Capital and labour substitutability in South Africa

C. Friedrich Kreuser and Neil A. Rankin

Abstract

Very little work has been done on the substitutability of capital and labour at the firm level in South Africa. This paper updates Behar (2010), the first South African paper to examine this issue at a micro-level. The results confirm Behar's broad finding – capital and labour are substitutes. This means that relative increases in the price of labour, through either higher wages or lower capital costs, encourage a substitution away from labour. The paper also finds that all types of labour, except managerial workers and unskilled production labour, are substitutes. Lastly, this paper investigates the association between firm-level estimates of own and cross-price elasticities of capital and the different type of labour, and firms' perceptions of obstacles. These estimates find no significant relationship between the cost of financing and the elasticity of capital and the types of labour in most cases. One interpretation of this is that the cost of finance is not a constraint for firms who want to become more capital intensive.

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1. Introduction

The issue of capital and labour substitutability, and substitutability between different types of labour, should be central to the South African employment debate. At the extreme, if machines and people are perfect substitutes then employment can be created without adding any more capital. If they are imperfect substitutes or complements, then capital is required for employment creation, and constraints to capital accumulation may be constraints to employment creation too. Within employment complementarity between different types of labour matters too. Can low skilled workers be hired instead of high skilled workers, or does one group need the other? What about semi-skilled workers? These relationships matter for South Africa, which has had persistently high rates of unemployment, particularly concentrated amongst those with the least skills.

The 'standard' narrative used to explain South Africa's high levels of unemployment is that those who are unemployed lack the skills which firms require. In this narrative the policy solution is simple (although the implementation may be difficult) – provide the requisite skills to those who are unemployed. Various government initiatives attempt this solution, for example Skills Education and Training Authorities (SETAs) train workers based on firms' needs, and learnerships provide subsidised employment and training for new entrants into jobs. These initiatives have not been very successful in creating employment. Rankin, Roberts, and Schöer (2015) find that immediately after completion those who participate in these initiatives are more likely to be in jobs than non-participants but this fades quickly. Furthermore, the way these institutions are financed, and the types of firms that use them, redistributes resources away from smaller and more labour-intensive firms towards larger and more capital-intensive ones. The skills-narrative often lacks any discussion of substitutability between factors of production, including between different types of labour, and the central role that prices play in encouraging firms to choose capital over labour, or one type of worker over another. Given South Africa's high levels of inequality and the large number of working poor (see for example Seekings, 2014 for a discussion of some of the nuances of South African inequality) discussing the effect that the relative price of labour has on demand is politically charged. However, avoiding this issue neglects a potentially important factor which may be limiting job creation. Furthermore, identifying the substitutability or complementarity between factors of production can also identify other bottle-necks. For example, employment creation amongst the unskilled may be limited because complementary inputs may be missing.

Almost all analysis of substitutability between factors of production in South Africa has been undertaken either on economy wide, or sector-level data (see for example Bonga-Bonga, 2009, Fedderke and Hill, 2011 and Kreuser, Burger, and Rankin, 2015). The only paper to investigate this substitutability at a firm level is Behar (2010). He uses manufacturing firm data from the 1998 National Enterprise Survey (NES), the October Household Survey (OHS) to generate estimates of wages for different types of workers, and costs of capital based on calculations by Fedderke, Shin, and Vase (2003) to estimate a translog cost function and a system of cost shares. These are then used to calculate elasticities of substitution between the various factors of production. His findings suggest that capital is a substitute for all occupations but that within labour, unskilled and semi-skilled labour are complements but unskilled and skilled labour are substitutes.

This paper attempts to update Behar (2010) in two ways, to verify the robustness of his results. First, it uses a different and more recent dataset. Second, it uses estimates of wages provided by firms rather than from a matched household survey. The results confirm Behar's broad finding – capital and labour are substitutes within the South African manufacturing industry. This means that relative increases in the price of labour, through either higher wages or lower capital costs, encourage a substitution away from labour. Our results also suggest that all types of labour, except managerial workers and unskilled production labour, are substitutes. This means relative prices (or wages) of different types of workers matter for both their own demand but also for the demand for other types of workers. For example that relative increases in wages for low-skilled workers would cause a decrease in their own demand but also an increase in the demand for workers further up the skills distribution. Thus policies which raise the wages of unskilled workers, like a National Minimum Wage would do, will reduce the demand for unskilled workers but raise the demand for those with more skills (although by not as much).

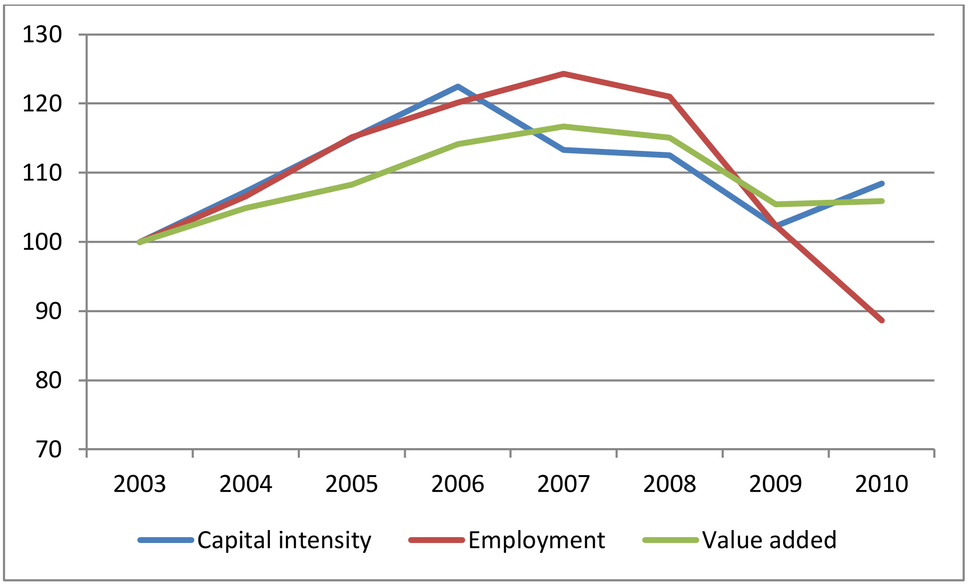
Lastly, this paper investigates the association between firm-level estimates of own and cross-price elasticities of capital and the different type of labour, and firms' perceptions of obstacles. These estimates find no significant relationship between the cost of financing and the elasticity of capital and the types of labour in most cases. One interpretation of this, which fits with the broader results, is that the cost of finance is not a constraint for firms who want to become more capital intensive. The estimates also indicate that where skilled and unskilled labour are complementary then firms rate labour regulations as a bigger constraint. The paper also finds that skills are a concern for firms where capital and managers, or where managers and unskilled workers, are more easily substitutable. Firms where managers and skilled production workers are complements are also more likely to rate this area as a concern. This suggests that when firms complain about a lack of skills in their workforce they may actually be referring to those with higher skills to begin with.

2. Capital intensity and employment in South African manufacturing

At an aggregate level value-added, capital intensity and employment are closely related in the South African manufacturing sector. Figure 1 shows this relationship for most of the 2000s. All three variables increase steadily in the first part of the period but then fall and plateau in the second half.

After 2008 employment falls substantially as the Global Financial Crisis reaches South African manufacturers. Interpreted simply, these aggregate trends suggest that South African manufacturing value-added grows through the addition of both capital and labour.

Figure 1. Trends in real value added, capital intensity and employment in South African manufacturing.



Source: Statistics South Africa (2012) Compendium of Industrial Statistics (2012). Series are real indices.

Regression analysis at the industry-level confirms this positive relationship (Table 1) and suggests that on average capital growth adds more to value-added growth than employment growth. These estimates of elasticity suggest that, once industry and year fixed effects are controlled for, value-added is almost doubly more sensitive to capital than to labour. This fits with broader economy-wide trends: Burger (2015) for example shows that labour's share of Gross Value Added (GVA) decreased substantially in the 20 year period post 1994, whilst capital's share increased.

These results indicate that manufacturing value-added growth will absorb relatively more capital than labour. This is a particular concern in South Africa with its high levels of unemployment. Furthermore, the structure of South Africa's economy is out of line with its emerging market peers – the relative contribution of manufacturing is falling (Rodrik, 2008). Rodrik blames the weakness of export-orientated manufacturing for the lack of job creation at the relatively low end of the skill distribution. His explanation for the decline in manufacturing is a decline in relative profitability rather than wages. However, his analysis is at an aggregate level which may mark more disaggregated trends.

Table 1. The relationship between value-added, capital stock and employment. OLS estimations.

	(1) ln(value added)	(2) ln(value added)	(3) ln(value added)	(4) ln(value added)
ln(capital stock)	0.231***	0.496***	0.228***	0.401***
	(0.0459)	(0.0740)	(0.0444)	(0.0763)
ln(employment)	0.203***	0.252***	0.105*	0.173***
	(0.0409)	(0.0405)	(0.0539)	(0.0588)
Industry fixed effects	N	N	Y	Y
Year fixed effects	N	Y	N	Y
Observations	208	208	208	208
R-squared	0.294	0.391	0.599	0.650

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: StatsSA (2012), Compendium of Industrial Statistics

Burger (2015) argues that institutions requiring higher returns drove investment in capital-augmenting labour-saving technology and thus capital intensification. Kreuser, Burger, and Rankin (2015) make a similar argument based on estimates from sector level data – technological change in South Africa has favoured capital over labour and thus resulted in an increase in capital's share in value-added. There is also evidence that compositional changes within jobs are important mechanisms driving observed outcomes. Bhorat, Goga, and Stanwix (2013) show that returns to high-skilled jobs, and those that cannot be automated increased during the period 2001-12, suggesting growth in demand for these types of jobs outstrips supply.

Table 2. Earnings changes, by task categories: 2001–2012

Task Category	2001	2011	% Change
ICT	664 119	1 091 338	64%
Automated	4 432 177	4 660 485	5%
Face-to-face	3 530 171	4 754 412	35%
On-site	6 819 508	7 702 578	13%
Analytic	1 883 114	2 879 530	53%

Source: (Bhorat, Goga, and Stanwix 2013)

Rankin (2016) also argues that the observed increase in manufacturing labour productivity over much of the last 20 years has to do with changing firm composition, and potentially job composition – low paid jobs in labour-intensive firms seem to be vanishing. His argument, that this may be due to substitutability between different types of labour, and/or the exit of the types of firms that cannot undertake this substitution, relies on the assumption that capital and labour are substitutes as are skilled and unskilled workers. This assumption is based on one paper in the South African context; Behar (2010).

3. The transcendental logarithmic cost function, labour demand and elasticity of substitution

This paper uses the transcendental logarithmic (translog) cost function approach as pioneered by Christensen, Jorgenson, and Lau (1973) to investigate substitutability between factors of production.[1] This has been used in the African context by (Behar 2010) for South Africa, and (Teal 2000) for Ghana. The translog cost function is defined as in [1] below, where *Cost* refers to total cost of the factors of production paid by the firm, w_i is the cost of factor i and y is a measure of total output of the firm. The first order condition of the cost function with respect to factor costs provides the cost share equations, as in [2].

$$Log\ Cost = \alpha_0 + \sum_i \alpha_i\ Log\ w_i + \frac{1}{2}\sum_i \sum_j \beta_{i,j}\ Log\ w_i\ \ Log\ w_j + \alpha_y Log\ y + \beta_{y,y} Log\ y\ Log\ y + \sum_i \beta_{y,i}\ Log\ y\ Log\ w_i \qquad [1]$$

$$\frac{d\ Log\ Cost}{d\ Log\ w_i} = s_i = \frac{w_i\ X_i}{C} = \alpha_i + \sum_j \beta_{i,j}\ Log\ w_i + \beta_{Y,i} Log\ y\ \forall\ i \qquad [2]$$

In the equations above the Slutsky symmetry implied by cost minimization results in the parameter restrictions in [3]. Axiomatically, the share equations must sum to unity so that the covariance matrix of the errors is singular should all share equations be estimated simultaneously. Following the literature, linear price homogeneity is imposed over the share equations (Greene, 2003; Behar, 2010). These restrictions are provided in [4]-[7].

$$\beta_{i,j} = \beta_{j,i}\ \forall\ i,j \qquad [3]$$

$$\sum_i \beta_{i,j} = 0 \qquad [4]$$

$$\sum_j \beta_{i,j} = 0 \qquad [5]$$

$$\sum_i \alpha_i = 0 \qquad [6]$$

$$\sum_i \beta_{Y,i} = 0 \qquad [7]$$

The main benefits of the translog cost function is that it allows for flexible and simple identification of the constant output elasticities of factor demand, [8], and the Allen partial elasticities of substitution, [9]. It should be noted that both of these elasticities are only at constant output as the elasticity of output with respect to a change in price is required to derive the unconditional effect. The constant output elasticity of factor demand is as a measure of the responsiveness of the demand of factor i due to a change in the price of factor j, while the elasticity of substitution is a

[1] The translog is a generalisation of the widely used Cobb-Douglas functional form. The appropriateness of using the translog over the Cobb-Douglas form can be empirically tested as in Teal (2000).

measure of the percentage change in the proportion of two inputs associated with a percentage change in the marginal rate of technical substitution (Jehle and Reny, 2011).

A further advantage of the translog specification is that testing certain technological assumptions is easy; $\beta_{Y,i} = 0 \, \forall i$ implies homothetic returns to scale. Where returns to scale of the firm is independent of factor prices, the cost function is homogeneous of degree $\frac{1}{\alpha_Y}$ where $\beta_{Y,Y} = 0$.

$$\eta_{i,j} = \frac{\beta_{i,j}+s_i s_j}{s_i} \text{ and } \eta_{i,i} = \frac{\beta_{i,i}+s_i s_i - s_i}{s_i} \quad [8]$$

$$\sigma_{i,j} = \frac{\beta_{i,j}+s_i s_j}{s_i s_j} \text{ and } \sigma_{i,i} = \frac{\beta_{i,i}+s_i s_i - s_i}{s_i s_i} \quad [9]$$

4. Data

The data used in this paper comes from the World Bank's Investment Climate Assessment (ICA) of 2004, a firm-level survey of predominantly manufacturing firms across the major metropolitan areas of South Africa. We limit our sample to manufacturing firms only. To estimate the translog cost function we require information on the price of capital, the wages of labour and total costs as well as factors of production shares in total costs.

The cost of capital is inherently difficult to calculate on the firm level as it often is an implicit cost. In his study, Behar (2010) uses the cost of capital as calculated from Fedderke *et al* (2003) using industry level data. However it is not clear that this aggregate approach is the appropriate method to calculate capital costs at the firm level since it makes strong assumptions about the depreciation rates of the firms themselves and the interest rates they face. Instead we calculate the user cost of capital as the sum of the rental rate and interest rate faced by firms. The rental rate of capital of each firm is calculated as the sum of machinery, vehicle and land rental or depreciation costs and the divided by the total capital stock of the firm. The interest rate faced by the firm is then calculated as the mean of the available long term, short term and overdraft interest rates. Where these interests rates are unavailable a mean interest rate is predicted using a regression of form [10] below where Γ includes log total sales, raw materials and total employment to the third order, log sale value of capital and current capital stock to the second order as well as controls for industry, export status, foreign ownership status and province. This form is used to constrain mean interest rate to the to the unit interval. Total cost of capital is then calculated as the predicted cost of capital multiplied by the book value of assets of the firm, as in [11], so that total factor costs of the firm is calculated as in [12].[2]

[2] This is estimated using a logit model. Mean interest rates are only available in 173 observations. Firms with missing capital stock were excluded, firms with missing rental entries for a specific group were assumed to spend nothing on that specific capital item

$$Mean\ Interest\ Rate_i = \frac{\exp(b+\Gamma\ )}{1+\exp(b+\Gamma)} \quad [10]$$

$$\hat{r} = \frac{Rental\ Costs}{Total\ Capital\ Stock} + Mean\ Interest\ Rate$$

$$Total\ Captal\ Costs = \ \hat{r} \times Book\ Value\ of\ Fixed\ Capital \quad [11]$$

$$Cost = Total\ Capital\ Costs + Total\ Labour\ Cost \quad [12]$$

As shown in Kreuser (2015) different wage measures may result in different shares in the ICA. Due to data availability the average wage line item in the ICA is used to inform wage shares as in equation [13]. These items were also used to calculate total labour costs. The share of each item is then simply its share in total costs.

$$Total\ Labour\ Cost_i = \sum_i Average\ Wage_i\ X_i\ \ \forall\ i = Managers, Sk.Production, USk.Production \quad [13]$$

In Table 3 the aggregate statistics of the sample is provided, while table 4 provides the industry and province-specific indicators. Table 4 shows that in our sample Gauteng firms predominate and that, unlike Behar, our sample only includes firms in the Western Cape, Eastern Cape, Gauteng and KwaZulu-Natal. In the estimations KwaZulu-Natal is grouped together with the Eastern Cape.

Table 3. Aggregate Statistics

Variable	Mean	Median	Std. Dev
Cost (R Millions)	12.88	6.29	18.39
Output (R Millions)	83.62	23.00	150.00
Bookvalue of Capital (R Millions)	13.12	7.08	24.30
Managers	15.49	10.00	16.00
Unskilled Production Workers	43.17	18.00	93.24
Skilled Production Workers	71.45	41.00	120.52
Interest Rate	0.15	0.12	0.07
Managers Ave. Annual Wage	225 634.8	208 000.0	119 136.6
Skilled Production Ave Annual Wage	99 801.7	84 000.0	62 369.0
Unskilled Production Ave. Annual Wage	38 180.8	36 000.0	28 074.8

Table 4. Industry and Provinces

Industry (ISIC code rev 3.1)	n	% of firms
Food (15)	20	7.97
Textiles (17-19)	20	7.97
Wood (20-22)	39	15.54
Chemicals (23-26)	44	17.53
Metals (27-28)	32	12.75
Machinery (29-33)	53	21.12
Vehicles (34-35)	9	3.59
Furniture and Other (36)	34	13.55
Province		
Western Cape	41	16.33
Eastern Cape	4	1.59
KwaZulu-Natal	15	5.98
Gauteng	191	76.1

Table 5 presents the descriptive statistics of the sample. Interestingly, unlike Behar (2010) we do not find a mean of 50% for capital costs in the manufacturing sector. Rather, at the firm level, we find this figure to be closer to 15% per firm. When we weight our firms by sales or output, this figure also ends up as approximately 15%.[3] Only 14% of firms in our sample export or are foreign owned. Most firms operate at around 80% of maximum capacity. The share of manager, skilled production worker and unskilled production worker costs are similar on average.

Table 5. Descriptive Statistics

Variable	Mean	Median	Std. Dev	Min	Max	Economy Average
ln Costs	15.76	15.65	15.76	12.99	18.76	
Capital Share of Costs	0.15	0.13	0.15	0	0.7	0.13
Managers Share of Costs	0.32	0.33	0.32	0.01	0.66	0.29
Skilled Production Workers Share of Costs	0.3	0.26	0.3	0.01	0.96	0.35
Unskilled Production Workers Share of Costs	0.23	0.21	0.23	0	0.78	0.23
ln Interest Rate	-1.98	-2.12	-1.98	-2.43	-0.19	
ln Managers Ave Wages	12.2	12.25	12.2	9.21	13.74	
ln Skilled Production Ave Wage	11.36	11.34	11.36	9.8	13.29	
ln Unskilled Production Ave Wage	10.43	10.49	10.43	9.55	12.74	
% Exported	14%	10%	14%	0%	100%	
Capacity Utilisation	79%	80%	79%	30%	100%	
Foreign Ownership	14%	0%	14%	0%	100%	

[3] Note that where we follow Behar and add an additional 20% as part of the effective tax rate, this figure increases to around 26% without affecting the results greatly. This is seen below.

5. Empirical method

The translog cost function is estimated with the systems of equations specified in [14]-[17] using an iterative feasible non-linear generalised least squares estimator, a non-linear variant of Zellner's seemingly unrelated regression estimator, in Stata. Slutsky symmetry is imposed in all equations with the linear price homogeneity restrictions being enforced by [18]-[23]. In [14] Θ includes controls for the firm's industry, province, foreign ownership status, production capacity utilised, and the proportion of output exported. In all regressions the share of capital in total cost is constrained to be below 80% while specific outliers were removed.[4] These specific outliers appear to bias the estimates considerably often resulting in a negative coefficient on α_M.

$$Log\ Cost = \alpha_0 + \alpha_r\ Log\ r + \alpha_M Log\ w_M + \alpha_S Log\ w_S + \alpha_U Log\ w_U + \frac{1}{2}(\beta_{r,r} Log\ r\ Log\ r + \beta_{M,M} Log\ w_M\ Log\ w_M + \beta_{S,S} Log\ w_S\ Log\ w_S + \beta_{U,U} Log\ w_u\ Log\ w_u) + \beta_{r,M} Log\ r\ Log\ w_M + \beta_{r,S} Log\ r\ Log\ w_s + \beta_{r,U} Log\ r\ Log\ w_u + \beta_{M,S} Log\ w_M\ Log\ w_s + \beta_{M,U} Log\ w_M\ Log\ w_u + \beta_{S,U} Log\ w_S\ Log\ w_u + \alpha_Y Log\ Y + \beta_{Y,Y} Log\ Y\ Log\ Y + \beta_{Y,r} Log\ Y\ Log\ r + \beta_{Y,M} Log\ Y\ Log\ w_M + \beta_{Y,S} Log\ Y\ Log\ w_s + \beta_{Y,U} Log\ Y\ Log\ w_U + \Theta \quad [14]$$

$$s_M = \alpha_M + \beta_{M,M}\ Log \frac{w_M}{r} + \beta_{M,S} Log \frac{w_S}{r} + \beta_{M,U} Log \frac{w_U}{r} + \beta_{Y,M} Log\ Y \quad [15]$$

$$s_S = \alpha_S + \beta_{M,S}\ Log \frac{w_M}{r} + \beta_{S,S} Log \frac{w_S}{r} + \beta_{S,U} Log \frac{w_U}{r} + \beta_{Y,S} Log\ Y \quad [16]$$

$$s_U = \alpha_U + \beta_{M,U}\ Log \frac{w_M}{r} + \beta_{S,U} Log \frac{w_s}{r} + \beta_{U,U} Log \frac{w_U}{r} + \beta_{Y,U} Log\ Y \quad [17]$$

$$\alpha_r = 1 - \alpha_M - \alpha_S - \alpha_U \quad [18]$$

$$\beta_{r,r} = 0 - \beta_{r,M} - \beta_{r,S} - \beta_{r,U} = \beta_{M,M} + \beta_{S,S} + \beta_{U,U} + 2\ (\beta_{M,S} + \beta_{M,U} + \beta_{S,U}) \quad [19]$$

$$\beta_{r,M} = 0 - \beta_{M,M} - \beta_{M,S} - \beta_{M,U} \quad [20]$$

$$\beta_{r,S} = 0 - \beta_{M,S} - \beta_{S,S} - \beta_{S,U} \quad [21]$$

$$\beta_{r,U} = 0 - \beta_{M,U} - \beta_{S,U} - \beta_{U,U} \quad [22]$$

$$\beta_{Y,r} = 0 - \beta_{Y,M} - \beta_{Y,S} - \beta_{Y,U} \quad [24]$$

6. Results

Table 6 presents the results of our estimates, including our preferred specification and a second set of estimations where we add a 20% tax inclusion to capital costs. Unlike Behar (2010) we cannot reject the assumption of homotheticity, meaning that factor shares are not a function of output. In

[4] These outliers were 12 firms employing more than 100 managers, 2 firms paying unskilled production workers less than R10 000 per year and one firm that manufactures tobacco. 2 Firms were further removed due to paying skilled or unskilled employees more than double the average wage of the previous firm.

terms of control variables we find that Western Cape and Eastern Cape firms are smaller than firms in Gauteng, while firms with foreign ownership are larger. Costs increase with the proportion of output exported.

Table 6. Translog results

Preferred Specification (no 20% tax inclusion)				Capital Cost with 20% Effective Tax Rate			
Variable	Coef.	Variable (cont.)	Coef. (cont.)	Variable	Coef.	Variable (cont.)	Coef. (cont.)
α_0	8.015***	$\beta_{Y.Y}$	0.032***	α_0	8.961***	$\beta_{Y.Y}$	0.034***
	(2.449)		(0.007)		(2.695)		(0.007)
$\alpha_{\tilde{r}}$	0.267*	$\beta_{Y,\tilde{r}}$	0.002	$\alpha_{\tilde{r}}$	0.175	$\beta_{Y,\tilde{r}}$	-0.002
	(0.155)		(0.005)		(0.227)		(0.007)
α_M	0.042	$\beta_{Y.Y}$	-0.008	α_M	0.099	$\beta_{Y.Y}$	-0.003
	(0.15)		(0.006)		(0.157)		(0.005)
α_S	0.275	$\beta_{Y,M}$	0.007	α_S	0.349*	$\beta_{Y,M}$	0.005
	(0.179)		(0.007)		(0.2)		(0.007)
α_U	0.417***	$\beta_{Y,S}$	-0.001	α_U	0.377**	$\beta_{Y,S}$	0
	(0.155)		(0.006)		(0.167)		(0.005)
$\beta_{r,\tilde{r}}$	0.01	Textiles	0.243	$\beta_{r,\tilde{r}}$	-0.011	Textiles	0.271
	(0.012)		(0.163)		(0.02)		(0.165)
$\beta_{r,\tilde{M}}$	-0.018*	Wood	0.082	$\beta_{r,\tilde{M}}$	-0.006	Wood	0.14
	(0.011)		(0.142)		(0.013)		(0.145)
$\beta_{r,\tilde{S}}$	0.007	Chemicals	-0.088	$\beta_{r,\tilde{S}}$	0.015	Chemicals	-0.057
	(0.013)		(0.14)		(0.016)		(0.144)
$\beta_{r,\tilde{U}}$	0.002	Metals	0.051	$\beta_{r,\tilde{U}}$	0.003	Metals	0.079
	(0.012)		(0.15)		(0.015)		(0.153)
$\beta_{M,M}$	0.121***	Machinery	-0.194	$\beta_{M,M}$	0.107***	Machinery	-0.186
	(0.018)		(0.139)		(0.016)		(0.142)
$\beta_{M,S}$	-0.03*	Vehicles	-0.269	$\beta_{M,S}$	-0.033**	Vehicles	-0.23
	(0.016)		(0.211)		(0.014)		(0.213)
$\beta_{M,U}$	-0.072***	Furniture	-0.014	$\beta_{M,U}$	-0.068***	Furniture	0.014
	(0.014)		(0.145)		(0.013)		(0.148)
$\beta_{S,S}$	0.058**	Western Cape	-0.237**	$\beta_{S,S}$	0.052**	Western Cape	-0.32***
	(0.023)		(0.092)		(0.023)		(0.093)
$\beta_{S,U}$	-0.034*	Eastern Cape or KZN	-0.822***	$\beta_{S,U}$	-0.033**	Eastern Cape or KZN	-0.91***
	(0.018)		(0.293)		(0.016)		(0.294)
$\beta_{U,U}$	0.105***	Foreign Ownership	0.198**	$\beta_{U,U}$	0.098***	Foreign Ownership	0.21**
	(0.023)		(0.098)		(0.021)		(0.099)
α_Y	-0.596**	Capacity Utilisation	0.19	α_Y	-0.702***	Capacity Utilisation	0.224
	(0.256)		(0.242)		(0.265)		(0.246)
		% Output Exported	0.528***			% Output Exported	0.608***
			(0.194)				(0.196)
Equation	Parameters	RMSE	R2	Equation	Parameters	RMSE	R2
l_cost	27	0.497	0.791	l_cost	27	0.497	0.793
s_man	5	0.129	0.153	s_man	5	0.114	0.150
s_ps	5	0.162	0.043	s_ps	5	0.157	0.039
s_pu	5	0.126	0.119	s_pu	5	0.116	0.122
Homothet-icity	0.6016	Joint Signifi-cance	0	Homothet-icity	0.8459	Joint Significance	0
Obs	251			Obs	247		

*** Sign is consistent for 95% of sample, ** Sign is consistent for 90% of sample, * Sign is consistent for 85% of sample.

The predicted shares based on the estimates of our preferred specification are presented in Table 7. These estimates are similar to the actual sample means with the main difference being that the predicted values show much less variation: capital's share is between 12%-20%, managerial workers between 4%-49%, skilled production workers between 22%-39% and unskilled production workers between 11%-44%.

Table 7. Predicted Shares

Variable	Mean	Median	Std. Dev	Min	Max
Capital Share	0.15	0.15	0.15	0.12	0.2
Man. Share	0.32	0.33	0.32	0.04	0.49
Skilled Production Workers' Share	0.3	0.3	0.3	0.22	0.39
Unskilled Production Workers' Share	0.23	0.22	0.23	0.11	0.44

In Table 8 the elasticities of substitution are provided for the preferred and tax specification. In both cases we find evidence that capital and all types of labour are substitutes (a positive sign) and that the elasticity is highest between capital and skilled production workers. Furthermore, we find that all types of labour, except managerial workers and unskilled production labour are also substitutes. This is in slight contrast to Behar (2010), who finds that many, but not all, types of labour are compliments. Like us, he too finds that skilled and unskilled workers are substitutes. Overall these results suggest that capital has the strongest substitutability with skilled production workers but the weakest with managers. Managerial workers are a weak compliment to unskilled production workers.

Table 8. Elasticities of Substitution

Actual Shares									
Preferred Spec.					Tax Spec				
	Cap	Man	PS	US		Cap	Man	PS	US
Cap	-6***	0.56	1.23***	1.07***	Cap	-2.99***	.91***	1.27***	1.07***
Man		-.75*	.65*	-0.09	Man		-1.02*	0.44	-0.44
PrS			-1.85***	0.34	PrS			-2.23***	0.06
PrU				-1.12	PrU				-1.18

Predicted Shares									
Preferred Spec.					Tax Spec				
	Cap	Man	PS	US		Cap	Man	PS	US
Cap	-5.41***	.62***	1.15***	1.05***	Cap	-2.87***	.91***	1.2***	1.06***
Man		-.92***	.70***	-0.01	Man		-1.21***	.55***	-.33***
PrS			-1.66***	.49***	PrS			-2.03***	.34***
PrU				-1.35***	PrU				-1.51***

**** Sign is consistent for 95% of sample, ** Sign is consistent for 90% of sample, * Sign is consistent for 85% of sample.*

The compensated elasticities of factor demand are reported in Table 9. The own elasticities of factors are negative, on average, in all cases, indicating that a rise in the price of the item will lead to a decrease in factor demand. However, for a small number of firms the own elasticities are not negative, which suggests that some of the predicted shares fall outside the firms production possibility frontier (Berndt and Christensen 1973).

Like with the uncompensated elasticity estimates. The own price elasticity for capital is higher than those for labour. An increase in the price of capital yields a 3 fold fall in demand, but also a 0.5% higher demand for managerial workers, 0.4% higher demand for skilled and 0.33% higher demand for unskilled production workers. Of the types of labour, skilled production workers are most sensitive to their own price. A 1% increase in the wages of skilled production workers is associated with a 0.5% decrease in own demand, a 0.37% increase in the demand for capital, a 0.21% increase in the demand for managers and a 0.11% increase in the demand for unskilled production workers.

Table 9. Compensated Elasticities of Demand

Actual Shares									
Preferred Spec.					Tax Spec				
	Cap	Man	PS	US		Cap	Man	PS	US
Cap	-3.108*	.448*	.368*	.323*	Cap	-1.721*	.215**	.166*	.118*
Man		-.27*	.17*	-.016*	Man		-.314*	0.092	-.075*
PrS			-.489*	0.067	PrS			-.514*	0.01
PrU				-0.269	PrU				-0.251
Predicted Shares									
Preferred Spec.					Tax Spec				
	Cap	Man	PS	US		Cap	Man	PS	US
Cap	-2.801*	.393***	.371*	.284***	Cap	-1.685*	.233***	.224*	.144***
Man		-.302***	.21***	-0.003	Man		-.335***	.145***	-.061***
PrS			-.505***	.107***	PrS			-.54***	.064***
PrU				-.3***	PrU				-.285***

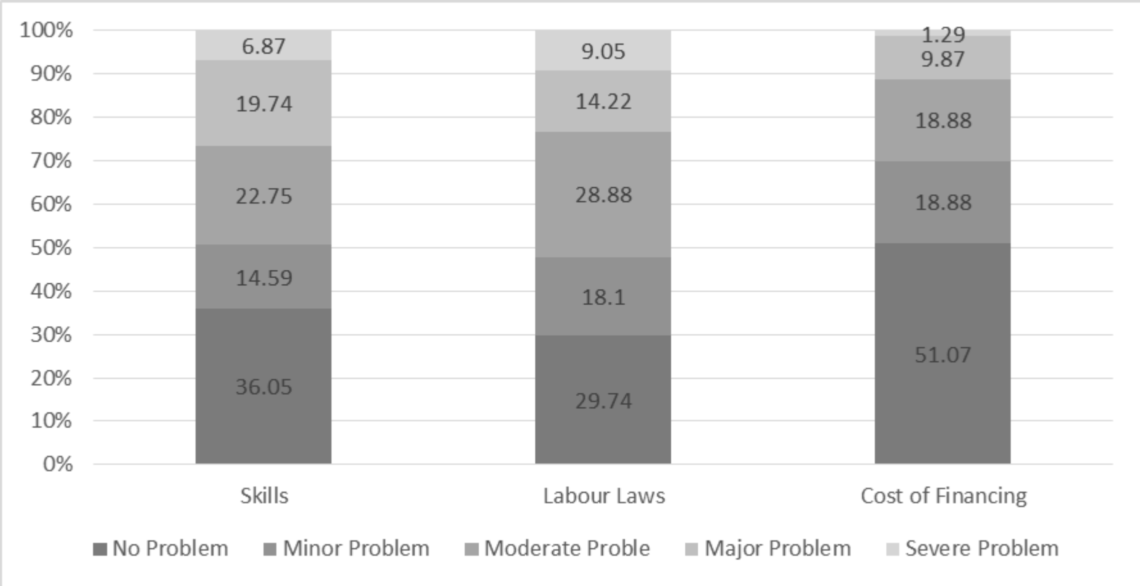
*** Sign is consistent for 95% of sample, ** Sign is consistent for 90% of sample, * Sign is consistent for 85% of sample.

7. Elasticities and constraints

The estimation approach allows us to calculate elasticities at the firm-level. The ICA survey also asked firms to rate certain factors as potential obstacles. Figure 2 shows the breakdown of responses for potential obstacles which are of direct relevance to the choice between factors of production (they are also the obstacles which firms rate as the most binding). 27% of firms in the sample rated the availability of skilled labour as either a severe or major problem, and 23% of firms rated South African labour legislation at a similar level. Finance was rated as a severe or major problem by 10% of firms. These proportions are obviously higher if the moderate problem category is included: skills and labour regulations are rated as at least a moderate problem by half the firms in the sample, and almost 30% of firms rate access to finance as at least a moderate problem.

There is evidence that firms perceive these areas as obstacles and may change their workforce composition as a response (see for example Rankin, 2006, on how various South African regulations and SMME outcomes are related). Table 10 presents the estimation results of an ordered probit when we include the estimated elasticities at a firm-level as an explanatory variable. There are a host of potential problems with this estimation approach, and thus we do not interpret these coefficients as causal, instead we use them to provide further insight into the potential constraints in South African factor markets.

Figure 2. Perceptions of firm-level obstacles



The estimations suggest that the composition of the workforce is associated with the perceptions of obstacles. Firms with higher levels of skilled production workers are more likely to rate skills of workers as more of a constraint; high levels of skilled production workers or high levels of unskilled production workers are both associated with stronger perceptions of labour regulations as a constraint.

In the skills and education of available workers estimation, firms where capital and managers are more easily substitutable are more likely to rate this area as a concern. Similarly, firms are more likely to rate this area as a concern where managers and skilled production workers are more easily substitutable. Finally, the less substitutable, or more complimentary managers and skilled production workers are the more likely firms are to rate this area as a concern. One interpretation of these results is that firms are concerned about the skills that managers have and thus where it is possible to substitute from capital or unskilled workers towards managers they are unable to due to binding skills constraints. The finding that this is a constraint for firms where skilled production workers and managers are complements also supports this explanation.

The labour regulations estimations also suggest a relationship between the substitutability of different types of labour and perceptions of labour regulations – where skilled and unskilled labour are complementary then firms are likely to rate labour regulations as a more severe constraint. Although both these types of labour are likely to be affected by labour regulations, Rankin (2006) shows that it is particularly amongst the unskilled where firms perceive labour regulations as binding. These results support this as firms which need both skilled and unskilled labour are likely to be directly affected by these regulations and thus perceive them as an obstacle, as they are not able to substitute away from unskilled labour to mitigate these regulations. The results for the costs of financing estimations also make sense – firms where capital and skilled production workers are complements are more likely to rate cost of financing as a problem. This suggests that firms that require both skilled production workers and capital may find the cost of capital a constraint.

Table 10. Ordered Probits on Obstacles faced by firms

	Skill and Education of Available Workers	Labour Regulations	Cost of Financing
Log Output	-0.0211	0.0581	0.0500
	(0.0878)	(0.0878)	(0.0941)
Log Cost	0.396	-0.0961	0.252
	(0.290)	(0.290)	(0.314)
Export Status	-0.0171	0.0471	0.212
	(0.155)	(0.153)	(0.162)
Capacity Utilization	-0.0775	-0.966*	-1.407**
	(0.546)	(0.539)	(0.566)
Foreign Ownership Status	-0.128	0.240	0.142
	(0.215)	(0.213)	(0.221)
Log Managers Emp.	-0.0587	-0.123	0.265
	(0.197)	(0.195)	(0.210)
Log Sk. Prd. Emp.	0.473***	0.225	-0.213
	(0.170)	(0.166)	(0.181)
Log Unsk. Prd. Emp.	-0.208	0.350*	0.161
	(0.190)	(0.189)	(0.200)
Log Capital	-0.441***	-0.275*	-0.441***
	(0.151)	(0.150)	(0.162)
Elasticity of Substitution between:			
Capital and Unsk. Prod.	0.0208	-0.0643	-0.0265
	(0.0644)	(0.0646)	(0.0699)
Capital and Sk. Prd.	-0.165	-0.00482	-0.448*
	(0.169)	(0.170)	(0.268)
Capital and Man. Prd.	0.186**	0.0381	0.0502
	(0.0774)	(0.0764)	(0.0800)
Sk. Prd. and Unsk. Prd.	-0.171	-0.258**	-0.0684
	(0.128)	(0.130)	(0.129)
Managers and Unsk. Prd.	0.124*	-0.0211	-0.0913
	(0.0653)	(0.0587)	(0.0626)
Managers and Sk. Prd.	-0.800***	-0.353	-0.470
	(0.279)	(0.276)	(0.295)
cut1	-1.640	-4.659*	-3.215
	(2.523)	(2.533)	(2.749)
cut2	-1.244	-4.150	-2.692
	(2.524)	(2.531)	(2.747)
cut3	-0.594	-3.305	-1.932
	(2.523)	(2.527)	(2.743)
cut4	0.342	-2.640	-0.887
	(2.522)	(2.527)	(2.746)
Observations	232	231	232
Pseudo R2	0.0328	0.0421	0.0393
F-test of model (p-value)	0.0897	0.0132	0.0843
* p<.1, ** p<.05, *** p<.01			

8. Discussion and conclusions

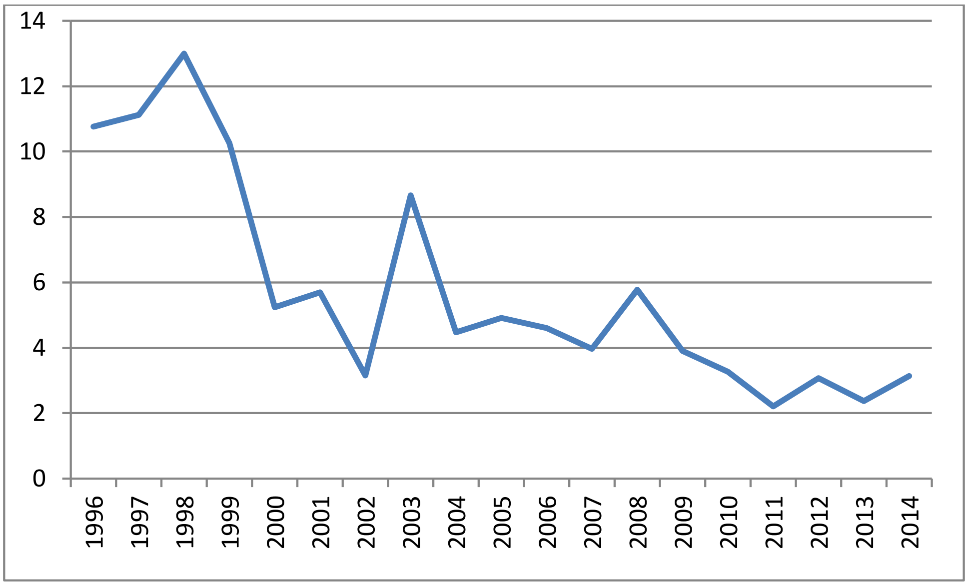
This paper uses a different dataset to replicate and extend the analysis of Behar (2010). The results confirm his broad finding – capital and labour are substitutes. This, and industry-level results, provide further evidence to support the arguments made by Burger (2014) and others that the observed decline in labour's share in GVA is due to substitution away from labour and towards capital. The industry-level estimates indicate that manufacturing value-added is more sensitive to the capital intensity of production than to employment. The estimated elasticities from the firm-data show that demand for capital is more sensitive to its own price than labour is to its own. Of the types of labour, demand for skilled production workers is the most sensitive to their price.

These results indicate that relative price may an important mechanism driving the observed changes in the share of labour and capital. South African real interest rates have followed a broad downward trend for most of the period since 1994. Thus the relative price of capital to labour has fallen, which our estimates suggest results in substitution away from labour. One reason for this fall in interest rates has been improvements in South Africa's macroeconomic, and especially monetary, policy during this period (see for example the discussion by Aron and Muellbauer, 2007). Although falling interest rates are likely to have an 'income effect' for firms allowing them to spend more on all factors of production, changes in relative prices, and the substitution effect identified here, will lead to higher capital intensity. South Africa's successful macro-policy which resulted in a lower price of capital, in an environment where labour costs have not adjusted and thus labour has become relatively more expensive has had unintended consequences in terms of the demand for labour within manufacturing. This is not to say that increasing interest rates, or substantial falls in the price of labour are the correct policy responses. Rather it highlights the need for policies for employment creation to work doubly hard to compensate for these changing relative prices.

The second broad set of findings is the degree of substitutability within labour. Like Behar the paper suggests unskilled (production) workers are substitutes for skilled (production) workers. It also finds that managers and skilled production workers are substitutes. This may suggest two types of labour 'technology' available to firms. One would be a combination of unskilled production workers and managers, a second would be dominated by skilled production workers. The substitutability between skilled and unskilled production workers also supports the argument made by Rankin (2016) that increased import competition and bargaining institutions that set wages higher than they ordinarily would be have resulted in, particularly smaller or labour-intensive firms, substituting away from unskilled (and lower paid) workers and towards skilled (and higher paid) workers.

These two types of labour 'technology' and the potential substitutability between them may help explain why some parts of organised labour have strong stances on two policies which change the price of lower-skilled workers. Some parts of organised labour have vociferously opposed the idea of a youth wage subsidy, and the implementation of the Youth Employment Tax Incentive. This incentive reduces the cost of hiring new, young, low-paid workers (most of who would be classified as unskilled). Based on the results in this paper this would reduce demand for skilled production workers (who are more likely to be the constituents of organised labour). A national minimum wage, which will increase the price of unskilled labour, is likely to have the opposite effect, and encourage substitution towards more skilled workers.

Figure 2. Real interest rates (%)



Source: World Development Indicators – series FR.INR.RINR

The broader argument made in this paper, that the falling relative price of capital (Figure 2) is an important explanation for the labour market outcomes we see, is supported by the relationship between the elasticities and perceptions of obstacles. Firms are more likely to mention the cost of financing as a constraint when capital and skilled production workers are complements but in no other cases. This suggests that no other elasticities show a relationship with the cost of finance, which may suggest that this is not a constraint to firms substituting away from labour.

The results from this paper are suggestive of certain relationships between factors of production in the manufacturing sector, rather than conclusive. More definitive results require better data and an exogenous identification strategy. The dataset being constructed from the South African Revenue Service's administrative dataset should provide better data, the challenge then becomes finding exogenous changes to identify causality. The results do suggest that the prices of factors of production do matter for the choices of inputs firms make. It is thus important that this is given more acknowledgement in South Africa's employment debate.

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