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Abstract

This study examines the cost performance of the South African motor vehicle industry, using data categorized by output level of the firms. The results are consistent with statistically significant economies of scale at the lowest output levels and a cost inefficiency averaging about seven to nine percent. The findings also suggest that, all else equal, the smallest firms and the largest firms have lower unit costs than mid-size firms.

Keywords: Firm size, Efficiency, Motor Vehicle Industry

I. Introduction

South Africa has long considered its motor vehicle industry to be a strategic factor in its economic development, at least partly because of its backward and forward linkages with other industries. In fact, it is one of two sectors that the government currently targets with industry specific policies.[1]

In 1996, employment in the motor vehicles, parts and accessories industry accounted for approximately 6.7 percent of total manufacturing employment and 7.7 percent of manufacturing salaries and wages in South Africa. The industry also produced about 8 percent of total manufacturing value added and 10.9 percent of total manufacturing output.[2] On the other hand, in 1993 (the last year for which foreign trade by industry group (SIC basis) is available in *South African Statistics*, the motor vehicle and parts industry had 710.5 million rand of exports, but 4,728.6 million rand of imports, resulting in an industry trade deficit of 4,016.1 million rand, more than double the overall trade deficit of 1,983.3 million rand.[3] Thus, while the motor vehicle industry was an important source of employment and value added in the South African economy, it also was responsible for a substantial trade deficit.

The South African automobile industry began in the 1920s with assembly plants for Ford (1924) and General Motors (1926). By the 1950s, eight motor vehicle assembly plants had been established, together with a variety of

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[1]Clothing and textiles is the other industry. See Kaplan (2004, p. 627.

[2]This (1996) is the latest year for which industry-specific data are reported in *South African Statistics*. See Statistics South Africa, *South African Statistics, 2003*, 2004, pp. 14.8 and 14.14.

[3]Central Statistical Service, *South African Statistics:1995*, 1997, pp. 16.9-16.12.

components manufacturers including producers of tires, batteries, and glass.[4] In 1960, Datsun (Nissan) vehicles were manufactured under license, and in 1961, a South African acquired a Toyota manufacturing franchise. Production of Mazdas was begun in the 1970s and later was acquired by a firm that was majority-owned by Anglo-American. Anglo-American also purchased Chrysler to form Amcar, an entirely South African owned company. With the onset of anti-apartheid sanctions in the late 1970s, Ford and General Motors sold their companies to local groups. Thus, South Africa was unique in that it had locally-owned producers of internationally recognized brand name vehicles. However, Volkswagen and BMW retained ownership of their subsidiaries and Mercedes Benz had fifty percent ownership of Mercedes Benz, SA.

The ownership picture changed once again in the 1990s after the sanctions were removed. By 1997, Ford, General Motors, Toyota, and Nissan had purchased ownership interests in the assembly industry, and Daimler Benz increased its percentage ownership of Mercedes Benz. As a result of all these developments, in 1998 there were seven motor vehicle assembly firms in South Africa: Toyota SA, Volkswagen SA, BMW SA, Mercedes Benz SA, Samcor, Automakers, and Delta.[5]

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[4]Besides Ford and GM, the assembly firms included South African Motor Assemblers and Distributors Limited (SAMAD), National Motor Assemblers Limited, Motor Assemblers Limited, Chrysler South Africa (Pty) Limited, Car Distributors Assembly Limited (CDA, now Mercedes Benz), and British Motor Company (Leyland). Although SAMAD originally produced Studebaker products in a plant near Port Elizabeth, Volkswagen later purchased an interest in the company and eventually sole ownership in 1974. National Motor Assemblers, in Johannesburg, assembled vehicles, including Peugeots, on a contract basis. Motor Assemblers was established in Durban and later became Toyota. See (Bell, 1990, pp. 63-64); (Dix, 1995, p. 23); and (Oberhauser, 1933, p. 113, note 4).

[5]Volkswagen also manufactured Audis, Mercedes Benz also made Hondas and Colts (Mitsubishi), Samcor produced Fords, Mazdas, and Mitsubishis; Automakers manufactured Nissans and Fiats, and Delta made Opels and Isuzus. All of these firms except for the German manufacturers were still partly locally owned. See

The South African motor vehicle industry has historically been characterized by the production of numerous makes and models, and this proliferation of vehicle platforms has long been considered to be a primary factor in the industry's high unit costs relative to those in other countries. The fragmentation of production was made economically feasible and encouraged by import tariff barriers that, together with local content requirements, were a fundamental part of government policy regarding the industry until 1995.[6]

In an attempt to rationalize the automobile industry and increase its international competitiveness, the South African government changed its strategy in 1995 with the introduction of the Motor Industry Development Program (MIDP). In contrast to a primary emphasis on a policy of industry protection and import substitution, the new policy package was outward oriented. It eliminated local content rules and provided incentives for both components manufacturers and assembly firms to export products, thereby earning credits that could be used to rebate import tariffs (referred to as an import-export complementation or IEC policy). These credits were tradable and could be used for duties on vehicles, parts, or materials. The new program also provided for a gradual reduction in import tariffs, a duty-free allowance of 27 percent of the wholesale value of vehicles, and an incentive for the production of more affordable small vehicles. In 1999, a Productive Asset Allowance (PAA) provision was added that allowed firms to generate duty

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(Barnes and Kaplinsky, 2000, p. 799); and (Barnes, 2000, p. 405).

[6]By 1993, there were seven assembly plants producing 34 different platforms. In 1997, none of these platforms had an annual volume as large as 30,000 units, and only four of them had production quantities as large as 20,000 per year. See (Barnes, Kaplinsky, and Morris, 2004, pp. 156-158); (Black, 2001, pp. 781-782); and (Barnes and Kaplinsky, 2000, pp. 799-801).

credits equal to twenty percent, distributed over five years, of the value of new investment in plant and equipment designed to increase production for export. The MIDP is currently scheduled to expire in 2012.[7]

After the introduction of the MIDP, the exports of motor vehicles and parts increased from 710.5 million rand in 1993 (about US $218 million) to over US $2 billion in 2001. Exports of vehicles increased from fewer than 10,000 per year to over 100,000 in 2004. Exports of motor vehicle parts, especially of catalytic converters and stitched leather seat covers, have also increased dramatically to over R22 billion per year. While exports have increased substantially since the implementation of the MIDP, the trade deficit of the automobile industry was still about R8 billion in 2001, since imports have also increased. Investment in plant and equipment has increased from less than 1 billion rand in 1995 to over R3.5 billion in 2004.[8]

However, the purpose of this paper is not to look at how the overall international competitiveness of the South African automobile industry has changed since the introduction of the MIDP in 1995. Other researchers have addressed that issue in a number of studies.[9] Rather, our objective is to examine how the cost efficiency of the firms in this industry historically varied by size of firm as well as look at the magnitude of the cost elasticity with respect to scale of output. We employ an augmented Cobb Douglas functional form with dummy variables to reflect the various firm size

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[7]See (Barnes, Kaplinsky, and Morris, 2004, p. 158); and (Flatters, 2005, p.2).

[8]See (Flatters, 2005, pp. 2-3); (Barnes, Kaplinsky, and Morris, 2004, pp. 158-161); and Central Statistical Service, *South African Statistics: 1995*, p. 16.12).

[9]For example, see (Barnes, Kaplinsky, and Morris 2004); (Damoense and Simon 2004); and (Flatters 2005).

categories as well as a stochastic cost function to look at the various factors affecting cost efficiency.

II. The Data and Model

The data used are census data reported by gross output size group. To the best of our knowledge, only six years of these data with industry output groupings had been reported in *South African Statistics* by 2006: 1972, 1976, 1979, 1982, 1985, and 1988, and we used all of them in this study. Although initially the firms were divided into twelve output categories, in later years these were expanded to thirteen.[10] To increase the consistency of the data, since there seemed to be a lot of variation in the very low output groups, we compressed these lower output categories. In the first model, we combined the data for the six lowest output categories into one group corresponding to firms with gross output less than 100,000 rand. The resulting model had data for seven different output categories. A second version of the model was estimated with the seventh, eighth, and ninth original data output categories also combined into one group of firms with output from 100,000 rand to less than one million rand. Consequently, in this version of the model there were five different output categories.[11]

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[10]The thirteen groups by gross output size group were the following ones: less than or equal to 1,999; 2,000 to 3,999; 4,000 to 9,999; 10,000 to 19,999; 20,000 to 39,999; 40,000 to 99,999; 100,000 to 199,999; 200,000 to 399,999; 400,000 to 999,999; 1,000,000 to 1,999,999; 2,000,000 to 3,999,999; 4,000,000 to 9,999,999; and above 10,000,000 rand.

[11]These categories were (1) gross output less than 100,000; (2) gross output of 100,000 to less than 1 million; (3) gross output from 1 million to less than 2 million; (4) gross output from 2 million to less than 3 million; and (5) gross output over 4 million rand. In the 1982 census the latter category was divided into two, with one category consisting of firms with output from 4 million to less than 10 million rand, and the second with output over 10 million rand. However, for consistency, we continued to keep these two categories combined in

The basic stochastic frontier cost function is based on the assumption that $E_i \geq C(Y_i, \mathbf{W}_i, \boldsymbol{\beta})$, where

$E_i = \Sigma W_{ij} X_{ij}$ is the expenditure on inputs X_j by the *i*th firm;

Y_i = the output produced by the *i*th firm;

$\mathbf{W}_i$ = a vector of input prices faced by the *i*th firm;

W_{ij} = the price of input *j* for firm *i*;

X_{ij} = the amount of input *j* used by firm *i*; and

$\boldsymbol{\beta}$ is a vector of cost function parameters.

Thus, C is the level of cost for output level *Y* given input prices $\boldsymbol{W}_i$ that should be achievable by firm *i* if it is both allocatively and technically efficient. However, at any point in time, firm *i* may not be achieving the minimum cost level (given its output and input prices) for two general reasons. The first explanation for higher expenditures than are theoretically achievable is random external events over which the firm has no control such as the weather, equipment performance, and, perhaps, "luck." The second reason is avoidable inefficiencies on the part of the firm. The expenditure function for a firm can, therefore, be restated as

$$E_i = C(Y_i, \mathbf{W}_i, \boldsymbol{\beta}) + v_i + u_i,$$

where v_i represents the deviations from the cost function caused by random events that the firm cannot control. It is usually assumed that these events could be favorable or unfavorable, so that v_i is normally distributed with a mean of zero and variance of σ_v^2.

The u_i term represents avoidable inefficiencies on the part of firm *i*

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the original category of firms with output of 4 million rand and above. See (Central Statistical Service, *South African Statistics*: 1978, p. 12.33; 1980, p. 12.38; 1986, p. 12.36; 1988, p. 12.36; 1992, p. 12.46; and 1994, p. 12.38).

and, therefore, is assumed to be nonnegative. Various functional forms for its distribution have been assumed, including the half-normal, truncated normal at some value greater than zero, exponential, and gamma.[12] In this study, the assumption that the u_i terms were exponentially distributed produced the most economically reasonable results. With this formulation of the model, the cost efficiency of firm *i* can be represented by the ratio of E_i to $C(Y_i, \mathbf{W}_i, \boldsymbol{\beta}) + v_i$. If this ratio is equal to 1, the firm is considered to be efficient, because deviations from $C(Y_i, \mathbf{W}_i, \boldsymbol{\beta})$ represented by v_i are random and beyond the firm's control. However, if this ratio is greater than one, it is because u_i, the avoidable deviation, is greater than zero, and the firm is to some extent inefficient.

The version of the expenditure function used in this study was

$$\ln E_i = \alpha_o + \alpha_Y \ln Y_i + \alpha_{YY} \ln Y^2 + \Sigma\beta_{ij}W_{ij} + \Sigma\gamma_s d_s + v_i + u_i,$$

where *i* refers to the *i*th size grouping of firms by level of output, $i = 1,2,\ldots,7$ in the first estimated relationship and $i = 1,2,..5$ in the second estimated relationship, where the output categories were further compressed. The *d* variables are dummy variables inserted to denote the output size class. Since the smallest size category was considered to be the base category, d_1 refers to size category 2, d_2 refers to size category 3, and so on. Thus *s* varied from 1 to 6 in the first estimated relationship and from 1 to 4 in the second relationship. The W_{ij} terms are the respective prices of inputs X_{ij}, where the inputs included capital, labor, and intermediate goods.[13]

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[12]See (Kumbhakar and Lovell, 2003, pp. 74-91 and Chapter 4); (Aigner, Lovell, and Schmidt, 1977); and (Greene, 1980).

[13]The following data were used in estimating the expenditure function. Total expenditure was equal to the sum of total salaries and wages, cost of materials, rent paid, depreciation, and net profit in millions of rand. Total

Regularity conditions require that a cost function be linearly homogeneous in input prices, and one way to impose this restriction is to normalize the expenditure and input price variables by dividing by one of the input prices (Kumbhakar and Lovell, 2003, p. 139). In this study, we used the price of capital as the normalizing variable. Thus, the final version of the estimated model was

$$\ln (E_i/W_K) = \alpha_o + \alpha_Y \ln Y_i + \alpha_{YY} (\ln Y)^2 + \Sigma\beta_{ij}(W_{ij}/W_K) + \Sigma\gamma_s d_s + v_i + u_i,$$

where $i = 1,2,\ldots,7$ in the first model, and $i = 1,2,\ldots,5$ in the second;

$s = 1,2,\ldots,6$ in the first model, and $s = 1,2,\ldots,4$ in the second;

and $j = L,M$ for labor and intermediate goods.

The stochastic cost function program in LIMDEP 8.0 (Greene, 2002) was used to estimate the expenditure functions.

III. Estimation Results

The outcomes of the estimation procedures are shown in Table 1. In the first model with the firms divided into seven output classes, all of the estimated parameters were significantly different from zero at the five

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output was calculated as the gross output of the industry in current rand (millions) divided by a price index for transport equipment output (1990=100). Because of data availability, the price of capital was given by the interest rate on first mortgage bonds before 1963, the yields on new issues of company stock debentures and notes from 1963-1980, and after 1980 by yields on company loan securities traded on the stock exchange. Again because of data availability, the price of labor was given by an index of South African motor industry minimum wage rates for journeymen before 1970, an index of average wages and salaries per employee in the motor trade industry between 1970 and 1973, and after 1973 an index of South African metal engineering industry wage rates. The price of intermediate goods was given by the price index for materials in mechanical engineering (1990=100). Because of data limitations, it was necessary to assume that the price of a particular input at a particular point in time was the same for all firms. The share of capital was calculated from the sum of rent paid, depreciation, and net profit. The data sources, International Monetary Fund, *International Financial Statistics Yearbook*, and Central Statistical Service, *South African Statistics*, are listed in the bibliography.

Table 1 Estimates of Cost Function Parameters
(t values)

Parameter	Model 1	Model 2
α_0	-2.615**	-3.600**
	(-5.004)	(-6.074)
α_Y	0.646**	0.820**
	(7.372)	(8.310)
α_{YY}	0.012**	0.005
	(3.407)	(1.253)
β_L	0.729	0.188
	(0.573)	(0.861)
β_M	0.864**	0.747**
	(7.243)	(3.737)
γ_1	0.132**	0.198**
	(3.271)	(2.161)
γ_2	0.179**	0.159**
	(3.391)	(2.022)
γ_3	0.208**	0.181**
	(3.413)	(2.032)
γ_4	0.194**	0.226*
	(3.208)	(1.675)
γ_5	0.214**	
	(3.338)	
γ_6	0.186*	
	(1.628)	
σ_v^2	0.0000008	0.00004
σ_u^2	0.00485	0.00769
θ	14.35319	11.40654
Log Likelihood	51.78640	34.86617

*Significantly greater than zero at the 10 percent level of significance.

**Significantly greater than zero at the 5 percent level of significance.

percent level of significance except in two cases. The first exception was γ_6, the coefficient of the dummy variable for the group of firms in the largest output class, which was significantly greater than zero at the ten percent level of significance. The second case was β_L, which was not significantly greater than zero at any reasonable significance level.

An estimate of returns to scale can be obtained from $(1/E_C)$, where E_C is the estimated cost elasticity of demand. In this model, the cost elasticity estimate is given by $E_C = \alpha_Y + 2\alpha_{YY} \ln Y$. At the mean output value, the calculated value of E_C given the parameter estimates was .998, and a Wald test was consistent with the hypothesis that the cost elasticity was not significantly different from one and that constant returns to scale existed at the mean level of output. However, the calculated value of E_C was equal to .845 at the minimum level of output, implying an estimated returns to scale coefficient of 1.183. This estimated value of the cost elasticity *was* significantly different from one at the 0.5 level of significance.

The estimated values of σ_v^2, σ_u^2, and θ $(= 1/\sigma_u)$ are also given in Table 1.

As shown there, the stochastic variance in expenditures is relatively small: σ_v^2 is virtually equal to zero (0.0000008). With an assumed exponential distribution for u, the expected value of u is equal to σ_u.[14] It follows that the estimated mean expenditure level was equal to $e^u \approx e^{.07} \approx 1.072$ times what it would have been without any inefficiency.

The estimates of the coefficients of the dummy variables for firm size class are interesting. The base model was the smallest size class, so the estimates of the γ_is are consistent with the hypothesis that, *ceteris paribus*,

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[14]See (Kumbhakar and Lovell, 2003, p. 81); and (Greene, 2000, pp. 69-70).

the smallest firms achieved the lowest costs. All of the estimated values of the γ_i terms were greater than zero at the five percent level of significance, except for that of γ_6, which was significantly greater than zero at the ten percent level of significance. However, little support was gleaned for the hypothesis that many of the γ_i estimates were statistically significantly different from one another. The estimated values of γ_1 and γ_5 were significantly different from each other at about the five percent level of significance, while those of γ_1 and γ_3 were significantly different at about the six percent level. Additionally, pairwise Wald tests were consistent with a statistically significant difference between γ_1 and γ_4 and γ_1 and γ_2 at about the eleven and nineteen percent levels of significance, respectively. However, none of the other pairwise Wald tests supported a statistically significant difference between the γ_i estimates.

In the second estimated model, the next three output categories after the first group were compressed into one to further explore the results with fewer output classes. The base output group for the second model was the same as that for the first model. However, the dummy variable d_1 now corresponds to a combined group that would include the next three output categories after the base group from the first model. Thus, γ_1 and d_1 correspond to the output group represented by γ_1, γ_2, and γ_3 (and, respectively, d_1, d_2, and d_3) from the first model. Accordingly, d_2 in the second model corresponds to d_4 in the first model, and so on.

In many respects, the results with this model were quite similar to those of the first model. All estimated coefficients were significantly different from zero at the five percent level of significance except for α_{YY}, β_L, and γ_4, which corresponds to γ_6 in the previous model. As in the previous model, γ_4 was significantly greater than zero at the ten percent level of significance. Again, while the calculated value of the cost elasticity given the estimates of α_Y and α_{YY} was less than one at the mean level of output (E_C = .968), it was not significantly different from one according to a Wald test. However, it was again significantly different from one at the minimum level of output.

None of the estimated values of the γ_i coefficients were significantly different from each other in pairwise Wald tests at levels of significance below thirty percent. Moreover, a likelihood ratio test using a x^2 statistic for the two models is consistent with the hypothesis that $\gamma_1 = \gamma_2 = \gamma_3$ in the first model are not equal. In this second model, the estimated $E(u) = 1/\sigma_u \approx 0.0877$. Accordingly, on average, the expenditure by a firm was $e^u \approx e^{.0877} \approx 1.092$ times larger than it would have been without any inefficiency.

IV. Conclusions

The issue of firm size and efficiency is an important one for a country concerned about its balance of trade deficit. In a recent paper, Naudé and Serumaga-Zake (2003) found that firm size as well as firm efficiency were significant factors in determining the ability of an individual firm to successfully export its products.[15]

The results from this study lead us to some interesting, albeit tentative, conclusions with regard to the relationship between firm size and unit costs. First, apparently the firms in the smallest output group achieved the lowest costs, everything else equal. And the firms in the

[15]However, while Calof (1993) acknowledged a positive correlation between firm size and participation in international trade, he also found evidence to suggest that firm size itself may not be a barrier to export markets.

second output group in the first model, represented by the estimate of γ_1, also appear to have achieved lower costs for a given level of output than those of groups 3 and 5 and possibly for groups 2 and 4 as well. However, it is also interesting that the firms in group 6 were possibly able to begin to reverse the trend of higher unit costs, given that there was no statistically significant difference between the estimated values of γ_1 and γ_6. Moreover, in both models the estimate of γ for the largest output group was significantly different from zero at only the 10 percent level of significance. Second, while both models yielded cost elasticity estimates consistent with economies of scale at both the minimum and mean levels of output, they were statistically significant based on Wald tests at only the minimum output level.

It appears that both the smallest firms and perhaps the largest firms in the South African motor vehicle industry were doing something right with respect to controlling costs, while the unit costs of the middle-sized firms were higher. Therefore, the issue of scale economies is perhaps not the problem throughout the entire automobile industry that it has been considered to be. However, it also appears that, on average, the firms in this industry have avoidable inefficiencies that raise their costs from about seven to nine percent.

Nevertheless, one must keep in mind that there is a very large variety of firms lumped together in this industry group, from manufacturers of various kinds of automobile parts to assemblers of final vehicles. Thus, the fact that the data are aggregated over a variety of producers in the industry might be at the root of some of these rather unexpected results. In addition, data limitations forced us to assume that input prices were the same for all of the firms, regardless of their size. It may be that some smaller firms were able to obtain some inputs (for example, labor) more cheaply because of their locations or particular labor needs. On the other hand, perhaps the very largest firms were also able to obtain some inputs (for example, capital) at lower prices because of their international connections and/or lower risk ratings.

Clearly, a less highly aggregated panel data set over an extended time period would be preferable to the data utilized in this study. However, until such data are available, the preliminary insights offered in the present study may be helpful to both policy makers and others interested in the performance of the South African motor vehicle industry.

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