A Microeconomic Analysis of the Level of Optimisation of the Capital and Labour Input Base of the South African Petroleum Industry

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ABSTRACT

High and rising fuel prices are taxing consumers and depress the economy, leading to high inflation and ever increasing cost of living. This study makes a micro-economic analysis of the allocation of the input factors of production of South African petroleum industry, to determine whether production factors are allocated most productively. It applies a Cobb-Douglas efficiency criterion in a unique way as measurement and quantification of productivity. It estimates a production function and determines the point of optimisation, and to what extent capital or labour are over- or under-utilised. It then also suggests how this can be rectified and what gains this may yield to the industry and the consumer.

It was found that the levels of labour productivity are continuously declining. Higher gains in output could have been achieved if expenditure on production factors were optimally allocated. What the optimal allocations should have been are then determined in monetary terms. Finally the paper accepts that the petroleum industry is estimating market demand fairly accurately without stockpiling of supplies. The paper then determines what the level of optimisation of the capital and labour input base in the manufacturing industry should have been and what the extent of savings could be if production factors are optimally allocated in the petroleum industry.

The study shows that the petroleum industry can assist in dampening the ever rising fuel prices through the streamlining of its internal operations. The results of the estimations are indeed interesting and substantiate the hypothesis that the low level of productivity does contribute significantly to the increasing cost of fuel in South Africa.

JEL Codes:

- L23 - Organization of Production
- D24 - Production; Cost; Capital; Capital, Total Factor, and Multifactor Productivity; Capacity
- L11 - Production, Pricing, and Market Structure; Size Distribution of Firms
- L65 - Chemicals; Rubber; Drugs; Biotechnology

Keywords Production; Optimalisation; Manufacturing; Petroleum Industry; Industrial development; Competitiveness

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1. INTRODUCTION

The optimal level of the labour and capital input base in the petroleum industry of South Africa is investigated in this study. It determines whether the industry is functioning at the optimal level, how much the deviation is costing the industry and how much could be gained when the input combination is rectified.

The fuel price in South Africa is constantly rising in the country with detrimental effects to the economy. The fuel price is an administered price in South Africa, set by the government, but the input price of fuel has a large effect on the setting of that price. If the industry can save on their allocation of funds to its input combination, it will in effect be possible to decrease the consumer price of fuel.

Van Zyl and Kleynhans suggested a unique way of determining productivity through the evaluation of the input combination of the factors of production in various publications (e.g. 1995 & 2002). The excellence of their method lies in the fact that it expresses productivity or the loss thereof and also the possible gains of higher productivity in monetary terms. As the findings are expressed in rand and cent, planners can use them directly in their development strategies.

As globalisation is a reality the South African economy, optimal levels have to be obtained to survive increasing international competition. Future competitiveness is critically dependent on higher levels of cost efficiency and especially on more productive labour and capital input.

It is therefore important to be able to measure and quantify the extent of the perceived lack of productivity. The Cobb-Douglas efficiency criterion provides a straightforward instrument for this purpose. The findings should help industry, labour unions, consumer and other interest groups to comprehend the full implications of the low levels of productivity in the industry.

This article will commence with an overview of the petroleum industry in South Africa. Then the theoretical concept of the efficiency criterion will be explained. Next a production function for manufacturing in the province will be estimated, which will provide the elasticities and other variables to estimate the optimal input ratios and efficiency criteria, based on historical achievements. Both scenarios of short and long term were considered. Thereafter the optimal utilisation of the total cost outlay will be determined and lastly the optimal factor allocation warranted by the market demand will be determined. In each case the optimal input combination of the factors of production are determined, the losses that occurred with the unproductive input combinations and possible gains in monetary terms. The paper concludes by evaluating the merits of the method applied, and the results.

It is important to note that this is still a work in progress and final estimations and results have not yet been obtained. This is only an illustration of what the researchers have in mind in the hope of finding more collaboration, from interesting parties.

2. THE STRUCTURE OF THE PETROLEUM INDUSTRY

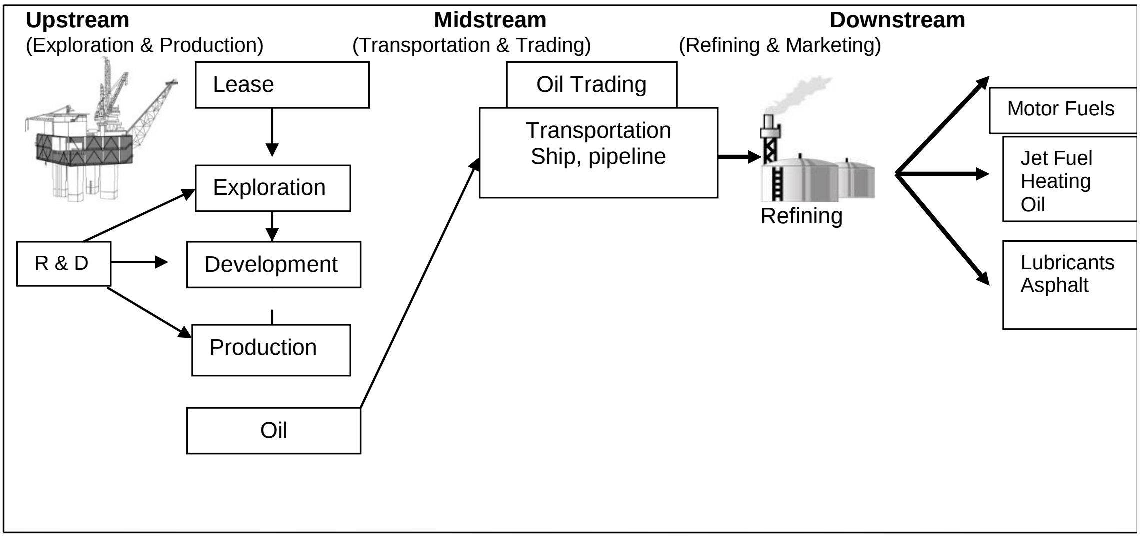
2.1 The petroleum industry

Oil is a significant element of the global energy mix (Finley, 2012). A small number of countries produce oil relative to all the nations in the world who consume products derived from the oil sector (Inkpen & Moffett, 2011:6). This section will review the oil sector value chain, the classification of the subsectors of the petroleum industry.

2.2 The oil industry value chain

The oil industry consists of three-sub sectors, namely the upstream, midstream and downstream (African Development Bank; 2009:34; Inkpen & Moffett, 2011:21). The upstream consists of the exploration for and production of oil (African Development Bank, 2009:34; Morse, 1999). The midstream consists of the storing, trading and transportation of crude oil (Inkpen & Moffett, 2011:23). The downstream includes the refining, marketing and sale of petroleum products (African Development Bank, 2009:34; Morse, 1999; Inkpen & Moffett, 2011:21). High oil prices and perceptions of oil being in short supply will drive capital investment for exploration and production (Favennec, 2001:38; Morse, 1999). The operating costs of oil fields tend to be low in comparison to the costs of exploration and development (Wait, 2013). The downstream is similarly capital intensive, refineries are costly to build but once refining has started, the marginal cost of refining a barrel of oil is only slightly more than the cost of the crude oil itself (Morse, 1999). The majority of value creation rests with the upstream sector, which is the focus of this research. The oil sector value chain is illustrated in Figure 2.1 below.

Figure 1: The oil industry value chain



Source: Adapted from Inkpen & Moffett (2011:21).

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. Exploration and development can only start once a lease has been acquired (Inkpen & Moffett, 2011:93). In most countries, with a few exceptions such as the USA and Canada, mineral rights are held by the country's national government (Inkpen & Moffett, 2011:87). Private oil companies want to maximise profits whilst host governments want to maximise their revenue from oil resources (Inkpen & Moffett, 2011:22). Licensing (lease) 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 (Tordo, 2007:3). Exploration and development rights are assigned through either a process of auctions, through an informal process of first-come-first-serve, or through a formal process such as "beauty contests" where companies compete by submitting exploration and development plans (Crampton, 2007:114; Crampton, 2010:289; Inkpen & Moffett, 2011:102). A well designed auction has the advantage of being both competitive and transparent (Crampton, 2010:289). The feasibility of an auction[1] will be depend on the quality of the oil resources (Crampton, 2010:289).

2.3 Contribution to the South African Economy

The petroleum industry contributes directly about 3.4% to the South African GDP. In nominal terms household spent R33.2 billion on petroleum products during 2005, which grew to R81.5 billion in 2012. In constant terms this expenditure more or less doubled during this period (SARB, 2013:S-113).

Petroleum products includes the manufacture of coke and petroleum products, refinery and synthesis of petroleum, manufacturing of petrol, kerosene, production of light, medium and heavy fuel oil and refinery gases such as ethane, propane and butane; lubricating oils, and greases, and the manufacture of other petroleum products for the petrochemical industry and for the manufacture of road coverings. Other products include white spirit, Vaseline, paraffin wax, petroleum jelly, blending of biofuels, such as blending of alcohols with petroleum (e.g. gasohol).

The United Nations (2013) ISIC codes C191 and C192 this sector includes the transformation of crude petroleum and coal into usable products. The dominant process is petroleum refining, which involves the separation of crude petroleum into component products through such techniques as cracking and distillation. This division also includes the manufacture for own account of characteristic products (e.g. coke, butane, propane, petrol, kerosene, fuel oil etc.) as well as processing services (e.g. custom refining). This sector also includes the manufacture of gases such as ethane, propane and butane as products of petroleum refineries. Manufacture of refined petroleum products (C1920) includes the manufacture of liquid or gaseous fuels or other products from crude petroleum, bituminous minerals or their fractionation products. Petroleum refining involves fractionation, straight distillation of crude oil, and cracking. Adding to this the industry includes a whole service industry and also does exploration for new oilfields.

3. DETERMINATION OF THE FUEL PRICE

The Hydrocarbons and Energy Planning Branch of the Department of Energy (2013) is responsible for setting the fuel price, as well as for energy efficiency, renewable energy and energy planning. The petrol price in South Africa is linked to the price of crude oil in international markets and is quoted in US dollars (US$) per barrel. International petrol prices are driven by supply and demand factors (DOE, 2013).

South Africa produced 23 571 million litres of liquid fuels product in 2005, of which 36 % of the demand is met by synthetic fuels (synfuels), produced locally, largely from coal and from natural gas. Products refined locally from imported crude oil meet the remaining 64%.

The liquid fuels industry was licensed in 2005 for the first time. The objectives of the licensing framework are given in the Petroleum Products Amendment Act 2003, Act 58 of 2003. The act states that the industry should promote efficient manufacturing, wholesaling and retailing petroleum industry and the current paper aims to contribute specifically to that aspect. The act also aims to ensure an environment conducive to efficient and commercially justifiable investment; promote the advancement of historically disadvantaged individuals; and create employment opportunities and small businesses in the petroleum sector.

Crude oil prices combined with the Rand/Dollar exchange rate play a major in determining petrol prices. The largest input cost factor at a crude-oil refinery is crude oil itself. The price for the products manufactured from crude oil includes a profit margin, in order to culver the refinery’s cost and hopefully makes a profit to ensure long-term sustainability and growth, especially to create jobs and wealth. When crude oil prices increase the petrol price has to follow.

To determine the Basic Fuels Price (BFP) the price of petrol quoted in US dollars at refined petroleum export refining centres in the Mediterranean area, the Arab Gulf and Singapore are considered. The import parity principle is used as a method of basic fuels price determination to ensure that local refineries can compete with international counterparts (DOE, 2013). This promotes cost efficiency and astute crude acquisition strategies to ensure survival in a volatile and competitive international environment, and eliminates local inflationary pressures.

Included in the petrol price is the cost to transport refined petroleum products to South African ports, set by London Tanker Brokers Panel on 1 January each year and adjusted monthly. This is based on a function of risks and supply and demand of ships transporting refined petroleum products internationally. Further a demurrage rates are added to compensate for freight delays. Then 0.15% insurance is added to cover insurance and other costs such as letters of credit, surveyors' and agents' fees and laboratory costs; a 0.3% loss allowance factor is added. Added to this is the Cargo Dues (Wharfage) to off-load petroleum products from ships into on-shore storage facilities by the National Ports Authority of South Africa; storage and handling fees at coastal terminals; and finally stock financing cost is based on the landed cost values of refined petroleum products (DOE, 2013).

The final petrol price at the pump, in the different fuel pricing zones (magisterial districts), domestic costs, imposts, levies and margins are added to the Basic Fuel Price (BFP). The price of crude oil only forms about 40% of the final price. Various levies, margins and taxes lead to the high price that consumers have to pay. The margin to wholesalers is added as well as refining costs, a zone-differential to inland consumers, to cover transport costs, a retailer’s margin, egalisation fund to stabilise fluctuations, customs and excise duties, a Petroleum pipelines levy, a fuel tax and the road accident fund premium. Finally also a Demand Side Management on 95 Unleaded Petrol (DMSL) levy is added to discourage the inland use of this 95 octane as the authorities consider it as "octane waste" and unnecessary inland.

As the major cause of price fluctuations is due at the input side, especially the price of crude oil, this paper makes the assumption that if the industry can allocate their inputs more optimally, it will assist in lowering the cost of fuel.

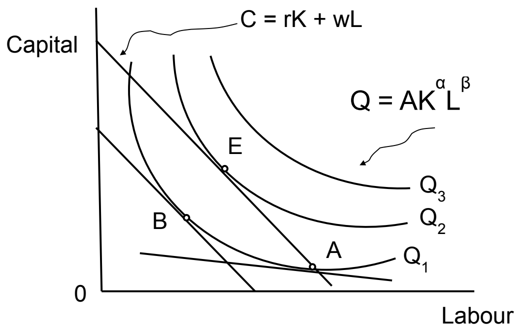
The structure and context in which the petroleum industry operates in South Africa was sketched above. In the following section the theoretical concept of the efficiency criterion will be explained to demonstrate how this study was done.

4. THE EFFICIENCY CRITERION

The theoretically purist and most widely used production function is the Cobb-Douglas function (Kleynhans, 2002:73) which states the relationship of labour (L) and capital (K) to output (Q) as: $Q=aK^{\alpha}L^{\beta}$. The level of technology is indicated by "a". With the inclusion of time series and other complications, further variables will also provide factor specific indications of technology. Parameter α is the output elasticity of capital and β the output elasticity of labour. Parameter β denotes the percentage change in output as a result of a percentage change in labour input, keeping capital constant (Cobb & Douglas, 1928:139-165).

The Cobb-Douglas production function is estimated by converting the function $Q = aK^{\alpha}L^{\beta}$ to logarithms as: $\ln Q = \ln a + \alpha \ln K + \beta \ln L$. By means of linear regression analysis parameters a, α and β are determined. The marginal products of labour and capital can respectively been expressed as $MP_L = \beta(Q/L)$ and $MP_K = \alpha(Q/K)$. The optimal cost efficient utilisation of production factors is obtained at the point where the last Rand is spent all factors yields equal marginal products: $\therefore (MP_L/w) = (MP_K/r)$ where w is the unit wage cost and r the unit cost of capital. This is represented as point E in Figure 2. The estimated production function can then be used to determine whether the input combination of an industry is optimal or sub-optimal (Kleynhans, 2002:74).

Figure 2: Optimal production level



If $MP_L/MP_K<w/r$ it is an indication of over-utilisation of labour, indicating a decline in labour productivity. On the other hand, if $MP_L/MP_K<w/r$, capital is over-utilised, indicating a decline in the productivity of the capital goods used and an over-utilisation of labour, *ceteris paribus*. The marginal rate of technical substitution of labour for capital is: $MRTS = MP_L/MP_K = (\beta/\alpha).(K/L)$. The optimum input mix of labour and capital is then at the point where $w/r = (\beta/\alpha).(K/L)$ or $(\beta/\alpha).(K/L) – (w/r) = 0$. Multiplying by α yields the input efficiency criterion $\psi = \beta(K/L) - \alpha(w/r) = 0$. If $\beta(K/L) - \alpha(w/r) < 0$ (thus $\psi < 0$) the industry is experiencing a decline in labour productivity since $\psi < 0$ implies that $(MP_L/MP_K) < (w/r)$ (Maurice & Smithson, 1985: 126-130).

The optimal utilisation of the labour component is expressed by the efficiency criteria (ψ) which is calculated utilising the formula $\psi = \beta(K/L) - \alpha (w/r)$ as indicated in the theoretical exposition above.

The prices of the factors of production can be calculated in various ways. The input price of labour (w) is obtained by dividing total salaries and wages by the number of employees. To make the price of wages comparable to the price of capital, the average wages (in R'000) per annum are deflated by the production price index. The input price of capital (r) is generally expressed as $r = Q_K(i + \delta)$ where Q_K is the unit acquisition cost of the capital stock. The rate of depreciation (δ) is calculated as the percentage of total capital depreciation and the real interest rates were obtained by deflating the long run rate by the PPI.

5. THE EMPERICAL RESULTS

Data for the years 1970 to 2012 were obtained from Quantec, StatsSA and the Quarterly Bulletins of the South African Reserve Bank. The production function for the petroleum industry was then estimated as $Q = 10.541 K^{0.061}L^{0,351}$, with a low R^2.

The necessary econometric analysis was conducted to address the problems of statistical significance and address the usual problems of estimation. Estimates were done for both the long and short term. To address especially the problem of multi-collinearity between input factors, a time series was added changing the production function to: $\ln Q_t = \ln a + \alpha \ln K_t + \beta \ln L_t + \gamma t + \varepsilon_t$ for the long-run estimation and use that in the shorter term estimation, taking differences: $d Q_t = \ln \xi_0 + \xi_1 d K_t + \xi_2 d L_t + \xi_4 (Q_{t-1} - a - \alpha \ln K_{t-1} - \beta \ln L_{t-1} - \gamma t) + \xi_5 \varepsilon_t$.

The output elasticity of labour (β) implies that a ten per cent increase in labour productivity would result in a 3.5 per cent increase in output, *ceteris paribus*. This indicates that the industry is not very labour intensive. The industry is regarded as labour intensive when more is spend on labour than on capital goods in the production process, when β is larger than α and/or the point of production on the isoquant graph is to the right of the point of optimisation – employing more labour.

The results for the period 1970 to 2012 are shown in Table 1. It is evident from the table that $\psi<0$ for most of the 43 production years, irrespective of the business cycle phases and since 1987 labour was over-utilised in every year. This is an indication of a continuous decline in the level of labour productivity. The next step is to quantify the decline in labour productivity in terms of cost wastage (in Rand).

TABLE 1
EFFICIENCY CRITERIUM (ψ)

Year	ψ	Input over-utilisation
1970	-185.243	L
1971	-45.154	L
1972	-57.1995	L
1973	12.47374	K
1974	13.1072	K
1975	20.52269	K
1976	30.88467	K
1977	90.51764	K
1978	-574.411	L

1979	18.11745	K
1980	29.26706	K
1981	322.1764	K
1982	64.90608	K
1983	-52.2772	L
1984	-24.7052	L
1985	-151.745	L
1986	68.55199	K
1987	-197.723	L
1988	-94.1441	L
1989	-720.424	L
1990	-117.068	L
1991	-102.598	L
1992	-54.3686	L
1993	-1300.21	L
1994	-94.753	L
1995	-185.528	L
1996	-56.363	L
1997	-198.253	L
1998	-123.236	L
1999	-103.653	L
2000	-99.466	L
2001	-102.366	L
2002	-153.214	L
2003	-135.333	L
2004	-125.245	L
2005	-118.523	L
2006	-101.257	L
2007	-95.354	L
2008	-89.563	L
2009	-92.351	L
2010	-82.321	L
2011	-85.656	L
2012	-96.321	L

The results have shown that the South African petroleum industry is not productive at the optimal point of factor utilisation. Labour are being over-utilised, producing at point A instead of at the point of optimalisation (E) in Figure 2. The following section will show the way towards the optimal point and how much the industry stands to win if such changes can be made.

5. THE OPTIMUM UTILISATION OF THE TOTAL COST OUTLAY

The optimal input ratio of labour and capital (z) must be such that $K/L = (\alpha w)/(\beta r)$. The optimum allocation of the labour input can be calculated from the optimal input ratio. Thus $L_o = (\beta rK)/(\alpha w)$. The optimum allocation of the labour input can also be derived from the isocost line for a specific cost outlay $C = rK + wL$ and $L = (C - rK)/w$.

Levels of production where $\psi = 0$ are rarely found in practice. Should the calculations show no optimal input allocation, it must be determined whether the calculated ψ is significantly different from 0. This is done by means of a t-test. The calculated t-statistic is $t = \psi / S\psi$ is the estimated ψ's own standard error and the estimated variance of ψ can be calculated as: $Var(\psi) = (K/L)^2 Var(\beta) + (w/r)^2 Var(\alpha) - 2(K/L)(w/r)Cov(\alpha,\beta)$. The estimated standard error of ψ is: $S_\psi = \sqrt{Var(\psi)}$. The absolute t-value of ψ is then calculated. Should it exceed the critical t-value, it can be said that ψ is significantly different from zero (Maurice & Smithson, 1985:128-130).

When evaluating the optimum total cost outlay, it is important to take note of the intensity factor and the factor demand equations, derived from the Cobb-Douglas function. The intensity factor is (β/α); the higher this ratio the more labour intensive the production technique (Koutsoyiannis, 1979:65). When $\psi = 0$, $\beta(K/L) - \alpha(w/r) = 0$ thus $L = K(\beta/\alpha)(r/w)$. Substituting K and L in the production function the factor demand equations are derived in terms of output and relative factor prices $L_d = [Q/L(r/w.\beta/\alpha)^\alpha]^{1/(\alpha+\beta)}$ (Heatfield, 1987:82).

The low levels of labour productivity in the industry over the period 1970 to 2012 had an adverse effect on the output level. From the results (see Table 2) it is evident that a better utilisation (input mix) of the cost outlay would have resulted in a higher output level.

The possible optimal output gain was calculated for every year since 1970.
For example, 1995: K = R1.484m; L = 57.345; w = 15 608; r = 0,0461; ψ = -185,578 indicating an over-utilised labour situation with declining productivity.
The true K/L ratio employed was K/L = 12.98433, while the optimal ratio should have been: $(K/L)_0$ ratio = z = $(\alpha w)/(\beta r)$ = 371.825 – indicating that the capital to labour input base was sub-optimal.
The money spent on the factors of production was: C = rK + wL
$\therefore$ C = R895.13m
The optimal input levels of capital and labour should have been:
$K_0 = (\alpha C)/(r\varepsilon)$ = R101.82m and $L_0 = (\beta rK)/(\alpha w)$ = 27 385 workers.
Test: K_0/L_0 = 371.825
The level of production was calculated as: $Q = aK^\alpha L^\beta$
The amount produced in that year was: Q_{true} = R3100.272m, but at the point of optimisation Q_o = R271.33m could have been produced utilising the same cost outlay.
The inefficiency output loss was: $Q_o - Q_{true}$ = R68.23m, where “0” indicates optimal and “true” the amount that was really occurred in that year.
The inefficient labour component is calculated as: $L_{true} - L_o$ = 29 959 excess workers.

Table 2 shows the possible output wasted in each of the last ten years (2003-2012) and the unproductive labour that was employed at the non-optimal factor allocation and total cost outlay levels.

From the table, it is obvious that the calculated output loss as a result of the employment of unproductive labour remained relatively high over the entire period.

TABLE 2
NON-OPTIMAL UTILISATION OF THE TOTAL COST OUTLAY

Year	Output loss (R mil.)	Unproductive labour (excess workers)
2003	300.3	32223
2004	210.7	34020
2005	658.8	34526
2006	244.9	34997
2007	222.8	34309
2008	125.3	33256
2009	146.3	32219
2010	811.9	30919
2011	187.9	30444
2012	268.2	29960

It would however be unwise to produce more than market demand requires. It would therefore be best to stay on the current isoquant and move to a lower cost line, indicated by point B in Figure 2. This would bring about cost savings, which can be to the advantage of both the petroleum industry and consumers at large. The following section gives attention to that scenario.

6. OPTIMAL FACTOR ALLOCATION ACCORDING TO MARKET DEMAND

Producing a higher output when an alternative optimal input combination is applied at the same cost-outlay would be unwise. Supply is closely answered by demand – to produce more would be a waste. The assumption in this paper is then also made that manufacturers are already supplying what the market currently demands. It is therefore better to continue manufacturing the same amount of output, but at an optimal input combination of production factors.

When an optimal factor allocation at a given labour and capital cost has been determined for a particular cost outlay, it can be used to determine the optimal factor allocation warranted by the market demand.

The optimum amount of labour in the industry required to meet market demand can be calculated by the use of the formula $L_D = \sqrt[\varepsilon]{Q_D / Z^{\alpha} L)}$ where Z = optimal K/L = $(\alpha w)/(\beta r)$ and $\varepsilon = (\alpha + \beta)$. The optimal capital input can be determined by $K_D = \sqrt[\alpha]{Q_D /(a L_D{}^{\beta})}$ (Kleynhans, 2002:76).

Table 3 lists the non-productive labour component per level of market demand and the possible cost gain as a result of better factor utilisation, for each year during 2003 to 2012. It can be seen from Table 3 that the petroleum industry is burdened by a significant number of non-productive labourers. These figures are disturbing when compared with the relevant facts. Real wages increased relatively, while the number of non-productive labourers had increased. This is an indication of a continuous decline in labour productivity.

TABLE 3
FACTOR WASTAGE ACCORDING TO MARKET DEMAND

Year	Unproductive labour	Possible cost gain with less labour employed (R mil. – real prices)
2003	61659	146.8146
2004	65093	62.93753
2005	66072	321.6911
2006	66968	199.2662
2007	63251	185.3256
2008	65651	221.7978
2009	61654	44.95409
2010	59172	6417.455
2011	58254	204.0643
2012	57330	376.2697

6. SUMMARY AND CONCLUSIONS

A) Evaluation of the Method Used

The Cobb-Douglas efficiency criteria and in particular its extensions, serve as effective and useful instruments to measure and quantify the extent of a decline in labour productivity in a particular industry.

The method is easy and economical to apply. More elaborate methods to obtain more accurate findings, better production functions and adjusting the figures to include changes in technology do not yield better results (see e.g. Kleynhans, 1996:15). The fact that it measures productivity in Rand and Cent makes this method unique.

The method gives production and process managers a useful instrument when planning, as it gives the exact number of unproductive labour units and indicates the value of capital that should optimally be applied and the loss due to unproductivily in specific monetary terms. It also indicates what returns can be gained in Rand and Cent terms. In this regard it is not only an indication of the problem of unproductivity but also suggests part of the solution.

The method utilises real values and when real interest rates are negative it is impossible to draw roots when applying it and thus makes this method useless for those years. Alternative interest and inflation rate series might then be employed like the BA rate or CPI, but this will be less accurate. As companies gain tax gains on their levels of depreciation, it is very difficult to determine the true value of depreciation. Companies are also reluctant to release their production figures to others for research purposes. Indexes are, however, more readily available and the same technique could be employed to determine the percentages of unproductive labour and the percentages with which inputs should change and how that will alter production figures and costs. Within firms this method can, however, be used with ease as well as by investment institutions where firms have to declare their figures to obtain funds.

B) Productivity of the South African petroleum industry

The results of the efficiency criteria measurements do indeed substantiate the view that the continuous decline in labour productivity in the petroleum industry of South Africa is an important cause of rising fuel prices. The key challenge facing all those associated with the industry is the improvement of labour productivity at a time when the overall productivity trend remains under pressure and wages and other costs have been rising at a faster rate than those of the overseas competitors have. The alternative is to employ more capital goods, mechanise, implement robotics and retrench those unproductive labourers.

The demands of the labour unions have probably compelled the industry to employ more labour at higher wage levels than would have been the case had management been at liberty to act more rationally. The low level of productivity per worker can probably also be attributed to the low worker ethics generally prevalent in the South African work force. The findings of this paper agree with other studies which indicate that South African industries are too labour intensive. Should the decline in labour productivity remain unchallenged, thousands of workers will have to be retrenched in order to bring unit cost down and make the industry more competitive.

The study has shown that it is possible to run the petroleum industry in South Africa more efficiently and in that way curb the rising cost of petroleum and petroleum products in the country.

It might be worthwhile to extend the research by breaking the industry and its data further down to investigate specific aspects, like retail and refining processes. This method can also be utilised in further research of other industries, like the declining gold mining industry and textiles.

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