DOMESTIC TRANSPORT COSTS AND THE LOCATION OF EXPORT-ORIENTED MANUFACTURING FIRMS IN SOUTH AFRICA: A CUBIC-SPLINE DENSITY FUNCTION APPROACH

By

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ABSTRACT.
In this paper, we attempt to provide empirical evidence on the significance of domestic transport costs in exports and the spatial location of manufacturing exporters. We use spatially disaggregated data on exports and manufacturing from South Africa and estimate modified cubic-spline density functions for manufactured exports from 354 magisterial districts between 1996 and 2004. It is found that (a) the proximity to a port (hub) is an important consideration in most export-oriented manufacturing firms' location with more than 70% of all manufacturing exports in South Africa originating from a band of 100 km from an export hub (port); and (b) there appears to be a second band of location of export-oriented manufacturing firms at a distance of between 200 and 400 kilometres from the hub. Over time we found that the number of locations from which manufacturing exports occurred in South Africa increased by 15% between 1996 and 2004 and that manufactured exports in the band between 200 km and 400 km from the nearest hub increased significantly, suggesting either an increase in manufactured exports that depend on natural resources due to demand factors, and/or a decrease in domestic transport costs over the time period.

Key words: Geographical economics, manufacturing exports, South Africa
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1. Introduction

In the geographical economics literature, transport costs influences international trade patterns and volumes. A growing number of studies have in recent years focused on establishing the empirical relevance of especially international transport costs. This literature is accumulating evidence that international transport costs have a significant impact on a country's trade volumes, especially if that country is landlocked or remote from its trading partners. As far as the effects of domestic transport costs are concerned, there have been fewer empirical studies despite the fact that the geographical economic literature emphasizes that domestic transport costs may influence the spatial location of exporters within a particular country or region. Therefore, in this paper, we attempt to provide empirical evidence on the significance of domestic transport costs in exports and the spatial location of exporters. We use spatially disaggregated data on exports and manufacturing from South Africa's and estimate a modified cubic-spline density function for manufactured exports from 354 magisterial districts between 1996 and 2004.

The paper is structured as follows. In section 2 a brief overview of the state of the economics literature on the relationship between transport costs, distance and exports. Section 3 discusses the spatial patterns of economic activity in South Africa. Section 4 presents the various cubic-spline density functions that will be used to model the impact of distance on exports (and indirectly the impact of transport costs) whilst section 5 reports the results from the estimated cubic-spline density functions. Section 6 provides a discussion of the results and section 7 concludes.

2. Transport Costs, Distance and Exports

In this paper, transport costs are defined as the costs incurred in moving freight[1]. These freight costs consist of direct and indirect elements. Direct elements include freight charges and insurance on the freight, whereas indirect elements include all costs incurred by the transport operator. Indirect elements vary with the shipment's characteristics. For example, holding costs for the products in transit, inventory costs (in the case of late deliveries) and costs incurred during preparation for transit (which depends on the shipment size) (Anderson & van Wincoop, 2003).

Transport costs have in recent years been recognised to have important and significant impacts on trade patterns and globalised production (Hoffmann, 2002). Limão and Venables (2001) state that transport and other costs of conducting business on an international level are key determinants of a country's ability to participate fully in the world economy, and especially to grow exports. Porto (2005) finds that for low-income countries, transport costs are amongst the most important of trade barriers.

Empirical studies support theory by providing the relevant evidence of the significance of transport costs for trade. The general consensus is that international transport costs negatively affect a country's trade volumes. Evidence from Limão and Venables (2001) indicate that if transport costs increased by 10 percent, trade volume would be reduced by 20 percent. High transport costs reduce foreign earnings from exports (UNCTAD Secretariat, 2003) and increases the price of imports, which elevates production costs and subsequently inflation (Radelet & Sachs, 1998; Hoffmann, 2002).

For countries located far from markets, the effect of transport costs on trade is more severe. Distance is an important part of international trade relations and the impact

[1] In a broader sense, transport costs could also include any number of costs that impede trade such as policy-induced trade barriers, for example, cultural or sociological barriers (Brakman, Garretsen & van Marrewijk, 2001).

of distance on transport costs has been widely documented. As distance increases, trade volumes decrease (Venables, 2001). Countries tend to trade with proximate partners (Grossman, cited in Anon., 2004), even if transport costs over distance have fallen (Hummels, 1999a). Approximately half of the world's trade takes place between countries located within 3 000 km of each other (Anon., 2004). The distance of trade for the average countries in the world has decreased, implying that distance matters (Carrere & Schiff, 2004). A possible reason for this occurrence is that distance is costly. It directly increases transaction costs in terms of additional transport costs of shipping goods, time costs of shipping date-sensitive goods, the costs of contracting at a distance (search costs), costs of obtaining information on remote economies and costs of communicating with distant locations (Overman, Redding & Venables, 2001; Venables, 2001).

Limão and Venables (2002) demonstrate that exports and imports of both final and intermediate goods carry transport costs that increase with distance. If a country is situated far from its trading partners, its CIF/FOB ratio[2] is higher than a country located close to its foreign markets. For example, Australia's CIF/FOB ratio is 10.3, whereas Switzerland has a ratio of only 1.7 (Radelet & Sachs, 1998). Busse (2003) illustrates this point through another example. The cost to ship a 40-foot container from Baltimore to China is around $13 000, whereas the cost to Rotterdam is only $2 000 (he follows the same method as Limão and Venables (2001), only with 2002 data). Venables (2005) argues that remoteness from economic activity increases transport costs and accounts for the poor export performance of many developing countries situated far from the major markets.

Apart from a country's external geography, its internal geography (if it is landlocked or coastal) also affects its transport costs. Landlocked countries also tend to have poor internal geography (access to ports), which correlates negatively with transport costs (Redding & Venables, 2003). Therefore, landlocked countries' transport costs are higher (approximately 50 percent) and have lower trade volumes (around 60 percent) than coastal countries (Radelet & Sachs, 1998; Limão & Venables, 2001). Martínez-Zarzoso Gracía-Menéndez and Suárez-Burguet (2003) support this argument by proving that exporters situated in landlocked countries incur extra costs since products transported have to switch between more modes of transport than coastal countries. These countries also seem to experience higher *ad valorem* rates than coastal countries and this exacerbates the effect of the high transport costs. Busse (2003) concludes that even with technological developments in transport, many developing countries continue to be challenged by geography in terms of being remote from major markets or landlocked.

Various methods have been used to measure the impact of transport costs on trade. The most popular measure of international transport costs is to calculate the CIF/FOB ratio (see footnote 2). Other methods are more direct, such as obtaining quotes from freight forwarders (Hummels, 1999b; Limão & Venables, 2001) and conducting interviews with transport operators (Martínez-Zarzoso *et al.*, 2003). The measurement of domestic transport costs has not been as popular a topic, with no commonly used method. In most cases, a proxy for domestic transport costs is applied. Elbadawi, Mengistae and Zeufack (2001) include domestic transport costs into an index that measures supplier and market access. The variables they use to measure domestic transport costs are the density of the road network (kilometres of roads), the quality of roads (the number of paved roads) and the total land territory of a country. They find

[2] CIF (Cost, Insurance, Freight) measures the value of imports, from the point at which it enters a country. This value includes cost, insurance and freight. FOB (Free On Board) measures the value of exports from the point when the merchandise is placed on the carrier. The difference between the values of these two incoterms is a measure of the cost of transporting an item from the exporting country to the importing country (Hummels, 1999a, 1999b; Brakman *et al.*, 2003).

that domestic transport costs act as a stronger constraint on exports than international transport costs. Limão and Venables (2001) use similar indicators to measure the costs of travel in and through a country. They add the density of the rail network, as well as the main telephone lines per person. Limão and Venables (2001) estimate that overland distance is seven (7) times more expensive than sea distance. Combes and Lafourcade (2005) extend existing research by developing a methodology to accurately measure domestic transport costs. They compute a measure of generalised transport costs by determining distance costs (fuel, price and fuel consumption, costs due to tolls that have to be paid on highways and maintenance operating costs) and time costs (labour costs, insurance charges, depreciation costs and general charges such as taxes).

From the above discussion it can be concluded that both international and domestic transport costs have significant effects on international trade, and that moreover, domestic transport costs may have a much stronger effect on exports than international transport costs. Despite this, the majority of studies have focused on international transport costs, with only a few studies (as cited above) focusing on domestic transport costs. Furthermore, even fewer studies are available that investigate the importance of domestic transport costs in an African country. Arguably, following recent contributions by Venables (2005) and Artadi and Sala-i-Martin (2003), Africa is the one continent in the world that faces the most significant challenges in terms of growth, development, exports and integration into the world economy, and is also one of the continents facing the most adverse physical geography (Bloom & Sachs, 1998). The role of domestic transport costs on manufactured exports and the location of exporting firms in Africa is therefore highly relevant. This paper attempts to fill this vacuum by studying the case of domestic transport costs and exports in South Africa.

3. The Context of South Africa

The optimal location of South Africa, as a halfway-point between the Far East and Europe, has led to its discovery in 1488 by the Portuguese. The Portuguese intended to use the Cape as a replenishment station to encourage trade between these two parts of the world. However, at that time the Dutch took over from Portugal as the dominant maritime power. It was the Dutch who eventually developed and governed the Cape as a provisioning station in 1652. The station developed into a colony as Dutch settlers and French Huguenots established themselves in the Cape. The Dutch continued their rule until the 1820 when the British took over. It was also during this period that the east-coast port of Durban developed into a stop-over for provisions and ship repair services. Due to political reasons, the settlers moved to the interior of the country. The events that followed led to a major shift in the structure of economic activity. Diamonds were discovered in Kimberley in 1867. A few years later, in 1886, gold was discovered in the Witwatersrand. Economic activity was now centred in and around these two locations and Johannesburg experienced rapid urbanisation. The role of the ports now became much more important as they handled exports of diamonds and gold. During this time, two wars broke out between the British and the settlers, which ultimately led to the establishment of the Union of South Africa in 1910. South Africa emerged into the international community under the rule of Prime Minister Smuts. This, however, only lasted until 1945. Several factors led to changes in the political situation that caused the exclusion of South Africa from the international community. The National Party came into power and their goal was to protect the Afrikaner from the British and the Black majority. The result was Apartheid (Naudé *et al.*, 2000; Naudé & Krugell, 2005).

Apartheid was a territorial, social and political segregation between different race groups (Naudé *et al.*, 2000). While economic activity during the 19th century was

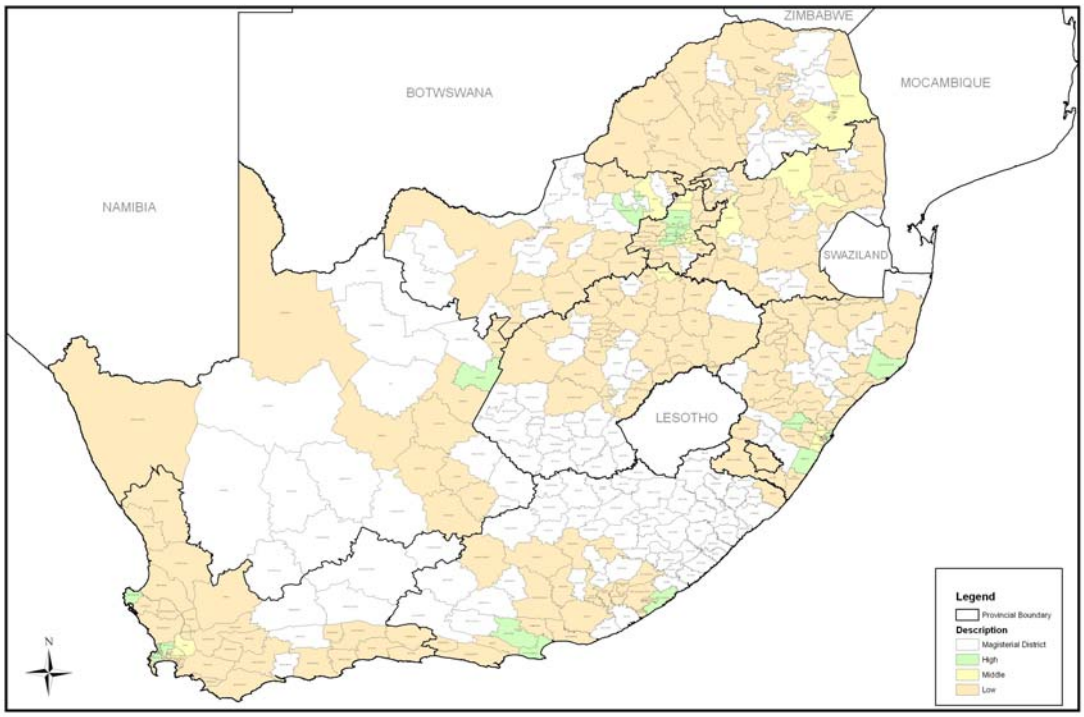
clustered, the Apartheid era had the opposite effect on it. Government developed Homeland Policies with the aim to prevent further urbanisation of Blacks in "white" cities. De-industrialisation took place and industries were located in various Homelands. Although these industries were subsidised by government, they were largely inefficient (Voges, cited in Naudé *et al.*, 2000). Workers could therefore not meet their economic demands and still had to travel large distances to "white" areas (Naudé *et al.*, 2000). Furthermore, the Groups Area Act was also implemented to ensure that cities were segregated. The effect of Apartheid on the spatial economy was severe. The spatial economy was plagued by inefficient land use, high transport costs, and under-investment in transport infrastructure, telecommunications and electric power. The result of Apartheid was unequal development of economic activity (Naudé & Krugell, 2005).

Where first the economy strived under the Apartheid rule, it slowly began to deteriorate. For example, South Africa experienced a decrease in world demand and prices of gold, a debt crisis, depreciation of the Rand, foreign exchange shortages and sanctions (Nel, cited in Naudé & Krugell, 2005). This continued until 1990 when liberalisation began to take place, which led to the lifting of sanctions against South Africa. In 1994 the first democratic election was held and Nelson Mandela became president. This transition from a closed to an open economy again changed the spatial structure of economic activity in South Africa (Naudé *et al.*, 2000). South African industries were now exposed to international competition. Subsequently, industries that could not cope with it closed down (for example, the textile industries in the Western Cape). Other industries that were able to move into new markets thrived (for example, the motor industry in the Eastern Cape). The location of economic activity was further influenced by the development of new growth areas between Johannesburg and Pretoria such as Midrand, foreign direct investment boosting IT and telecommunications, declining employment opportunities in manufacturing due to fluctuating commodity prices and skilled shortages, the development of the informal sector of the economy and finally the shift towards service-based and knowledge-intensive activities (Nel, cited in Naudé & Krugell, 2005). With regard to the Homelands, there was no longer any incentive to support their industries. This resulted in large pools of labour seeking employment in urban areas far from the Homelands (Naudé *et al.*, 2000).

The current situation is that South Africa's spatial distribution of economic activity is still highly unequal. Around 70 percent of the country's GDP is produced in only 19 of the urban areas (Naudé & Krugell, 2005). Around 22 of the 354 magisterial districts produced 84 percent of the total manufacturing exports in 2002. South Africa's skew spatial distribution is clearly evident here, as Gauteng (Johannesburg, Randburg, Boksburg, Germiston and Kempton) produce 32.7 of that percentage. The other large agglomerations that export manufactures are Durban-Pietermaritzburg (11.32 percent), Pretoria-Brits (7.9 percent) and Cape Town-Belville (5.98 percent) (Naudé & Gries, 2004; Naudé & Krugell, 2005). Economic activity is also skew in the sense that the cities located near ports are smaller than those situated inland (Krugell, 2005). This contrasts with theory that argues that exporters will locate closer to ports in order to minimise transport costs. The reason is that distance creates transport costs, which in turn influence the location decisions of firms that produce manufactures for the export market (Naudé & Gries, 2004). Therefore, domestic transport costs are a relevant issue in South Africa, especially as the major sources of manufactured exports are located inland[3].

[3] South Africa's transport costs accounted for around 13 percent of GDP in 2003, which is high in comparison with other emerging markets. Brazil's transport costs, for example, are only 8 percent of their GDP (Ramos, 2005). The largest part of South Africa's total logistics cost is attributed to transport costs. Logistics costs include throughput (i.e. the total amount of goods that are transported and stored), transport costs, warehousing costs, inventory costs and management and administration costs (CSIR, 2004). Transport costs make out 78 percent of the secondary sector's total logistics costs and 60 percent of the primary sector's (CSIR, 2004; Chasomeris, 2005)

Figure 1: Location of manufactured exports in South Africa



Source: Authors' own calculations from data from Global Insight Southern Africa; Map provided by GISCOE Potchefstroom

Figure 1 provides an indication of the spatial location of the magisterial districts that export manufactured goods. The manufacturers that export a high percentage (more than 1 percent) of the total manufactured exports are coloured in green. The manufacturers that export between 0.5 and 1 percent are coloured yellow. Those that export less than 0.50 percent are coloured orange. It is evident that the majority of manufactured exports originate in the vicinity of one of the major export hubs, namely City Deep (situated in Gauteng), Durban harbour (situated in KwaZulu-Natal), Port Elizabeth (situated in the Eastern Cape) and Cape Town harbour (situated in the Western Cape). Figure 2 provides a similar view, except that the locations of manufacturers are illustrated in terms of distance (kilometres). The darker the colour of the magisterial district, the further the manufacturers located from each of the major export hubs. Figure 2 also provides an indication of the transport infrastructure of South Africa.

Figure 2: Location of manufactured exports relative to transport infrastructure

(The second map makes the file too big to upload to the conference web site. We will include it in later versions and in the presentation)

Source: Authors' own calculations from data from Global Insight Southern Africa; Map drawn by GISCOE Potchefstroom

4. Empirical Results

4.1 Methodology

Cubic splines are piecewise functions whose "pieces" are polynomials of degrees less than or equal to three, joined together to form a smooth function (Poirier, 1973). The reason for the development of spline functions was to overcome the problems experienced with piecewise linear regression functions (Suits, Mason & Chan, 1978). Piecewise linear regression functions suffer from discontinuity in its derivatives. This discontinuation at the kinks of the linear regression makes analyses of for example, shifts in elasticities and marginals, difficult (Suits *et al.*, 1978).

Cubic spline functions have been applied to various study disciplines, one of which is urban studies. Anderson (1982, 1985) applies the spline function empirically to study urban population densities in order to determine the urban population density (or spatial structure) of a metropolitan area (Alperovich, 1995).

Assume that there is a central business district in the metropolitan area and any location in this area can be expressed as a distance from the centre. For this purpose, census tract data is used to determine the density of the population at various distances from the city centre (Zheng, 1991). The density-distance relationship is estimated by using piecewise, continuous polynomials (Zheng, 1991). Suits *et al.* (1978) initially developed a spline density function where the density variable is regresses into three polynomial expressions of the distance variable (Skaburskis, 1989). The function is as follows:

$$T = [\alpha_1 + \beta_1(K - K_0) + \chi_1(K - K_0)^2 + \delta_1(K - K_0)^3]Y_1 +$$
$$[\alpha_2 + \beta_2(K - K_1) + \chi_2(K - K_1)^2 + \delta_2(K - K_1)^3]Y_2 +$$
$$[\alpha_3 + \beta_3(K - K_2) + \chi_3(K - K_2)^2 + \delta_3(K - K_2)^3]Y_3 + \nu \quad (1)$$

K is the distance from the tract to the city centre, K_0 is the distance of the closest tract, K_1 is the first interior knot and K_2 is the second interior knot. Y_1, Y_2 and Y_3 are dummy variables defined on the various intervals on the X-axis, in other words they locate each tract in its segment along the distance variable (Y_i, where i = 1, 2, 3…). The parameters α β, χ and δ describe the spline and υ is a normally distributed disturbance term with a zero mean and constant variance (Anderson, 1982; Skaburskis, 1989). In equation (1), there is however, no guarantee that the function is continuous at knots K_0, K_1 and K_2. A further problem is that the derivatives are also discontinuous at these knots. It is for this reason that Suits *et al.* (1978) improved their function by adding constraints to the coefficients. The constraints make the function continuous and guarantees continuity of the first and second derivatives. The improved density function can be written as:

$$T = \alpha_1 + \beta_1(K - K_0) + \chi(K - K_0)^2 + \delta_1(K - K_0)^3 +$$
$$(\delta_2 - \delta_1)(K - K_1)^3 Y_1 * + (\delta_3 - \delta_2)(K - K_2)^3 Y_2 * \quad (2)$$

$Y_i^* = 1$ if, and only if $K \geq K_i$. That is, $Y_i^* = 0$ until K reaches K_i, then $Y_i^* = 1$ thereafter (Anderson, 1982). Zheng (1991) has modified the spline density function by omitting the second dummy term and adding an error term. His version of the spline density function (used in this paper) is written as:

$$M_r = \alpha + \beta(K_r - K_0) + \chi(K_r - K_0)^2 + \delta_i(K_r - K_0)^3 +$$
$$\sum_{i=1}^{n-1}(\delta_{i+1} - \delta_i)(K_r - K_i)^3 Y_i + \mu_r$$

$Y_i = 0$ if $K_r \geq K_i$
$Y_i = 0$ otherwise. (3)

As far as we are aware there has not been any study that uses the cubic-spline density function to estimate the impact of distance/domestic transport costs on trade.

4.2 Data

Data on exports of manufactured goods were obtained from Global Insight Southern Africa's Regional Economic Focus database. This database is compiled by data supplied by the South African Revenue Services and the Department of Customs and Excise. The documentation required from exporters by the department of Customs and Excise captures their postal codes or street addresses. This data per postal code is mapped to one of the 354 magisterial districts to provide information on exports from each magisterial district. The magisterial allocations are then compared to the national totals as contained in the South African Reserve Bank Quarterly Bulletin. The data is, however, not flawless as exports are measured at current world prices. In other words, taxes and subsidies are not included in value added. This causes a peculiarity in the export share

measure, as some of the magisterial districts have an export share greater than 100 percent (Naudé & Gries, 2004). Data of two of the dependent variables are used, namely manufactured exports and gross value added.

The only other variable for which data were obtained is distance. In urban spline density studies, actual distances are not used. Distance is calculated by the "great circle" formulae in which distance is measured directly (in other words, "as the crow flies"). In this paper, actual distances are used. The Internet service Shell Geostar (www.shellgeostar.co.za) was used to obtain the shortest route from each of the magisterial districts to each of the major export hubs in South Africa. The hubs used were Cape Town harbour, Port Elizabeth harbour, Durban harbour and City Deep[4]. The shortest distance to one of these hubs were chosen as the actual distance, as it is assumed that exporters strive to minimise their transport costs.

4.3 Results

Cubic-spline density functions were applied to different sets of data, using STATA 9. The data sets included the average of manufactured exports between 1996 and 2004 and manufactured exports in 1996 and 2004 respectively. Similar data sets were also developed for each of the export hubs. In the cubic-pline density functions, the furthest distance from a hub was used to calculate the knots. Cubic-spline density functions were developed for three, four and five knots for each of the data sets. The results indicated that three knots seemed to provide the best fit to the data. Appendix 1 contains the results of the cubic-spline density functions for all of the data sets using three knots.

4.3.1 Location of manufacturers

In order to provide an overview of the relevance of domestic transport costs on the location of manufactured exports in South Africa, cubic-spline density functions were applied to the average of manufactured exports over the period 1996 to 2004. The number of magisterial districts that exported manufactures during this period is 267. Figure 3 illustrates the results. From figure 3, it is clear that the largest volumes of exports are generated within a 100 kilometres from the export hub. This suggests that proximity to a port (hub) is an important consideration in most export-oriented manufacturing firms' location, and that domestic transport costs therefore do matter.

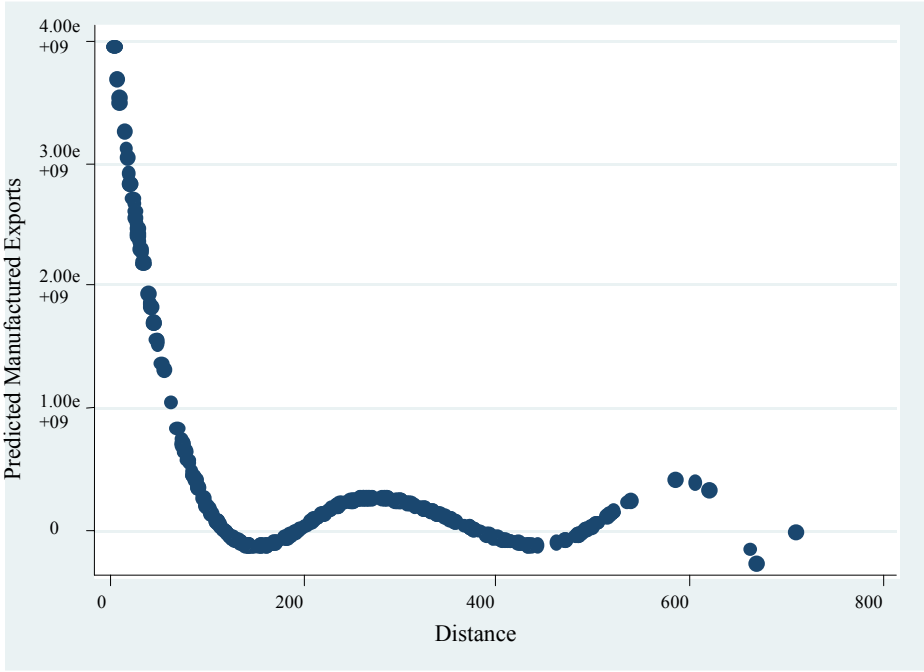
It is also noticeable from figure 3 that there is not a uni-directional decrease in export-orientation as the distance from the port/hub increases. In fact in South Africa there appears to be a second band of location of export-oriented manufacturing firms at a distance of between 200 and 400 kilometres from the hub. Several large manufactured exporters are situated in this band. A third band occurs at around 600 km. However, the manufactured exports that originate from this distance are resource based.

Figure 4 compares the density functions for the value of manufacturing exports in 1996 and 2004. In 1996 only 193 of the 354 magisterial districts hosted exported manufactures, whilst in 2004 the number rose to 223 – a 15% increase. The general increase in manufacturing exports from all locations is evident in the rightwards shift of the density function in figure 4. It can also be seen that the amplitude of the 2004-density function in the band between 200 km and 400 km from the hub increased, suggesting greater exports from locations rather further away from the hub. This could suggest an

[4] Each one of these export hubs facilitate export of manufactured goods. The other export hubs in South Africa were excluded, due to the fact that the use of these hubs would lessen the degrees of freedom in the cubic-spline density functions.

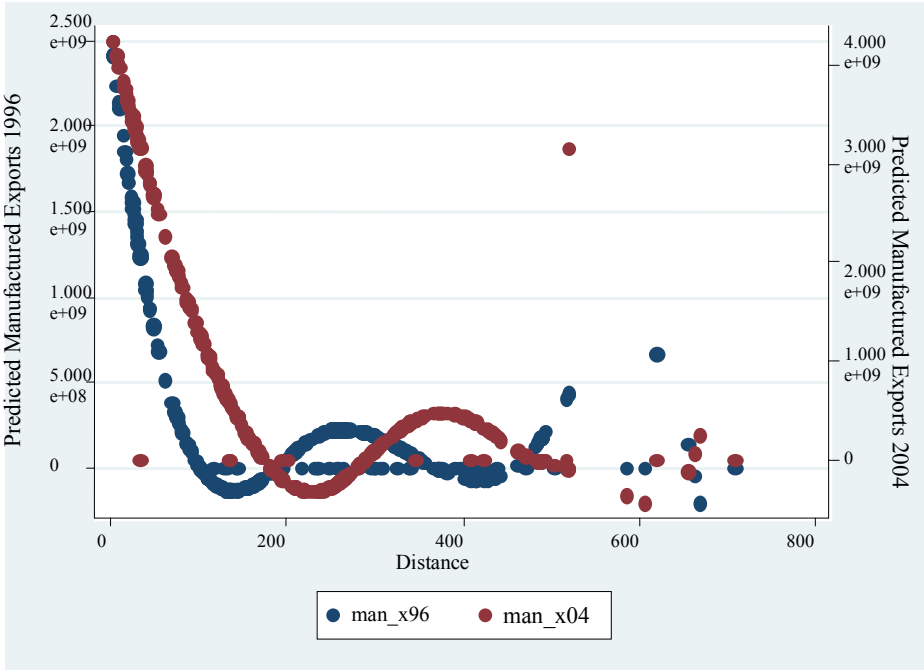
increase in manufactured exports that depend on natural resources due to demand factors and/or a decrease in domestic transport costs over the time period.

Figure 3: Average Manufactured Exports from 1996 to 2004



If the three spline density functions in figures 3 and 4 are compared, it seems that distance is a better explanation for the level of exports on the average, as the adjusted R-squared is 20% (the adjusted R-squared for 1996 is 17% and for 2004 14%).

Figure 4: Manufactured Exports in 1996 and 2004



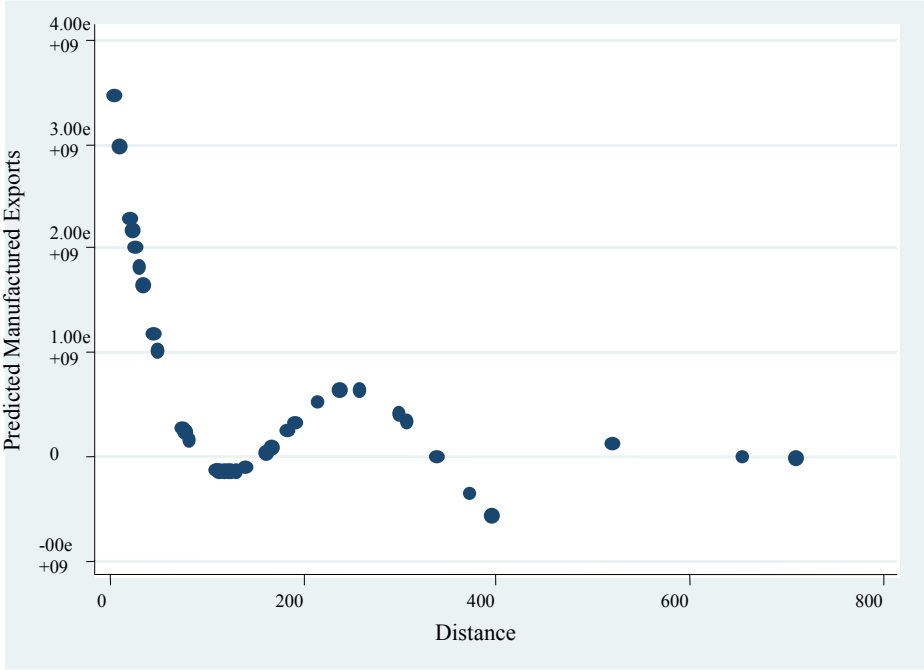
4.3.2 Location of Manufacturers in terms of the Export Hubs

In this section, the impact of domestic transport costs on the level of manufactured exports is determined from each of the export hubs in South Africa.

4.3.2.1 Cape Town

Export activity around Cape Town harbour is limited, as on average only 35 of the magisterial districts export manufactures via Cape Town. The spline density function of the average of manufactured exports in this data set provides a similar picture to that of the national average (see figure 5).

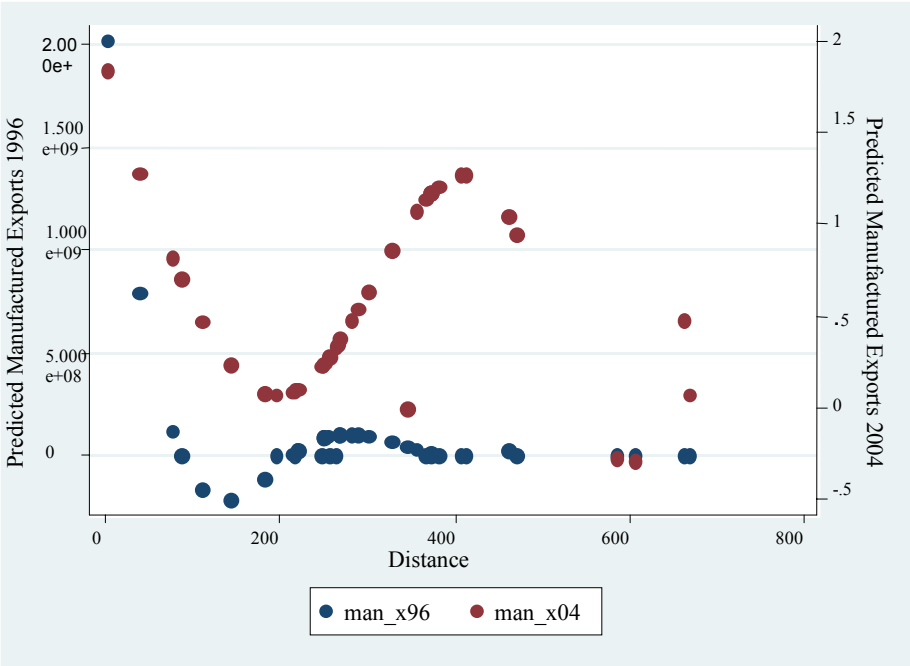
Figure 5: Manufactured Exports of Cape Town from 1996 to 2004



4.3.2.2 Port Elizabeth

The case of Port Elizabeth is interesting when the start (see figure 6) and end year (see figure 8) of the data period is compared. In 1996, 37 magisterial districts around the Port Elizabeth harbour exported manufactures. The number increased in 2004 to 48. The density pattern in both years is the same; however the level of manufactured exports is much higher in 2004. This increase can be attributed to about three or four magisterial districts that have shown high levels of growth during the period between 1996 and 2004, specifically Mosselbay, Knysna and George.

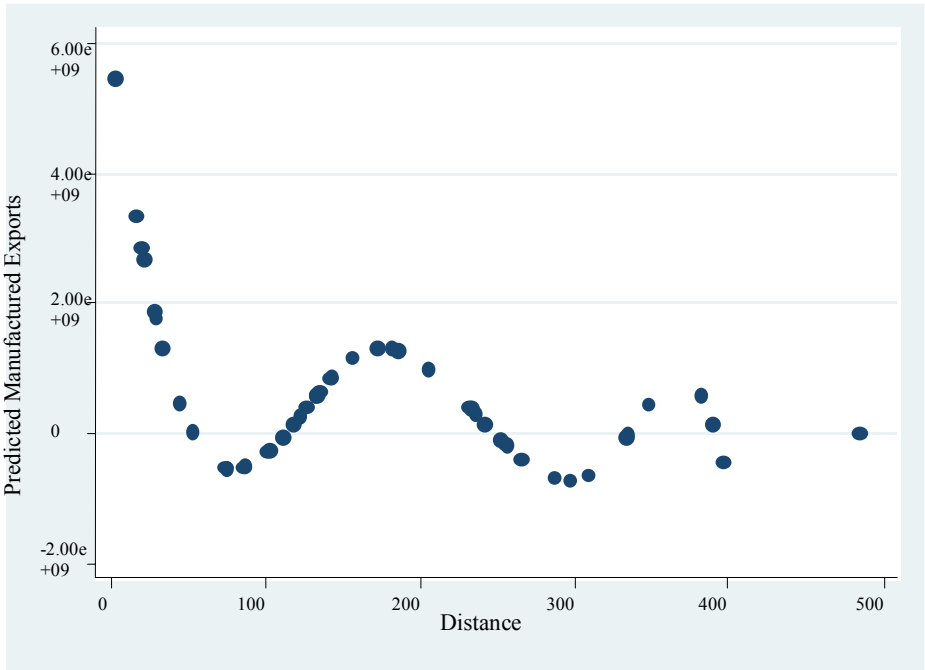
Figure 6: Manufactured Exports in 1996 and 2004



4.3.2.3 Durban

Durban harbour is the largest of the export hubs and around 48 of the magisterial districts export directly to it. The density pattern of Durban differs from the national pattern, as large levels of manufactured exports originate in a broader band (see figure 7). This is due to the two major manufacturing magisterial districts located in the second and third bump of the density pattern.

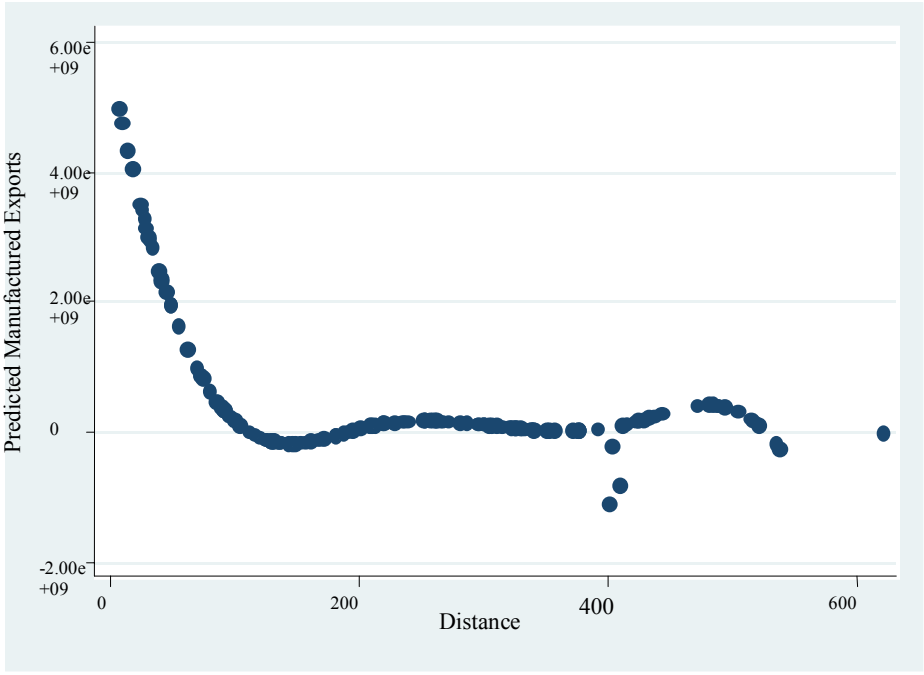
Figure 7: Average Manufactured Exports of Durban from 1996 to 2004



4.3.2.4 City Deep

City Deep is located in Gauteng, which is where the majority of the manufacturing activity occurs (136 of the 354 magisterial districts in that vicinity export manufactured goods). The level of manufactured exports seems to remain constant from 150 kilometres onwards (see figure 8).

Figure 8: Average Manufactured Exports of City Deep from 1996 to 2004



5. Discussion

In all instances where cubic spline density functions were applied to the various data sets, the results indicated that distance is negatively related to the level of manufactured exports (see Appendix 1). The results obtained are in line with that of Zheng (1991) for the case of metropolitan spatial structures. The majority of exporters of manufactured goods are located within 100 kilometres from the export hub. A second "zone" of export density occurs between 200 and 400 kilometres.

Table 1 provides information on the location of the manufacturers of the 9 sectors of manufactured exports. The majority (in excess of 70 percent) of manufactured exports is produced within 100 kilometres of the nearest export hub. For certain goods, such as electronics, about 98% of manufacturing takes place within 100 km's of an export hub. Further away from an export hub (in excess of 100 kms) one tends to find in South Africa furniture, textiles, and metal products which tend to be produced largely for the domestic market and which is relatively more intensive in natural resources. Thus, the patterns and evolution of the location of manufacturing exporters in South Africa tend to support the idea that domestic transport costs matter for exports.

Table 1: Percentage Exports per Sector by Distance

Sector	Distance (in km) from nearest export hub							
	0 –100	**101 – 200**	**201 – 300**	**301 – 400**	**401 – 500**	**501 – 600**	**600 +**	**Total %**
30 Food, beverages and tobacco products	84.28	8.14	4.25	2.76	0.50	0.05	0.02	100
31 Textiles, clothing and leather goods	79.15	1.50	12.50	6.59	0.25	0.01	0.00	100
32 Wood and wood products	82.39	16.62	0.47	0.39	0.12	0.00	0.00	100
33 Fuel, petroleum, chemical and rubber products	78.60	14.34	1.38	2.12	3.56	0.01	0.00	100
34 Other non-metallic mineral products	94.21	2.74	2.19	0.74	0.09	0.02	0.00	100
35 Metal products, machinery and household appliances	75.75	20.12	0.84	2.43	0.52	0.01	0.33	100
36 Electrical machinery and apparatus	92.74	0.97	6.05	0.12	0.08	0.02	0.01	100
37 Electronic, sound/vision, medical and other appliances	98.79	0.64	0.32	0.10	0.13	0.01	0.00	100
38 Transport equipment	81.28	3.92	14.36	0.26	0.11	0.06	0.00	100
39 Furniture and other items NEC and recycling	71.53	2.47	1.94	0.82	23.23	0.00	0.01	100

Source: Authors' own calculations using Global Insight's REF data

If one compares the location of manufactured exporters over time, i.e. compare the level and location of manufactured exports in 1996 and in 2004, two structures are evident (see figure 4). Firstly, exporters seemed to have located further away from the hub within the first 100 kilometres. Secondly, the level of manufactured exports in the second "band" (originating around 400 kilometres from the hub) has increased significantly from 1996 to 2004. Domestic transport costs might have declined, the manufacturers have obtained ways with which they are able to overcome the incidence of these costs, or the demand for these kind of manufactured goods may have made its exporting more profitable.

6. Conclusions

In the geographical economics literature, transport costs influences international trade patterns and volumes. A growing number of studies have in recent years focused on establishing the empirical relevance of especially international transport costs. This literature is accumulating evidence that international transport costs have a significant impact on a country's trade volumes, especially if that country is landlocked or remote from its trading partners.

It was concluded in this paper that both international and domestic transport costs have significant effects on international trade, and that moreover, domestic

transport costs may have a much stronger effect on exports than international transport costs. Despite this, the majority of studies have focused on international transport costs, with only a few studies (as cited above) focusing on domestic transport costs. Furthermore, even fewer studies are available that investigate the importance of domestic transport costs in an African country. Given that Africa is the one continent in the world that faces the most significant challenges in terms of growth, development, exports and integration into the world economy, and is also one of the continents facing the most adverse physical geography. The impact of domestic transport costs on manufactured exports and the location of exporting firms in Africa are therefore highly relevant. This paper attempted to fill this vacuum by studying the case of domestic transport costs and exports in South Africa.

South Africa's spatial distribution of economic activity is, like those in many other countries, highly unequal. Around 70 percent of the country's GDP is produced in only 19 of the urban areas. In terms of exports, around 22 of the 354 magisterial districts produced 84 percent of the total manufacturing exports in 2002. Economic activity is also skew in the sense that the cities located near ports are smaller than those situated inland. Therefore, domestic transport costs are a relevant issue in South Africa, especially as the major sources of manufactured exports are located inland.

In determining whether distance and transport costs from a particular location to an export hub matters for export-oriented manufacturing firms matter in South Africa, this paper estimated a number of cubic-spline density functions for manufactured exports in 1996 and 2004 and for average manufactured exports over the period 1996-2004.

Cubic splines are piecewise functions whose "pieces" are polynomials of degrees less than or equal to three, joined together to form a smooth function. These have been applied to various study disciplines, especially urban studies. As far as we are aware there has not been any study that uses the cubic-spline density function to estimate the impact of domestic transport costs on trade.

From the cubic-spline density functions it was found that in South Africa the largest volumes of exports are generated within a 100 kilometres from the export hub. In particular between 70 percent and 98 percent of manufactured exports is produced within 100 kilometres of the nearest export hub. For certain goods, such as electronics, about 98 percent of manufacturing takes place within 100 km's of an export hub. Further away from an export hub (in excess of 100 kms) one tends to find in South Africa furniture, textiles, and metal products which tend to produce largely for the domestic market and which is relatively more intensive in natural resources.

The above suggests that, barring some important exceptions, that the proximity to a port (hub) is an important consideration in most export-oriented manufacturing firms' location. However, it was also found that the relationship between exports and distance from an export hub is not one-directionally negative. In fact in South Africa there appears to be a second band of location of export-oriented manufacturing firms at a distance of between 200 and 400 kilometres from the hub. Several large manufactured exporters are situated in this band. A third band occurs at around 600 km. However, the manufactured exports that originate from this distance are resource based.

Comparison over time found that the number of locations from which manufacturing exports occurred in South Africa increased by 15 percent between 1996 and 2004 and that manufactured exports in the band between 200 km and 400 km from the nearest hub increased. This could suggest an increase in manufactured exports that depend on natural resources due to demand factors and/or a decrease in domestic transport costs over the time period. Although further research could clarify whether or not the increase in manufacturing exports in the band further away from the export hub

was due to increases in demand and/or decreases in transport costs, it remains that transport costs are an important and significant determinant of the location of export-oriented manufacturing firms in South Africa, and the location near to an export hub is important. It also suggests that improving the efficiency of export hubs, and even creating additional export hubs (e.g. through dry ports) as the government is currently planning, would contribute positively towards increasing the volume of manufactured exports from South Africa.

APPENDIX 1

3 knots	Total Hubs			City Deep			*Port Elizabeth*		
Parameter	**Avg.**	**1996**	**2004**	**Avg.**	**1996**	**2004**	**Avg.**	**1996**	**2004**
a	4.10e+09 (9.03)**	2.51e+09 (7.44)**	4.33e+09 (7.60)**	5.56e+09 (6.44)**	3.93e+09 (6.27)**	8.59e+09 (4.96)**	5.53e+09 (10.96)**	2.10e+09 (13.32)**	2.10e+09 (13.32)**
b	-6.96e+07 (-6.05)**	-4.66e+07 (-5.13)**	-3.79e+07 (-5.11)**	-1.01e+08 (-4.25)**	-8.50e+07 (-4.56)**	-1.71e+08 (-2.89)**	-9.92e+07 (-8.47)**	-4.15e+07 (-10.16)**	-4.15e+07 (-10.16)**
c	366691.1 (4.75)**	260066.1 (4.13)**	73710.2 (3.39)**	570014.9 (3.27)**	540854.2 (3.80)**	1125287 (2.18)**	535952.2 (7.06)**	234692.9 (8.17)**	234692.9 (8.17)**
d_1	-598.3 (-4.09)**	-440.5 (-3.60)**	1.10e-06 (0.63)	-1019.6 (-2.79)**	-1044.7 (-3.41)**	-2381.9 (-1.86)*	-895.3 (-6.27)**	-404.3 (-6.99)**	-404.3 (-6.99)**
$d_2 - d_1$	756.2 (3.20)**	606.2 (2.88)**	-1143.5 (-0.83)	1228.2 (2.17)**	1436.8 (2.91)**	2774.0 (1.51)	1025.3 (5.11)**	497.2 (4.95)**	497.2 (4.95)**
$d_3 - d_4$	-539.4 (-1.08)	-684.1 (-1.36)	-2318.6 (-0.42)	-1214.0 (-0.69)	-2550.0 (-1.37)	-1037.5 (-0.46)	-224.0 (-0.98)	-245.4 (-1.15)	-245.4 (-1.15)
$d_4 - d_5$	1.36e+09 (0.44)	1.81e+09 (0.77)	-2.72e+09 (-0.53)	9.99e+09 (0.54)	2.25e+10 (1.06)	5.68e+10 (0.10)	5.36e+10 (0.07)	5.42e+10 (0.21)	5.42e+10 (0.21)
SE	1.7e+09	1.2e+09	2.8e+09	1.9e+09	1.3e+0.9	3.3e+09	5.4e+08	1.6e+08	1.6e+09
Adj. R^2	0.20	0.17	0.14	0.21	0.23	0.18	0.69	0.86	0.43
No. obs.	267	193	223	136	103	112	48	26	37

3 knots	Durban			Cape Town		
Parameter	**Avg.**	**1996**	**2004**	**Avg.**	**1996**	**2004**
a	5.83e+09 (4.50)**	4.25e+09 (4.01)**	8.46e+09 (4.08)**	2.64e+09 (5.11)**	1.32e+09 (4.74)**	3.62e+09 (5.17)**
b	-1.90e+08 (-3.65)**	-1.53e+08 (-3.45)**	-2.77e+08 (-3.26)**	-6.01e+07 (-3.49)**	-3.18e+07 (-3.33)**	-7.43e+07 (-3.55)**
c	1757031 (3.35)**	1508956 (3.24)**	2625725 (2.98)**	413788.9 (2.86)**	223499.7 (2.74)**	458370.3 (2.87)**
d_1	-4676.2 (-3.19)**	-4177.0 (-3.11)**	-7148.5 (-2.84)**	-835.5 (-2.54)**	-457.4 (-2.42)**	-833.2 (-2.55)**
$d_2 - d_1$	6934.6 (2.89)**	6692.2 (2.77)**	11353.2 (2.51)**	2266.7 (1.73)*	1259.2 (1.63)	1247.9 (2.11)**
$d_3 - d_4$	-15042.7 (-1.29)	-98784.0 (-0.59)	-192053.1 (-0.62)	-174552.3 (-1.08)	-6604.0 (-1.14)	-1508.0 (-1.07)
$d_4 - d_5$	4.80e+10 (1.00)	5.26e+11 (0.55)	1.03e+12 (0.58)	2.21e+12 (1.08)	2.66e+10 (1.07)	3.66e+09 (0.66)
SE	1.9e+09	1.5e+09	2.9e+09	8.7e+08	4.6e+08	1.2e+09
Adj. R^2	0.20	0.20	0.18	0.30	0.28	0.30
No. obs.	48	33	38	35	31	36

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