tax value due to IOCs and the extent of distortions created by the fiscal system. The Alberta and Papua New Guinea systems are ranked highest in terms of after-tax returns while creating the least distortions. The SNJDZ (PSC) system has a high tax burden for IOCs but with median distortionary effects. The Trinidad and Tobago (PSC) holds a median tax burden for companies but has strong distortionary effects. The Tanzania system scored the lowest ranking with both low after-tax returns and high distortionary effects. Iledare (2004) uses a hypothetical oil field, a discounted cash flow model and government take to measure the impact of two different fiscal arrangements on exploration, production and government take. The study compares a PSC system to a Joint Venture Arrangement (JVA – concession with government participation) for Nigeria. The study concludes that if the government aims to maximise wealth for society, direct government participation might not be the best option. However, a move from JVA to PSC would also not necessarily lead to wealth maximisation.

Rapp, Litvak, Kokolis and Wang (1999) compare the standard government take measure with a discounted government take as a tool to apraise the fiscal component of upstream investment decisions. The discounted government take incorporates the timing of payments to governments as well as the timing of revenues and costs and should be preferred above the standard take measure. Rutledge and Wright (1998) analysed the distribution of rewards between the government and IOCs in the United Kingdom Continental Shelf (UKCS) and compared the system to that of Norway. They found that IOCs enjoyed higher profitability than those operating in other oil provinces around the world and recommended the reform of the UKCS fiscal system. Abdo (2010) also analysed the UK regime and the relaxation of tax terms over time, which failed to increase the government take. The World Bank (1995) ranked global fiscal systems on various economic yardsticks, including the rate of return, net present value, government take and geological risk. The study found that regions disconnected from other regions and that countries in the same region had similar fiscal terms. The average fiscal system was found to be regressive and front-end-loaded (government take is higher in the first six years of production and lower during the rest of the period).

3. Selected petroleum fiscal systems

South Africa's upstream is in the early stage of development and mainly focused on exploration for commercially viable reserves. Namibia, Mozambique, Uganda and Tanzania are also in the early stages but with significant discoveries and some are already producing or are in the process of moving to production. For this reason, these countries were selected for comparison with South Africa's current fiscal regime. The selected petroleum fiscal systems are summarised in Table 2 below.

Table 2: Characteristics of selected petroleum fiscal systems

Country	Royalties	Production sharing[3]	Income tax rate	Resource rent tax	State equity[4]
Mozambique	10% (oil), 6% (gas)	**R Factor based (P)** 10%-60% (State) 90%-40% (Contractor)	32% (25% holiday 1st 8 years)	None	Yes, through ENH (National Hydrocarbon Corporation)
Namibia	5%	None	35%	APT (Formula)	None. However, companies may offer interest to NAM COR (National Petroleum Corporation of Namibia)
S outh Africa	0.5-5% (EBIT)	None	28%	None	10% through PetroSA (C)
Tanzania	12.5% (of gross production) (in kind)	**Production (V)** **Oil:** 70%-90% (State) 30%-10% (Contractor) **Gas:** 60%-85% (State) 40%-15% (Contractor)	30% (25% local listed)	25%-35% rr Additional Profit Tax (APT Formula)	20% (C) TPDC (Tanzania Petroleum Development Corporation)
Uganda	5%-12.5% incremental(fo r oil production of 0-7500 bpd) in kind or Cash	**Production (V)** 40%-65% (State) 60%-35% (Contractor) (For production of 0-40 000 bpd)	30%	0-80% ror	15% (20% block4B)

Source: Adapted from Sunley, Baunsgaard & Simard (2002:15), Ernst & Young (2012) and Palantir (2013).

In the case of a hypothetical, but realistic, natural resource find (i.e. oil and/or gas), the development and international competitiveness of South Africa's oil and gas extraction industry will mainly be cost driven. Along with capital, labour, energy and material inputs, the supply of the natural resource input has to be cost competitive if South Africa is to receive net benefits from developing potential domestic oil and gas resources (Chitiga et al., 2010). The alternative of importing primary oil and gas products to meet refinery requirements and/or importing refined product to ultimately satisfy consumer needs would be economically efficient if South Africa did not have a comparative advantage in the production of any domestic oil and gas resources.

In the next section, we use a computable general equilibrium (CGE) model of South Africa, described in Van Heerden et al. (2006) and Van *Heerden et al.* (2008) respectively, to analyse the potential impact on the South African economy of various oil and gas resource tax scenarios. The idea is not to explicitly model the *timing* of the developments (exploration and discovery, followed by investment and ramp up) or the *development* itself, but instead to analyse a static, short- and long-term set of scenarios that estimate the associated fiscal policies that might accompany such developments. More specifically, a fiscal system (i.e. consisting of different combinations of royalties, income rate tax, resource rent tax and production sharing) similar to the fiscal systems of each of the four countries (other than South Africa) in Table 2, will be modelled. Thus, each scenario will represent the fiscal system of each country applied to the South African economy and compared to the current (or base case) South African fiscal system. In general equilibrium models, each industry is linked to the rest of the economy through backward and forward physical flows of and corresponding payments for goods and services on competitive markets. Simulation results are presented after the model is described in the following section.

4. Modelling approach

4.1. The CGE model

As we are interested in the economy-wide impacts, and in particular the upstream impacts of the local crude oil, petroleum and gas sector's latent tax policies at the macro and meso/sector levels, the most appropriate modelling tool is a computable general equilibrium (CGE) model. A CGE model is an economy-wide model that includes feedback between demand, income and production structure, and where all prices adjust until decisions made in production are consistent with decisions made in demand (Dervis et al., 1985:132). The model is applied (or computed) using economy-wide consistent data on a particular economy as is normally contained in a Social Accounting Matrix (SAM). In the present case we use the most recent published SAM for South Africa (i.e. the official 1998 SAM) published by Statistics South Africa (SSA, 2001). Other parameters, in particular expenditure elasticities, are obtained from outside the model (typically from econometric studies or by making plausible guesstimates) (Van Heerden et al., 2008).

The CGE model provides a simulation laboratory for doing controlled experiments on the South African economy, changing parameters and exogenous variables and computing the impact of those changes on the economy. The results of these experiments provide information about the empirical magnitudes of such impacts, linking them to changes in the economic environment and/or particular policy instruments. The use of simulation models to do counterfactual experiments is very useful for policy analysis, allowing the analyst to isolate the impact of particular policy changes or exogenous shocks (Chemingui and Lofgren, 2004).

In this paper we use a South African adaptation of ORANI-G to solve the model. It is known as the UPGEM (University of Pretoria General Equilibrium Model) and was developed for South Africa by the University of Pretoria (see e.g. www.monash.edu.au/policy/oranig.htm for a list of all the country models that have been built in the ORANI-G style). The specific version of the UPGEM model used in these simulations distinguishes 39 sectors (6 additional agricultural and 6 additional energy related sectors were added to the original 27 economic sectors in the official 1998 SAM—see Van Heerden et al. (2006)), 12 household/income types and 4 ethnic groups (Van Heerden et al., 2008). For a more detailed exposition of the modelling approach followed in UPGEM, see Horridge (2002); and for a detailed exposition on the energy specifications of the UPGEM, as well as for recent applications of the model to environmental issues in South Africa, see Van Heerden et al. (2006) and Van Heerden et al. (2008).

4.2. The CGE equations

The main equations used in the UPGEM are derived from the constrained optimisation of neo-classical production and utility functions. Producers choose inputs to minimise the costs of a given output, subject to non- increasing returns to scale industry functions. Consumers are assumed to choose their purchases in order to maximise utility functions subject to budget constraints. Production factors are paid according to their marginal productivity (Van Heerden et al., 2008).

At the equilibrium level the UPGEM's solutions provide a set of prices that clears all commodity and factor markets and makes all individual agents' optimisations feasible and mutually consistent. The behavioural equations of the model are augmented by sets of equations showing the flows of income in the economy as well as sets of equations defining an economic equilibrium in each market as the point where supply equals demand (Van Heerden *et al.*, 2008). Equilibrium is reached through adjustments in prices and/or quantities.

In terms of demand for intermediate inputs, producers are allowed to substitute between domestic and imported intermediate commodities based on relative price changes in the domestic and imported commodities (Horridge, 2002). The producers need to minimise,

$$\sum_{m} P_m X_m \quad (m = 1,2,3) \quad (1)$$

subject to the production function,

$$z = \left(\sum_{m} \delta_m [X_m]^{-\rho}\right)^{-1/\rho} \quad (m = 1,2,3) \quad (2)$$

where σ in,

$$\sigma = \frac{1}{1+\rho} \quad (3)$$

is an elasticity of substitution between domestic and imported commodities for use in intermediate production. In terms of total industry output, it is assumed that producers use the intermediate inputs and primary factors in fixed proportions to produce any given output (standard input-output assumption). This implies that producers cannot substitute primary factors for intermediate inputs to increase production. However, allowance is made for the more efficient use of intermediate inputs due to technological changes (Horridge, 2002). Total output is derived from a Leontief production function, which is a special case of the CES production function, where (see equation 3) is set to 0.

As a part of the focus of this paper is on government income, some comments on the modelling of expenditure and income in the UPGEM may be appropriate. Government expenditure is treated as fixed in real terms. Exogenous shocks can be applied to government expenditure (total and structure) in order to evaluate changes in expenditure patterns. Government income is specified in terms of indirect taxes, corporate taxes, personal income taxes, customs and excise taxes levied and subsidies paid (Horridge, 2002).

4.3. The crude oil, petroleum and gas sector in the UPGEM (i.e. the base case)

The Crude Oil, Petroleum and Gas sector (CruPetGas) in the UPGEM database is represented by an industry that produces crude oil, petroleum and gas for domestic use only. The cost structure of the industry is important for the results and is shown in Table 3. The industry pays most of its revenues to intermediates, thus the service providers (e.g. engineering, mining, etc.), who assist in the extraction activity of the natural resources, receive most of the revenues from the extraction. Approximately 19% of revenues go the labour (both skilled and unskilled), 18% to capital and 8% to land. One can think of the payments to land in the database as being the profits of the extraction that go to the owners of the mining licence. Some more features regarding the crude oil, petroleum and gas sector, as captured in the UPGEM database, are detailed in Table 3.

Table 3: Crude oil, petroleum and gas industry structure in 1998

Input	S hare (%)	Comment
Land	7.7	Includes gross margin
Capital	17.9	
Skilled labour	12.6	Technicians, professional workers, operators, etc.
Unskilled labour	6.7	Elementary, domestic & unspecified workers
Intermediates	46.9	Engineering, mining services
Imported intermediates	6.2	Industrial machinery
M argins	1.5	Trade/Transport
Indirect/Production taxes	0.5	Excludes royalties

Source: Complied using the UPGEM database.

In the current UPGEM database it is not possible to distinguish between the different shares of royalties, income tax and state equity that make up the 0.5% in Table 3. Thus, the aggregate tax rate figure will be split according to the shares specified for South Africa in Table 2 (i.e. a maximum rate of 5% for royalties, 28% for income tax and 0% for resource rent tax).

The structure of the South African economy, in terms of sectoral contribution derived from the UPGEM database, is listed in Table 4. In terms of GDP, it is seen that the general government is the biggest contributor (at 11.7%). The crude oil, petroleum and gas industry contributed 0.3% to sectoral output in 1998 (the SAM used is based on 1998 prices, but the same methodology could easily be applied to the latest figures for the industry) and ranks 35th out of the 39 sectors in the database.

According to the UPGEM, imports of crude oil, petroleum and gas products were estimated to be R1,467 million. This represented roughly 3.3% of total imports in South Africa for the year 1998 (Table 4, column 5). South Africa also had a positive trade balance and recorded a surplus of R12,867 million on its balance of payments (BoP) in 1998. The surplus on the BoP corresponded to 6.8% of exports and 0.2% of GDP. The coverage ratio (ratio of total exports to total imports) is estimated to be 1.69.

Table 4: Structure of the South African economy in 1998

	Share of total (%)				Export intensity	Import penetration
	GDP	Employment	Exports	Imports	(%)	(%)
Total GDP	*100*	*100*	*100*	*100*	*13.4*	*7.9*
Irrigated field	0.2	0.1	0.5	0.3	31.5	10.5
Dry field	0.7	0.2	1.7	1.0	31.8	10.6
Irrigated horticulture	0.6	0.4	1.6	0.4	36.8	5.1
Dry horticulture	0.2	0.1	0.4	0.1	36.3	5.1
Livestock	1.1	0.6	0.0	0.2	0.0	1.3
Forestry	0.3	0.4	0.1	0.7	4.9	18.1
Other Agriculture	0.4	0.3	0.0	0.4	0.0	7.1
Coal	1.4	1.0	5.3	0.4	52.0	2.3
Gold	2.1	3.0	14.7	0.0	92.8	0.0
Crude, petroleum & gas	0.3	0.2	0.0	3.3	0.0	82.1
Other mining	2.2	1.8	16.0	10.3	99.3	37.7
Food	6.6	2.7	5.1	4.2	10.5	5.1
T extiles	1.7	1.6	2.0	2.0	16.4	9.7
Footwear	0.2	0.2	0.1	0.2	6.0	9.9
Chemicals & rubber	4.1	2.7	5.7	7.9	18.6	15.2
Petroleum refineries	2.6	0.9	3.7	10.0	19.3	31.0
Other non-metal minerals	0.9	0.7	0.8	1.8	11.6	15.4
Iron & steel	1.6	0.8	9.9	12.0	85.0	60.8
Non-ferrous metal	0.9	0.3	5.6	5.7	83.6	50.0
Other metal products	1.9	1.6	1.3	3.8	9.1	15.7
Other machinery	2.4	2.0	2.1	2.6	12.0	8.7
Electricity machinery	0.9	0.5	1.0	2.6	15.1	22.6
Radio	0.5	0.4	0.9	5.6	24.7	94.6
T ransport equip	3.1	1.8	4.7	8.7	20.1	22.1
Wood, paper & pulp	3.2	1.9	4.9	6.8	20.7	17.1
Other manufacturing	1.2	1.0	2.9	1.0	32.8	6.9
Electricity	2.1	1.8	0.2	0.0	1.6	0.0
Water	0.6	0.2	0.0	0.0	0.0	0.1
Construction	5.2	3.6	0.0	0.1	0.1	0.1
T rade	10.1	11.1	0.1	0.1	0.1	0.1
Hotels	1.6	1.0	1.7	0.8	13.7	3.8
T ransport services	5.5	5.5	3.4	3.1	8.3	4.6

Community services	2.8	2.7	0.6	1.2	3.2	3.6
Financial Institutions	7.4	6.7	1.9	0.8	3.4	0.8
Real estate	4.4	0.8	0.0	0.1	0.1	0.2
Business activities	2.6	3.8	0.4	1.1	1.9	3.3
General government	11.7	28.0	0.0	0.0	0.0	0.0
Health services	1.8	1.6	0.1	0.0	0.6	0.1
Other service activities	3.0	6.0	0.4	0.7	1.6	1.9

Source: Compiled using the UPGEM database

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

South Africa also has a well-developed synthetic fuels industry facilitated by the country's abundance of coal resources and offshore natural gas (Chitiga *et al*., 2010). These permit South Africa to meet 35 to 40% of its domestic liquid petroleum requirements while 14% is exported. Thus, the country presented a coverage ratio of oil and oil products of 0.8 in 1998, which is relatively high for a net oil-importing country (Chitiga *et al*., 2010).

4.4. Specification of the economic environment

In the UPGEM, South Africa is assumed to be a small country in which both foreign currency import prices and prices for South African exports are largely determined on world markets. The model also requires an assumption about the macroeconomic environment in which the fiscal system(s) of the oil and gas extraction industry is to be simulated. Results are presented below for both a short-run and long-run economic environment. There are assumed to be significant rigidities in the economy in the short -run, but the economy adjusts fully to the shock in the long run.

To implement the simulation a number of further assump tions were made which related to the closure of the model. An in-depth discussion on the closure of CGE models can be found in Horridge (2000). See also Van Heerden et al. (2006) and Van Heerden et al. (2008) for a discussion on the short- and long-run closures specific to the UPGEM.

In the present case the first set of simulations were done using a short-run comparative static closure for the model. This implies that the impact reflects the change in a short period of time (approx. two to three years) before investment can react to the changed market conditions. Herein, land, the rate of return on capital, employment, trade balance, technology variables and the real wage (realwage), amongst others, are taken as exogenous. On the income side of GDP we have real wage and capital exogenous (and real cost of labour) and nominal rate of return on capital to adjust. On the expenditure side of GDP we have aggregate investment, government consumption and inventories as exogenous, while consumption and the trade balance are left to adjust. This gives us insight into the effect of the suggested policies on South Africa's consumption and competitiveness.

All technological change variables and all tax rates are exogenous in the closure. Exogenising tax rates allow the change and testing of different tax policies. The model differentiates between 11 different labour groups. Each of these can be classified as either skilled or unskilled. Fixed supply of highly skilled and skilled labour in the short run is assumed, but perfectly elastic unskilled labour supply. This assumption reflects the South African labour market realistically and allows for testing the effect of certain policies on the levels of employment of unskilled labour. Finally, the nominal exchange rate is set to be the numeraire in each of the simulations.

Some key features of the long-run economic environment are:

- labour remains mobile between industries but aggregate employment is assumed to be fixed and real wages adjust to changes in economic conditions;
- Industry capital stocks vary to equalise rates of returns across industries that are determined on world financial markets; and
- Private consumption adjusts to changes in permanent income, and the financing of capital expansions requires increased domestic saving.

All results represent deviations from the values that the variables would have taken in the absence of the simulation shocks. All prices in both models are expressed relative to the consumer price index. The nominal exchange rate has been adjusted in the results to represent units of foreign currency per South African Rand. Hence, a real exchange rate appreciation is indicated by a positive number.

4.5. Policy scenarios

The base case scenario representing the current crude oil, petroleum and gas industry fiscal system for South Africa is compared to a number of policy scenarios representing levels similar to the fiscal systems of each of the four countries (other than South Africa) specified in Table 2.

Scenarios 2 to 5 will represent the fiscal system of each other country applied to the South African economy and compared to the current (or base case) South African fiscal system (i.e. Scenario 1). (Please note that, due to the complexity of implementing production sharing in the current UPGEM model, this tax option is not included in any of the scenarios. Accordingly, the policy scenarios that are simulated with the UPGEM are described in Table 5.)

Table 5: Details of simulations

Simulation	Description
Scenario 1: Production increase (PIC)	A 20% increase in crude oil, petroleum and gas production under the current South African petroleum fiscal system as captured in the UPGEM . The current fiscal system is set at a maximum rate of 5% for royalties, 28% for income tax and 0% for resource rent tax.
Scenario 2: Mozambique fiscal system (M FS)	Royalties set at 16% (this is modelled as an annual production tax on the industry —that is essentially a tax on the firm‘s profits, additional to the ordinary indirect taxes levied by the government), thus an 11% increase in the current rate; income tax set at 32%; thus a 4% increase in the current rate; and resource rent tax at 0% (the same as in Scenario 1).
Scenario 3: Namibia fiscal system (NFS)	Royalties set at 5% (the same as in Scenario 1); income tax set at 35%; a 7% increase in the current rate; and resource rent tax at 30% (up 30% from 0%).
Scenario 4: Tanzania fiscal system (TFS)	Royalties set at 12.5%, a 7.5% increase in the current rate; income tax set at 30%; a 2% increase in the current rate; and resource rent tax at 30% (up 30% from 0%).
Scenario 5: Uganda fiscal system (UFS)	Royalties set at a maximum of 12.5%, a 7.5% increase in the current rate; income tax set at 30%; a 2% increase in the current rate; and resource rent tax at a maximum of 80% (up 80% from 0%).

Source: Compiled by authors

Note: Scenarios 2-5 will include Scenario 1, but under different fiscal systems (as mentioned earlier).

All results presented in the next section are in the form of percentage changes from the base case scenario. The economy-wide simulation results presented from the UPGEM analysis generally serve to highlight the extent to which the subsectors of the crude oil, petroleum and gas sector are interconnected and further illustrate how the sector is connected with the rest of the economy. It should be noted, however, that the simulation results should be interpreted as being indicative of the actual impact of increased taxation in the crude oil, petroleum and gas sector on the South African economy.

5. Modelling results

The macroeconomic results for the UPGEM simulations based on Scenarios 1-5 are given in Table 6. As simulated in the UPGEM, the first column for both the short- and long-run results in Table 6 corresponds to a 20% increase in production from the crude oil, petroleum and gas industry. In the second, third, fourth and fifth columns the results of the different taxation scenarios are reported.

5.1. Short- and long-run macro-economic simulation results

The key macroeconomic simulation results derived from the UPGEM for the tax and production shocks to the crude oil, petroleum and gas sector, given in Table 6, are summarised and briefly discussed as follows. In general, results are discussed for Scenarios 2 to 5. Reference is made to Scenarios 1 and 6 where results are noteworthy.

5.1.1. Real gross domestic product

A 20% short- or long-run increase in production in the crude oil, petroleum and gas extraction sector (Scenario 1), increases real national gross domestic product (GDP) by 0.15% in the short run and decreases GDP by 0.12% in the long run in the UPGEM model. In the short run, for scenarios 2-5, real gross domestic product is increased by between 0.15 and 0.19% as a result of a 20% increase in crude oil, petroleum and gas output (the greatest increase is experienced under the Ugandan tax system scenario). The long-run impact on output of a 20% rise, alongside the different tax regimes, is a decrease in GDP of between 0.03 and 0.12%.

The reasons for the decrease in real GDP in the long run are that the increased taxes cause prices to rise, which causes wage rates to rise, increasing production costs, which reduces export demands, and makes imports more attractive. Moreover, government tax revenue increases, but if this is not handed back, purchasing power is reduced, resulting in a contraction in total demand.

These results also reflect the relatively small size of the crude oil, petroleum and gas industry, with the simulated impact of a 20% increase in crude oil, petroleum and gas production on real gross domestic product is on average less than 0.2% in both the short- and long-run. The increased taxes levied on production in the crude oil, petroleum and gas sector also boosts government revenues.

5.1.2. Real consumption and consumer prices

The increase in real income stemming from the expansion of the crude oil, petroleum and gas sector results in increased consumption in all the short-run scenarios mainly due to gains in real income. In the long run, consumers are not able to adjust to the permanent changes in real income, and all industries are also not able to invest in new capital stock due to long-run profit opportunities being negated by the increased taxation in the sector. Accordingly, real consumption expenditure and real investment expenditure decrease by 0.15% and 0.32% (on average) respectively over the long run.

In the short-run scenarios of MFS, TFS and UFS, consumer prices increase due to the inflationary pressures resulting from the higher royalties (set at between 12.5% and 16%) paid under these scenarios, compared to the PIC and NFS scenarios where royalties are set at 5%. In the long run, consumer prices increase by 0.04% (on average) as a result of the increase in export and import prices, alongside the increase in taxation.

5.1.3. Employment and real wages

The increase in production from the crude oil, petroleum and gas sector results in a slight increase in the demand for labour in the sector and in related activities. Aggregate employment in the short-run increases by approximately 0.01%, placing upward pressure on real wages.

In the short run, in ORANI-type models, there is no constraint on the supply of labour for given real wages. Increased national requirements for labour translate into increased national employment or, equivalently, decreased unemployment in the short run. By contrast, the supply of labour is fixed in the long run and real wages decrease to clear the labour market. In the long run, real wages decrease by 0.63% (on average across all the long-run simulations).

The simulated long-run shift in the composition of the aggregate labour force is towards professional occupations and away from relatively more labour cost sensitive occupations such as those individuals most likely to be employed in other export and import competing industries where production is lower than would otherwise have been the case.

Table 6: Short- and long-run effects of crude oil, petroleum and gas policies for the economy (% change)

	Short-run					Long-run				
Policies	PIC	MFS	NFS	TFS	UFS	PIC	MFS	NFS	TFS	UFS
Indicators	1	2	3	4	5	1	2	3	4	5
Macro-economic effects										
Gross Domestic Product (GDP)	0.149	0.175	0.159	0.177	0.193	-0.119	-0.055	-0.105	-0.060	-0.038
Employment	0.011	0.005	0.010	0.006	0.003	0.000*	0.000*	0.000*	0.000*	0.000*
Change in unskilled employment	0.045	0.022	0.039	0.022	0.012	0.000*	0.000*	0.000*	0.000*	0.000*
Average Real Wage Rate	0.080	0.060	0.077	0.063	0.058	-0.638	-0.619	-0.634	-0.621	-0.615
Domestic Consumption	0.083	0.058	0.079	0.061	0.054	-0.205	-0.127	-0.188	-0.134	-0.107
Consumer Price Index	0.048	-0.008	0.032	-0.007	-0.033	0.032	0.037	0.034	0.038	0.040
Government Consumption	0.000*	0.000*	0.000*	0.000*	0.000*	-0.205	-0.127	-0.188	-0.134	-0.107
Real Investment Expenditure	0.000*	0.000*	0.000*	0.000*	0.000*	-0.313	-0.318	-0.315	-0.318	-0.320
Exports (Volume Index FOB)	0.094	0.238	0.136	0.237	0.308	-0.393	-0.385	-0.395	-0.389	-0.392
Export Price Index	-0.019	-0.048	-0.027	-0.047	-0.062	0.079	0.077	0.079	0.078	0.079
Imports (Volume Index CIF)	-0.325	-0.350	-0.335	-0.352	-0.368	-0.864	-0.863	-0.867	-0.866	-0.871
Import Price Index	0.000*	0.000*	0.000*	0.000*	0.000*	0.562	0.562	0.562	0.563	0.563
Sector effects										
Value added (Price)										
Natural Resources	-2.066	-2.086	-2.071	-2.085	-2.094	-0.003	0.004	-0.001	0.004	0.008
Crude oil, petroleum and gas	-22.922	-22.916	-22.922	-22.918	-22.917	0.000	0.000	0.000	0.000	0.000
Manufacturing	-0.048	-0.084	-0.057	-0.082	-0.099	0.227	0.226	0.227	0.227	0.228
Petroleum refineries	-1.046	-1.082	-1.059	-1.084	-1.106	4.891	4.902	4.896	4.904	4.913
Services	0.107	0.038	0.088	0.040	0.007	-0.192	-0.183	-0.190	-0.184	-0.179
Electricity	0.099	0.050	0.087	0.053	0.032	-0.174	-0.181	-0.174	-0.179	-0.179
Employment (Volume)										
Natural Resources	-0.956	-1.603	-1.027	-1.477	-1.610	1.476	0.490	1.373	0.678	0.488
Crude oil, petroleum and gas	-10.489	-18.235	-11.441	-16.832	-18.604	14.867	3.621	13.677	5.749	3.545
Manufacturing	0.233	0.292	0.248	0.289	0.315	-0.173	-0.147	-0.171	-0.152	-0.147
Petroleum refineries	4.255	4.272	4.258	4.269	4.273	-5.372	-5.408	-5.388	-5.413	-5.438
Services	0.006	0.000	0.001	-0.004	-0.012	0.056	0.070	0.056	0.066	0.067
Electricity	0.057	0.087	0.063	0.083	0.093	0.127	0.176	0.134	0.168	0.179
Household effects										

Real household consumption	0.097	0.077	0.094	0.079	0.072	-0.221	-0.139	-0.204	-0.146	-0.118
African	0.048	0.022	0.045	0.026	0.019	-0.127	-0.060	-0.112	-0.065	-0.041
Coloured	0.084	0.066	0.081	0.068	0.063	-0.196	-0.107	-0.178	-0.115	-0.085
Indian/Asian	0.143	0.131	0.140	0.131	0.126	-0.283	-0.193	-0.266	-0.203	-0.175
White	0.113	0.087	0.108	0.090	0.081	-0.279	-0.194	-0.261	-0.202	-0.172

*Source: UPGEM simulation results * Exogenous by assumption.*

Note: All values represent the percent change in a variable.

5.2. Industry output and employment results

In general, an expansion in crude oil, petroleum and gas production and the associated tax systems has a larger impact on output and employment in upstream industries in the short run, but a relatively larger inter-industry impact in downstream industries in the long-run.

5.2.1. The crude oil, petroleum and gas sector

The employment effects of both the short- and long-run scenarios for the crude oil, petroleum and gas sector are mixed. Within the crude oil, petroleum and gas extraction sector production decreases are associated with decreased employment in the crude oil, petroleum and gas industry, but increased employment in the downstream petroleum refineries industry. In particular, labour requirements in the petroleum refineries industry are simulated to increase by 4.27% in the short run, when real wages are fixed, and to decrease by 5.4% in the long run. Labour requirements fall by 15.12% in the short run and increase by 8.29% in the long run in the crude oil, petroleum and gas industry. This result is consistent with the assumption in the UPGEM that there is more flexibility to substitute other inputs for labour in the crude oil, petroleum and gas industry. Therefore, as the relative price of labour increases, there is strong substitution away from labour in this industry.

As simulated and reported in Table 6, the separate industries in the crude oil, petroleum and gas sector are connected in the sense that a 20% increase in production in the crude oil, petroleum and gas sector has some impact on production in the other industries, although the size of the impact varies considerably.

5.2.2. Upstream and downstream sectors

Industries upstream to the crude oil, petroleum and gas sector produce inputs that are used by the sector itself. Output from these upstream industries decreased in both the short and the long run as a result of the expansion of production from the crude oil, petroleum and gas sector alongside different forms of increased taxation. As a result, some upstream industries decrease their demand for inputs, including labour. In particular, industries which manufacture machinery used by the crude oil, petroleum and gas sector and the associated industries which require concrete and steel products in construction and in operating processes employed in the crude oil, petroleum and gas extraction sector reduce production in response to the decreased needs of the crude oil, petroleum and gas sector.

The largest production contraction in upstream activity occurs in the other natural resources sectors. This industry's production is simulated to decrease by 2.08% over the short run and increase marginally by 0.002% in the long run. Labour requirements in this industry are simulated to decrease by 1.34% in the short run and increase by 0.9% in the long run (when real wages decrease).

Servicing a large portion of the crude oil, petroleum and gas sector's transport needs, there is a short-run decrease in output of 0.13% from the transport services industry and an increase of 0.12% in the long run, while the industry which produces the associated capital stock (transport equipment) expands by 0.02% in the short run and contracts by 0.16% in the long run. Also, those sectors supplying capital goods used directly by the crude oil, petroleum and gas sector, contract and expand in the short and long run.

Downstream industries to the crude oil, petroleum and gas sector are those industries which use intensively the sector‘s output. The largest percentage increases in industrial production, admittedly from a small base, occur in electricity generation. In the short-run, electricity generation increases by 0.06% and in the long-run it decreases by some 0.18%. Employment in the sector expands in both the short and long run. Activity in the petroleum refining industry, contracts by more than 1% in the short run, and expands by 4.9% in the long run.

Households

Overall, in terms of household expenditure, the groups that are affected the most (both positive and negative across the two time horizons) by the expansion in crude oil, petroleum and gas production and the associated tax systems are the Indian/Asian and white South Africans – across all income groups. This is to be expected as these two groups are represented the most in those sectors affected through the simulations.

6. Modelling limitations

As with any economic modelling approach, the CGE modelling technique employed in this study has its limitations. These include:

- A productivity shock is used to deliver the increased wealth that the crude oil, petroleum and gas sector development will generate, which is a simplification of how this would happen in reality.
- The analysis is static, looking at the impacts of alternative fiscal systems associated with the crude oil, petroleum and gas sector on the South African economy at a point in time many years in advance. In reality, the benefits of the developments will be spread across the life of the projects, initially with investment into the facility increasing demand for construction and building; operational expenses including demand for intermediate inputs and labour; supply of fuel after the facility is running; and taxation revenue varying across the project lifetime. We do not explicitly model the dynamics of the developments over time.
- While the model database is highly disaggregated, it still invariably suffers from aggregation bias.
- The CGE model is based on Statistics South Africa’s SAM tables, with decisions based on neoclassical economics. Structural changes to the economy from the developments are therefore not captured in the modelling, nor are any non-competitive market structures. This means the actual distribution of costs and benefits may differ in reality if firms with market power absorb price and cost movements in their profits.

7. Policy implications and conclusion

The price increases in the South African economy that would necessarily accompany the introduction of taxation on the crude oil, petroleum and gas sector, would have a negative impact on the South African economy under the PIC (or current South African fiscal system) and NFS (Nigeria fiscal system) scenarios in the long run. The effects are positive for all other scenarios. The impacts are mainly on industries which are strongly linked to the crude oil, petroleum and gas sector.

The government would gain additional income from taxes paid by the crude oil, petroleum and gas industry. However, in most cases the cost to the economy would negate the total income benefit to the government.

Table 7: Costs and Benefits

	Short-run					Long-run				
Policies	**PIC**	**MFS**	**NFS**	**TFS**	**UFS**	**PIC**	**MFS**	**NFS**	**TFS**	**UFS**
Indicators	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Total additional income to the government	291	636	304	546	568	549	966	552	845	851
Total change in GDP	1,105	1,291	1,176	1,307	1,428	-877	-404	-778	-445	-280
Net benefit / cost (-)	1,396	1,927	1,479	1,854	1,996	-328	562	-226	400	570

Source: Calculations based on UPGEM results.

Although some of the scenarios present positive results when comparing government income and overall income to the economy, the cost in terms of higher domestic prices and forfeited economic growth and employment opportunities render these scenarios unfavourable.

Notes:

1. Cost oil: A term used in PSCs for the oil (or revenue) that is used to pay the IOC/contractor for exploration, development and operating costs (Johnston, 2003:335).

2. Profit oil: A term used in PSCs for the share of oil that is left after accounting for royalty and cost oil which is allocated to the host government and IOC respectively (Johnston, 2003:356).

3. Production sharing linked to physical volume of production (V), years of production (T), or realized profitability (P).

4. The maximum equity share that the state can select to take, often on a carried basis (C).

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