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The Optimal Distance to Port for Exporting Firms

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Abstract

Success in international trade depends, amongst other things, on distance from markets. Most new economic geography models focus on the distance between countries. In contrast much less theorizing and empirical analysis have focused on how distances within a country—for instance due to the location behaviour of exporting firms—matter to international trade. In this paper we contribute to the literature on the latter by offering a theoretical model to explain the optimal distance that an export-oriented firm would locate from a port. We present empirical evidence from South Africa in support of the model.

Keywords: distance, transport costs, manufactured exports

JEL classification: R0, R4, F14

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1 Introduction

Success in international trade depends, amongst other things, on distance[1] from markets. Distance is important for trade since it raises trade costs, particularly transport costs[2] and storage (waiting) costs, all of which lower the profitability of exporting.

Most studies on the relationship between international trade and transport costs focus on international shipping costs (i.e. the cost of transporting goods once they leave port) or on port efficiency (longer transit times at ports raise overall trade costs). Notable studies include Radelet and Sachs (1998), Martínez-Zarzoso et al. (2003), Clark et al. (2004), and Micco and Serebrisky (2004). Less work has focused on the link between domestic transport costs and trade, perhaps under the assumption in trade theory that domestic transport costs do not matter or that trade takes place between countries, where countries are treated as ‘pinpoints’ without their own internal distances. If this assumption is relaxed then export production must take place somewhere within the space of a country, and profit maximizing firms that are export-oriented will need to choose the optimal distance from a port through which their exports have to pass. This requirement is often not taken into account in studies focusing on either plant location or concentration studies (e.g. Zhou 2007), or in studies that focus on the differences in export success between rural and urban areas (e.g. Eff and Livingston 2007). In most traditional location studies, where transport or logistic costs are explicitly acknowledged, optimal firm location is evaluated against all markets, and not in particularly against the desire or need to export to international markets (e.g. McCann 1993). Where the need to export to international markets is concerned, it is however increasingly acknowledged that physical distance is significant (e.g. Basevi and Ottaviano 2002; Elbadawi et al. 2006). Our underlying hypothesis is that it is not only the physical distance from the foreign market that is important in the location decision of the firm, but the physical distance between a firm and its preferred port. Neglecting the relationship between the location and geographical concentration of export industries and the port through which their exports are shipped may also limit our understanding of the degree to which different sub-national regions within a country benefit—or suffer—from export-oriented growth strategies and globalization. The unequal spatial impact of greater openness to trade has been recognized in the literature (Overman et al. 2001; Traistaru et al. 2002), although relatively little theoretical and empirical work has addressed the role that access to a port can play.

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1 Despite improvements in transport infrastructure and logistical services, distance remains important for trade. A recent survey pointed out that ‘The death of distance is exaggerated. Trade costs are large, even aside from trade policy barriers and even between apparently highly integrated economies’ (Anderson and van Wincoop 2004: 691).

2 A number of recent studies have confirmed the links between distance and transport costs. A 1 per cent increase in distance increases transport costs by approximately 0.25 per cent. This matters for trade, since trade flows decrease as distance increases. For example, Venables (2006) finds that trade volumes decrease with distance and presents various elasticities of trade volumes at different distances, relative to their value at 1,000 km. With an elasticity of trade to distance of –1.25, trade volumes decline by 82 per cent at 4,000 km and 93 per cent at 8,000 km. Often greater distances require longer transit times for goods (e.g. as they have to pass more borders or ports) which imposes additional costs (Hummels 1999; 2001).

In this paper we contribute to the understanding of the location of exporting firms by proposing a theoretical model of the location decision of an exporting firm that explicitly takes distance to a port into consideration. The paper is structured as follows. The model is set out in section 2; in section 3 we present empirical evidence from South Africa; and section 4 concludes the paper.

2 Model

In order to determine the location decision of an exporting firm, we look at a representative firm of a particular industry i. The representative firm produces with labour L_i, human capital H_i, and intermediate goods M_i, which are all imported. Production technology is of the Cobb-Douglas type.[3]

$$Y_i = L_i^{\alpha_i} H_i^{\beta_i} M_i^{\gamma_i} = \kappa_i^{1-\alpha_i} \mu_i^{\gamma_i} L_i, \quad \kappa_i = \frac{H_i}{L_i}, \quad \mu_i = \frac{M_i}{H_i} \tag{1}$$

While fraction x_i^D of the firm's output is supplied to the domestic market without additional transaction or transportation costs, fraction x_i^X must be transported to a port incurring transaction cost for each export unit τ_i^X per unit of distance Δ_i (see Fujita and Mori 1996 on the impact of distance to port and port efficiency on the location of firms). As all intermediate goods must be imported, the firm has to pay price p^M for the international imports and $\tau_i^M \Delta_i$ for transportation to the location of production, where industry specific transportation costs of imports are τ_i^M and the distance from port to the production site is Δ_i.

Factor costs of the local factor are not identical with respect to the spatial location of the production process. As we expect a port to be part of an economic centre or agglomeration, we can make use of some stylized facts of spatial distribution of factor prices. With respect to labour a standard pattern of spatial analysis is a decreasing wage rate with an increasing distance to the centre. Wages w can be expected to fall with the distance to the centre

$$w = w(\Delta_i) = \Delta_i^{-\eta_L} \tag{2}$$

where η_L is a constant elasticity of wage reaction with respect to distance. In addition to labour we could also include other local factors of production like land following a similar pattern of spatial distribution of factor prices.

In contrast to labour costs, the cost of human capital increases with the distance to the centre. Proximity to the full variety of skills and human capital in an urban centre will make it easy for firms to find the appropriate kind of human capital that will match the job requirements. As the availability of human capital decreases with the distance to the centre, search costs for required skill levels will increase. Non-availability of human capital may even lead to prohibitive costs outside a centre. Therefore the effective costs related to human capital v, including search costs, can be expected to increase with the

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3 For the linear homogeneous functions we have $\alpha + \beta + \gamma = 1$.

distance to the centre. Denoting the elasticity of human capital costs with respect to distance as η_H, the effective costs of a unit of human capital is given by

$$\upsilon = \upsilon(\Delta_i) = \Delta_i^{\eta_H} \tag{3}$$

In order to determine the optimal location of the production process, the firm maximizes profits by choosing the optimal distance from port

$$\underset{\max! \to \Delta_i}{\pi_i} = L_i^{\alpha_i} H_i^{\beta_i} M_i^{\gamma_i} - w(\Delta_i) L_i - \upsilon(\Delta_i) H_i - \tau_i^M \Delta_i p_i^M M_i - \tau_i^X \Delta_i x^X Y_i \tag{4}$$

For this problem the F.O.C. $\frac{d\pi_i}{d\Delta_i} = 0$ can be rearranged to obtain

$$0 = F = \Delta_i^{-1}[\eta_L \Delta_i^{-\eta_L} - \eta_H \Delta_i^{\eta_H} \kappa_i] L_i - [x_i^X \tau_i^X + \tau_i^M x_i^M] \kappa_i^{1-\alpha_i} \mu_i^{\gamma_i} L_i \tag{5}$$

where $\kappa_i = \frac{H_i}{L_i}$ denotes the human capital intensity and $\mu_i = \frac{M_i}{H_i}$ gives the import intensity of the industry under consideration. Due to the non-linearities in this condition, we cannot explicitly determine the optimal distance of industry i's firm to the port. However, we can derive an implicit function $\Delta_i^*(\ldots)$ which links the optimal distance to the port with some industry and firm specific characteristics such as industry specific export shares x_i^X and transportation costs for exports τ_i^X, input value shares $x_i^M = p_i^M M_i / Y_i$ and transportation costs for imported intermediates τ_i^M, human capital intensity κ_i and intensity of intermediate imports μ_i, and total employment as an indicator of the size of the firm L_i.

Proposition 1. *The optimal distance to port for a firm of industry i*

Δ_i^*, *is an implicit function*[4]

$$\Delta_i^* = \Delta_i^*(\tau_i^X, x_i^M, \tau_i^M, x_i^X, \kappa_i, \mu_i, L_i) \tag{6}$$

For any industry i we can now determine how the various factors affect the optimal distance to port:

Proposition 2. *Industries are located closer to a port and agglomeration*

(*a*) *the more export oriented* $\frac{d\Delta_i^*}{dx_i^X} < 0$

(*b*) *the more import dependent* $\frac{d\Delta_i^*}{dx_i^M} < 0$ *and*

4 For proof see Appendix 1.

(c) *the higher the import intensity* $\frac{d\Delta_i^*}{d\mu_i} < 0$.[5]

The higher a firms export share, the more significant its output transportation concerns. Hence the distance to port is expected to decline. Especially if domestic land transportation is a significant component of total shipping costs, these costs can be reduced by moving the production site closer to the port. A similar expectation is suggested for production processes with high import shares. Firms specializing in the pure assembly of international intermediates for export are expected to be rather close to an international port.

Proposition 3. *Industries are located closer to a port the higher the transport costs of unit exports* $\left(\frac{d\Delta_i^*}{d\tau_i^X} < 0\right)$ *and unit intermediate imports* $\frac{d\Delta_i^*}{d\tau_i^M} < 0$.[6]

While transportation costs are apparently becoming less important in advanced, high income economies they still play a crucial role in the process of regional development in developing economies. For many technology and skill intensive goods transportation is just a small fraction of total value-added. These goods are easy to carry or transfer and pure transportation costs per unit are not a significant component of the value chain. However, industrialization in developing economies is often driven by adjusting to international comparative advantages. Hence, labour intensive goods of low value and often high transportation costs per unit belong to the typical profile of industry products of developing countries. Therefore, the ability to provide easy and cheap access to an international port is important to fully realize the potential comparative costs advantages inherent in a region. With increasing transportation costs per unit of output or international input, the distance of the exporting firm's production site to the international port is expected to decline. See also Ellison and Glaeser (1994), and Martin and Rogers (1995).

In other words, for exporting firms the degree of internationalization (the importance of exports and imports) and the resulting transportation costs will be an important reason for selecting a site within a catchment area of a port. If the port is also an urban centre or agglomeration two additional aspects come into effect. First, human capital and technology intensive firms require proximity to specific human capital and research institutions which are typically in urban centres and agglomerations (Audretsch and Feldman 1996; Davis and Weinstein 2002, 2003). Hence these firms are most likely to be located in or very close to a centre.

Proposition 4. *Industries are located closer to a port and agglomeration the more sophisticated and human capital intensive the production process and hence the more human capital intensive the industry* $\frac{d\Delta_i^*}{d\kappa_i} < 0$.[7]

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5 For proof see Appendix 2. As all partial derivatives of the implicit function Δ^* are subject to the assumption that $\eta_H > 1$ we assume that search costs for suitable human capital increase disproportionately to the increase in distance from the centre.

6 For proof see Appendix 3.

7 For proof see Appendix 4.

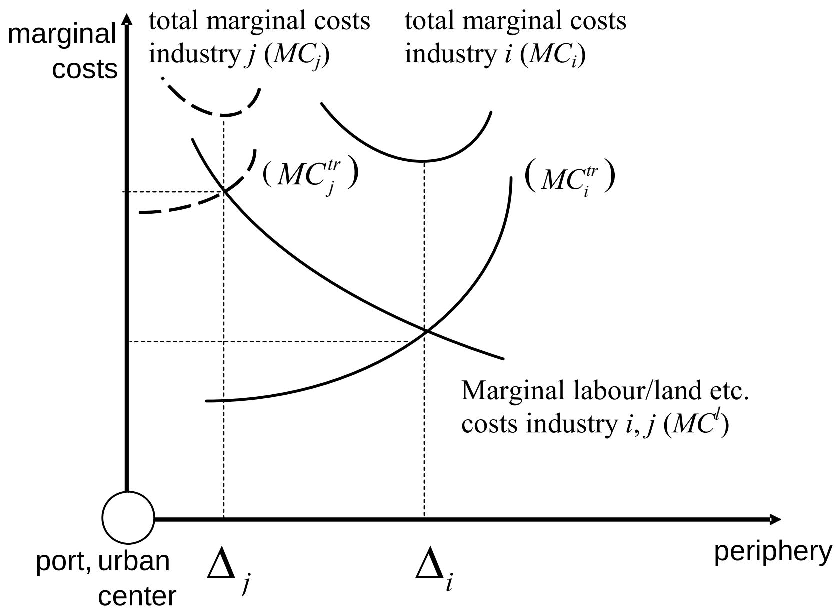
If a firm is large in terms of employment of labour or if its production is land and physical resource intensive, the costs of using these input factors decrease with the distance to the centre. Hence, these firms and industries, including many manufacturing industries in developing economies, are expected to be located not in the centre but rather at a certain distance to a hub (Head et al. 1995).

Proposition 5. *Firms are located at a greater distance to a port or centre the larger a firm (in terms of employment) and the more labour, land or physical resource intensive its production* $\frac{d\Delta_i^*}{dL_i} > 0$.[8]

However, high export or import shares may lead these industries to locate at an optimal distance to an export hub.

The pattern and the development of marginal costs with respect to distance are illustrated in Figure 1. In this diagram we look at the effects of the distance to the hub Δ on the components of marginal costs of two different industries *i* and *j*. As indicated by the MC^l curve both industries face an identical spatial pattern of domestic marginal labour (and other domestic factor) costs with respect to Δ. With an increasing distance to the hub these factors can be acquired at a lower cost. Further, marginal transaction costs MC^{tr} of both exporting firms are different for the two firms with respect to Δ. If *i* is less human capital intensive, or less dependent on international exports or imports, or

Figure 1: Costs and marginal costs with respect to the distance to port



8 $\frac{d\Delta_i^*}{dL_i} > 0$ hold as long as the wage effect is larger than transport cost effect. For proof see Appendix 5.

has less product specific transportation costs per unit than j, the $MC^{tr}_{i,j}$ curve of i is below the curve of j. After adding the respective two marginal cost curves to total marginal cost (MC_{ij} curve) it is easy to identify the optimal distance to the hub for each industry $\Delta^*_{i,j}$. An industry, for example, with a higher export share will be located closer to the hub than an industry with a low export share.

In the next section, we present empirical evidence using data on exports and location from South Africa.

3 Empirical evidence

3.1 Model

Equation (6) provides the basis for our empirical estimate. It can be written as an econometric model as follows in equation (7):

$$\Delta_i = \alpha + \beta_1 X_i + \beta_2 M_i + \beta_3 T + \beta_4 H + \beta_5 L + \mu_i \qquad (7)$$

Where Δ_i is the distance of a firm (or location) from the nearest port, X_i is the value of total exports from firm i (location i), M_i is the value of total imports to firm i (location i), T_i is transport cost incurred by firm i (location i), H_i is the level of human capital used by firm i (available in location i) and L_i is a measure of the resource intensity of production in firm i (location i). Here μ_i is an error term.

We index the variables in equation (7) with reference to both the firm and a location, the reason being that the most ideal level of data would be on the firm level. However, such data is generally lacking as most representative firm-level surveys rarely contain information on transport costs and in particular distances from the closest ports. To overcome this problem we use site-specific data on 354 sub-national regions (magisterial districts) in South Africa. Given that the result derived in equation (6) suggests that locations that are distant from a port will be characterized by lower trade, higher transport costs, less human capital, and a tendency towards more resource-intensive production, we should find the same relation between distance and the explanatory variables in equation (7) as in equation (6). In particular in equation (7) we expect $\beta_1 < 0, \beta_2 < 0, \beta_3 < 0, \beta_4 < 0$ and $\beta_5 > 0$.

In practice, reliable data on transport costs are notoriously difficult to find. In the present case, we do not have direct data on transport costs. In principle, and as is generally assumed in gravity models, there is a direct relationship between distance and transport costs, so that one could argue for the omission of T_i from equation (7). This could however be a mistaken argument for omitting T_i since the relationship between transport costs and distance can break down for a variety of reasons. One is that the type of goods transported will incur different costs. This will imply for instance that in the present case transport costs will differ between exports and imports when the compositions of these are different between locations. In the present case we can however omit direct inclusion of T_i for a different reason, namely that only if X_i, $M_i > 0$ will $\beta_3 \neq 0$. In other words for firms (and locations) that do not engage in international trade the effect of transport cost in determining the distance from a port should be 0. Thus we can re-write equation (7) as follows:

$$\begin{aligned}\Delta_i &= \alpha + (\beta_1 T_i)X_i + (\beta_2 T_i)M_i + \beta_4 H + \beta_5 L + \mu_i \\ &= \alpha + \tau_1 X_i + \tau_2 M_i + \beta_4 H + \beta_5 L + \mu_i\end{aligned} \tag{8}$$

Here, the coefficients τ_1 and τ_2 will reflect the influence of transport costs, and differences between τ_1 and τ_2 could reflect differences in transport costs between exports and imports. We estimate equation (9) using OLS (adjusted for heteroskedasticity).

3.2 Data

Data on sub-national exports are difficult to find. It is also difficult to find firm-level data on a sub-national level that are sufficiently rich to allow the modelling of distance and transport costs to and from a port. In the present case we use data from South Africa, where sub-national level data (on a magisterial district level) has recently been made available on exports, imports, human capital, and sub-national production by the firm Global Insight Southern Africa. Their data on exports and imports can be judged to be reliable as it was obtained from the South African Revenue Services (SARS) and Department of Customs and Excise.

Data on the independent variables, human capital, and resource intensity of production were obtained from Global Insight Southern Africa's Regional Economic Focus. The human capital measure is an education measure—the number of people per locality with the school degree 'matriculation' and higher. According to Global Insight Southern Africa, the number of persons in this education category in each magisterial district was first estimated using 1996 census data collected by Statistics South Africa. The trend in educational attainment between 1996 and 1999 was then estimated from the 1999 October Household Survey and used to interpolate national level educational attainment for the years 1997 and 1998. From 2000 onwards, Labour Force Survey raw data was used to calculate the national trend in educational attainment. The resource intensity of production in each magisterial district was proxied using data on the share in gross value added from primary production (mining and agriculture).

The distance variable we use is the actual distance (in kilometres) between the magisterial districts and the major export hubs in South Africa. The export hubs are: City Deep (a dry port for containers situated in Gauteng), Durban harbour (in KwaZulu-Natal), Port Elizabeth harbour (in the Eastern Cape) and Cape Town harbour (situated in the Western Cape). The reason for including only these ports is that—as they are equipped to handle containers and higher value products—the majority of exports move through them. These hubs are also situated on one or more of the three main freight corridors, namely Gauteng to Durban, Gauteng to Cape Town, and Gauteng to Port Elizabeth. Around 62 per cent of all imports and exports are moved through one or more of these corridors (DoT 2005). In terms of the data, the shortest distance from each magisterial district to one of these hubs was chosen as the distance variable, as it is assumed that exporters strive to minimize their transport costs. The internet service Shell Geostar (www.shellgeostar.co.za) was used to obtain these distances. Shell Geostar is a mapping service that provides detailed maps and distances between any two locations in South Africa.

3.3 Empirical results

3.3.1 Descriptive statistics

Table 1 summarizes the dataset. It can be seen that the average distance from a port for the 354 magisterial districts is 268 km, and that on average R723 million (about US$120 million) is exported from and R682 million (about US$114 million) is imported into a magisterial district. The average share of primary production (mining and agriculture value added) in total gross value added in a district was 10 per cent, and about 14 per cent of the population of the average district had a tertiary qualification or at least a completed secondary qualification. On average a district contained 128,228 people and produced R3,054 million (US$509 million) per annum in gross value added.

Table 2 shows the correlation coefficients between the variables (an asterisk indicates significance at the 5 per cent level). The distance variable (our dependent variable) negatively correlates with all of the explanatory variables: the highest correlation is with human capital (0.45). Correlations between explanatory variables are positive, and generally small except for the correlation between exports and imports (0.79). As this could be a source of multicollinearity in our regression model, we take a number of steps to control for this, such as estimating the regression alternatively with only exports and imports, and by using total trade (exports + imports).

Table 1 Summary of data

Variable	Mean	Standard deviation
Distance (km)	268	157
Exports (million Rand)	723	421
Imports (million Rand)	682	347
% Primary production	10	4
% Population with tertiary education	14	8
Population	128,228	158,600
Size (square km)	3,450	5,485
Gross value added (million Rand)	3,054	9,610

Table 2 Correlation coefficients

	Distance	Exports	Imports	Primary share	Human capital
Distance	1				
Exports	-0.21*	1			
Imports	-0.28*	0.79*	1		
Primary share	-0.11*	0.20*	0.06	1	
Human share	-0.45*	0.43*	0.50*	0.13*	1

Note: * significant at 5 per cent.

Given our interest in the relationship between trade and distance (and given the assumption that transport costs are only binding in the case of positive trade) it should be noted that in our sample there are 67 districts with no exports, 37 districts with no imports, and 28 districts with neither exports nor imports. Generally, most places (76 per cent) that did not record any imports also did not record any exports. This would suggest that access to imported inputs is important for firms to export in South Africa, which is consistent with other studies on determinants of South African exports (e.g. Edwards and Alves 2006). Generally, districts with positive exports were on average 134 km closer to a port than places with no exports, which is consistent with our theoretical model. They also tend to have significantly more human capital (15 per cent compared to 9 per cent), with a lower share of primary production in total gross value added (9 per cent compared to 16 per cent). Finally, if distance to port matters for exports, and the number of ports are relatively limited, the implication is that export oriented firms would need to cluster. Our context of districts would lead to the expectation that exports are spatially concentrated. Indeed, in the present sample we find that only 5 per cent of districts are responsible for 80 per cent of the value of South Africa's exports.

3.3.2 Regression results

Our basic regression results are contained in Table 3. It contains the results from estimating three models: a basic OLS regression (column 2); an OLS regression but with the Huber/White/Sandwich estimator of the variance so as to obtain robust standard errors (column 3); and a least absolute deviation (LAD) estimator (column 4). The Huber/White/Sandwich estimator of the variance is used because diagnostic tests of the basic OLS regression indicated the presence of heteroskedasticity. We also use the

Table 3 Regression results (with imports and exports)

Variable	Coefficient	Robust SE	LAD
Constant	6.36	6.36	6.26
	(10.59)	(10.82)	(13.62)
Exports	–0.004	–0.004	–0.02
	(–0.24)	(–0.34)	(1.69)
Imports	–0.13	–0.13	–0.11
	(–6.08)	(–6.54)	(–6.82)
Human capital	–0.43	–0.43	–0.27
	(–3.18)	(–2.97)	(–2.56)
Primary share	0.11	0.11	0.09
	(3.04)	(3.28)	(3.40)
Adjusted R^2	0.42	0.43	Pseudo R^2 = 0.21
Number of observations	278	278	278

Note: t-ratios are given in parenthesis.

LAD estimator because the diagnostic tests on the basic OLS regression results found that the disturbance term (μ_i) was non-normal. Non-normality implies fat tails that are due to outliers in the disturbance term—which a visual inspection of the scatter plot of the residuals from the regression confirmed.[9] In such cases, use of an LAD is recommended (Dasgupta and Mishra 2004). In Table 3 the dependent variable is the natural logarithm of distance from a port (explanatory variables are also used in natural logarithms). The t-ratios are given in parenthesis.

Table 3 shows that all of the regression coefficients have the expected signs, and that in the case of the OLS regressions (columns 2 and 3) all the coefficients, except for the coefficient on exports, are statistically significant. With the LAD estimator, all of the coefficients are statistically significant, including the coefficient on exports that is now significant at the 10 per cent level. The strongest single effect on distance from a port is the need for human capital, which as Table 2 indicated, is positively associated with both export production and imports. The effect of imports on distance is substantially larger than that of exports: however, due to the possibility of multicollinearity, we re-estimate the results in Tables 4 to 6 so as to avoid this. In Table 4 we omit imports.

Table 4 shows that all of the coefficients are of the expected sign and statistically significant, except for the primary share in gross value added in case of the LAD estimation. The effect of exports is negative and significant suggesting that the need to export will imply a location closer to a port. As in Table 3, the largest single effect is due to the need to have access to human capital in production. In Table 5, we omit exports from the regression.

Table 4 Regression results (without imports)

Variable	Coefficient	Robust SE	LAD
Constant	6.40	6.40	6.62
	(10.17)	(10.75)	(7.60)
Exports	–0.07	–0.07	–0.07
	(–5.04)	(–5.44)	(–3.58)
Imports	—	—	—
Human capital	–0.74	–0.74	–0.56
	(–5.73)	(–5.51)	(–3.13)
Primary share	0.10	0.10	0.06
	(2.54)	(2.80)	(1.12)
Adjusted R^2	0.33	0.33	Pseudo R^2 = 0.13
Number of observations	278	278	278

9 These outliers are due to a number of locations close to a port, with fewer than predicted exports.

Table 5 Regression results (without exports)

Variable	Coefficient	Robust SE	LAD
Constant	6.34	6.34	6.64
	(12.15)	(12.40)	(11.50)
Exports	—	—	—
Imports	–0.12	–0.12	–0.12
	(–9.01)	(–8.19)	(7.49)
Human capital	–0.42	–0.42	–0.26
	(–3.56)	(3.37)	(–1.96)
Primary share	0.10	0.10	0.05
	(3.10)	(3.24)	(1.57)
Adjusted R^2	0.43	0.43	Pseudo R^2 = 0.21
Number of observations	278	278	278

Table 6 Regression results (exports + imports)

Variable	Coefficient	Robust SE	LAD
Constant	6.2	6.2	6.30
	(10.23)	(10.55)	(10.35)
Exports + Imports	–0.10	–0.10	–0.10
	(–7.26)	(–6.82)	(–7.38)
Human capital	–0.52	–0.52	–0.27
	(–3.80)	(–3.65)	(–2.04)
Primary share	0.11	0.11	0.10
	(3.11)	(3.37)	(2.25)
Adjusted R^2	0.33	0.33	Pseudo R^2 = 0.19
Number of observations	278	278	278

From Table 5 can be seen that, as in Table 4, all the coefficients are of the expected sign and statistically significant, except for the coefficient on the primary share in the case of the LAD estimation. In Table 6, we take the sum of exports and imports in place of separate imports and exports.

In Table 6, all the variables are of the expected sign and statistically significant. Overall, from Tables 4 to 6 we can conclude that the results are reasonably robust and confirm our theoretical proposition. For the specific South African case under focus, the empirical results suggest that the optimal distance of location from a port for export oriented firms is determined by its need for skilled human capital and their need to source imports. The relative sizes of the coefficients with $\tau_1 < \tau_2$ suggest that transport costs on imported goods may be relatively more important than transport cost on exports to the location decision. In locations more distant from a port, the share of primary production (agriculture and mining) tends to be higher.

4 Concluding remarks

We started this paper by postulating that distances within a country matter to trade. Specifically, our point of departure was that the location decisions of export-oriented firms will have to take into consideration the distance from the closest port, given that all international transactions need to pass through a port. Generally, the location behaviour of export-oriented firms has been neglected in the regional and international economics literature. Most often, the focus is either on international distances and transport costs, or when the concern is the location of firms, on transport costs. We have argued, however, that transport cost is only one component of distance that affects optimal location (and that transport cost may in itself not be a straightforward proxy for distance or vice versa). In the economic model presented in this paper, we showed that the components of distance that affect the location of export oriented firms include skilled human capital, imported input requirements, and the natural resource intensity of production. Because ports are mostly located in urban areas (they are usually part of an agglomeration) wages can be expected to fall as the distance to the port increases. This, together with the degree of natural resource intensity, creates a dispersal force whereby the requirement for human capital and intermediate imported inputs creates a pull effect in the direction of the port. We have illustrated that for each firm, the eventual optimal location will depend on the different marginal costs.

With an increasing export share of a firm’s output transportation becomes increasingly important and hence the distance to port is expected to decline. Especially if domestic land transportation costs are high, the production site will be closer to the port. A similar expectation is suggested for production processes with high import shares. Further, if the port is also an urban centre two additional aspects come into effect. First, human capital and technology intensive firms require proximity to specific human capital. Hence these firms are most likely to be located close to a centre. Second, if a firm is large or its production processes land and physical resource intensive, the costs of using these input factors will decrease with the distance to the centre. Hence, these industries are expected to be located not in the centre but rather at a certain distance to a hub.

In order to test the predictive power of the model, we tested it using data on sub-national exports, imports, human capital, and primary production from 354 magisterial districts in South Africa over the period 1996–2006. These results supported our model rather robustly, showing that the optimal distance of an export-oriented firm's site from a port is determined by its need for skilled human capital and its need to source imports. We also found that in locations more distant from a port, the share of primary production (agriculture and mining) tends to be higher, the skill levels of human capital lower, import intensity lower, and that consequently exports are also lower. The relative sizes of the coefficients for exports and imports suggested that in South Africa transport costs on imported goods may on average be relatively more important than transport cost on exports to the location decision—which supports the argument that distance is an imperfect proxy for transport costs.

Appendix

Appendix 1a

For the F.O.C. and S.O.C. for profit maximization or cost minimization with respect to distance to port we obtain:

$$\frac{d\pi_i}{d\Delta_i} = -\tau_i^X x_i^X Y_i + \eta_L \Delta_i^{-\eta_L - 1} L_i - \eta_H \Delta_i^{\eta_H - 1} H_i - \tau_i^M p_i^M M_i = 0$$
$$= \eta_L \Delta_i^{-(\eta_L + 1)} L_i - \eta_H \Delta_i^{\eta_H - 1} H_i - \left(\tau_i^X x_i^X + \tau_i^M x_i^M\right) Y_i$$

and

$$\frac{d^2\pi_i}{d\Delta_i^2} = -(\eta_L + 1)\eta_L \Delta_i^{-(\eta_L + 2)} L_i - (\eta_H - 1)\eta_H \Delta_i^{\eta_H - 2} H_i < 0 \text{ for } \eta_H > 1$$

Appendix 1b

Taking the F.O.C. and the assumption $\eta_H > 1$, we can define a function F

$$0 = F = \frac{1}{\Delta_i}\left[\eta_L \Delta_i^{-\eta_L} L_i - \eta_H \Delta_i^{\eta_H} H_i\right] - \left(\tau_i^X x_i^X + \tau_i^M x_i^M\right) Y_i$$

$$F = \frac{1}{\Delta_i}\left[\eta_L \Delta_i^{-\eta_L} - \eta_H \Delta_i^{\eta_H} \kappa_i\right] L_i - \left(\tau_i^X x_i^X + \tau_i^M x_i^M\right) \kappa_i^{1-\alpha_i} \mu_i^{\gamma_i} L_i$$

with

$$\frac{dF}{d\Delta_i} = -\eta_L(\eta_L + 1)\Delta_i^{-\eta_L - 2} L_i - \eta_H(\eta_H - 1)\Delta_i^{\eta_H - 2} H_i$$
$$= -\Delta_i^{-2}\left[\eta_L(\eta_L + 1)\Delta_i^{-\eta_L} L_i + \eta_H(\eta_H - 1)\Delta_i^{\eta_H} H_i\right] < 0$$

and use these properties to proof proposition 1:

Proof A differentiable function f has the regular value y if for all $x \in f^{-1}(y)$ the Jacobi-Matrix $Df(x)$ has full rank. The derivative of F with respect to Δ_i is not 0. So 0 is a regular value of F. Because of this, and as the partial derivatives of F are obviously continuous, we can use the implicit function theorem, i.e. for a marginal neighbourhood of any vector $(\tau_{i_0}^X, x_{i_0}^M, \tau_{i_0}^M, x_{i_0}^X, L_{i_0}, H_{i_0}, M_{i_0})$ we find an implicit function Δ_i^*.

$$\Delta_i^* = \Delta_i^*(\tau_i^X, x_i^M, \tau_i^M, x_i^X, L_i, H_i, M_i)$$

Appendix 2

$$\frac{d\Delta_i^*}{dx_i^X} = -\frac{\frac{\partial F}{\partial x_i^X}}{\frac{\partial F}{\partial \Delta_i}} = -\frac{\Delta_i^2 \tau_i^X Y_i}{\left[\eta_L \left(1+\eta_L\right) \Delta_i^{-\eta_L} L_i + \eta_H \left(\eta_H - 1\right) \Delta_i^{\eta_H} H_i\right]} < 0$$

$$\frac{d\Delta_i^*}{dx_i^M} = -\frac{\frac{\partial F}{\partial x_i^M}}{\frac{\partial F}{\partial \Delta_i}} = -\frac{\Delta_i^2 \tau_i^M Y_i}{\left[\eta_L \left(1+\eta_L\right) \Delta_i^{-\eta_L} L_i + \eta_H \left(\eta_H - 1\right) \Delta_i^{\eta_H} H_i\right]} < 0$$

$$\frac{d\Delta_i^*}{d\mu_i} = -\frac{\frac{\partial F}{\partial \mu}}{\frac{\partial F}{\partial \Delta_i}} = -\frac{\Delta_i^2 \gamma_i \left(\tau_i^X x_i^X + \tau_i^M x_i^M\right) \kappa_i^{1-\alpha_i} \mu_i^{\gamma_i - 1}}{\left[\eta_L \left(1+\eta_L 1\right) \Delta_i^{-\eta_L} + \eta_H \left(\eta_H - 1\right) \Delta_i^{\eta_H} \kappa_i\right]} < 0$$

Appendix 3

$$\frac{d\Delta_i^*}{d\tau_i^X} = -\frac{\frac{\partial F}{\partial \tau_i^X}}{\frac{\partial F}{\partial \Delta_i}} = -\frac{\Delta_i^2 x_i^X Y_i}{\left[\eta_L \left(1+\eta_L\right) \Delta_i^{-\eta_L} L_i + \eta_H \left(\eta_H - 1\right) \Delta_i^{\eta_H} H_i\right]} < 0$$

$$\frac{d\Delta_i^*}{d\tau_i^M} = -\frac{\frac{\partial F}{\partial \tau_i^M}}{\frac{\partial F}{\partial \Delta_i}} = -\frac{\Delta_i^2 x_i^M Y_i}{\left[\eta_L \left(1+\eta_L\right) \Delta_i^{-\eta_L} L_i + \eta_H \left(\eta_H - 1\right) \Delta_i^{\eta_H} H_i\right]} < 0$$

Appendix 4

$$\frac{d\Delta_i^*}{d\kappa_i} = -\frac{\frac{\partial F}{\partial \kappa_i}}{\frac{\partial F}{\partial \Delta_i}} = -\frac{\Delta_i^2 \left[\eta_H \Delta_i^{\eta_H - 1} L_i + (1-\alpha_i)\left(\tau_i^X x_i^X + \tau_i^M \frac{M_i}{Y_i}\right) \kappa_i^{-\alpha_i} \mu_i^{\gamma_i} L_i\right]}{\left[\eta_L \left(1+\eta_L\right) \Delta_i^{-\eta_L} L_i + \eta_H \left(\eta_H - 1\right) \Delta_i^{\eta_H} H_i\right]} < 0$$

Appendix 5

$$\frac{d\Delta_i^*}{dL_i} = -\frac{\frac{\partial F}{\partial L_i}}{\frac{\partial F}{\partial \Delta_i}} = \frac{\Delta_i^2 \left[\eta_L \Delta_i^{-(\eta_L + 1)} - \alpha_i \left(\tau_i^X x_i^X + \tau_i^M x_i^M\right) Y_i L_i^{-1}\right]}{\left[\eta_L \left(1+\eta_L\right) \Delta_i^{-\eta_L} L_i + \eta_H \left(\eta_H - 1\right) \Delta_i^{\eta_H} H_i\right]} > 0$$

as long as the wage effect $\left(\eta_L \Delta_i^{-(\eta_L+1)}\right)$ is larger than the transport cost effects $\alpha_i \left(\tau_i^X x_i^X + \tau_i^M x_i^M\right) Y_i L_i^{-1}$.

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