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On the Determinants of Bilateral Intra-industry Trade: An Application to South Africa's Automobile Industry

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Paper to be presented at the 14th Annual Africa Econometrics Conference to be held at the Sheraton Hotel, Abuja, Nigeria, 8-10 July

Abstract

As there is evidence that vertical intra-industry trade (*differentiation by quality*) is the dominant intra-industry trade pattern in the South African automobile industry (Damoense and Jordaan, 2009). This study investigates c*ountry*- and *industry*-specific determinants of bilateral intra-industry trade (IIT) patterns between South Africa and trading partners in the automobile industry. The empirical strategy adopts panel data econometric techniques (gravity model) using bilateral harmonised system data spanning the period 2000-2007. The empirical results reveal that foreign direct investment (FDI) and economies of scale influence vertical IIT and horizontal IIT (*differentiation by variety*) in a similar manner; whilst relative difference in economic size and product differentiation influence them differently. Further, distance and automotive assistance negatively influences vertical IIT whilst trade openness stimulates it with no effect on horizontal IIT except for the negative consequences of tariffs. The net effect of trade barriers applied to the automobile industry, including trade costs are major sources deterring bilateral IIT in the domestic industry. Also, the findings assert that FDI strategies and motives of multinational firms in the automobile industry are *market-seeking* over preference to *efficiency-seeking*. The authors propose further trade liberalisation and deregulation of the South African automobile industry that could attract more vertical (efficiency-seeking) FDI and in doing so enhance intra-industry trade levels.

Key words: intra-industry trade patterns, gravity model, automobile industry, South Africa

JEL: F14, L62

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1. Introduction

In the international microeconomic literature, the study of intra-industry trade (IIT) is by and large associated with imperfect competition, economies of scale and differentiation of products[1]. Verdoon (1960) and Balassa (1966) were amongst the first pioneers who acknowledged the existence of intra-industry trade, namely the two-way exchange (export and import) of products within a specific industry between different economies. The Grubel and Lloyd (1975) index is by far the most popular empirical measure to determine the extent of intra-industry trade. Over time, several authors developed alternative measures (indices) of IIT (Aquino, 1978; Abd-el-Rahman, 1991; Fontagné and Freudenberg, 1997; Brülhart, 1994; Nilsson, 1999; Kandogan, 2002, 2003). Further, empirical studies of IIT recognised the importance of detangling aggregate IIT into patterns of vertical IIT and horizontal IIT (Falvey, 1981; Falvey and Kierzkowski, 1987) so as to investigate the determinants of each intra-industry trade pattern. This is supported by Greenaway, *et. al*., (1985) and others, that reveal several country and industry factors influence vertical IIT and horizontal IIT in different manners.

Very few published studies deal with intra-industry trade in South Africa (Parr, 1994; Petersson, 2002, 2005; Al-Mawali, 2005; Sichei, *et. al*., 2007). Although Al-Mawali (2005) decomposed IIT into vertical IIT and horizontal IIT, his study investigated only the influence of country-specific factors on bilateral IIT using 22 Manufacturing sectors (ISIC) in South Africa for the period 1994-2004. The most recent study by Sichei, *et. al*., (2007) examined the impact of several determinants on South Africa-United States of America (USA) IIT in selected services between 1994-2002. However, their study did not separate aggregate IIT into vertical IIT and horizontal IIT for South Africa- USA IIT services. This study differs from previous studies conducted for South Africa in two ways; firstly it focuses on a *specific* industry, namely the automobile industry and second, it examines the role of *industry*-specific factors in addition to *country*-specific factors of intra-industry trade patterns, namely vertical IIT and horizontal IIT. This present study is an extension of Damoense and Jordaan (2007, 2009).

Beginning 1989, there has been substantial trade policy reform in the industry (see Damoense and Agbola, 2009) and in 2013 an alteration in government policy is expected to be installed upon the termination of the present Motor Industry Development Programme (MIDP) which was introduced in September 1995. Under the new programme (also referred to as the revised MIDP), namely; the Automotive Production and Development Programme (APDP) tariffs are expected to remain at 25 per cent and 20 per cent for finished imported vehicles and component parts, respectively from 2012 until 2020. In addition to

[1] Although Davis (1995) argue that economies of scale is not a necessary condition for intra-industry trade. In addition, vertical IIT can be explained by Hecksher-Ohlin (H-O) trade theory that assumes comparative advantage and constant returns to scale.

tariffs, a range of fiscal incentives[2] (automotive assistance) are expected to be offered to vehicle and component producers to undertake investments to increase manufacturing output and capacity, improve economies of scale, technology transfers and upgrading, and research and development (R&D) related to engineering and design activities, etc. (DTI, 2008). Largely attributable to the provisions under the MIDP, the domestic industry has been an important recipient of FDI by multinational firms in recent years (Damoense and Jordaan, 2007). Most major vehicle producers and first-tier component firms have extensive production operations in the local market, especially directed for exporting to multi-locations. The automobile industry is an important industrial sector in the South African economy characterised by many elements aligned with IIT theory and thus represents an interesting case of IIT patterns to investigate.

The objective of this study is to analyse the determinants of bilateral intra-industry in South Africa's automobile industry over the period 2000-2007. This study identifies several explanatory variables of country- and industry-specific factors influencing IIT and its components (vertical IIT and horizontal IIT) applicable to the automobile industry in South Africa and is discussed in Section 3. A gravity modelling approach is adopted to examine the determinants of IIT trade patterns between South Africa and selected bilateral trade partners in the automobile industry in order to improve the understanding of policy makers and trade advisors of the impact of the different determinants underlying vertical IIT and horizontal IIT.

The study adopts the following format. Besides this introduction, Section 2 provides a review of the intra-industry trade empirical literature. Section 3 provides evidence of intra-industry trade patterns in South Africa's automobile industry. Thereafter, section 4 describes the empirical strategy adopted in the study and discusses the data. The empirical results and discussions are offered in section 5. Finally, section 6 concludes.

2. A review of related studies of intra-industry trade (IIT) patterns

There is plentiful empirical evidence in the IIT literature theory that highlights the important role of country-specific factors, while the role of industry-specific factors is less explored. As in most past studies, the average level of GDP of the two trading partners provides a proxy for the *size of the market*. A larger average market size is expected to benefit from the potential economies of scale in production and trade and as a result increase the variety and quality of differentiated products. Quite a few studies measure *average standard of living* by using GDP per capita expressed as an average of the bilateral trading partners. Countries with high levels of per capita incomes are associated with high levels of economic development, and thus are expected to increase the share of IIT. The level of per capita income is also a proxy for the level of capital-labour ratio (supply perspective) (Helpman and Krugman, 1985) as well as a proxy for the ability

[2] These include local assembly allowance and production incentives (rebateable duty credits) and automotive investment allowance (supplemented by discretionary company-specific allowances) (DTI, 2008).

to purchase better varieties and sophistication of differentiated products (demand perspective) (Lancaster, 1980).

According to the literature, if the absolute difference in per capita GDP (as a proxy for *absolute economic distance*) between countries is large, the share of vertical IIT in aggregate IIT is likely to increase and thus a positive sign for this explanatory variable is hypothesised as in Falvey and Kierzkowski (1987). A negative sign for horizontal IIT (Helpman and Krugman, 1985) is expected where absolute economic distance is a proxied by differences in capital-labour endowment ratios as in (Clark and Stanley, 1999). Large per capita income gaps between trading partners occurs as a result of greater levels of inequality of economic development and has been investigated by Hirschberg, *et. al*., (1994); Gullstrand, 2001; Chemsripong, *et al*., (2005); and Byun and Lee (2005). In addition, according to Linder (1961) greater differences in GDP per capita difference reveal divergences in demand structures and tastes of trading partners. Durkin and Krygier (2000) and Fukao, *et. al*., (2003) find evidence of a positive association between differences in GDP per capita and vertical IIT reflecting larger differences in relative wages stimulates vertical IIT. Moreover, several studies use additional explanatory variables, such as public expenditure on education, electric power consumption per capita, etc. in an attempt to capture similarities between trading partners (Zhang, *et. al.*, 2005).

Relative difference in economic size is used to capture the influence of relative difference in factor proportions and endowments between nations. Relative economic distance is a better measure compared to absolute difference in market size as the second measure is sensitive to the trading partner's size whereas the former is standardised and normalised to one. Freudenberg, Fontangé and Péridy (1997) find that vertical IIT is positively influenced by larger relative difference in economic size implying that dissimilar countries in respect of factor endowments and technologies trade in products differentiated by quality (Falvey and Kierzkowski, 1987). On the other hand, larger relative difference in economic size negatively affects horizontal IIT indicating that similar countries trade in products differentiated by variety (Helpman and Krugman, 1985).

The *geographic proximity* between bilateral trading partners as measured by the distance variable is presented in the empirical IIT literature as a key determinant deterring intra-industry trade. Greater distances impose large transport and trade costs thereby reducing the intensity of intra-industry trade. Most empirical studies find that geographical distance negatively influence intra-industry trade (Clarke and Stanley, 1999; Türkan, 2005). However, there are exist several studies that find distance to positively influence IIT (Kind and Hathcote, 2004; Zhang, *et. al*., 2005; Zhang and Li, 2006) while others find no significant impact on IIT (Thorpe and Zhang, 2005). As a result of greater regional integration, advancement in ICT and the reduction in international transport costs (rail, road, air freight and shipping) it may be that distance do not necessarily deter intra-industry trade.

Several studies examine the influence of *foreign direct investment* (FDI) on IIT trade patterns and conclude that the larger the FDI in an industry, the greater the levels of IIT. The coefficient is expected to be positive for HIIT and negative for VIIT (Zhang and Li, 2005). Veeramani (2007) reports FDI to be positively correlated to IIT, suggesting that IIT levels increases with greater multinational involvement. However, when FDI is interacted with trade barriers, the coefficient becomes negative indicating that large trade barriers cause MNCs to undertake market-seeking FDI (Veeramani, 2007). Also, in Byun and Lee (2005), the negative sign on the FDI coefficient imply that vertical IIT and FDI may act as trade substitutes as hypothesised by Caves (1988). Zhang, *et. al*, (2005) also find a negative sign on the FDI coefficient implying that greater FDI activities reduce vertical IIT resulting in some agglomeration effects of FDI. Others such as Zhang and Li (2006) and Zhang, *et. al*., (2005) find a positive relationship between FDI and horizontal IIT and aggregate IIT. In studies by Fukao, *et. al*, (2003) and Zhang and Li (2005) positive relationship between FDI and the share of vertical IIT is found in the context of international theory of fragmentation.

Typically, a negative relationship between *trade barriers* and the share of IIT is predicted (Hellvin, 1996; Sharma, 2004) Most studies use the level of tariffs as a proxy for trade barriers, (despite other forms of trade barriers – quotas, quantitative restrictions, non-tariff barriers, etc.) and find that a reduction in trade barriers (tariffs) increased intra-industry trade (Zhang, *et. al*., 2005; Veeramani, 2007). In contrast there are a limited number of studies that reveal a positive relationship between trade barriers and IIT (Kind and Hathcote, 2004; Al-Mawali, 2005). In particular, Al-Mawali (2005) relates the positive impact of the level of tariffs on bilateral IIT in South Africa's manufacturing sector to provisions of the MIDP that is argued to encourage multinational activity. However, the tariff data used in his study was not specifically applied to the automobile industry as is done in this study. Kind and Hathcote (2004) use tariff data applied to the clothing sector and find a similar positive impact of tariffs on IIT between USA and fabric trading partners. Sharma (2004) examine the impact of artificial trade barriers as measured by the effective rate of assistance (ERA) on Australia's manufacturing intra-industry trade patterns and find that it negatively influences both vertical and horizontal IIT in the pre-liberalization period. Besides tariffs, this study introduces a novel industry explanatory variable, namely *automotive assistance* (eg. duty drawbacks, subsidies and investment incentives, etc.) provided under government policy aimed at strengthening the domestic auto industry (increasing domestic production, especially to enhance exports and provide employment), to investigate its impact on the intensity of IIT in the automobile industry and will be discussed in section 3.

The empirical literature proposes the examination of the effects of *economies of scale* (EoS) on intra-industry trade (Greenaway, *et. al*., 1995; Aturupane, *et. al*., 1999; Montout, *et. al*., 2002; Sharma, 2004; Byun and Lee, 2005; Thorpe and Zhang, 2005; Faustino and Leitãlo, 2007). Montout, *et. al*., (2002) utilise minimum efficient scale (MES) as an index of scale economies initially constructed by Menon, Greenaway and Milner (1999) that captures the relative productivity associated with larger firms' *vis-à-vis* smaller firms in the automobile industry. In previous studies a positive sign is found on the EoS coefficient for horizontal IIT (Thorpe and Zhang, 2005; Sharma, 2004). In Montout, *et. al.* (2002), the sign on the MES coefficient is negative for horizontal IIT aligned with the argument of a small number of firms and large EoS. The study by Veeramani (2007) argues that the negative sign on the MES coefficient indicate that product homogeneity discourages IIT (horizontal). With reference to vertical IIT, few authors find a positive sign on the MES coefficient (Aturupane, *et. al*., 1999; Greenaway, *et. al*., 1999) suggesting that greater EoS stimulates vertical IIT. Alternately, a negative coefficient is found on MES for vertical IIT supporting the argument that larger plant sizes are conversant with lower units costs of production (large EoS) thus reducing the incentive to outsource production activities and thereby reducing the propensity to engage in intra-industry trade differentiated by quality (Feenstra and Hanson, 1997; Clark and Stanley, 1999; Thorpe and Zhang, 2005), especially in the context of international production and fragmentation of the production process.

The degree of *product differentiation* on intra-industry trade patterns have been assessed by a number of authors (Hellvin, 1994; Hu and Ma, 1999; Bernhofen and Hafeez, 2001; Sharma, 2004; Clark, 2005; Veeramani, 2007; Chang, 2009). Several authors (Hellvin, 1994; Hu and Ma, 1990; Veeramani, 2007) report significant findings of the impact of the PD variable on the extent of IIT (horizontal), whereas Aturupane, *et. al.*, (1999) and Chang (2009) reveal statistically significant findings for vertical IIT. Few studies report no statistical evidence to support the claim that product differentiation has any significant impact on the intensity of intra-industry trade patterns (Sharma, 2004; Buyn and Lee, 2005; Faustino and Leitãlo, 2007). The insignificant findings of the PD variable may be attributable to the reliability of the difference proxies for PD as an explanatory variable. Byun and Lee (2005) argue that an improved measure of PD is perhaps warranted to improve its significance as an explanatory variable explaining IIT patterns. Next, the study provides evidence on intra-industry trade in South Africa's automobile industry for the period 2000-2007.

3. Evidence of intra-industry trade patterns in the automobile industry

On examination of bilateral IIT between South Africa and 20 countries in the automobile industry, the study by Damoense and Jordaan (2009)[3] find evidence that the local industry is largely dominated by vertically differentiated intra-industry trade (VIIT) (*differentiated by quality products*). The computed bilateral shares of aggregate IIT, vertical IIT, horizontal IIT (*differentiated by variety products*) and one-way trade (OWT)

[3] Damoense and Jordaan (2009) employ the *trade type* methodology by Fontagné and Freudenberg (1997) initially put forth by Abd-el-Rahman (1991) to disentangle total trade (TT) into one-way trade (OWT) and IIT. Next, using the *threshold* methodology by Falvey (1981) and Falvey and Kierzkowski (1987) the share of IIT was separated into shares of VIIT and HIIT. See Damoense and Jordaan (2009) for a detailed discussion of trade patterns in the South Africa's automobile industry.

for selected trading partners for 2000, 2003 and 2007 are reported in Table 1 below. A summary of the of the steps followed in the methodology to empirically measure the intensity of intra-industry trade and trade patterns is provided in Table A1 of Appendix.

According to Table 1, bilateral IIT between South Africa-Japan (36.6 per cent to 74.9 per cent) and South Africa-USA (56.6 per cent to 64.0 per cent) reveal rising levels over the 2000-2007 period with vertical IIT being the dominant IIT trade pattern reaching levels of 100.0 per cent and 84.4 per cent of total IIT in 2007. Significant but declining IIT trends are experienced by Germany (80.0 per cent to 46.4 per cent) and UK (62.1 per cent to 52.1 per cent) between 2000 and 2007. Nonetheless by 2007, vertical IIT account for 92.7 per cent and 96.3 per cent of total IIT for Germany and UK, respectively. Shifting trade patterns from OWT to IIT between South Africa-Spain (78.1 per cent to 49.8 per cent) and South Africa-France (81.9 per cent to 50.3 per cent) are illustrated in Table 1.

Table 1. Direction of bilateral shares of IIT trade patterns in the automobile industry

Country	2000				2003				2007			
	VIIT	HIIT	IIT	OWT	VIIT	HIIT	IIT	OWT	VIIT	HIIT	IIT	OWT
NAFTA												
USA	0.561	0.005	0.566	0.434	0.194	0.008	0.202	0.798	0.540	0.101	0.640	0.360
Asia-Pacific												
Japan	0.366	0.000	0.366	0.634	0.492	0.000	0.492	0.508	0.749	0.000	0.749	0.251
China	0.023	0.000	0.023	0.977	0.285	0.000	0.285	0.715	0.071	0.000	0.071	0.929
India	0.109	0.001	0.110	0.890	0.488	0.000	0.488	0.512	0.057	0.040	0.097	0.903
Australia	0.055	0.000	0.055	0.945	0.110	0.000	0.110	0.890	0.086	0.063	0.149	0.851
China, Hong Kong	*n/a*	*n/a*	0.070	0.930	*n/a*	*n/a*	0.064	0.936	*n/a*	*n/a*	0.012	0.988
Taiwan	*n/a*	*n/a*	0.010	0.990	*n/a*	*n/a*	0.082	0.918	*n/a*	*n/a*	0.056	0.944
Thailand	*n/a*	*n/a*	0.072	0.928	*n/a*	*n/a*	0.167	0.833	*n/a*	*n/a*	0.095	0.905
Rep Korea	*n/a*	*n/a*	0.009	0.991	*n/a*	*n/a*	0.014	0.986	*n/a*	*n/a*	0.007	0.993
Europe												
Germany	0.727	0.075	0.802	0.198	0.523	0.138	0.661	0.339	0.430	0.034	0.464	0.536
UK	0.593	0.028	0.621	0.379	0.215	0.288	0.503	0.497	0.502	0.019	0.521	0.479
Spain	0.153	0.067	0.219	0.781	0.150	0.005	0.155	0.845	0.187	0.302	0.489	0.511
France	0.179	0.002	0.181	0.819	0.235	0.014	0.249	0.751	0.205	0.298	0.503	0.498
Sweden	0.008	0.000	0.008	0.992	0.091	0.000	0.091	0.909	0.183	0.000	0.183	0.817
Italy	0.208	0.019	0.227	0.773	0.292	0.002	0.294	0.706	0.168	0.062	0.230	0.770
Turkey	0.167	0.060	0.227	0.773	0.267	0.000	0.267	0.733	0.057	0.057	0.000	0.943
MERCOSUR and Africa												
Brazil	0.503	0.132	0.634	0.366	0.417	0.044	0.461	0.539	0.211	0.018	0.229	0.771
Zambia	*n/a*	*n/a*	0.249	0.751	*n/a*	*n/a*	0.101	0.899	*n/a*	*n/a*	0.011	0.989
Mozambique	*n/a*	*n/a*	0.161	0.839	*n/a*	*n/a*	0.187	0.813	*n/a*	*n/a*	0.018	0.982
Angola	*n/a*	*n/a*	0.009	0.991	*n/a*	*n/a*	0.003	0.997	*n/a*	*n/a*	0.006	0.994

Source: Author's computations from Quantec

Notes: n/a=low levels of IIT therefore vertical IIT and horizontal IIT not computed.

In table above: TT= [(VIIT+HIIT) = IIT] + OWT = 1

In the discussion below, shares of VIIT and HIIT in total IIT is calculated as: [(VIIT/IIT) + (HIIT/IIT)= 1, in order to illustrate the dominance of the intra-industry trade pattern.

Interestingly, for Spain and France, horizontal IIT (61.8 per cent and 59.2 per cent of total IIT, respectively) exceeds that of vertical IIT in 2007 implying that these countries prefer trading products differentiated by varieties with South Africa. In addition, Table 1 shows diminishing shares of IIT, though IIT is dictated by vertical IIT for trade between South Africa-India and South Africa-Brazil for the same period. Significant bilateral vertical IIT is found for South Africa-Brazil between 2000 and 2007 (79.3 per cent to 92.1 per cent of total IIT) and for South Africa-India between 2003 and 2007 (100.0 per cent to 58.8 per cent of total IIT).

As can be seen in Table 1 above, for trade with several Asia-Pacific countries; Thailand, Taiwan, Republic of Korea, China, China (Hong Kong) and Australia minimal IIT levels are shown and the apparent dominance of OWT is revealed. Similarly, trade between South Africa and Mozambique, Zambia and Angola is dominated by OWT[4]. Interestingly, bilateral IIT levels for South Africa-Zambia and South Africa-Mozambique were in excess of 10.0 per cent in early 2000 but then decreased substantially to less than 2.0 per cent by 2007.

Summing up, the results signify the existence of high shares of vertical IIT dominating intra-industry trade between South Africa and trading partners in the automobile industry. This reflects differences in income levels, factor endowments, human capital and technology intensities between dissimilar trading nations. Although not illustrated and discussed here (see Damoense and Jordan, 2009) within vertical intra-industry trade (VIIT), South Africa produce and export high quality (HQ) differentiated automotive products contrary to theoretical expectations (Falvey and Kierzkowski, 1987; Flam and Helpman, 1987) that lower income countries produce and export low quality (LQ) vertical products whereas the opposite is true for higher income nations[5]. Thus, there is evidence that vertical IIT in the automobile industry can partially be underpinned by the theory of fragmentation of internationalisation of production whereby MNC activities and FDI are essential determinants (Fukao, *et. al*., 2003; Kimura, *et al*., 2007; Wakasugi, 2007). The findings also indicate that horizontal IIT is not as important in South Africa’s automobile industry while traditional trade models of comparative advantage remains omnipresent for trade between South Aica and several trading partners as shown in Table 1.

According to Table 1, only 13 countries report feasible aggregate intra-industry levels that can be meaningfully decomposed into vertical IIT and horizontal IIT trade patterns[6]. In light of this, 13 of the 20

[4] Although bilateral IIT levels for Zambia and Mozambique is greater than 10 per cent. They were not included in the gravity model due to data unavailability of most their explanatory variables.
[5] It is therefore not surprising that difference in GDP per capita as an explanatory show up as insignificant in the estimated models.
[6] It is common practice in the empirical literature to declare the existence of IIT when the computed index is at least 10 per cent.

countries are employed in the gravity models of vertical IIT, horizontal IIT and aggregate IIT to be estimated in section 4.

4. Methodology and data

This study adopts a three dimensional panel data set (time *t*, reference country *i* and partner country *j*) in the automobile industry to conduct an econometric investigation of the determinants of IIT patterns for the years 2000-2007. More specifically, a gravity model is adopted in this study as first proposed by (Isard, 1954) and adopted later by others (Tinbergen, 1962; Poyhonen, 1963; Deardoff, 1984) to examine and make predictions about bilateral trade flows. The econometric gravity model is derived from *Newtonian theory of gravitation* in which Newton's (1687) universal law of gravity states that the force of gravity is positively related to the mass of two attracting bodies (as measured by average market size) and inversely related to the square of their distance (as measured by trade costs) (Piermatini and Teh, 2005). In recent years the gravity model has gained renewed interest in the international trade literature (Anderson and van Wincoop, 2003; Baldwin and Taglioni, 2006).

4.1 Dependent variable(s)

The dependent variable is the share of IIT that varies over aggregate IIT, VIIT and HIIT where the computed shares of each trade type lie between 0 and 1. The authors wish to highlight that very few studies have used the trade type methodology (Fontagné and Freudenberg, 1997) to empirically measure the intensity of IIT and subsequently separate IIT into vertical IIT and horizontal IIT patterns (Montout, *et. al.*, 2002; Fontagné and Freudenberg, *et. al*., 2005; Ando, 2006; Damoense and Jordaan, 2009). In turn, the computed indices of the shares of IIT, VIIT and HIIT are then used as dependent variables in a gravity model specification[7] (Montout, *et. al*., 2002).

In this study, the dependent variables (vertical IIT, horizontal IIT and aggregate IIT) as well independent variables have been transformed to natural logarithms. Now, in some instances where zero values are observed, especially in case where non-existent shares of horizontal intra-industry (HIIT) are encountered, the transformation of zero values becomes undefined. In order to solve this problem, all reported zero observation values of the dependent variable, in the case of the horizontal IIT regression model only, were replaced with 0.001 instead of dropping the observations. A similar approach is used by Türkan (2005). Past empirical studies adopt different econometric specifications and transformation of the dependent variable (linear, logistic, probit, etc.), however Balassa and Bauwens (1988) and others argue that the estimation results derived from different model specifications do not alter the results significantly.

[7] The majority of studies use the GL (1975) index as the dependent variable; others use the Brülhart (1990) index, Nilsson (1994) index and Kandogan methodology (2002, 2003) to measure the extent IIT and in turn decompose it into VIIT and HIIT.

4.2 Independent variables and hypotheses to be tested

Several country[8]- and industry-specific hypothesised relationships have been identified in the literature to analyse the determinants of the bilateral shares of aggregate IIT, VIIT and HIIT in the automobile industry (see Table 2 for expected signs of explanatory variables). The study performs empirical analyses using pooled OLS, FE and RE models for three regression models of IIT, VIIT and IIT. The determinants and hypotheses of IIT patterns are discussed below.

4.2.1(a) Relative differences in economic size (RDGDP)

Hypothesis (a): The greater the relative difference in economic size between trading nations, the larger the share of VIIT whereas the smaller the share of HIIT. Most empirical studies reveal a statistically significant relationship between the share of IIT and relative differences in the size of the economies of the trading partners. As in Balassa (1986) and Balassa and Bauwens (1987), the relative difference in market size is expressed as:

$$RDGDP_{ij,kt} = 1 + \frac{[w \ln w + (1 - w)\ln(1 - w)]}{\ln 2}$$

$$\text{where } w \equiv \frac{GDPi}{GDP_i + GDP_j} \qquad (1)$$

and GDP_{ijt}=gross domestic product and $RDGDP_{ijt}$=relative difference in gross domestic product between country *i* and *j*, where the $RDGDP_{ijt}$ varies between 0 and 1 and is independent of the absolute market size of the partner country.

On the production side, countries similar in size tend to trade more in different variety products (Helpman and Krugman, 1985), thus a negative relationship between horizontal IIT and relative difference in economic size is expected. In addition, according to the Linder's (1961) hypothesis, countries similar in size demand greater variety products. Alternately, according to the H-O hypothesis (Falvey, 1986; Falvey and Kierzkowski, 1987) countries with larger relative differences in factor endowments, proportions and technologies will trade more, thus a positive relationship between vertical IIT and relative difference in market size is expected. The sign for aggregate IIT will depend on the dominant pattern of IIT and therefore there is no *a priori*.

[8] This study experimented with usual country factors such as market size (bilateral average of GDP or product of GDP of two countries), average of standard of living (average of GDP per capita or GNI per capita), absolute difference in GDP per capita or GNI per capita and difference in electric power consumption per capita. The inclusion of these explanatory variables in the final estimation yield unsatisfactory results potentially due to co-linearity problems between the explanatory variables and were thus dropped from the final model.

4.2.1 (b) Geographic distance (DIST)

Hypothesis (b): The greater the geographical distance between trading partners, the lower the shares of all IIT. Geographic distance is typically used as a proxy for transport costs, insurance costs, delivery times and market access barriers. Many studies use kilometres or miles to measure geographic distance between the capital cities of trading partners. Since the commonly used distance variable (Lee, 1992; Hu and Ma, 1999; Sharma, 2004; Veeramani, 2007) is time invariant, thus it could not be used in fixed effects (FE) models. This study adopts the weighted distance variable which varies over time (Balassa, 1986; Stone and Lee, 1995) as a proxy for geographical distance between countries *i* and *j*, where the weight is the ratio of GDP of country *j* to the sum of total GDPs of all its trading partners and is computed as follows:

$$WDIST_{ij,kt} = \frac{DIST_{ij} * GDP_{jt}}{\sum_{j=1}^{13} GDP_t} \qquad (2)$$

As greater distances between trading partners leads to lower IIT, a negative relationship between the share of vertical IIT, horizontal IIT and aggregate IIT and the distance parameter is expected, according to the IIT empirical literature.

4.2.1 (c) Trade orientation

Hypothesis (c): The greater the degree of trade openness, the larger the shares of VIIT, HIIT and aggregate IIT. Several studies use a trade orientation (TO) variable as a proxy for trade openness (Chemsripong, *et. al*., 2005; Thorpe and Zhang, 2005; Clarke and Stanley, 2003; Clark, 2005 Zhang and Li, 2006). The TO variable is estimated by constructing residuals from a regression with trade (exports plus imports) per capita as the dependent variable and population and gross national income per capita as explanatory variables (Stone and Lee, 1995). The expected sign is positive for TO for all IIT patterns.

4.2.1 (d) Foreign direct investment (FDI)

Hypothesis (d): Greater levels of efficiency-seeking FDI, the larger the shares of VIIT and HIIT. Alternately, greater levels of market-seeking FDI, the smaller the shares of VIIT and HIIT. FDI and its effects on aggregate IIT and its components have been investigated in the empirical literature (Hu and Ma, 1999; Byun and Lee, 2005; Zhang et. al., 2005; Zhang and Li, 2006; Veeramani, 2007; Chang, 2009). Generally, FDI is hypothesised to be positively correlated with the share of total, horizontal and vertical IIT and is regarded at efficiency-seeking FDI type. However, a negative sign on the FDI coefficient suggest that FDI may substitute for trade and the FDI type is of the market-seeking FDI type.

Levels of FDI in the automobile industry are typically associated with high levels MNC involvement, technology transfers and specialisation in production plants located in different countries. Now, in the absence of industry level FDI data, this study use inward FDI stocks as a percentage of gross fixed capital formation (GFCF) to capture the amount of FDI activities by MNCs in the automobile industry. This approach is reasonable since the automobile industry in South Africa is the largest manufacturing industry contributing 21 per cent to manufacturing output. In addition, Original Equipment Manufacturers (OEMs) and first-tier component firms in automobile industry have important links with MNCs.

4.2.1 (e) Tariffs (TAR)

Hypothesis (e): The lower the level of tariffs, the greater the shares of VIIT, HIIT and aggregate IIT. Typically, a negative relationship between trade barriers and the share of IIT is predicted (Sharma, 2004). Most studies use the level of tariffs as a proxy for trade barriers, despite other forms of trade barriers (quotas, quantitative restrictions, non-tariff barriers, etc) and find that a reduction in trade barriers (tariffs) increased intra-industry trade (Sharma, 2004; Zhang, *et. al*., 2005; Veeramani, 2007). As a result of trade agreements with specific automotive provisions, preferential lower tariffs are applied to the automobile industry. Thus, trade agreements serve to reduce trade barriers thereby resulting in trade-creating effects between trading countries and are likely to result in rising IIT levels in the automobile industry. On the other hand, two studies reveal a positive relationship between trade barriers and IIT (Kind & Hathcote, 2004; Al-Mawali, 2005). In this study, the tariff variable used is calculated as the bilateral average level applied MFN tariff rates for HS 6 digit level (WTO, 2009).

4.2.1 (f) Automotive assistance (AA)

Hypothesis (f): The predicted sign for automotive assistance and its impact on IIT patterns is indeterminate. Automotive assistance refers to any form of 'assistance' (tariffs, non-tariff barriers and fiscal, etc.) offered to foreign firms or MNCs to embark on vertical and horizontal FDI. Trade and industrial policy applied to automobile industries for the most part include a set of trade barriers such as; import tariffs, non-tariff barriers (NTBs)[9], including various fiscal incentives that potentially offset import tariffs payable. Kimura, *et. al*., (2007), argues that duty drawbacks (rebateable credits) assist in reducing the impact of trade barriers which enhance intra-industry trade. Even though such measures may reduce nominal tariff barriers it actually increases effective protection to the industry insulating inefficient domestic producers from international competition thereby reducing IIT. The argument in favour of government fiscal assistance (export and production subsidies) to selective industries such as the automobile industry is attributable to the

[9] Examples of non-tariff barriers (NTBs) include quantitative restrictions (QRs), administered protective measures such as local content requirements, countervailing duties, anti-dumping measures, differential rules of origin, etc.

attractiveness of MNC foreign investment inflows, employment benefits, technology spillovers and export opportunities (limited size of domestic market) (Leipziger, *et. al*., 1997). However, others argue that higher effective protection (although reducing nominal protection) make for inefficient vehicle production and pose negative welfare effects on society as a whole (Flatters, 2003; Damoense and Agbola, 2009). It can be argued that by lowering incentives such export subsidies, some firms will be forced to leave (inefficient) thus reducing the number of firms or plants (increasing economies of scale and specialisation), resulting in higher output and trade contributing to rising IIT levels.

This study attempts to investigate the influence of automotive assistance, especially from the perspective of protection and government support on IIT in the automobile industry in South Africa. Now, it is very complicated to find a suitable proxy to measure automotive assistance especially, in a panel setting. Nevertheless, this study adopts a measure of absolute differences between partner countries *i* and *j* using industry employment data. The use of employment data to compute a proxy for AA is reasonable as Kumar and Gallagher (2007) cites various examples of jobs provided by MNC auto firms attributable to government financial assistance. A positive sign indicates that greater automotive assistance serves to stimulate all IIT types. Conversely, a negative sign reveal that lower automotive assistance is expected to have a positive influence on IIT patterns. Thus, the predicted sign for AA is indeterminate.

4.2.1 (g) Economies of scale (EoS)

Hypothesis (g): The larger economies of scale, the smaller the share of HIIT whilst the direction of the share of VIIT is indeterminate. Scale economies represent an important determinant of IIT (Byun and Lee, 2005; Thorpe and Zhang, 2005; Veeramani, 2007; Faustino and Leitão, 2007). In the case of horizontal IIT, the existence of EoS provides a motivation for multinational firms to spread fixed costs of knowledge capital across multiple plants and thereby reduce average costs as output expands. However, the influence of the number of firms has implications for economies scale (Aturupane, *et. al*., 1999) thus the predicted sign of scale economies depends largely on the market structure of the industry. In this study, as a result of data availability for the panel of countries under study, a new measure is used to examine the impact of EoS on bilateral IIT in the automobile industry. Here, the bilateral average of vehicle production (units) between trading partners *i* and *j* is computed as a proxy for economies of scale. Thus, a negative relationship is hypothesised between economies of scale and the share of horizontal IIT, whereas there is no *a priori* for vertical IIT.

4.2.1 (h) Product Differentiation

Hypothesis (h): The greater the degree of product differentiation, the larger the share of vertical IIT and the lower the share of horizontal IIT. According to theoretical and empirical studies of IIT, product differentiation is an important determinant of intra-industry trade (Byun and Lee, 2005; Faustino and Leitão, 2007; Chang, 2009). Several studies differentiate between vertical product differentiation and horizontal product differentiation (Bernhoffen and Hafeez, 2001; Faustino and Leitãlo, 2007). Balassa and Bawens (1987) and Hu and Ma (1990) use the Hufbauer (1970) index as a proxy for the degree of PD and have been modified by Fontágne, *et. al.*, (1997) as follows:

$$PD_{ij,kt} = \sum_{i\in j}\left[\frac{XV_{it}}{\sum_{i\in j} XV_{it}} \times \frac{\max(UV_{ij,kt}^{X}, UV_{i..t}^{X})}{\min(UV_{ij,kt}^{X}, UV_{i..t}^{X})}\right] \tag{3}$$

where $PD_{ij,kt}$=degree of product differentiation, XV_i=export value of host country, UV^x=unit value of exports and $UV_{i.t}$=average unit value of XV_i to all trading partners.

The computed degree of PD measure is equal to or greater than 1, where values close to 1 indicate low degrees of product differentiation and values further away from 1 is conversant with higher degrees ofproduct differentiation (vertical). According to Fontágne, *et. al*., (1997), the index provides an average unit value dispersion of export unit values for a given product *k* aggregated over the sum of all products within a given industry and is a measure of vertical differentiation of a product. Now, after observing that the PD variable appears to be non-linear in profile, a quadratic transformation of the PD variable is included as an explanatory variable in the regression models to capture the non-linear the effect of the explanatory variable. Therefore, a positive (negative) relationship is expected over some unspecified range for vertical IIT (horizontal IIT) while the opposite relationship is expected beyond that scope. As similar transformation of the PD variable is done in Veeramani (2007) although advertising expenditure as percentage of sales is used as proxy for the degree of product differentiation in his study.

4.2.1 (i) Trade imbalance

Hypothesis (i): The smaller the trade imbalance, the larger all IIT patterns. As in Byun and Lee (2005), Thorpe and Zhang (2005) and Clark (2005), this study includes a trade imbalance (TIMB) control variable equal to net trade as a proportion of total trade as shown in Equation (4) below. Now, if there is balanced trade, then TIMB=0, otherwise TIMB=1.

$$TIMB_{ij,kt} = \frac{\left| X_{j,kt} \quad M_{j,kt} \right|}{(X_{j,kt} + M_{j,kt})} \tag{4}$$

This control variable has typically been used in a regression model of IIT the Grubel and Lloyd index (1975) as a dependent variable. This control variable has not yet been used in a regression model with the trade overlap index as dependent variable. The expected sign is negative implying that the IIT(z) index is biased in the presence of trade imbalances and that the estimation results should be interpreted bearing this in mind.

4.3. Gravity model specification

The hypotheses of this study as stated above will be tested using the specified panel data regression model:

$$y(z)_{ijt} = \alpha_n + \beta X_{it} + \delta_t + \varepsilon_{ijt} \qquad (5)$$

where: y_{ijt} = IIT index between the home country *i* and its trading partner *j* for period *t*, and *z* varies over, vertical IIT, horizontal IIT and aggregate IIT. X_{nit} is a vector of explanatory variables including country-specific and industry-specific variables with variation in dimensions *n* and *t*; where α_n = country effect, *n*=1…N, δ_t =time effect, *t*=1…T and ε_t = white noise disturbance term that is independent and randomly distributed with E (ε_{it})=0; Var $(\varepsilon_{it}) = \sigma^2 \succ 0$. The specific effects ($\delta_t$ and α_n) can be treated as fixed parameters or random parameters, namely fixed effects (FE) model and random effects (RE) model.

The gravity model to be estimated can be specified as:

$$\begin{aligned} \ln IIT(z)_{ijt} &= \alpha_0 + \alpha_1 \ln RDGDP_{ijt} + \alpha_2 \ln WDIST_{ijt} + \alpha_3 \ln FDI_{ijt} + \alpha_4 \ln TO_{ijt} + \alpha_5 \ln TAR_{ijt} + \alpha_6 \ln AA_{ijt} \\ &+ \alpha_7 \ln PD_{ijt} + \alpha_8 \ln PD^2{}_{ijt} + \alpha_9 \ln EoS_{ijt} + \ln \alpha_{10} TIMB + \varepsilon_{ijt} \end{aligned} \qquad (6)$$

The expected signs for the vertical IIT regression equation are:

$\alpha_1 > 0, \alpha_2 < 0, 0 < \alpha_3 < 0, \alpha_4 > 0, \alpha_5 < 0, 0 < \alpha_6 < 0, \alpha_7 > 0, 0 < \alpha_8 < 0, 0 < \alpha_9 < 0, \alpha_{10} < 0$

The expected signs for the horizontal IIT regression equation are:

$\alpha_1 < 0, \alpha_2 < 0, 0 < \alpha_3 < 0, \alpha_4 > 0, \alpha_5 < 0, 0 < \alpha_6 < 0, \alpha_7 < 0, \alpha_8 > 0, 0 < \alpha_9 < 0, \alpha_{10} < 0$

Lastly, the expected signs for aggregate IIT will depend on the strength of the impacts of vertical IIT and horizontal IIT.

Table 2. Definitions and proxies of explanatory variables and expected signs

Explanatory variable	*Variable*	*Proxy*	*IIT*	*HIIT*	*VIIT*
Relative difference in economic size	RDGDP	Factor endowment and technology differences between *i* and *j*	+/-	-	+
Geographic distance	WDIST	Weighted distance between capital cities of *i* and *j*	-	-	-
Tariffs	TAR	Average MFN automotive tariff rates of *i* and *j*	-	-	-
Automotive assistance	AA	Difference in average number of paid industry workers between *i* and *j*	+/-	+/-	+/-
Foreign direct investment	FDI	Inward FDI as a% of gross fixed capital formation (GFCF)	+/-	+/-	+/-
Economies of scale	EoS	Average of total vehicle production (units) between *i* and *j*	+/-	+/-	+/-
Product differentiation	PD	Revised Hufbauer index as a measure of degree of product differentiation	+/-	-	+
	PD^2	Quadratic of PD	+/-	+	-
Trade orientation	TO	Degree of trade openness	+	+	+
Trade imbalance	TIMB	Control variable	-	-	-

All variables are transformed into logarithmic form. Panel unit root tests of the variables were not conducted in this study as the time period (T) of the panel is less than 10 years (T=8<10) since the minimum panel length requirement for panel unit root tests are 10 years. Now, a key advantage of panel data estimation is that it allows for controlling unobservable effects, which otherwise could lead to omitted variable bias. This study estimates pooled OLS model, fixed effects (FE) model and random effects (RE) model. The pooled OLS model is the most restrictive and implies no heterogeneity between countries. The FE model allows for separate intercepts in the sample and assumes constant unknown parameters to be estimated. The choice between pooled OLS and FE models is determined by the F-test (Baltagi, 2005; see Appendix A) On the other hand, the RE model assumes that the intercepts are random and use generalised least squares (GLS) which is based on orthogonality assumption that the unobserved effects are uncorrelated with the explanatory variables. Generally, the choice of model between FE model and RE model is can be determined by the Hausman Test (Verbeek, 2004; see Appendix A) that compares a more efficient model against a less efficient model but ensures that the most efficient model is also consistent. The Hausman Chi-square test statistic of the null hypothesis is that the estimated coefficients using RE model are the same as those of the FE model. However, according to Baltagi (2005), RE models are inappropriate specifications if the number of cross-sections (N) is small as is the case in this of study (N=13).

4.4. Data

Harmonised system (HS) 6-digit product level data was used to compute bilateral intra-industry trade shares of IIT, VIIT and HIIT spanning the period 2000-2007. Trade data is taken from the Quantec database and is reported in US dollars. A sample of 13 selected countries is used in this study accounting for around 76 per cent of South Africa's total automotive trade. In this study, some difficulties were encountered in finding appropriate and consistent *industry data* because such data especially for South Africa and several of its trading partners are not reported in mainstream databases such as OECD STAN, etc. and are therefore not easily obtainable. Country variables such as GDP, GNI per capita and population were obtained from the World Bank's World Development Indicators database. Foreign direct investment data was obtained from FDI Stat online (UNCTAD). Historical MFN applied tariff data HS 6-digit level (average) was obtained from the World Trade Organisation (WTO) International Trade and Tariff data website. The International Organisation of Motor Vehicle Manufacturers (OICA) website provides annual data on motor vehicle production for each country. Industry employment data was taken mainly from LABOSTA. However, missing industry employment data for China and India were obtained from Chinaonline.com and Indiastatonline.com. In the case of South Africa, missing industry employment data was obtained from the Quantec database. Bilateral distance data was obtained from Mayer and Zignago (2006) (see CEPII website). Data sources of variables used in the econometric investigation are summarised in Table A2 of Appendix.

5. Estimation results and discussion

This study estimates the statistical significance of the determinants of bilateral VIIT, HIIT and aggregate IIT using the following specified models: OLS pooled model, fixed effects (FE) model and random effects (RE) model. Thus the study estimates a gravity model according to Equation (6) with the estimation results for pooled OLS, FE and RE models for IIT reported in Table 3. It is important to emphasize that the countries under the study were pre-determined and not randomly chosen; but were selected based on their trading partner status and aggregate bilateral intra-industry trade levels with South Africa. Therefore, it is not surprising that the estimation results for the random effects (RE) model appear to be inefficient and biased. Nevertheless, estimation results of the RE model for VIIT, HIIT and aggregate IIT are reported in Table A4 of the Appendix. Accordingly, in all three RE regression models, the explanatory powers are poor with Adjusted R^2=0.23,-0.01 and 0.22, respectively for VIIT, HIIT and aggregate IIT. In addition, most of the coefficients are statistically insignificant and have the unexpected wrong signs. Furthermore, according to the Hausman test (Verbeek, 2004), the inappropriateness of RE model compared to the FE model is verified as indicated in Table 3 below.

Under FE model and RE model, it is assumed that the disturbances are homoskedastic yielding constant variances. A violation of this assumption implies that the estimates of the regression coefficients are consistent but not efficient. To overcome potential problems associated with heteroscedasticity, White's cross-section robust variance-covariance matrix is used to produce the corrected standard errors and t-statistics as reported in Table 3 and Table A3 and A4 of the Appendix.

Table 3. Estimation results of bilateral shares VIIT, HIIT and IIT for a panel of 13 countries

Explanatory variables	*Dependent variables*					
	Pooled model			*Fixed effects model*		
	VIIT	HIIT	IIT	VIIT	HIIT	IIT
Constant	0.5407 (0.2327)	-22.9731 (-3.3445)***	-3.3368 (-1.8086)*	13.0365 (1.9690)**	33.4351 (2.3123)**	13.0331 (1.4632)
$RDGDP_{ijt}$	3.1404 (4.7791)***	5.3574 (4.1916)***	2.7238 (4.6992)***	1.4639 (1.7799)*	-5.3706 (-2.6561)***	0.7806 (1.2353)
FDI_{ijt}	0.0510 (0.6400)	1.2359 (7.3280)***	0.1702 (2.6217)***	-0.2898 (-3.3251)***	-1.1952 (-3.4633)***	-0.3261 (-2.3568)**
TO_{ijt}	-0.6363 (-4.0201)***	-1.4375 (-5.1168)***	-0.6237 (-3.8013)***	1.1658 (1.9815)**	0.2464 (0.1752)	0.7946 (0.9386)
EoS_{ijt}	0.1188 (0.8479)	1.9480 (3.9381)***	0.3562 (3.0437)***	-0.7187 (-1.9142)**	-4.4124 (-3.1476)***	-1.0199 (-1.8312)*
$TIMB_{ijt}$	-0.2459 (-8.0773)***	-0.2108 (-1.4221)	-0.2285 (-6.0488)***	-0.1043 (-3.4565)***	-0.2387 (-1.555)	-0.1063 (-2.2956)**
PD_{ijt}	0.4278 (3.9250)***	-1.2717 (-2.7823)***	0.3402 (2.7211)***	0.2083 (1.6793)*	-1.1807 (-3.6320)***	0.1237 (0.9872)
$PD^2{}_{ijt}$	-0.1078 (-5.6776)***	0.4154 (3.6964)***	-0.0896 (-2.5881)***	-0.0759 (-2.7802)***	0.3198 (3.9375)***	-0.0603 (-2.0711)**
TAR_{ijt}	-0.1137 (-0.6444)	-0.0126 (-0.0318)	0.0127 (0.0632)	-1.3506 (-1.5337)	-10.2823 (-8.6524)***	-2.7638 (-2.5452)***
AA_{ijt}	0.0516 (0.9137)	-0.0625 (-0.2804)	-0.0142 (-0.4039)	-0.4588 (-3.0660)***	-0.1389 (-0.4161)	-0.2995 (-2.5452)***
$WDIST_{ij}$	-0.7228 (-4.8681)***	-2.1891 (-6.7366)***	-0.6312 (-3.636)***	-1.0340 (-4.4361)***	0.8182 (0.5600)	-0.8417 (-3.1015)***
Adjusted R^2 F-test Hausman test	0.47	0.50	0.50	0.78 4.24*** [#]86.63***	0.74 11.19*** 27.69***	0.73 4.82*** 58.73***

Notes: White cross-section t-values are given in parenthesis.

Asterisks indicate (1%)***, (5%)** and (10%)* levels of statistical significance.

[#] A negative Hausman test statistic is reported for vertical IIT. A negative Hausman statistic is not an unusual outcome in small samples and is caused by estimated parameter variance differences that are non-positive semi-definite and cannot be interpreted because the Chi-square distribution is non-negative (STATA Corp, Ooms and Perlings, 2005). Following Schreiber (2009), this study uses the absolute value of the Hausman test statistic.

Of the three specifications employed in this study, the pooled OLS model is the most restrictive and implies the inexistence of heterogeneity between cross-sections, namely; individual countries within the panel. This means that all countries tend to respond to changes in the explanatory variables in a similar fashion. In the FE model, heterogeneity across cross-sections is assumed by acknowledging different intercepts for every country in the panel. FE can have two dimensions, cross-section effects and time effects. In the latter, time dummies are used to assess if whether certain determinants that are homogenous across countries may change over time such as technology, political and law institutions, etc. that are not overtly accommodated in the econometric specification.

There were some missing observations in the data set. In most cases, missing data of explanatory variables were replaced with growth rates based on previous years. Under the FE model, all three regression models for bilateral shares of VIIT, HIIT and IIT appear to be well explained, since the Adjusted R^2 is equal to 0.78, 0.74 and 0.73, respectively. According to the F-test (Baltagi, 2005), the null of no country effects (or poolability) is rejected for all three models since the critical $F_{12,90}$ (=1.83)<F_{stat} (=4.11, 6.19 and 4.26) for vertical IIT, horizontal IIT and aggregate IIT. Next, according to the Hausman test statistics for all three models, where the Chi-square $(10)_{stat}$ = 86.63, 27.69 and 58.73 > Chi-square $(10)_{crit}$=23.21 for vertical IIT, horizontal IIT and aggregate IIT, respectively confirm the inappropriateness of the RE model over the FE model. Thus, the FE model is preferred over the RE model and the pooled OLS and is discussed at this juncture. The selection of the FE model for this study is supported by Egger (2000) that argues in favour of choosing FE models when estimating trade flows between predetermined selections of countries.

The empirical results are in line with theoretical models for explaining VIIT and HIIT. As expected, the *relative difference in economic size* (*RDGDP*) is positive and statistically significant for vertical IIT and negative and statistically significant for horizontal IIT *a priori*. This result implies that as countries differ in relative market size and potentially differ in relative factor endowments, the larger the share of vertical IIT as the potential gains from trade in quality products are greater. On the other hand, the potential gains from trading variety products are reduced when relative difference in economic size is large. This result partly partially confirms the Hecksher-Ohlin (H-O) theory for vertical IIT including the explanation of fragmentation theory of international production in the case of vertical IIT in intermediate products (Feenstra and Hanson, 1997). Similarly, the econometric results of HIIT regression conform to Helpman and Krugman (1985) model of HIIT whereby countries of similar sizes and factor endowments and technologies trade products that are differentiated by variety. In addition, the significant effects of tariffs and market-seeking FDI associated with multinational activities on horizontal IIT conforms to the theoretical expectations of the Markusen and Venables (2000) model.

The results reveal that *foreign direct investment* (FDI) is negative and statistically significant at the 1 per cent level for all intra-industry trade patterns. This implies that FDI influence VIIT and HIIT in the same way, namely market-seeking FDI where MNCs enjoy benefits associated with growing emerging markets, location advantages and substantial trade barriers. Similar findings of such FDI motives as a determinant of horizontal IIT and vertical IIT have been reported by Byun and Lee (2005), Zhang, *et. al*., (2005), Veeramani (2007) and Chang (2009). Moreover, the results of this study suggest that intensive FDI activities by MNCs in the automobile industry are a substitute for trade thereby reducing vertical IIT and horizontal IIT and as a result may potentially lead to agglomeration effects in the automobile industry. This is not surprising as high trade barriers provide incentives for multinational firms to engage in market-seeking FDI activities (Veeramani, 2007).

The sign on the *trade orientation* (TO) coefficient has the correct positive sign as expected for all trade types but is statistically significant at the 1 per cent level for VIIT and not significantly different from zero for HIIT and VIIT. Thus, the degree of trade openness is important for VIIT but not for HIIT and aggregate IIT. The empirical findings also show that *weighted geographical distance* (WDIST)[10] deters VIIT and IIT, whereas HIIT is not affected. The sign on the coefficient on WDIST is negative and highly statistically significant at the 1 per cent level for vertical IIT, horizontal IIT and aggregate IIT. In addition, the impact of the distance variable on vertical IIT has implications for international production and fragmentation theory (Jones and Kierzkowski, 1999, 2001) in which service links costs are essential for enhancing vertical trade (Kimaru, *et. al*., 2007). If this is the case, the result entails the need for further economic development and greater investments and advancements in infrastructural projects relating to information and communications technologies (ICT), transport (rail, road and freight) technologies in an attempt to effectively lessen the barriers of trade for vertical trade and thereby reduce distance between countries and regions.

There is evidence that *tariffs* (TAR) impact negatively on intra-industry trade, although the impact is highly statistically significant at the 1 per cent level and 5 per cent level for HIIT and aggregate IIT. There is no significant impact on VIIT. The implication for automotive policy is to reconsider reducing automotive tariff rates further in attempt to potentially improve HIIT. Interestingly, this is in contrast to the new tariff programme expected to be implemented under the future ADPD commencing 2013 when the MIDP expires in 2012 and is likely to reduce intra-industry trade in differentiated product varieties and thereby reduce consumer welfare.

The coefficient of the *automotive assistance* (AA) variable is negative and significant at the 1 per cent level of significance for VIIT and IIT, and negative but insignificant for HIIT. Thus, lower automotive

[10] This study also experimented with the time invariant distance (DIST) variable in the estimation. In the second stage regression model, individual effects are regressed on the distance variable (DIST) as well as regional dummies (NAFTA and EU). The results indicate that the coefficient on the distance (DIST) variable had the right sign but imposed no significant impact on intra-industry trade patterns. Additionally, NAFTA had a positive and significant sign whilst EU had a negative and insignificant sign on IIT patterns. In the end, the WDIST variable was chosen over the time-invariant DIST variable.

assistance is expected to positively influence VIIT. This result implies the existence of potential labour adjustment costs in the short run but as the industry becomes more efficient trade (and possibly improved welfare) trade opportunities are likely to be created. This finding is accordance with the WTO Agreement on Subsidies and Countervailing Measures (SCM) to be phased out. Also, the study experimented with interactions between tariffs and automotive assistance (TAR*AA) and revealed a positive and statistically significant impact on VIIT, HIIT and IIT at the 1 per cent level. This interaction changes the significance of few of the independent variables and slightly reduces the overall fit of the model (3-5 per cent). Nevertheless, this finding suggests that protection and assistance to the automobile industry increase intra-industry levels. Similar findings have been reported by Al-Mawali (2005) and Kind and Hathcote (2006) as already pointed out.

Next, the statistically significant sign for the *economies of scale (EoS)* variable is consistently negative for all intra-industry trade types implying that VIIT and HIIT are not influenced differently by EoS. This finding is as expected *a priori* for horizontal IIT consistent with the argument of small number of firms and the existence of large EoS in the automobile industry for products differentiated by variety. Similar findings have been reported in Veeramani (2007) and Montout, *et. al*., (2002) in their investigations of the influence of EoS on horizontal IIT in India's manufacturing industry and NAFTA's automobile industry, respectively. The result for vertical IIT implies that EoS negatively influences it and is aligned with the view of Clarke and Stanley (1999) and Thorpe and Zhang (2005) that explain the behaviour of EoS in the context of fragmentation (outsourcing) and international production theory. In addition, the result on the EoS coefficient for vertical IIT is in agreement with claim that a large number of firms operate in competitive markets according to H-O hypothesis based on comparative advantage and the non requirement of economies of scale. Thus, reducing the number of firms (increasing plant size) and increasing production volumes and lowering unit costs thereby achieving greater EoS that could subsequently positively influence vertical IIT in the automobile industry.

The *product differentiation (PD)* variable was found to be positive and statistically significant for VIIT and negative and statistically significant for HIIT as expected *a priori*. Thus, greater differentiation of quality products in the automobile industry stimulates VIIT, whilst non-standardisation of product variety stimulates HIIT. These results are in line with findings by Byun and Lee (2005) for HIIT and VIIT as well as evidence provided by Clarke (2005) and Veeramani (2006) for IIT (horizontal). The PD^2 variable has the opposing signs compared to the PD coefficient as expected and is statistically significant at the 1 per cent level for both vertical IIT and horizontal IIT. In the absence of the PD^2 variable, the coefficient on PD has the unexpected wrong (correct) sign for VIIT (HIIT) but is not significantly different from zero for both VIIT and HIIT with the exception of aggregate IIT. Thus, these results imply that the inclusion of the PD^2 variable is justified in the econometric models.

Finally, the *trade imbalance* (TIMB) control variable is negative and statistically significant at 1 per cent as expected for all types of IIT conforms to the idea that the trade imbalance bias associated with the computed shares (indices) of VIIT, HIIT and aggregate IIT as dependent variables ought to be controlled especially given the existing large automotive trade deficit balance (Damoense and Jordaan, 2007).

According to the FE model, country-specific effects imply the existence of unobservable features unique to each country that may hamper or strengthen bilateral intra-industry trade between South Africa trading partners. These results of the country specific coefficients are reported in Table A3 of the Appendix. A negative sign indicate that there exist specific factors relevant to Australia, France, Sweden, Spain, Italy, Turkey and India that have not been considered as explanatory variables in the gravity model in Equation 6 that serves to reduce bilateral vertical IIT with South Africa. On the other hand, for the rest of the countries that possess positive signs indicate that some vertical IIT can be explained by other explanatory variables that positively influence vertical IIT as indicated by these country fixed effects coefficients. For horizontal IIT and aligned with the same argument as before; Japan, Australia, Sweden, Turkey and Italy have negative signs revealing the importance of country- and industry-specific factors not considered here that potentially reduce bilateral horizontal IIT with South Africa and *vice versa*. Thus, the econometric results confirm that Sweden (-4.037), Turkey (-3.290) Australia (-2.219) and to a lesser extent Italy (-1.257) and Spain (-0.9904) are "outliers in vertical IIT" (Damoense and Jordaan, 2009) as specified by the significant values of the country-specific coefficients reported in Table A3 of the Appendix. Additionally, although not reported here, the inclusion of time dummies in the FE model showed no statistically significant impact on vertical IIT and horizontal IIT indicating that the determinants of each IIT pattern do not appear to vary over time.

6. Concluding remarks

The purpose of this study is to investigate country- and industry-determinants of the different patterns of intra-industry trade in South Africa's automobile industry. The study use South Africa's bilateral trade with 13 countries for the automobile industry during the period 2000-2007 to test the hypotheses.

In sum, FDI and economies of scale affect HIIT and VIIT in the same way. As expected, VIIT between South Africa and bilateral trading partners can partially be explained by traditional H-O trade theory whereby countries of differing economic sizes tend to trade products that are differentiated by quality. Interestingly, the proposal that South Africa has comparative advantages in producing and exporting high-quality vertical differentiated products (Damoense and Jordaan, 2009) is in contrast to theoretical predictions by Falvey and Kierzkowski (1997) and can in some ways be explained by vertical fragmented production chains occurring within the same product category (Ando, 2006). This phenomenon is supported by government assistance (export and investment subsidies) and trade barriers incumbent in automotive policy that attract MNCs and first-tier component firms into the domestic industry for reasons already mentioned. By contrast, HIIT is largely supported by theoretical models of horizontal IIT (Helpman and Krugman, 1985; Markusen and Venables, 2000) in which similar countries trade in products differentiated by variety and tariffs and FDI are important factors influencing two-way trade in products differentiated by varieties.

Further, the presence of MNCs displaces trade by reducing factor price differences between countries thereby encouraging agglomeration activities in the domestic industry. Although, difference in per capita income is not used in the final model, difference in relative market size conform partly to theoretical expectations that similar countries engage in trading different variety products (horizontal IIT) whereas countries with relative differences exchange and trade different quality products (vertical IIT)[11]. Apart from EoS and FDI, distance, trade openness and automotive assistance are also important in explaining VIIT.

The implications of the findings of this study for future automotive policy in South Africa argue for further trade liberalisation and deregulation of the local industry. Trade barriers (tariffs, NTBs and automotive assistance) as part of automotive policy should be reduced and geared towards more unbiased competitive practices that can contribute to increased manufacturing output and stimulate trade. Perhaps, some consolidation in the domestic industry is necessary and can contribute to the achievement of economies of scale in production and profitability in the long run that can outweigh short term adjustment costs (eg. labour). The study is of the opinion that greater investments should be directed to ICT and physical infrastructure (roads, rail, shipping and freight) to improve trade costs associated with distance and service links connections necessary for vertical IIT and fragmentation and international production. Taking into consideration these recommendations for trade and industrial automotive policy motives to attract efficiency-seeking FDI that is complementary to trade could be encouraged.

It is accepted in the empirical literature that the gravity methodology does not allow for the evaluation of welfare implications of intra-industry trade which is an obvious caveat of this study. At best, the findings of the study argue that trade barriers negatively influence intra-industry trade and indirectly infer efficiency concerns and welfare implications in the automobile industry. Further research is necessary to investigate welfare and efficiency concerns using different methodologies such as computable general equilibrium (CGE) modelling as the gravity model is not necessarily appropriate for such an investigation.

7. References

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[11] As already discussed, the relationship between difference in GDP per capita and intra-industry trade patterns are ambiguous (See Damoense and Jordaan, 2009).

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8. Appendix

Table A1. Summary of classification of trade patterns

Trade Pattern	*Formula of index/ degree of trade overlap*	*Description*
Two-way trade or intra-industry trade (IIT)	$GL_{ij,kt} = \frac{(X_{ij,kt}+M_{ij,kt})-\lvert X_{ij,kt}-M_{ij,kt}\rvert}{(X_{ij,kt}+M_{ij,kt})}$	Index lies between 0 and 1 = share of intra-industry trade in total trade
One-way trade (OWT) or inter-industry trade	$FF_{ij,kt} = \frac{Min(X_{ij,kt}, M_{ij,kt})}{Max(X_{ij,kt}, M_{ij,kt})} \leq 10\%$	No significant overlap ≤10 per cent reflects OWT.
Horizontal intra-industry trade (HIIT)	$1-\alpha \leq \frac{UV^{X}_{ij,kt}}{UV^{M}_{ij,kt}} \leq 1+\alpha$	Overlap/IIT with small unit value differential where α=0.25
Vertical intra-industry trade (VIIT)	$\frac{UV^{X}_{ij,kt}}{UV^{M}_{ij,kt}} < 1-\alpha$ or $\frac{UV^{X}_{ij,kt}}{UV^{M}_{ij,kt}} > 1+\alpha$	Overlap/IIT with large value unit value differentials where α=0.25

Source: Author's compilation

Table A2. List of variables used in the econometric analysis

Variable	*Description*	*Data source*
Trade data	HS 6-digit product level data for automotive and related codes	Quantec database
AGDP	GDP used to calculate bilateral average of GDP between *i* and *j*	WDI
RDGDP	Index (Balass and Bauwens, 1988)	
DGDPC	Difference in GDP per capita between *i* and *j*	WDI
ELECONS	Difference in electric power consumption per capita between *i* and *j*	WDI
WDIST	Great circle distance between country *i* and *j*, where the weight is the ratio of GDP of country *j* to the sum of total GDPs of all its trading partners	Mayer and Zignago (2006)
DIST	Great circle distance between capital cities of trading partners *i* and *j*.	Mayer and Zignago (2006)
REG	Dummy variable equal to1 if countries *i* and *j* have trading arrangements, else 0 (European Union, NAFTA, Asia).	DUM
TAR	Average MFN applied tariff rates HS 6 digit level (average of H87...) between *i* and *j*	WTO
AA	Automotive assistance is proxied by the difference in the number of paid employment in industry[a] between *i* and *j*	LABOSTA
FDI	Inward FDI stocks[b] (million US$) as a percentage of Gross Fixed Capital Formation (GFCF)	UNCTAD, FDI Stat
EoS	Average of total vehicle production (units) between *i* and *j*	OICA
PD	Product differentiation (PD) as proxied by revised Hufbauer index.	Fontagné, et. al. (1997)
TO	Trade orientation is computed as the residuals from a regression of per capita trade on per capita income and population	Stone and Lee (1995)
TIMB	Control variable defined as net trade as a proportion of total trade	Quantec database

Notes: [a]Values for China and India are obtained from www.chinaonline.com and www.indiastat.online, respectively.
[b]FDI stocks is the value of the share of their capital and reserves (including retained profits) attributable to the parent enterprise, plus the net indebtedness of affiliates to the parent enterprise.

Table A3. Fixed country-effects for bilateral VIIT, HIIT and IIT for 13 countries

Country	*Dependent variables*		
	VIIT	HIIT	IIT
Japan	3.0401	-3.567*	1.8785
Australia	-2.2192*	-9.4539*	-2.9446*
United States	4.3639	5.1884	3.9099
United Kingdom	0.3454	0.3137	0.3510
Germany	1.7256	4.5265	1.6771
France	-0.0770*	2.2771	0.1687
Spain	-0.9904*	1.2936	-0.7220*
Sweden	-4.0377*	-9.3560*	-4.4101*
Turkey	-3.2902*	-7.3021*	-3.5338*
Brazil	1.3863	8.1699	2.2129
China	1.2411	6.2161	1.8770
India	-0.2300*	4.6538	1.0061
Italy	-1.2578*	-2.9598*	-1.3872*

*Asterisks indicate negative country effects

Table A4. Estimation results of bilateral shares of IIT, VIIT and HIIT for a panel of 13 countries

Explanatory variables	*Dependent variables*		
	Random effects model		
	VIIT	HIIT	IIT
Constant	-0.7176 (-0.1149)	-8.6581 (-0.7290)	-2.6788 (-0.4286)
$RDGDP_{ijt}$	3.1996 (2.3640)**	2.8845 (1.7266)*	2.9833 (2.2427)**
FDI_{ijt}	-0.0703 (-0.5792)	0.2568 (0.6266)	-0.0084 (-0.0957)
TO_{ijt}	-0.4162 (-1.3878)	-0.5929 (-0.6463)	-0.4933 (-1.6350)
EoS_{ijt}	0.2320 (0.4872)	0.5249 (0.4973)	0.3574 (0.7433)
$TIMB_{ijt}$	-0.1782 (-3.4245)***	-0.2194 (-1.2909)	-0.1733 (-2.584)***
PD_{ijt}	0.4354 (2.3911)***	-0.6972 (-1.5344)	0.3725 (1.5224)
$PD^2{}_{ijt}$	-0.1161 (-3.3800)***	0.2508 (2.1768)**	-0.0957 (-1.8120)*
TAR_{ijt}	-0.2005 (-0.6098)	-1.1727 (-1.5619)	-0.2043 (-0.6112)
AA_{ijt}	-0.0784 (-0.7903)	-0.1393 (-0.5261)	-0.0907 (-1.0036)
$WDIST_{ij}$	-0.7047 (-2.1405)**	-1.0955 (-1.5035)	-0.6904 (-2.0320)**
Adjusted R^2	0.23	-0.01	0.22

Notes: White cross-section t-values are given in parenthesis.

Asterisks indicate (1%)***, (5%)** and (10%)* levels of statistical significance

Random country effects not reported.

A. Econometric tests used in the regression analysis

1. *F-test for Fixed Effects* (Baltagi, 2005)

$H_0: \mu_1 = \mu_2 = \mu_{N-1} = 0$ (No individual effects; same intercept for across all cross-sections)

$H_A: =$ Not all equal to 0

$$F = \frac{(RRSS - URSS)/(N-1)}{URSS/(NT-N-K)} \sim F_{(N-1),(NT-N-K)}$$

If the computed F-test statistic is greater than the F distribution with (N-1) and (NT-N-K) degrees of freedom for the numerator and denominator, respectively, the null hypothesis is rejected. Thus, the FE model is appropriate as countries are heterogeneous.

2. *Hausmen Test (Verbeek, 2004)*

H_0: Explanatory variables are uncorrelated with individual effects

H_A: Explanatory variables are correlated with individual effects

$$H = (\hat{\beta}_{FE} - \hat{\beta}_{RE})'[\hat{V}\{\hat{\beta}_{FE}\} - \hat{V}\{\hat{\beta}_{RE}\}]^{-1}(\hat{\beta}_{FE}\hat{\beta}_{RE})$$

Where $\widehat{\beta}_{FE,}\widehat{\beta}_{RE}$ are the estimated coefficients from the FE and RE estimators and the $\widehat{V}s$ represent the covariance matrices of FE and RE, respectively. Now, if the computed Hausman test statistic is larger than the Chi-squared distribution with k degrees of freedom (explanatory variables), the null is rejected indicating that the RE estimates are not consistent and that the FE model is the appropriate model.