DETERMINANTS OF SOUTH AFRICA-US INTRA-INDUSTRY TRADE IN SERVICES: A WILD BOOTSTRAP DYNAMIC PANEL DATA ANALYSIS[1]

MOSES MUSE SICHEI, CHRIS HARMSE AND FRANS KANFER

Abstract
The study attempts to empirically identify factors that determine South Africa-US intra-industry trade (IIT) in selected services during the period 1994-2002. The study utilises Liu-Davidson-Flachaire wild bootstrap, which is robust to heteroscedasticity and provides estimates of the degree of parameter bias. The empirical results, in principle, show that South Africa-US IIT in the selected services is determined by factors similar to goods-based "North-South" IIT studies. Specifically, differences in *per capita* income and differences in market size negatively affect IIT. The study also indicates that US foreign direct investment in South Africa positively contributes to the unaffiliated IIT in services.
Keywords: Intra-industry trade, dynamic panel data, wild bootstrap

1. INTRODUCTION

The steady growth of the services sector's contribution to Gross Domestic Product (GDP) and employment is a characteristic feature of most modern economies. The increase in the contribution of services is attributed to a revolution in information communication technology (ICT) and liberalisation the in context of the General Agreement on Trade in Services (GATS). In South Africa, its contribution to GDP rose from 50% in 1990 to 58% in 2002 while its share in employment increased from 56% in 1990 to 65% by 2002 (UNCTAD, 2004a).

What is international trade in services? Lee and Lloyd (2002:160) define international trade in services in two ways. Firstly, services are economic flows that take place between residents and non-residents of an economy. This is attributed to the International Monetary Fund's edition 5 of the Balance of Payments manual, hereafter referred to as "BMP5" (International Monetary Fund, 1993). Secondly, Article 1 of GATS (in World Trade Organisation, 2002:286-287) defines trade in service using four modes of supply: cross-border supply (mode 1), consumption abroad (mode 2), commercial presence (mode 3) and presence of natural persons (mode 4). Lee and Lloyd (2002:161) argue that most trade economists currently think in terms of GATS modes of supply. However, no

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statistics of services trade by GATS modes are available in most countries (including South Africa) since BMP5 is still the basis of data collection.[2]

Despite its dominance in national output and job creation, services account for less than a quarter of total trade in South Africa and the US (the leading producer and exporter of services in the world) due to its limited tradability and unreliable data. Nonetheless, there are reasons to expect its increased dominance in international trade in future. Firstly, ICT coupled with increasing prevalence of electronic commerce, continue to enhance the tradability (storability and transportability) of services. Secondly, more services sectors are being liberalised through multilateral trade negotiations under the GATS framework, widening the scope for trade. Indeed, according to UNCTAD (2004b), foreign direct investment (FDI) is increasingly shifting towards services.

The enhanced internationalisation of services has two opposite economic welfare implications for South Africa. On one hand, the increase generates standard comparative advantage gains (specialisation and exchange) and non-comparative advantage gains (pro-competitive, exploitation of economies of scale, increased variety and lower factor market adjustment costs of trade). Additionally, liberalisation of trade in services could be consistent and complementary to sustainable development in the context of the Doha Development Agenda. On the other hand, the increased tradability may lead to higher factor market adjustment costs along the lines of Stolper-Samuelson or the vertical differentiation model of Flam and Helpman (1987).

However, to understand the benefits and costs of South Africa's trade in services with the US (South Africa's leading exports destination of services in the Organisation for Economic Co-operation and Development (OECD) countries) calls for a need to disentangle "intra-industry trade" (IIT) from "inter-industry trade" because they have different causes and consequences. Inter-industry trade in services entails exports of one type of service in exchange for another *(i.e.* from different service industries). Using a definition attributed to Grubel and Lloyd (1975:20), IIT in services is a simultaneous exports and imports of services that belong to the same industry.

The study focuses on the determinants of South Africa—US unaffiliated IIT in selected services during the period 1994-2002. The choice of the US among many of South Africa's trading partners is motivated by the fact that it is the latter's leading exports destination in the OECD countries, availability of bilateral international trade data (US Bureau of Economic Analysis), and the need to complement other research (such as Hodge and Nordas, 2001; Walley and Keith, 2003) in informing trade policy in the services sector such as the SACU[3]-US Free Trade Agreement negotiations.

The novelty of this paper is in attempting to find the empirical determinants of South Africa-US unaffiliated[4] IIT in selected services during the period 1994-2002 utilising wild bootstrapping in the context of panel data. The paper is in the spirit of other research focusing on "North-South" trade in services (Sapir, 1985; Clark and Stanley, 1999; Kunin and Zigic, 2003).

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[2] While this framework categorise service industries in a way that is meaningful economically, it does not show the origin and destination of services trade.

[3] The Southern African Customs Union came into existence in 1969 and includes the following countries South Africa, Botswana, Lesotho, Namibia and Swaziland.

[4] This is trade flow, which does not involve related parties. For instance, service trade between Coca Cola South Africa and its parent company in the US is excluded.

The empirical results support modern trade theories with regard to dissimilarities in demand structure, degree of market openness and economies of scale. Firstly, dissimilarities in demand structure between South Africa and the US reduce the level of trade in differentiated services. Secondly, economies of scale play a significant role in determining the level of unaffiliated IIT in the selected services. Finally, US FDI in South Africa increases unaffiliated IIT

The rest of the paper is organised as follows. Section 2 provides a theoretical basis for the determinants of unaffiliated IIT in services. Section 3 deals with model specification while section 4 focuses on the data. Section 5 is devoted to the estimation methodology. Section 6 presents the estimation results and discussion. The final section is devoted to conclusions.

2. THEORETICAL FRAMEWORK

There is a great diversity of models focusing on differentiated IIT, as well as alternative market structures such as monopolistic competition leading to Chamberlin-Heckscher-Ohlin (CHO) models and oligopoly. The determinants and predictions of these models are different while in some cases it is quite difficult to discriminate between them (Andresen, 2003). Despite these inherent problems, many empirical studies of IIT have tried to identify those features that are common to all, or to most of these models. However, in view of data problems, the features are subject to measurement errors.

Andresen (2003), using a classification proposed by Greenaway and Milner (1989), provides a survey of the determinants of IIT in goods. On the one hand, there are country-specific determinants, which are divided into five broad categories: economic development, market size, geographic proximity, economic integration and barriers to trade. On the other hand, there are industry-specific determinants which cover the categories of service differentiation, economies of scale, market structure, product life cycle and the role of multinational corporations.

Most of the empirical studies of IIT have been restricted to trade in goods. However, there are a few studies dealing with services trade. Lee and Lloyd (2002) conduct an empirical analysis of inter-country differences in IIT in services for the OECD. Using data from the *1998 edition of Services Statistics on International Transactions (1987-1996),* the study found that IIT was uniformly high in 20 OECD countries and nine service industries, and was stable over time. However, for 17 out of the 20 countries, combining goods and services trade reduces the magnitude of trade imbalances. This in turn raises the level of IIT because of the negative empirical relationship between the level of IIT and trade imbalance.

Li *et al.* (2003) measured the extent of IIT for insurance services for the US with her trading partners in 1995 and 1996. The study found that the IIT model of insurance services captured key factors that are important in increasing the volume of IIT in insurance services. These include differences in *per capita* income, market concentration in goods and services, trade imbalance, market size, FDI, affiliated trade and market openness.

3. MODEL SPECIFICATION

In constructing the model, the study combines the "country-specific" and "industry-specific" determinants highlighted in Greenaway and Milner (1989) in one equation;

$$IIT_{it} = f\left(IIT^{+}_{it-1},\ \bar{P}_t,\ \bar{S}_{it},\ \Delta\overset{+}{E}_t,\ \overset{+}{D}SA_{it},\ \bar{TSA}_{it},\ \overset{+}{TUS}_{it},\ \bar{FI}_{it},\right) \quad (1)$$

IIT_{it} is the unadjusted GL index for IIT in unaffiliated services computed using equation 2.6 in Grubel and Lloyd (1975:22). P_t is an index of the difference in nominal *per capita* income between South Africa and US, used as a proxy for dissimilarities in demand structure. S_{it} is an index of the difference in market size between the US and South Africa and is used as a proxy for economies of scale. ΔE_t is the change in nominal Rand-US dollar exchange rate (Rand/$). DSA_{it} is an index of the degree of economic freedom (deregulation) in South Africa. TSA_{it} and TUS_{it} are Hoekman (1995)-type services trade openness indices in terms of market access and national treatment for all modes of supply in South Africa and the US, respectively. FI_{it} is US foreign direct investment in South Africa.

The subscript *i* denotes the fth service sector *(i* = Airfreight services; Education services; Financial services; Legal services; Management, Consulting and Public Relations services; Ocean Freight services; Ocean Port services; Research & Development, Royalties and Fees; Telecommunication services and Travel or tourism services). The subscript t denotes the fth year *(t*= 1994, 1995, 2002).

Most econometric studies of the determinants of IIT employ the ordinary least squares (OLS) or its variants. The GL index, most commonly used in empirical studies, varies between 0 and 1 but OLS may provide forecasts which are not within the 0 to 1 range. Using the approach in Balassa and Bauwens (1987), equation 1 is estimated as;

$$y_{it} = \alpha + \beta_1 y_{it-1} + \beta_2 P_t + \beta_3 S_{it} + \beta_4 \Delta E_t + \beta_{i5} DSA_{it} + \beta_6 TSA_{it} + \beta_7 TUS_{it} + \beta_8 FI_{it} + \varepsilon_{it} \quad (2)$$

Where $y_{it} = \log\left(\frac{IIT_{it}}{1 - IIT_{it}}\right)$ *i.e.* the odds ratio of IIT.

The expected signs are:

$$\beta_1 > 0, \beta_2 < 0, \beta_3 < 0, \beta_4 >, \beta_{i5} > 0, \beta_6 < 0, \beta_7 > 0, \beta_8 < 0 \quad (3)$$

The disturbance term is specified as a two-way error component model,

$$\varepsilon_{it} = \mu_i + \lambda_t + \nu_{it} \quad (4)$$

μ_i denotes service-specific effects, $\lambda_t$denotes year-specific effects, and $\nu_{it}$is an idiosyncratic disturbance term, which varies across services and time. No normality assumption is made about this error term in finite samples since statistical inference is done using nonparametric bootstrapping techniques.

4. THE DATA

IIT_{it}: Mirrored[5] unaffiliated services trade data are used to calculate South Africa—US adjusted GL index. The data are taken from the United States Bureau of Economic

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' Mirrored data refers to the fact that data is collected from the trading partner's side. This means that US imports are treated as South Africa's exports and *vice versa.* There are limitations in this approach such as under-invoicing. However, it is hoped that the US has an efficient system of recording international transactions.

Analysis (http://www.bea.gov/bea/di/1001serv/intlserv.htm). The descriptions of the services are in US Department of Commerce (1998). The data is in nominal US dollars (millions) and is not deflated due to lack of sectoral deflators.

P_t: Nominal GDP *per capita* (US$) for South Africa and US are collected from the IMF's International Financial Statistics. Instead of taking absolute values of inter-country differences *m per capita* incomes, equation 4 in Balassa and Bauwens (1987:927) is used to calculate relative differences that take values between 0 and 1.

S_{it}: Data used to calculate differences in market size was collected from different sources. Proxies for market size variable differ from service to service as shown in Table 1 below.

Equation 4 in Balassa and Bauwens (1987:927) is used to calculate an index of relative inequality which is robust to size bias.

ΔE_{it}: The change in Rand-US dollar exchange rate (Rand/$). The data is collected from the IMF International Financial Statistics.

DSA_{it}: Index of Economic Freedom published by the Fraser Institute (http://www.freetheworld.com/) is used as a proxy to measure the degree of deregulation in a particular service sector in South Africa. The different proxies are shown in Table 2 below.

TSA_{it} *and* TUS_{it}: Index of trade openness in the services sector and are constructed using Hoekman-(1995) frequency methods (See Sichei, 2005). This is to some extent related to the economic freedom index. However, these indices are more specific to international trade in services.

Table 1. Proxies for market size

Service	Proxy of market size	Source
Air freight	Air transport freight (million tons per KM)	World Development Indicators
Education	South African students enrolled in US tertiary institutions and *vice versa*	Open doors. http://opendoors.iienetwork.org/
Financial services	Foreign assets of banking and financial institutions	IMF International Financial Statistics
Legal services	Civil cases of debt	STATSA and Federal Court
Management, consulting and public relations	Data on other services in UNCTAD services trade data	UCTAD
Ocean freight	Merchant shipping fleets: total (000 gross registered tons)	UN Statistical Yearbook
Ocean port services	Merchant shipping fleets: total (000 gross registered tons)	UN Statistical Yearbook
Research & development, and testing services	Trademarks and patents granted	World Intellectual Property Organisation (WIPO) http://www.wipo.int
Telecommunications	Fixed telephone lines and mobile subscribers per 1,000 people	World Development Indicators
Travel	Number of tourist arrivals	World Development Indicators

Source: Authors' construction.

Table 2. Degree of deregulation (economic freedom)

Sector	Proxy for the degree of deregulation
Air freight services	Regulatory trade barriers
Education and training services	Country overall rating of economic freedom by Fraser institute
Financial services	Access to sound money
Legal services	Integrity of the legal system
Management consulting and public relations services	Freedom to exchange with foreigners
Ocean freight services	Regulatory trade barriers
Ocean port services	Regulatory trade barriers
Research & development and testing services	Protection of intellectual property rights
Telecommunication services	Freedom to exchange with foreigners
Travel services	Country overall rating of economic freedom by Fraser institute

FI_{it}: Mirrored sectoral FDI (US$mn) is collected from the US Bureau of Economic Analysis. FDI includes the initial transaction between two entities and all subsequent financial transactions between them and among affiliated enterprises, both incorporated and unincorporated.

5. THE ESTIMATION METHODOLGY

Mirrored data from the US Bureau of Economic Analysis (US dollars) are sorted to identify "genuine IIT" using a methodology pioneered by Abd-el-Rahman (1991). Consequently IIT is a structural feature of trade in a particular service sector if the minority service flow[6] is at least 12% of the majority service flow.

The panel data model in equation 2 is estimated within a general linear model (GLM) framework. GLM is an extension of the multivariate regression model in a number of ways. Firstly the GLM allows for linear transformation or linear combinations of multiple dependent variables. This provides the ability to analyse effects or repeated measures and thus encapsulates a panel data model. Secondly since GLM uses generalised inverses, it can provide solutions to normal equations when the regressors are linearly dependent.

The paper uses bootstrap methodology introduced by Efron (1979) to conduct hypothesis tests. Bootstrapping is a statistical method of estimating the sampling distribution of an estimator by resampling with replacement from the original sample with a view to deriving robust estimates of standard errors and confidence intervals of population parameters. The use of bootstrap is predicated on the fact that first-order asymptotic theory approximation (classical statistical inference), commonly used in econometrics, assumes that a statistic has a known sampling distribution[7] and readily available method of computing its parameters. If any of these two assumptions fail, the first-order asymptotic theory approximation approach to statistical inference will be flawed. This calls for bootstrapping, which enables robust statistical inference when any of the two or both assumptions do not hold. The study uses bootstrap for three reasons. Firstly, as pointed out by Horowitz (2001) bootstrap provides a better Type I error approximation than the first-order asymptotic theory. Secondly, it can estimate the degree of coefficient bias. This is quite important in detecting potential endogeneity in the dynamic panel data specification used in this study. Finally, it can be used as a check on the adequacy of the first-order asymptotic theory approximation.

Alternative dynamic panel estimators are the first different generalised method of moments (GMM) estimator of Arellano and Bond (1991), the system GMM estimator of Arrellano and Bover (1995) and Everaert and Pozzi (2004). Our bootsrap-based approach is in the spirit of Everaert and Pozzi (2004) in dealing with potential endogeneity problems.

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[6] This terminology is used to refer to either exports or imports whenever there is a deficit or surplus in bilateral trade in services. If South Africa's service imports from the US are lower than service exports for the same period, imports are described as "minority service flow" while exports are referred to as "majority service flow".

[7] For instance, in a linear regression model, its error term is assumed to be normally, identically and independently distributed with zero mean and constant variance.

The standard error components model given in equation 4 assumes that the regression disturbances are homoscedastic with the same variance across time and individual service sectors. This is a restrictive assumption in South Africa—US unaffiliated I IT covering diverse service sectors.

Baltagi (2001) warns that assuming homoscedastic disturbances when heteroscedasticity exists will result in consistent but inefficient estimates of the regression coefficients. Additionally, the standard errors of these estimates will be biased unless a robust standard error is computed which corrects for the possible presence of heteroscedasticity.

Bootstrap methods rely on simulation to approximate finite-sample distribution of pivotal test statistic. A statistic is pivotal if its sampling distribution does not depend on unknown parameters. In order for such methods to be reasonably accurate, it is desirable that the data generating process (DGP) used for drawing bootstrap samples should be as close as possible to the true DGP that generated the observed data, assuming that the DGP actually satisfies the null hypothesis. This presents a serious problem if the regression model has errors with heteroscedasticity of unknown form, *i.e.* if the form of heteroscedasticity is unknown, it cannot be imitated in the bootstrap DGP

Davison and Hinkley (1998:272) argue that the best approach to deal with heteroscedasticity of unknown form is wild bootstrap. Wild bootstrap estimates variances from individual residuals. Mammen (1993:257) notes that it is called *wild bootstrap* because n factorial[8] different distributions of residuals are estimated by only n observations. Wild bootstrap was originally proposed by Liu (1988) following the work of Wu (1986) and Beran (1986). Liu (1988) established the ability of the wild bootstrap to provide refinements for the linear regression model with heteroscedastic errors and further evidence was provided by Mammen (1993), Davidson and Flachaire (2001) and Flachaire (2003). Mammen (1993) showed that under some regularity conditions, wild bootstrap is asymptotically justified in the sense that the asymptotic distributions of the various statistics are the same as the asymptotic distributions of their wild counterparts.

In the wild bootstrap literature, two distributions of the error term are commonly used. Mammen (1993) suggested the following two-point distribution:

$$F_1 : t_i = \begin{cases} -\dfrac{(\sqrt{5}-1)}{2}, with \quad probability \quad p = \dfrac{(\sqrt{5}+1)}{2\sqrt{5}} \\ \dfrac{(\sqrt{5}+1)}{2}, with \quad probability \quad 1-p \end{cases} \tag{5}$$

Liu (1988) introduced the use of Rademacher distribution in wild bootstrap. Rademacher distribution, named after Hans Rademacher, is a discrete probability distribution which has a 50% chance for either 1 or —1. The probability mass function (pmf) of this distribution is:

[8] Written as n! meaning *n* X *(n* - 1) X («- 2) … X 1

$$F_2 : t_i = f(k) = \begin{cases} \frac{1}{2} & if \quad k = 1 \\ \frac{1}{2} & of \quad k = -1 \\ 0 & Otherwise \end{cases} \tag{6}$$

As pointed out in Liu (1988) and Mammen (1993:257), this lattice distribution satisfies three requirements:

$$E(t_{it}) = 0,\ E(t_{it}^2) = 1 \quad \text{and} \quad E(t_{it}^3) = 1 \tag{7}$$

The first condition in equation 7 shows that the Rademacher distribution centres the bootstrap statistic around zero. The second condition states that the Rademacher distribution centres the variance around 1 while the last condition corrects for skewness in the Edgeworth expansion of the sampling distribution of the parameter estimates.

Davidson and Flachaire (2001) show that, on the basis of theoretical analysis and simulation experiments, wild bootstrap tests based on the Rademacher distribution, F_2, usually performs better in finite samples than those based on the F_1. A SAS bootstrap macros is used to perform the Liu-Davidson-Flachaire wild bootstrap using the following algorithm:

Firstly, equation 2 is estimated using GLM procedure in SAS and residuals, e_{it}, generated. The second step entails transforming the residuals using the second form of Mackinnon and White (1985) heteroscedasticity consistent covariance matrix estimator (HCCME):

$$a_{it}e_{it} = \left(\frac{1}{\sqrt{1-h_{it}}}\right)v_{it} \tag{8}$$

Where $a_{it}e_{it}$ are the modified residuals, $a_{it} = \frac{1}{\sqrt{1-h_{it}}}$, $h_{it} = X_{it}(X'X)^{-1}X'_{it}$ *i.e.* the leverage is the jth element of the orthogonal projection matrix on to the span of the columns of X. v_{it} is the idiosyncratic error term in equation 4. This adjustment compensates for the fact that the OLS residuals (and thus GLM) tend to understate the true errors.

In the third step, since the SAS software does not have a customised Rademacher distribution in equation 6, this was done manually. This entailed generating a series, which is a sequence that alternate between 1 and —1. Since there are 90 observations in total, 45 of take the value of 1 while the remaining take value —1 effectively constructing a Rademacher variable.

Fourthly, resampling with replacement is done for the generated variable following the F_2 distribution.

Fifthly, this is multiplied with the modified residuals in equation 8 as follows:

$$v_{it}^* = a_{it}e_{it}t_{it} \tag{9}$$

Sixthly, bootstrap vector of response variables, $\left(y_{it}^{*}\right)_{b}$, are generated by adding the resampled vector of residuals for that sector to the vector of fitted response as follows:

$$\left(y_{it}^{*}\right)_{b} = \hat{y}_{it} + v_{it}^{*} \tag{10}$$

Seventhly, bootstrapped response variables are regressed using GLM on the fixed explanatory variables to estimate a bootstrapped vector of coefficients, $\hat{\beta}_{b}^{*}$.

$$\left(y_{it}^{*}\right)_{b} = \hat{\beta}_{b}^{*'} z_{it} + \eta_{it} \tag{11}$$

Eighthly, this procedure from the first to the sixth step is repeated $\mathbb{B}$ times (in this case, B = 3,000). The bootstrapped regression coefficients for each resample are placed in a (3,000 X 36) matrix. Each column in this matrix is converted into an estimate of the sampling distribution of the $\hat{\beta}$ by placing a probability of 1/3,000 on each value of $\hat{\beta}_{b}^{*}$.

Ninthly, the bias of the estimated coefficients is computed in line with Mooney and Duval, (1993:30-33) as follows:

$$Bias(\hat{\beta}) = \hat{\beta} - \hat{\beta}_{(.)}^{*} \tag{13}$$

Where $\hat{\beta}_{(.)}^{*} = \dfrac{\sum_{b=1}^{B} \hat{\beta}_{b}^{*}}{B}$

This step does not only determine whether endogeneity is a serious problem but it also informs the decision of which method to use in constructing confidence intervals.

Finally, confidence intervals are constructed using the percentile method (Davison and Hinkley 1998:202-205). This entails sorting the bootstrap parameters in ascending order and then selecting the appropriate percentiles. For instance, with 3,000 replications and using the 95% confidence interval, the bootstrapped parameter number 75 is selected as the lower confidence limit value and number 2925 as the upper confidence limit value in the empirical distribution function (EDF). Hypothesis tests can then be performed.

6. ESTIMATION RESULTS AND DISCUSSION

(a) First-Order Asymptotic Theory Results

The panel data model in equation 2 is estimated within a GLM framework. Table 3 presents the results. The results are referred to as first-order asymptotic theory because they use first-order asymptotic distribution of the test statistic under the null to approximate Type I critical values. The rationale for this approximation is the fact that most test statistics in econometrics are asymptotically pivotal because their asymptotic distributions do not depend on unknown population parameters when the null hypothesis being tested is true. On the basis of this, an approximate Type I critical value can be obtained from asymptotic distribution theory without knowledge of where the true DGP is in the set specified by the null hypothesis.

In view of the fact that these results form the basis of bootstrapping, a number of diagnostic tests were performed. These include test of equality of variance and detection of influential observations.

Table 3. First-order asymptotic theory panel data estimation results

Independent variables and service sector	First-order asymptotic theory results		
	Estimate	Std error	p-value
Intercept	73.496***	19.278	0.000
y_{it-1}	−0.385***	0.078	0.000
Difference in per capita income	−126.738**	42.887	0.004
Difference in market size	−16.428**	6.528	0.015
US foreign direct investment in SA	29.593**	14.562	0.047
Nominal exchange rate (Rand/$)	67.154*	36.059	0.068
Openness to services trade in SA	−6.679	4.999	0.187
Openness to services trade in the US	−1.128	3.644	0.758
Deregulation in South Africa:			
Air freight services	−2.063	1.425	0.154
Education and training services	2.322*	1.376	0.097
Financial services	1.505	1.376	0.279
Legal services	−0.391	2.984	0.896
Management, consulting and public relation services	4.337*	2.288	0.063
Ocean freight services	−4.647**	1.425	0.002
Ocean port services	8.802**	2.447	0.001
Research development and testing services	3.153	2.513	0.215
Telecommunications services	−8.474**	3.356	0.015
Travel (tourism) services	1.287	1.415	0.367
Service-specific fixed effects:			
Air freight services	24.214*	8.685	0.007
Education and training services	−11.549	8.383	0.174
Financial services	−3.949	9.046	0.664
Legal services	−6.708	14.712	0.650
Management, consulting and public relation services	−22.740*	12.295	0.070
Ocean freight services	40.920***	8.558	0.000
Ocean port services	−56.507***	14.388	0.000
Research development and testing services	−15.230	17.654	0.392
Telecommunication services	54.305**	17.818	0.004
Travel (tourism) services[a]	−2.756		
Time-specific effects:			
1994	−4.383**	1.777	0.017
1995	−2.152	2.560	0.404
1996	−8.805**	3.590	0.017
1997	−0.866	1.514	0.570
1998	−4.648**	2.085	0.030
1999	4.314*	2.316	0.068
2000	6.114**	2.070	0.005
2001	4.731**	2.098	0.028
2002[a]	5.695		
Diagnostic statistics			
Rsquare	0.684095		
Adjusted R-square	0.502806		
F-statistic	3.50(0.000)		
Durbin-h	1.0008		
First-order autocorrelation coefficient	−0.0707		

Notes: Sample period: 1994-2002.

[a] The effects of travel service-effects are estimated as minus the sum of other service effects. The same applies to the time-specific effects of 2002.

*, **, and *** imply significance at 10%, 5% and 1%, respectively.

The test of equality of variances is done using Levene's test (Levene I960). Levene's test checks whether the variances of two or more populations are equal. Table 4 shows that the variances of the residuals from the different service sectors are statistically different *(i.e.* there is heteroscedasticity).

Influential observations are those observations whose presence in the data can have distorting effect on the parameter estimates and possibly the entire analysis. Outliers are data points that contain unusual dependent values (Mukherjee *et al.* 1998).

The following observation statistics are used: hat-values, covratio, Dffits and CookD. The hat-value measures the leverage of the regression. This implies that if the hat-value

Table 4. Tests of equality of residual variances

Service sector	Mean	Standard deviation
Airfreight	6.957e-14	0.694
Education and training	4.322e-14	1.389
Financial services	5.035e-14	0.736
Legal services	4.706e-14	0.854
Management consulting and public relations services	3.863e-14	0.746
Ocean freight services	8.091e-14	2.533
Ocean port services	−2.137e-14	3.442
Research development and testing services	6.291e-14	0.959
Telecommunications	6.906e-14	1.430
Travel (tourism services	5.018e-14	1.389
Levene's F-test statistic	2.540(0.013)	

Note: Type I error probability in brackets.
Source: SAS statistical software output.

Table 5. Liu-Davidson-Flachaire wild bootstrap results (3,000 replications)

Independent variables and service sector	Estimate	Std error	Bias	Confidence interval	(Percentile method) %
Intercept	74.744***	19.039	−0.066	31.579, 124.273	99
y_{it-1}	−0.386***	0.148	0.007	−0.729, −0.062	99
Difference in per capita income	−129.108***	40.751	0.058	−220.852, −41.813	99
Difference in market size	−16.678***	4.915	0.051	−29.183, −4.332	99
US foreign direct investment in SA	29.455*	18.239	0.008	1.284, 58.098	90
Nominal exchange rate (Rand/$)	68.606**	34.245	−0.042	3.721, 134.201	95
Openness to services trade in SA	−6.627	4.345	−0.012	−13.323, 0.308	90
Openness to services trade in the US	−1.051	1.644	−0.047	−3.909, 1.730	90
Deregulation in South Africa:					
Air freight services	−2.077*	1.159	0.012	−4.026, −0.205	90
Education and training services	2.189**	1.187	0.112	0.024, 4.521	95
Financial services	1.466	1.053	0.037	−0.285, 3.167	90
Legal services	−0.324	2.310	−0.029	−4.020, 3.344	90
Management, consulting and public relation services	4.351***	2.060	−0.007	0.130, 9.301	99
Ocean freight services	−4.693***	1.899	0.024	−9.446, −0.547	99
Ocean port services	8.839**	4.065	−0.009	1.146, 16.462	95
Research development and testing services	3.24**	1.644	−0.053	0.115, 6.483	95
Telecommunications services	−8.484***	2.248	0.004	−13.927, −3.288	99
Travel (tourism) services	1.249	1.057	0.036	−0.589, 2.937	90
Service-specific fixed effects:					
Air freight services	24.280***	8.084	−0.008	5.631, 44.193	99
Education and training services	−10.676*	6.129	−0.142	−20.955, −0.994	90
Financial services	−3.654	5.839	−0.050	−12.887, 6.452	90
Legal services	−7.167*	12.795	0.036	−28.433, −1.352	90
Management, consulting and public relation services	−22.878***	10.180	0.014	−46.733, −1.352	99
Ocean freight services	41.231***	15.010	−0.021	9.363, 73.926	99
Ocean port services	−56.715***	24.558	0.008	−114.372, −0.412	99
Research development and testing services	−16.014	10.447	0.075	−33.909, 1.438	90
Telecommunication services	54.232***	12.095	0.006	24.689, 83.467	99
Travel (tourism) services[a]	−2.639				
Time-specific effects:					
1994	−4.495***	1.419	0.079	−8.569, −1.387	99
1995	−2.224	2.274	0.032	−5.991, 1.739	90
1996	−9.005***	3.474	0.058	−16.993, −1.806	99
1997	−0.803	1.353	−0.047	−3.056, 1.224	90
1998	−4.733**	2.090	0.041	−8.626, −0.466	95
1999	4.437**	2.238	−0.055	0.128, 8.618	95
2000	6.242***	2.081	−0.062	1.542, 11.419	99
2001	4.771***	1.643	−0.024	0.968, 8.690	99
2002[a]	5.81				

Notes: Sample period: 1994-2002.
[a] The effects of travel service-effects are estimated as minus the sum of other service effects. The same applies to the time-specific effects of 2002.
*, **, and *** imply significance at 10%, 5% and 1%, respectively.

Table 6. Influential data observations

Obs	Service industry	Year	Residual	h	Covratio	Dffits	CookD
1	Afre	1994	−0.155	0.436	3.449	−0.091	0.000
2	Afre	1995	0.417	0.316	0.744	0.173	0.001
3	Afre	1996	−0.518	0.294	0.260	−0.200	0.001
4	Afre	1997	−0.650	0.265	2.415	−0.229	0.001
5	Afre	1998	0.326	0.299	2.723	0.128	0.000
6	Afre	1999	0.544	0.277	2.526	0.199	0.001
7	Afre	2000	1.456	0.377	1.744	0.728	0.015
8	Afre	2001	−1.228	0.408	2.131	−0.671	0.013
9	Afre	2002	−0.193	0.446	3.496	−0.117	0.000
10	Educ	1994	0.102	0.720	6.954	0.155	0.001
11	Educ	1995	−1.914	0.354	1.129	−0.899	0.022
12	Educ	1996	0.144	0.318	2.860	0.060	0.000
13	Educ	1997	−1.329	0.443	2.031	−0.805	0.018
14	Educ	1998	−0.906	0.341	2.399	−0.405	0.005
15	Educ	1999	0.637	0.262	2.416	0.223	0.001
16	Educ	2000	1.610	0.261	1.443	0.565	0.009
17	Educ	2001	0.386	0.335	2.837	0.169	0.001
18	Educ	2002	1.270	0.325	1.921	0.543	0.008
19	Fins	1994	−0.043	0.801	9.852	−0.097	0.000
20	Fins	1995	−0.182	0.443	3.486	−0.110	0.000
21	Fins	1996	−0.349	0.421	3.265	−0.197	0.001
22	Fins	1997	0.531	0.448	3.252	0.324	0.003
23	Fins	1998	−0.300	0.370	3.037	−0.146	0.001
24	Fins	1999	0.639	0.274	2.452	0.232	0.002
25	Fins	2000	0.581	0.288	2.538	0.221	0.001
26	Fins	2001	−1.035	0.349	2.660	−0.474	0.006
27	Fins	2002	0.157	0.473	3.689	0.103	0.000
28	Legs	1994	0.019	0.409	3.318	0.010	0.000
29	Legs	1995	−0.007	0.474	3.725	−0.005	0.000
30	Legs	1996	−1.211	0.299	1.949	−0.478	0.006
31	Legs	1997	0.232	0.255	2.599	0.079	0.000
32	Legs	1998	1.372	0.232	1.670	0.435	0.005
33	Legs	1999	0.674	0.250	2.353	0.226	0.001
34	Legs	2000	−0.781	0.364	2.613	−0.374	0.004
35	Legs	2001	−0.865	0.364	2.516	−0.414	0.005
36	Legs	2002	0.568	0.323	2.668	0.240	0.002
37	Mcps	1994	−1.463	0.454	1.818	−0.918	0.023
38	Mcps	1995	0.701	0.413	2.890	0.387	0.004
39	Mcps	1996	0.025	0.305	2.821	0.010	0.000
40	Mcps	1997	1.081	0.275	2.048	0.395	0.004
41	Mcps	1998	−0.167	0.233	2.539	−0.053	0.000
42	Mcps	1999	−0.075	0.221	2.514	−0.023	0.000
43	Mcps	2000	−0.122	0.342	2.966	−0.055	0.000
44	Mcps	2001	−0.528	0.343	2.774	−0.237	0.002
45	Mcps	2002	0.548	0.408	3.035	0.298	0.003
Critical values				0.800	1.200	1.260	1.650

Notes: Afre–Airfreight services; *Educ*–Education and training services; *Fins*–Financial services; *Legs*–Legal services; *Mcps*–Management, consulting and public relations services; *Ocfr*–Ocean freight services; *Ocps*–Ocean port services; *Rdts*–Research, development and testing services; *Tels*–Telecommunications services; *Trav*–Travel (tourism) services. Shaded observations are influential since they are above the critical values.
Source: Influential observations.

point is moved up or down, the regression surface will tend to follow it. Covratio statistic measures the effect of observations on the covariance matrix of the parameter estimates. The Dffits statistic is a scaled measure of the change in the predicted value for the fth observation. Large absolute values of Dffits indicate influential observations. The CookD statistic is an overall measure of the influence of the ith observation on all the parameter estimates.

Tables 6 and 7 present stacked influential data statistics for each observation. The first four columns refer to the observation number, service industry, year and residual,

Table 7. Influential data observations (continued)

Obs	Service industry	Year	Residual	h	Covratio	Dffits	CookD
46	Ocfr	1994	3.728	0.569	0.011	3.572	0.305
47	Ocfr	1995	3.133	0.525	0.098	2.535	0.164
48	Ocfr	1996	−2.465	0.304	0.607	−1.003	0.027
49	Ocfr	1997	−2.330	0.272	0.730	−0.855	0.020
50	Ocfr	1998	−1.721	0.294	1.339	−0.671	0.012
51	Ocfr	1999	−1.592	0.415	1.579	−0.892	0.022
52	Ocfr	2000	0.788	0.369	2.621	0.382	0.004
53	Ocfr	2001	0.625	0.435	3.081	0.368	0.004
54	Ocfr	2002	−0.165	0.555	4.361	−0.140	0.001
55	Ocps	1994	−0.992	0.572	3.077	−0.888	0.022
56	Ocps	1995	−1.012	0.778	3.958	−2.051	0.116
57	Ocps	1996	−0.288	0.753	7.491	−0.509	0.007
58	Ocps	1997	2.520	0.306	0.565	1.033	0.029
59	Ocps	1998	0.894	0.285	2.262	0.337	0.003
60	Ocps	1999	−1.383	0.330	1.785	−0.601	0.010
61	Ocps	2000	−4.541	0.335	0.009	−2.153	0.112
62	Ocps	2001	7.763	0.350	0.000	4.759	0.357
63	Ocps	2002	−2.961	0.588	0.100	−2.928	0.218
64	Rdts	1994	−0.358	0.798	8.686	−0.797	0.018
65	Rdts	1995	1.012	0.778	3.958	2.051	0.116
66	Rdts	1996	0.288	0.753	7.491	0.509	0.007
67	Rdts	1997	−0.920	0.451	2.735	−0.568	0.009
68	Rdts	1998	−1.402	0.282	1.699	−0.525	0.008
69	Rdts	1999	1.021	0.266	2.089	0.362	0.004
70	Rdts	2000	0.801	0.362	2.583	0.381	0.004
71	Rdts	2001	−0.255	0.356	2.992	−0.119	0.000
72	Rdts	2002	−0.187	0.376	3.111	−0.092	0.000
73	Tels	1994	−1.223	0.447	2.221	−0.749	0.157
74	Tels	1995	−1.446	0.453	1.845	−0.905	0.023
75	Tels	1996	2.669	0.445	0.362	1.667	0.074
76	Tels	1997	0.204	0.625	5.128	0.217	0.001
77	Tels	1998	0.500	0.377	2.938	0.249	0.002
78	Tels	1999	0.064	0.281	2.724	0.024	0.000
79	Tels	2000	1.106	0.352	2.183	0.511	0.007
80	Tels	2001	−1.882	0.356	1.167	−0.890	0.022
81	Tels	2002	0.008	0.455	3.598	0.005	0.000
82	Trav	1994	0.385	0.725	6.492	0.601	0.010
83	Trav	1995	−0.701	0.347	2.635	−0.319	0.003
84	Trav	1996	1.705	0.314	1.368	0.708	0.014
85	Trav	1997	0.661	0.437	3.047	0.391	0.004
86	Trav	1998	1.405	0.380	1.822	0.709	0.014
87	Trav	1999	−0.530	0.259	2.479	−0.183	0.001
88	Trav	2000	−0.897	0.261	2.197	−0.313	0.003
89	Trav	2001	−2.982	0.335	0.274	−1.349	0.048
90	Trav	2002	0.955	0.378	2.446	0.476	0.006
Critical values				0.800	1.200	1.260	1.650

Notes: Afre–Airfreight services; *Educ*–Education and training services; *Fins*–Financial services; *Legs*–Legal services; *Mcps*–Management, consulting and public relations services; *Ocfr*–Ocean freight services; *Ocps*–Ocean port services; *Rdts*–Research, development and testing services; *Tels*–Telecommunications services; *Trav*–Travel (tourism) services. Shaded observations are influential since they are above the critical values.
Source: Influential observations output from SAS statistical software.

respectively. The last four columns refer to the hat-values, Covratio, Dffits and CookD statistics, respectively. The last row shows critical values for the four statistics. Any observation with a statistic greater than the critical value is influential. All these data points are shaded. For instance, data point 1994 for financial services is influential using the hat-value. This implies that if this point is moved up or down, the regression surface will tend to follow it.

The problematic data points were investigated and found that the influential observations are not due to flaws in data collection. Consequently, the influential data

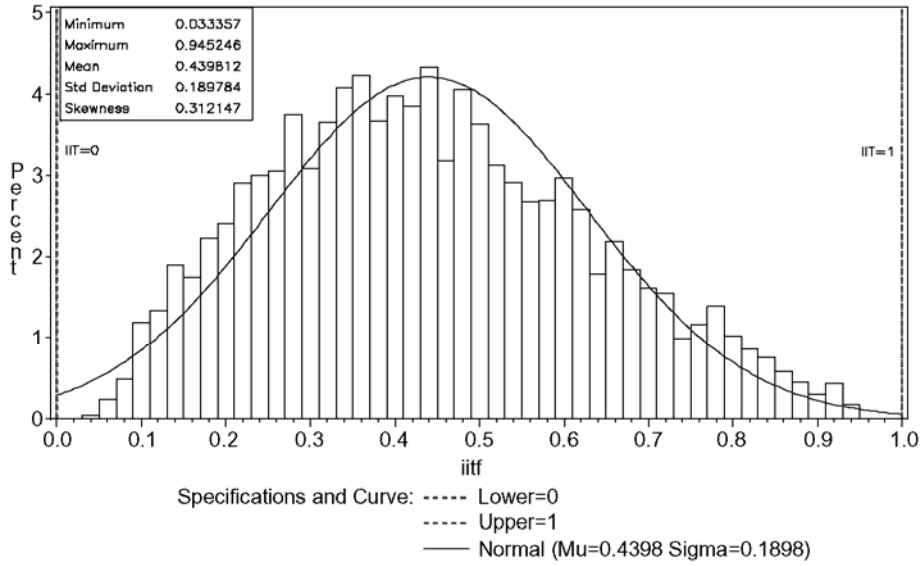

Figure 1. EDF of the predicted South Africa–US IIT in financial services
Source: SAS statistical software output from Liu-Davidson-Flachaire wild bootstrap algorithm.

points were not discarded. Instead, information from the influential data statistics is used to inform the bootstrapping process. Firstly, the covratio statistic shows that pairs resampling cannot be used because regressors are not interchangeable as they affect the precision of the estimates. Secondly, the Dffits and leverage statistics show that pooling of residuals from different sectors in the residual resampling process may not be appropriate. Instead, stratified resampling or wild bootstrap should be used.

The overall explanatory power of the model (in terms of adjusted R^2) shows that the regressors explain about 50% of the variation in log odds of IIT. The F-statistic shows that the regressors are jointly significant in explaining the dependent variable. The Durbin h statistic shows that the model does not suffer from serial correlation problem.

(b) Bootstrap Results

Table 5 presents the bootstrap results. The fourth column in this table display standardised bias *{i.e.* bias in equation 13 divided by bootstrap standard error). Since the standardised bias is below 0.25 a threshold suggested in Efron (1982), the estimates in equation 2 are unbiased and therefore endogeneity in the dynamic panel data model is not a serious problem.

The model is consistent with Grubel and Lloyd (1975) since it predicts IIT within the 0 and 1 range in all the services. Fig. 1 confirms this for predicted IIT in financial services.[9] A normal distribution line is superimposed on the histogram to determine whether the parameter's EDF is bell-shaped with normal tails or not. Although the study utilises a classical interpretation of probability, as opposed to Bayesian approach, the EDF for IIT provides an approximation to the underlying DGP for South Africa-US unaffiliated IIT in selected services.

[9] The EDFs of predicted IIT for the other services are available from the authors.

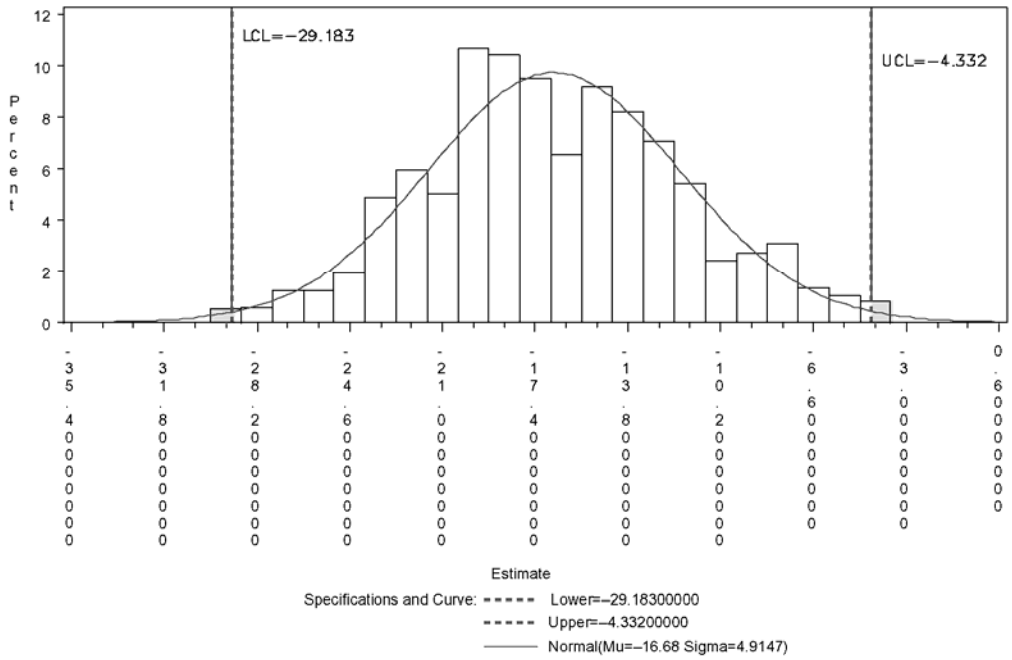

Figure 2. EDF of the coefficient for the difference in market size between South Africa and the US (99% confidence intervals)
Source: SAS statistical software output from Liu-Davidson-Flachaire wild bootstrap algorithm.

Unlike the classical approach in Table 3, the testing of hypotheses in wild bootstrap is done by looking at whether the null hypothesis, $\beta = 0$, is contained in the confidence interval of the bootstrap results. For example, in the case of the difference in market size, the bootstrap confidence intervals do not contain $\beta = 0$ implying that it is statistically significant.

This can be seen graphically in Fig. 2, which shows the EDF of this coefficient with its 99% wild bootstrap confidence intervals. The LCL and UCL refer to 99% lower and upper confidence intervals, respectively. Since $\beta = 0$ is not contained in the interval, the difference in market size is statistically different from zero. The same can be done for all the other coefficients.

The coefficient of 74.744 for the intercept term in Table 5 is interpreted as the global mean since *effects coding* is used in constructing fixed effects. The service-specific effects are deviations from this grand mean as opposed to *regression coding*, where the effects would be deviations from a reference class.

(c) Interpretation of the Results

The coefficient for the lagged dependent variable (y_{it-1}) is negative and statistically significant. The fact that there is a positive bias as shown in column 4 of Table 5 confirms a theoretical postulation by Nickell (1981) that in a dynamic panel data model, if the population parameter is negative, then the bias is positive and *vice versa.*

Differences in demand structure, proxied by differential in *per capita* income, has a negative sign as anticipated and is statistically significant at 1% level. This is in line with the CHO model of horizontally differentiated IIT (HUT) and agrees with many "North-South" studies on IIT in goods presented in Table 1 0.1 of Greenaway and Milner (2002:184). The results are similar to those in Li *et al.* (2003, 2005). The results are, however, inconsistent with vertically differentiated IIT (VIIT) theoretical model of Flam and Helpman (1987) and the empirical findings by Clark and Stanley (1999) dealing with goods and Lee and Lloyd (2002) study on services. These studies postulate a positive relationship between *per capita* income and IIT. Additionally, despite our inability to disentangle HUT from VIIT, the consistency with CHO model implies that the former dominates South Africa-US IIT in services.

The difference in market size is negatively related to odds ratio of unaffiliated IIT. The results agree with both models of "love-of-variety" (Krugman, 1979) and "the ideal-variety" (Lancaster, 1980), which suggest that larger markets have the potential to allow for greater differentiation in services. The finding is consistent with the results in Li *et al.* (2003, 2005). The difference in market size proxy differences in existence of economies of scale and the different ability of South Africa and US to provide differentiated services. The results confirm the fact that the limited market size in South Africa reduces the opportunities for firms to produce and export differentiated and competitive services as compared to the US. This means that there is need to expand the market size for services sector in South Africa so that firms can reap economies of scale.

The results show that US FDI in South Africa has a positive relationship with log odds of unaffiliated IIT in services. The positive relationship is consistent with the theoretical trade models of Helpman and Krugman (1985), Markusen and Venables (1998, 2000). This means that presence of US multinationals complement rather than substitute exports of services by South African firms. The finding also agrees with the results in Li *et al.* (2003, 2005). This is, however, not consistent with the view that FDI should substitute unaffiliated IIT. The results show that US multinational corporations overcome costs of trade barriers in services by establishing themselves in South Africa (host country) and then generate arms-length trade with the US (home country).

The results show that nominal exchange rate has a positive and significant effect on IIT. This means that a depreciation of the South African Rand against the dollar makes South African exporters of services competitive and discourages imports from the US.

Trade openness to all the four modes of supply (cross-border, consumption abroad, commercial presence and presence of natural persons) in South Africa and the US are inimical to unaffiliated IIT in services. In terms of the sign, the results are in line with Falvey's (1981) model of VIIT, which demonstrates that countries with lower tariff barriers have higher levels of IIT. The coefficient is, however, statistically insignificant and is contrary to the results of Lee and Lloyd (2002:170) who find a positive and insignificant relationship. The difference in the finding with Lee and Lloyd (2002) may emanate from the method used to define a proxy for trade orientation. Their trade orientation is proxied by residuals from a regression of the log of *per capita* services trade on the log of *per capita* income and log of population. Our study uses the Hoekman (1995) trade barriers indices constructed using GATS schedules.

The degree of deregulation in South Africa has the expected positive sign in most services except airfreight; legal services; ocean freight and telecommunication services.

However, the finding is statistically significant in airfreight; educational and training services; management and consulting services; ocean freight; ocean port services; research development and testing services and telecommunication. This finding is in line with the results in Li *et al.* (2003).

The service-specific effects are deviations from the global mean (74.744). On one hand the service-specific effects are positive for airfreight; ocean freight and telecommunication services. This means that there are time-invariant service-specific characteristics which bolster South Africa—US I IT in the service sectors. On the other hand, there are negative service-specific effects in education services; financial services; legal services; management, consulting and public relations; ocean port services; research development and testing services and travel. This means that there are time-invariant unique characteristics in these services that tend to discourage South Africa's exports and instead promote imports of services from the US and should be identified using sector-specific surveys.

The time-specific effects are also interpreted with reference to the grand mean (intercept). The coefficients for the period 1994-1998 are negative but positive thereafter. However, in terms of statistical significance, the coefficients for the periods of 1994, 1996, 1998, 2000 and 2001 are significant. This pattern confirms the fact that following South Africa's political dispensation in 1994, imports of services from the US dominated but this changed from 1999 onwards.

7. CONCLUSIONS

The empirical results show that South Africa—US IIT in services is determined by factors similar to those in other "North-South" IIT studies (such as Clark and Stanley, 1999). Specifically, IIT is determined by differences in *per capita* income, US FDI in South Africa, the degree of economic freedom in South Africa, and service-specific and time-specific effects.

Firstly, there is a significant negative relationship between the log odds ratio of IIT and the *per capita* income difference, indicating the significance of demand similarities or differences in capital—labour ratios in generating South Africa—US IIT in the selected services.

Secondly, the difference in market size is negatively related to the odds ratio of IIT, which confirms the theoretical argument that IIT is associated with economies of scale. This shows that the limited market size in South Africa reduces the opportunities for firms to innovate and produce differentiated and competitive services as compared to the US. There is thus a need to expand the market size for services in South Africa so that exporters can reap economies of scale, which can be done through programmes that increase the purchasing power of South Africans as well as regional economic integration *{e.g.* SACU).

Thirdly, there is a positive relationship between FDI and IIT thus supporting the new trade theories that emphasise the role of multinational corporations in complementing the increase in the volume of trade rather than as a substitute for trade. This finding calls for the need to strengthen South Africa-US investment initiatives.

Fourthly, the service-specific characteristics are inimical to IIT in education and training services; management consulting and public relations; ocean port and travel. There is therefore a need to identify these characteristics using industry level survey.

Finally, time-specific effects are negative for the period 1994-1998 but positive thereafter. This pattern confirms the efficacy of liberalisation policy in South Africa.

Some policy implications do emerge from the negative and significant relationship in the difference in *per capita* income. First, although data problems limited our ability to disentangle HUT from VIIT, the agreement of the results with the former means South Africa—US trade in services involves dissimilar economies[10] and initiatives to promote such trade in the form of regional integration *{e.g.* SACU-US FTA) while trade liberalisation is inimical to intra-industry specialisation. Second, the low South Africa—US HUT in services entails higher factor market adjustment in terms of job losses.[11]

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[10] This is pointed out by Greenaway and Milner (2002:192).

[11] In other words, most firms supplying services would be located in the US to supply services in South Africa.

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