WORKING PAPER – DRAFT FORMAT

Title **:Identifying the trade theory model behind Botswana's sectoral exports**

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Abstract

This paper applies a sectoral gravity model to explain Botswana's bilateral export trade flows. The study employed panel data econometric techniques on each of the country's five export sectors. A trade structure and a sector specific trade arrangement are included in the respective gravity model equation to characterize the peculiarity of Botswana's trade patterns. The trade structure variable is used to identify the trade model behind any given sector's exports. Empirical results show that of the five sectors investigated, the diamond and the textile sectors' export trade follows a product differentiation model. The Heckscher–Ohlin model underpins exports in vehicle/automotive, copper, nickel & mate; and meat export sectors. The study also determined that the specific trade arrangements positively affect Botswana's trade sectoral export to its trade partners.

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1.1 Introduction

The importance of exports to any country or region emanates from its supposed positive contribution to economic growth of that country/region. This export-growth nexus becomes very important to a developing country such as Botswana given its quest to achieve higher levels of economic growth and development. Export becomes a potential avenue through which this growth objective may be achieved, as it is assumed to positively affect economic growth. This positive effect of exports on the level of economic activity is understood to work both on the demand and supply sides of any economy. On the demand side, an increase in exports will cause induced consumption, investment and government expenditure (in the Keynesian framework) and this will further call for the supply side to positively respond through induced changes in technology and the endowed recourses, so as to satisfy the requirements of the induced demand.

Following Blumenthal (1972) and Jaffee (1985), the total impact of (sectoral) exports can broadly be divided into four parts. Firstly, there is a direct effect. Since the value added by exports is a part of gross domestic product (GDP) following the Keynesian macroeconomic framework[2], a rise in the former implies a rise in the latter.

Secondly, export industries affect growth through their effect on other backward and forward industries. That is, for export industries to produce for exportation it demand raw materials and inputs from other industries (the backward linkage). At the same time the export industry supply intermediate inputs to other domestic industries (the forward linkage – under the assumption that the export sector do not export 100 percent of its output) besides exporting. Because of these linkages, the export sector will generally provide an overall positive impact on the growth of the domestic economy.

Thirdly, since exports are a source of foreign exchange, it affects growth via imports especially of vital production inputs and raw materials. Given that most developing country's production activities depends on imported inputs and capital equipment, these purchases can be made by using the foreign currency earned from exports (among other sources of foreign currency).

Lastly, Jaffe (1985) argued that there is a broader theoretical point that suggests a positive correlation between export dependence and the growth of an economy. This line of thinking suggests that involvement in world trade is a commonly employed indicator of integration into, and expanded production for the capitalist world-economy (Bennett, 1980). This integration is argued to provide a platform for transforming the mode of production from primitive to high technology techniques. This transformation results in an economy that can effectively and efficiently produce for the contemporary world economy. More openness and involvement in world export trade by any country will increase its chances of attaining and sustaining high economic growth rates (Ragin and Delacroix, 1979).

[2] The Keynesian framework expresses: GDP = Consumption + Investment + Government expenditure + **Exports** – Imports

Given this background, it follows that export policy usually becomes an important tool to achieve economic growth in developing countries. Thus, to come up with sound and objective sectoral export policies, there is need for an analysis which addresses two issues. Firstly, an investigation which categorize sectoral exports as falling into either Heckshen-Ohlin (H-O) or product differentiation theoretical structures. Secondly, an inquiry which investigates the various sectoral export destinations. In the latter examination, both current and potential sectoral export destinations are important as far as harnessing the process through which exports can contribute to economic growth. As will be detailed in the paper, sectoral export destinations of Botswana has evolved, among other factors from the codes of colonial attachments, comparative advantage, trade agreements, specialized market arrangements, as well as from the advantages of proximity.

1.2 Brief Country Background

Botswana's economic growth trend since independence in 1966 has been remarkable. Contrasting the periods soon after 1966 and today, significant differences can be noted. For instance, at independence, the country was one of the poorest whose developmental and recurrent expenditures were dependent on foreign aid. On the other hand, over the years, the contemporary Botswana has experienced self-sustainable economic growth, with GDP per capita of above US$11 000 as of 2006, making it an upper middle income country by World Bank classification. In fact, it is considered the richest non-oil producing country in Africa.

Historical economic activity indicates that in 1966, 40 percent of the economy's GDP and 90 percent of employment were mainly from the agriculture sector. This agricultural sector's contributions has however declined sharply over the years to such an extent that the sector only contributed about 4 percent and 16 percent, respectively by the mid 1990s. These contributions further declined to less than 3 percent and 8 percent respectively, by the end of 2006. On the other hand, the mining sector has taken an important role of contributing towards the country's economic activities, especially during the beginning of the 1990s. Since the early 1990s to date, the diamond sector has been contributing an average of above 35 percent to GDP, accounting for more than 70 percent of Botswana's export revenues and contributing around 53 percent towards total government income.

Table 1 provides the percentage contributions of each of the nine export sectors towards Botswana's total export revenue. As shown from the table, the major contributor over the years has been the diamond sector, which accounted for over 70 percent per annum for the period reported. This clearly indicates the mono-export characteristic of the country. Besides the diamond sector, the other four important export sectors are copper, nickel and matte; textiles; vehicles and parts; and meat and meat products. The copper, nickel and matte sector's contribution has been increasing over the years, from an annual average proportional share of 4.9 percent for the period 1996 to 1999, to a share of 10.7 percent in 2006. Such a trend is encouraging as it shows a movement towards export diversification.

Textile exports on the other hand have maintained an average proportional share of below five percent. The proportional revenue shares of vehicles and parts, and meat and meat products have been dwindling from an average of around 10.5 and 2.5 percent to slightly less than one percent for the period between 1996 and 2006, respectively. Nevertheless, these sectors still contribute meaningful to the economy in terms of employment and GDP. Overall, the above five sectors contribute more than 94 percent towards the country's total export revenue, shown in Table 1.

Table 1: Principal exports by percentage of total export value

Sector \ Year	1996-1999^{+}	2000	2001	2002	2003	2004	2005	2006
Diamonds	73.3	82.6	84.8	82.1	76.8	75.4	74.9	79.1
Copper, Nickel, Matte	4.9	5.8	4.1	4.4	9.6	9.6	10.3	10.7
Textiles	2.6	1.7	1.3	1.8	1.8	3.4	5.0	3.2
Meat & Meat Products	2.5	1.8	2.5	1.7	2.1	1.5	1.7	0.8
Vehicles & Parts	10.5	2.1	2.0	3.3	3.5	3.4	2.5	0.9
Sub total	**93.8**	**94**	**94.7**	**93.3**	**93.8**	**93.3**	**94.4**	**94.7**
Live animals	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Hides & Skins	0.3	0.3	0.4	0.2	0.2	0.2	0.1	0.1
Soda Ash	1.0	0.7	0.9	0.5	0.6	0.6	0.5	0.2
Other goods	4.9	5.0	3.9	6.0	5.4	6.0	5.0	4.9
Overall Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Source: own calculations using data from Botswana Central Statistical Office.
Note: '$^{+}$' Means four-year average

From Table 1, it can be concluded that the five sectors (diamond; copper, nickel and matte; textiles; vehicles and parts; and meat and meat products) are very important sectors in Botswana, hence warranting a more detailed analysis.

1.3 Justification and motivation for the research

Sentsho (undated) argues that Botswana has followed an export-led-growth strategy for more than a century (since 1885 to date). Statistical evidence indicates that export has played and continues to play a very significant role in the economic growth of the country. Specifically, export contributes over 50 percent towards the country's annual GDP, above 60 percent towards government revenue as well as a significant percentage towards employment levels.

Whilst the above information provides a clear testimony of the importance of exports to the economy of Botswana, the following contributions can be pointed out. Firstly, no systematic study has been done yet to understanding the determinants of these exports at especially sectoral level. To address this apparent shortcoming, this paper intends to analyze the determinants of the country's five major sectoral exports.

Secondly, it can be argued that export policy can serve as a valuable instrument for destination country-specific export promotion when policy formulation takes into account the trade structure of different export sectors. This implies that proper implementation of such policies requires a detailed understanding of the underlying trade models involved in the structure of any export sector. Nevertheless most past studies which employed gravity trade models on analyzing export never studied model identification. This research, through introduction of an innovative new sector specific variable to control for model structure, intends to contribute towards sectoral gravity model identification by attempting to identify whether a given sectoral gravity export model follows either a Hecksher – Ohlin/Ricardian trade model structure or a product differentiation trade model structure.

1.4 Objectives of the research

The specific objectives of this paper are to:

1. Investigate the determinants of the country's sectoral exports; and

2. Categorize and identify the structure of sectoral exports into either Hecksher-Ohlin/Ricardian trade model or differentiated products trade model.

2 The Gravity Model

Whilst the gravity model have been used in a number of fields of studies such as human migration and investment flows across countries, its application in international trade seems to dominate its overall use. The gravity trade model borrows from Newton's gravitational theory. Newton's theory postulates that the force of attraction between two separate entities i and j is a positive function of the entities' respective masses and inversely related to the squared distance between the objects. In analyzing trade using the same gravity principle, the entities are replaced by a pair of countries, while the countries' masses are proxied by the respective gross domestic product (GDP) with distance replaced by a variable representing resistance (which in most cases is the actual distance between the pair of trading countries).

Application of the gravity equation in the context of international trade for the first time was independently done by Tinbergen (1962) and Pöyhönen (1963) who, nonetheless, did not make any attempt to justify it theoretically but instead referred to a simple analogy with physics. The earliest and not completely successful attempts to provide a theoretical justification for the gravity equation include Linneman (1966), Leamer and Stern (1970) and Leamer (1970). However, Celsik (2007) claim that derivation of the gravity equation from a formal model was not possible until the product homogeneity assumption, typical of the early neoclassical trade literature, was relaxed.

There are broadly two competing models of international trade that provide theoretical justification for the gravity model. They are the differentiated products model and the Heckscher-Ohlin model. Anderson (1979) popularized the differentiated product model. His point of departure was the use of the Armington assumption that products were differentiated by country-of-origin. Thus Anderson (1979) demonstrated how to derive a gravity equation by employing the properties of a Cobb-Douglas expenditure system in a case where each good was produced by one country only. Helpman's (1987) theoretical exposure also assumed monopolistic competition and product differentiation among firms in all industries rather than countries. The monopolistic competition approach was viewed as a stylish way of endogenizing product differentiation and explaining formally the basis for the Armington assumption. The main purpose of monopolistic competition in Helpman's (1987) model was to assure that different countries specialize in production of different varieties of differentiated products due to the existence of economies of scale at the firm level which enhances the incentives for foreign trade.

In contrast, Deardorff (1995) has shown that the gravity model can be derived from several variants of the Heckscher-Ohlin (H-O) model based on comparative advantage and perfect competition if it is properly considered. He determined that the absence of all barriers to trade in homogeneous products causes producers and consumers to be indifferent to the trading partners, both domestic and foreign, so long as they buy or sell the desired goods. Based on this assumption, he derived expected trade flows that correspond exactly to the simple frictionless gravity equation whenever preferences are identical. Hummel & Levinsohn (1995) conducted an empirical test with a set of non – Organization for Economic Co-operation and Development (OECD) countries where monopolistic competition was not so plausible. Their results proved that the gravity equation was also efficient in explaining the trade flows among developing countries where inter-industry trade was dominant with scarce monopolistic competition. Their findings questioned the uniqueness of the product differentiation model in explaining the success of the gravity equation and proved that a variety of other models, including the H-O model, can serve as alternatives.

Following the aforementioned theoretical developments, it is generally accepted that a number of trade models are responsible for the empirical success of the gravity equation. While the H-O theory would account for the success of the gravity equation in explaining bilateral trade flows among countries with large factor proportion differences and high shares of inter-industry (so-called 'North-South' trade), the differentiated product model would serve well in explaining the bilateral trade flows among countries with high shares of intra-industry trade (so called 'North-North' trade) in increasing returns with monopolistic competition. Therefore the different theories underlying the gravity equation suggest different trade policy implications.

Thus, given that the Heckscher-Ohlin theory and various product differential models can be used to firmly support the generation of a gravity model equation, there is a need to at least identify which trade model fits better for bilateral export trade flows even at sectoral level. It follows therefore that model identification for empirical gravity model application remains a great challenge. To this end, this research intends to empirically contribute to this debate.

Although theoretical developments for sectoral gravity models are still scarce, one notable study which developed a sectoral gravity model which is adopted in this research was by Marques (2004: 4–9). This sectoral gravity model (though relatively similar to the traditional representation) can be represented as follows:

$$\text{Log } X^{k}_{ij} = \alpha_0 + \alpha_1 \log Y_i + \alpha_2 \log Y_j + \alpha_3 \log P_i + \alpha_4 \log P_j + \alpha_4 \log D_{ij} + \alpha_5 Z_{ij} + \alpha_6 \log \Pi_j + \varepsilon_{ij} \quad (1)$$

Where:

X^{k}_{ij} = is the value of sector *k* export trade flow from country *i* to country *j;*

Y_i and Y_j = are the countries' GDP

P_i and P_J = are the size of population in both countries (regions);

D_{ij} = physical distance from the economic centre of country *i* to that of country *j;*

Z_{ij} = a vector of dummy variables to take into account trade arrangements, border sharing, etc among the countries

Π_j = importer's inflation rate

α_0 = a constant;

Overall, in the gravity models trade is assumed to occur when domestic production is not equivalent to domestic demand. The GDP of the exporting country measures productive capacity, while that of the importing country measures absorptive capacity. A positive relationship is expected between these variables and trade. One may replace GDP by GDP per capita, though population will be dropped from the equation in such a case.

Population is used as a measure of country size, and larger countries (as measured by population) are assumed to have more diversified production and tend to be self-sufficient. A negative correlation will be expected between population and export trade in such a scenario. However, Bergstrand (1985), pointed out that there is an inconsistency in this argument, as larger populations allow for economies of scale which are translated into higher exports therefore, the sign of the coefficient of the exporting country would be indeterminate.

Head (2003) alluded to the fact that distance in gravity models acts as a sort of tax "wedge," imposing trade costs, and resulting in lower equilibrium trade flows. Thus, as distance between trading partners increase, export flows are expected to decline. In this case, theory predicts a negative relationship between export trade and distance.

Inflation measures the purchasing power of the importing countries. The sign for this variable is indeterminate. Both negative and positive signs are supported by theories from international finance. When an importing country is in an inflationary period, it means that citizens will try to avoid domestic inflation by importing (with the assumption that world import prices will be relatively lower compared to domestic prices). In this case, a positive relationship between inflation and imports (exports from Botswana's side) will be expected. On the other hand, inflation means that most consumers will scale down their purchases including imports, as their real purchasing power falls, thus resulting in a negative relationship between imports (Botswana's exports) and inflation.

Z_{ij} is a vector of trade arrangement dummies, both general and sector specific. General dummies include an African dummy, Southern African Development Community (SADC) member dummy, and Southern African Customs Union (SACU) member dummy. Sector specific dummies include the textile African Growth Opportunities Act (AGOA) dummy, meat and meat products Cotomou Agreement dummy and diamond's UK De Beers Diamond Trading Company dummy. In all the cases, the dummy will take a value of one if a trading partner is a member described by the dummy and zero otherwise. Membership to a regional economic grouping normally generates a significant increase in trade (Carrere, 2006). Thus coefficients of all the trade related arrangement dummies are expected to be positive.

Equation (1) represents the traditional or basic gravity trade model that has been employed in most empirical studies. The study is now at a position to add another new explanatory variable called revealed comparative advantage index (RCAI) (explained in Appendix A1). This new variable is intended to identify Botswana's trade pattern. That is, RCAI is included in order to see whether Botswana's sectoral exports follow the Hecksher-Ohlin trade model or the differentiated products trade model. The resulting equation is thus equation (2):

$$\text{Log } X^{k}_{ij} = \alpha_0 + \alpha_1 \log Y_i + \alpha_2 \log Y_j + \alpha_3 \log P_i + \alpha_4 \log P_j + \alpha_4 \log D_{ij} + \alpha_5 Z_{ij} + \alpha_6 \log \Pi + \alpha_7 \mathbf{RCAI} + \varepsilon_{ij} \quad (2)$$

Earlier, the study alluded to the importance of model identification as different theories underlying the equation normally results in measurable different estimations in key parameter values. It therefore can be emphasized that attempts are needed at this juncture to identify which trade model fits better for Botswana's sectoral bilateral exports. The RCAI variable is designed in such a way that its coefficient, α_7, will identify the underlying trade model from the empirical estimation results.

According to equation (2), if Botswana's sectoral patterns of trade follow the Hecksher–Ohlin trade model structure, that is trading more with a country in a complementary trade (inter-industry), the RCAI coefficient α_7 will have a positive sign. If, on the other hand, Botswana's sectoral patterns of trade follow the differentiated product model based on intra-industry trade, then the RCAI coefficient will have a negative sign and will be inversely related to the trade volume.

Nevertheless, caution has to be taken when interpreting the coefficient α_6 just by either Hecksher-Ohlin trade model or differentiated product model. Given that the dependent variable X^{k}_{ij} (bilateral sectoral export) is calculated by adding both inter-industry and intra-industry trades, any of these two models could increase the bilateral export trade flows. As such the study's model identification is dependent on the dominant strength between the two trade theories. For instance, in a situation where the study identifies the

Hecksher-Ohlin as the trade model underlying a given sectoral export, it implies a situation where there should be both types of trade models (H-O and product differentiation), with Heckscher-Ohlin trade structure remaining as the dominant structure behind that sectoral export trade. As a result the estimate of α_6 provides a basis for categorizing three mutually exclusive hypotheses:

$\alpha_7 > 0$ Trade model follows a Hecksher-Ohlin (inter-industry) structure
$\alpha_7 < 0$ Trade model follows a product differentiation (intra-industry) structure
$\alpha_7 = 0$ Indeterminate of the trade model

Thus the research will employ equation (2) for the sectoral gravity estimations and for the purpose of identifying the structure of the sectoral gravity model. Nevertheless, for comparative purposes, the basic equation (1) will also be estimated to parallel each sectoral equation (2).

2.1 Empirical Review

On the empirical side, a number of studies have been done at sectoral level. The aim of Marques and Metcalf's (2005) study was to investigate the relative importance of different determinants of sectoral trade, such as location and endowments, in shaping the trade patterns of a heterogeneous trade bloc, such as the enlarged European Union (EU). This objective was achieved by estimating a gravity model of trade flows between country groups with different skilled/unskilled labor ratios and different spatial and non-spatial trade costs, in sectors with different degrees of economies of scale and skill-intensity.

The Marques and Metcalf's (2005) study's results are summarized as follows. First, income and size were not significant determinants of Spain's trade irrespective of the fact that the country was the richest and largest in the Southern part of the EU. Second, size was found to be a more significant determinant of trade than income in the central EU, whereas exactly the opposite was true for the eastern peripheries. Third, income catching-up was found to impact on the enlarged EU internal trade patterns. The results indicated that economic distance increases center–periphery trade, but decreases periphery–periphery trade. Last, along with size and income, human capital endowments were found to be an important determinant of trade. These endowments revealed a different type of relationship between the center and each of the peripheries namely that human capital endowments increased Eastern trade, but decreased Southern trade.

Molinari (2003) employed the gravity model to estimate the level and trends of the implicit sectoral integration effects between EU members, in order to assess both the level and the evolution of EU trade integration since the 1970s. The study employed a gravity-type equation for the purpose of comparing the EU effects, both on average and over time. Estimated results showed that, on average, the textile sector was by far the most integrated trade sector with two EU countries trading 43% more than two non-EU countries. On the other hand, non-metal products and the chemical sectors were the least trade integrated sectors in the EU, both with an EU integration effect of only 9%.

The main objective of Ciuriak and Kinjo's (undated) study was to try and address the criticism levelled against the gravity model that it does not take into account comparative advantage. The study considered this criticism as critical given that comparative advantage forms the bedrock of economists' understanding of international trade. To address this problem, the study introduced a trade specialization index (TSI) as an additional variable into a gravity model to capture the degree of complementarity of trading partners' comparative advantage. The study's general findings were that the trade specialization index (TSI) clearly distinguished countries that were generally believed to be "most similar" from those that were believed to be "most different". According to the study, TSI's explanatory power in the gravity equation was good, comparing well with other established variables and it improved the overall goodness of fit of the gravity equation.

3 Estimation Procedure

3.1 Pooled versus Individual effects

Generally, panel data regression differs from normal time-series or cross-section regressions in that its econometric representation contains double subscript on its variables. An illustrative representation can take the following form:

$$y_{it} = \alpha + X'_{it}\beta + \mu_{it}, \qquad i = 1, \ldots, N;\ t = 1, \ldots, T \qquad (3)$$

with *i* denoting households, individuals, firms, countries, etc and *t* denoting time. The *i* subscript, therefore, represent the cross-section dimension, whereas *t* denotes the time-series dimension. α is a scalar, while β is a $K \times 1$ matrix and X_{it} is the i^{th} observation on K explanatory variables. In empirical literature, most of the panal data estimations utilize a one-way error component model for the disturbances, with

$$\mu_{it} = \mu_i + \nu_{it} \qquad (4)$$

where μ_i denotes the unobservable individual specific effect and v_{it} denotes the remainder disturbance. In our sectoral gravity equation, y_{it} (represented by X_{ij}^k in the actual empirical model equation 2) will measure the value of exports from a given sector, whereas X_{it} (in equation 3) contain a set of variables such as respective GDPs, distance and populations. On the other hand, μ_i (in equation 4) (or ε_{ij} in equation 2) is time-invariant and it accounts for any individual country-specific effect that is not included in the regression, such things as race, language etc. The remainder disturbance v_{it} is considered as a well-behaved white noise error term.

When it comes to estimation, one may assume that there are no individual country-specific effects present in the panel, thus assuming all the countries in the panel to be the same, and the estimation will have one (or a single) coefficient for the μ_i. The second possible option is to estimate an equation where individual country-specific effects are assumed to be present in the panel. This study's analysis will accept the latter option and therefore be based on the pooled model, though results of the country specific individual effects will be presented in the Appendix.

3.2 Fixed Effects Model (FEM) versus Random Effects Model (REM)

Basically there are two different models which can be used to estimate the individual country specific effects, that is, the fixed effects model or the random effects model. Given these two possible estimation models, a decision regarding the treatment of these effects as either fixed or random has to be made. Following Baltagi (2005:15), "the random effects model (REM) is an appropriate specification if we are drawing N individuals from a large population". On the other hand, Egger (2000:26) argue that the fixed effects model (FEM) is appropriate when estimating trade flows between ex ante predetermined selection of nations. Since the research is concerned with trade flows between Botswana and its main trading partners, the FEM will be more appropriate than the REM specification for capturing the country–specific effects.

3.4 Possible Endogeneity

Possible issues of endogeneity might involve the use of both RCAI and GDP (or GDP per capita) on the right hand side of equation (1) and equation (2). This section addresses these issues. There should be no endogeneity problem emanating from the use of RCAI since, although RCAI is based in part on exports, all the information in it is based on the composition and not on the level of exports. Thus, the dependent variable has information on the level of exports which is different, with the information contained in the RCAI.

Although economic size and income per capita is treated as exogenous variables in both equations (1) & (2), there is however theoretical and empirical support for the impact that exports can have on income. The possibilities of endogeneity of these variables, therefore, cannot be denied. To resolve this potential problem, Cyrus (2007:162), among others suggested the use of instrumental variables (IV) such as factor accumulation variables – physical capital, human capital, and labor accumulation rates – as instruments for income as these instrumental variables are assumed to be uncorrelated with the error term in a gravity regression. Despite suggestions to use instrumental variables, most authors (including Cyrus 2007) have found no greater improvements in terms of results when one uses instrumental variables. This study experimented with physical capital as a potential IV in place of GDP and the results were either the same with the one where GDP is used or in some cases worse.

3.4 Univariate characteristics of variables

The general procedure to be followed in a case where a panel has enough time-series length (that is, panel with time length (T) of above 10 years), is that the variables should be tested for stationarity before estimation.

The investigation of the univariate characteristics of the data which entail panel unit root tests is generally important given the fact that the unit root test is the first step encouraged in the determination of a potentially cointegrated relationship between variables. Normally, in the case where all the variables used in the estimation are stationary, then the traditional estimation methods can be used to estimate the relationship between variables. On the other hand, in the case where variables are nonstationary, a test for cointegration will be required. There are basically six potential panel unit root tests that can be employed for a panel stationarity test and these are summarized in Table A1 of the Appendix.

Given that the study's panel covers 1999 to 2006, which is 8 years, less than the minimum panel length of 10 years required for unit root tests, this study will not perform panel root tests.

3.5 Data Sources

All export series in US dollars used in this section are obtained from Trade and Industrial Policy Strategies (TIPS) South Africa database. This database provides a comprehensive interactive database for all trade categories from Harmonized Commodity Description and Coding System (HS) 2 to (HS) 8 digits, showing the export amount in USD as well as in local currency (Pula), the various export destinations, and the export partners' shares in the country's total exports of a given product line. The data on distance are from the following website: *www.timeanddate.com*. Population data and GDP series are from the International Monetary Fund (MF)'s World Economic Outlook (WEO) and International Financial Statistics (IFS).

4 Estimated Results

This section presents the estimated results for the pooled equations, equation (1) being the traditional or basic gravity equation, while equation (2) represents the modified gravity equation in which RCAI has been introduced to take account of equation model structure. The results for fixed model for equation (2) are presented in Appendix A3.

4.1 Diamond Sector

The result from the pooled model in Table 2 shows that both Botswana and the importers' respective GDP per capita are important determinates of diamond's exports.

An increase in GDP per capita for both Botswana and importer partners will result in increasing (Botswana) diamond export. This relationship is, as explained in Section 2, according to theoretical expectations.

The coefficient on diamond's RCAI is negative. According to the interpretation template provided in Section 2, this implies that diamond exports follow a product differentiation structure. Thus, a percentage increase in diamond's RCAI will result in a 38.5 percent increase in the proportion of total diamond exports which follows the product differentiation trade model structure.

The result also indicates that the diamond trade arrangement dummy, representing the De Beers Trading Company (situated in UK) trade arrangement through which over 90 percent of Botswana's diamond sells are handled, positively affect the mineral's exportation. This sign is theoretically expected, since trade arrangements are mostly aimed to improve trade flows (exports and imports).

The positive sign on distance is wrong as theory predicts it should be negative. A possible explanation may be that, as a means of avoiding the sector's activities falling into the trap of 'blood diamonds' like other African countries, Botswana prefers trading with buyers in far off nations, as opposed to customers in the domestic market or neighbouring countries. The assumption being that, with proximity buyers, there will be a temptation by many potential illegal diamond miners to come into the industry as they will be able to illegally sell the diamond quickly to nearby buyers located in the country or neighbouring countries.

Table 2: **Diamond Sector Regression Results**

Variable	**Equation 1**	**Equation 2**
Constant	9.30 (0.90)	76.15 (2.76)***
Botswana GDP per capita	4.61 (1.36)	7.269 (2.17)**
Importer GDP per capita	-10.3 (-3.16)***	-10.72 (-3.50)***
RCAI for Diamond		-38.49 (2.59)**
De Beers Trading Co. dummy	2.73 (3.27)***	2.72 (3.48)***
Distance in Kilometers	6.50 (3.16)***	6.76 (3.49)***
Adjusted – R^2	0.29	0.38
F-Test	5.85	6.64

Notes: [***], [**], [*] significant at 1%, 5%, 10% level
t-statistics in parenthesis

Comparing the performance of the two equations using the adjusted R^2 and F-test, indicates that equation (2), the modified gravity model performs better than the traditional model equation (1)

4.2 Copper, Nickel & Mate Sector

Regression results from the Copper sectoral exports in Table 3 shows that the sector follows the Heckscher – Ohlin (H–O) trade model structure as evidenced by a positive coefficient on the RCAI variable. A unit percent increase in RCAI will result in a 3.5 percent increase in the proportion of copper exports following the H–O trade model structure.

The coefficient on distance is negative and this is what is expected from theory. Gravity theory predicts that an increase in distance between trading partners will reduce trade (export) flows between the partners. In this case, a one percent increase in distance will reduce copper exports by 1.45 percent.

The tabulated results also show that increased inflation in the importer partner will positively affect Botswana's copper exports. Thus, as inflation increase in the importing countries, demand (imports of) for copper from Botswana will also increase.

Table 3: Copper, Nickel and Mate Sector Regression Results

Variable	Equation 1	Equation 2
Constant	6.03 (2.53)**	
Importer GDP	4.70 (5.54)***	4.20 (5.25)***
Importer population	-4.72 (-4.04)***	-3.99 (-3.76)***
RCAI for Copper		3.85 (2.60)**
Distance in Kilometers	-2.1 (-2.77)***	-1.45 (-2.54)**
Importer Inflation	3.56 (5.29)***	3.46 (5.05)***
Adjusted – R^2	0.40	0.39
F-Test	8.80	8.46

Notes: [***], [**], [*] significant at 1%, 5%, 10% level
t-statistics in parenthesis

4.3 Motor Vehicle Sector

Both Botswana's GDP and the importing partners' GDP positively increase motor vehicle sector's exports and this is in line with theory. Specifically, a unit increase in Botswana and importing countries' GDP will lead to 0.5 and 0.7 percent increase in automotive exports, respectively.

The trade structure coefficient indicates that the sectoral exports follows the H–O trade model, with a unit increase in RCAI causing a 1.4 percent increase in the proportion of automotive exports following H–O trade structure model.

Distance has a negative sign which is expected from theory and carries the same explanation as one offered above, while the sign on importing partners' population is positive. An increase in the population of importing partners simply means that they will demand more transport in the form of motor vehicles, hence importing more automobiles from Botswana. Table 4 presents the results for the automotive sector.

Table 4: Motor Vehicles Regression Results

Variable	**Equation 1**	**Equation 2**
Constant	6.49 (3.50)***	7.21 (4.032)***
Importer GDP	0.72 (2.35)***	0.725 (2.35)**
Botswana GDP	2.42 (2.71)**	2.51 (2.82)***
RCAI for Motor Vehicles		1.385 (2.16)**
Importer Population	0.60 (1.68)*	0.61 (1.73)*
Distance in Kilometers	-2.03 (5.31)***	-2.03 (-5.39)***
African dummy	1.30 (1.78)***	1.29 (1.78)*
Adjusted – R2	0.43	0.44
F-Test	23.51	20.85

Notes: [***], [**], [*] significant at 1%, 5%, 10% level
t-statistics in parenthesis

Border and proximity effects, as represented by the African dummy indicates that motor vehicle exports increase when trading with countries closer to Botswana, compared to trading with countries far off.

Overall performance of the two equations indicates that they both perform relatively the same.

4.4 Textile Sector

Textile sector's exports increase as the GDP for both the importing countries and Botswana increase. Specifically, textile exports increase by 1.6 percent and 4.2 percent, respectively, when GDP for importing countries and that of Botswana increases. These results are shown in Table 5.

The coefficient on RCAI is negative and this indicates that the sectoral export model follows a product differentiation trade structure. A percentage unit increase in RCAI will raise the proportion of total textile exports following the product differentiation trade model by 2.2 percent. The increases in inflation in the importer countries as well as the border and proximity effects both have positive impact on Botswana's textiles exports.

Table 5: Textiles Regression Results

Variable	**Equation 1**	**Equation 2**
Constant		
Importer GDP	1.60 (8.42)***	1.62 (8.60)***
Botswana GDP	2.41 (2.76)***	4.17 (4.01)***
RCAI for textiles		-2.22 (-2.71)***
Importer Inflation	0.002 (1.56)	0.002 (1.72)**

AGOA dummy	1.25 (1.95)**	1.36 (2.14)**
Distance	-0.64 (-2.92)***	-1.29 (-4.11)***
African dummy	2.99 (7.72)***	2.56 (6.06)***
Adjusted – R^2	0.34	0.36
F-Test	20.77	22.29

Notes: [***], [**], [*] significant at 1%, 5%, 10% level
t-statistics in parenthesis

The AGOA trade arrangement dummy indicates a positive effect of the country's textiles exports. This is in agreement to trade theory which expects trade to increase in the presence of regional trade arrangement.

4.5 Meat Sector

Increase in both Botswana and importers' GDP, as shown in both equation (1) and equation (2) from Table 6 results in a positive effect on the sectoral meat export. These positive signs, as explained before, are according to theoretical expectations.

The positive sign on the coefficient of RCAI in equation (2) indicates that Botswana's meat exports are mainly driven by the Heckscher – Ohlin (H–O) trade theory. Thus, a unit percent increase in RCAI will result in a 3.96 percent increase in the proportion of total meat exports following the H–O trade model structure.

In equation (1), both the Cotonou trade arrangement and distance have wrong signs as theory predicts a positive sign for the former and a negative sign for the latter. Nevertheless, both coefficients for these two variables are not statistically significant. Equation (2) indicates that the above two variables have signs predicted by theory though they are not statistically significant.

Table 6: Meat Regression Results

Variable	Equation 1	Equation 2
Constant		
Importer GDP	0.94 (2.72)***	0.84 (2.41)**
Botswana GDP	2.92 (1.81)***	3.75 (2.32)**
RCAI for meat		3.96 (2.12)**
Importer Inflation	-0.74 (-1.85)*	-1.05 (2.12)**
Cotonou dummy	-1.09 (-1. 47)	0.64 (-0.84)
Distance	0.50 (1.28)	-0.13 (-0.26)
Adjusted – R^2	0.16	0.20
F-Test	4.58	4.74

Notes: [***], [**], [*] significant at 1%, 5%, 10% level
t-statistics in parenthesis

5 CONCLUSION

This study applies a sectoral gravity model to explain Botswana's bilateral export trade flows using panel data econometric techniques. Five sectoral gravity equations for each of the five export sectors are estimated. Trade structure and sector specific trade arrangement variables are included in the respective gravity model equation to characterize the peculiarity of Botswana's trade patterns. Specifically, the trade structure variable captures the trade model behind any given sector's exports. The empirical results show that of the five sectors investigated, the diamond and textiles sectors' export trade follows a product differentiation model. The Heckscher–Ohlin model underpins exports in vehicle/automotive, copper, nickel & mate; and meat export sectors. The study also determined that the specific trade arrangements positively affect Botswana's trade export to its trade partners.

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APPENDIX

A1 REVEALED COMPARATIVE ADVANTAGE

Revealed comparative advantage (RCA) was pioneered by Bella Balassa (1965). The approach emanated from difficulties in measuring an industry's actual comparative advantage in production and trade. Specifically, given the difficulties in (i) accounting for all the factors which influence an industry's comparative advantage, and (ii) actually measuring and comparing these factors between countries and industries, Balassa argued that the revealed performance of an industry's trade pattern would serve as a reasonably adequate indicator of that industry's comparative advantage (Hamilton and Svensson, 1984).

RCA says if a country can produce a good at a lower cost relative to other countries, then with international trade, that country should devote more of its scare resources to the production of that good. Through trade, that country can obtain other goods at a lower price (opportunity cost), in exchange for the good in which it has a comparative advantage. Thus according to the predictions of RCA, if a country has a comparative advantage in the production of a good, it should be found to export a higher proportion of that good relative to other countries.

Following Balassa's (1965), RCAI formulation is expressed as follows:

$$RCA_{ij} = (X_{ij}/X_i) / (X_{wj}/X_w) = (X_{ij}/X_{wj}) / (X_i/X_w) \quad \text{(A1}$$

where: RCA_{ij} = country i's revealed comparative advantage for good j

X_{ij} = i^{th} country's exports of commodity (or industry) j

X_i = i^{th} country's total exports

X_{wj} = world exports of commodity (or industry) j

X_w = total world exports

RCA_{ij} measures a country's exports of a sector (or commodity or industry) relative to its total exports and to the corresponding world exports. A comparative advantage is "revealed", if RCA >1. On the other hand, if RCA_{ij} is less than unity, the country is said to have a comparative disadvantage in the commodity/industry.

A2 DIFFERENT TYPES OF PANEL UNIT ROOT TEST STATISTICS

Table A1: Different types of panel unit root tests statistics

Test	**H_0**	**H_A**	**Assumption of the unit root process (Common/ individual)**	**Test statistic**	**When to reject H_0 and associated inference in this case**
Levin, Lin, Chu (LLC) (2002)	Each individual time series contains a unit root	Each time series is stationary	Common	Adjusted (standardised) ***t*-statistic** t^*_ρ on pooled regression: $\tilde{e}_{it} = \rho\tilde{v}_{i,t-1} + \tilde{\varepsilon}_{it}$	$p<0.05$; panel is stationary
Breitung (2000)	Each individual time series contains a unit root	Each time series is stationary	Common	Adjusted (standardised) ***t*-statistic** on pooled regression: $e^*_{it} = \rho v^*_{i,t-1} + \varepsilon^*_{it}$	$p<0.05$; panel is stationary
Im, Pesaran, Shin (2003)	Each individual time series contains a (series specific) unit root, $\rho_i = 0 \ \forall_i$	Some (but not all) of the individual series have unit roots, i.e., $p_i<0$ for at least one i.	Individual	Weighted, standardised ***t*-statistic** based on t-stats of individual ρ_i coefficients (individual ADF statistics)	$p<0.05$; panel is stationary
ADF-Fisher (Madala & Wu 1999; Choi 2001)	Each individual time series contains a (series specific) unit root, $\rho_i = 0 \ \forall_i$	Some (but not all) of the individual series have unit roots, i.e., $p_i<0$ for at least one i.	Individual	**Combined information on *p*-values** of individual unit root tests: $P = -2\sum_{i=1}^{N} \ln p_i$	$p<0.05$; panel is stationary
PP-Fisher Madala & Wu 1999; Choi 2001)	Each individual time series contains a (series specific) unit root, $\rho_i = 0 \ \forall_i$	Some (but not all) of the individual series have unit roots, i.e., $p_i<0$ for at least one i.	Individual	**Combined information on *p*-values** of individual unit root tests: $P = -2\sum_{i=1}^{N} \ln p_i$	$p<0.05$; panel is stationary
Hadri (2000)	No unit roots in any of the series in the panel	All series contain unit roots	Common	Two standardised ***Z*-statistics** (based on two *LM* statistics, where one allows for heteroskedastisity accros *i*)	$p<0.05$; panel is non-stationary

Source: author compilation

A3 FIXED EFFECTS REGRESSION RESULTS

This section presents the regression results from the fixed effects models. Estimated results indicate that only the motor vehicle sector has meaningful fixed effects model as evidenced by the fact that all variables in the equation are statistically significant. On the other hand, the fixed effects models for the other four sectors are not statistically significant.

Table A2: **Diamond Sector Regression Results**

Variable	**Fixed Effects Model**
Botswana GDP per capita	-1.10 (-0.22)
Importer GDP per capita	2.76 (0.41)
RCAI for Diamond	-34.98 (-2.41)**
Adjusted – R^2	0.41
F-Test	5.09

Notes: [***], [**], [*] significant at 1%, 5%, 10% level
t-statistics in parenthesis

Table A3: Copper Sector Regression Results

Variable	**Fixed Effects Model**
Importer GDP per capita	0.44 (0.35)
Botswana GDP per capita	6.61 (1.95) *
Importer Inflation	-0.14 (-0.48)
Adjusted – R^2	0.78
F-Test	20.30

Notes: [***], [**], [*] significant at 1%, 5%, 10% level
t-statistics in parenthesis

Table A4: Motor Vehicles Regression Results

Variable	**Fixed Effects Model**
Constant	-8.36 (-3)***
Importer GDP per capita	1.942 (2.425)**
Botswana GDP per capita	1.935 (2.139)**
RCAI for Motor Vehicles	1.328 (2.478)**
Adjusted – R2	0.60
F-Test	11.39

Notes: [***], [**], [*] significant at 1%, 5%, 10% level
t-statistics in parenthesis

Table A5: Textiles Regression Results

Variable	Fixed Effects Model
Constant	-5.95 (-0.90)
Importer GDP	1.82 (1.59)
Botswana GDP	-3.67 (-1.55)
RCAI for textiles	2.33 (1.71)*
Botswana population	64.71 (1.54)
Pula/USD exchange rate	-2.53 (-1.18)
Adjusted – R^2	0.56
F-Test	9.58

Notes: [***], [**], [*] significant at 1%, 5%, 10% level
t-statistics in parenthesis

Table A6: Meat Regression Results

Variable	Fixed Effects Model
Constant	6.39 (1.95)**
Importer GDP	-1.06 (-0.699)
Botswana GDP	1.07 (0.514)
RCAI for meat	0.61 (0.32)
Importer Inflation	-0.39 (-0.45)
Adjusted – R^2	0.52
F-Test	6.77

Notes: [***], [**], [*] significant at 1%, 5%, 10% level
t-statistics in parenthesis