Title: An empirical test of the Dutch Disease hypothesis on Botswana's main exports

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Abstract

Although the Dutch Disease (DD) model clearly predicts that a resource boom always hurt a country's manufacturing exports, the case of Botswana however defies this predicted resource curse. Whilst qualitative literature describes how the country has managed to avoid the resource curse hook, this study econometrically test the DD hypothesis on the country's main export products from the manufacturing, mining and agriculture sectors. The study employed the gravity trade model to test this hypothesis. Estimated results indicated that, diamond exports, instead of hurting the country's exports, it rather boosted exports from manufacturing, mining and agricultural sectors.
“There can be no doubt that diamonds have played a major part in the transformation of our country’s fortunes and the lives of our citizens…Revenue from diamonds has enabled Government to fund virtually 100% of basic education, provide virtually free healthcare, build infrastructure that has supported our economic activity and to fund 80% of the anti-retroviral drugs that have give hope to our fellow citizens living with HIV/AIDS”

[Former President Mogae of Botswana, 13th November 2006]

“For our people, every diamond purchase resents food on the table; better living conditions; better healthcare; safe drinking water; more roads to connect our remote communities and much more” [Former President Mogae of Botswana, 7th June 2006]

“We have prudently used the revenues from diamonds to build a modern nation and a vibrant economy” [Former President Mogae of Botswana, 7th June 2006]

[Source: available at: diamondfacts.org]
1.0 Introduction

Although controversies still exist as to the effect of natural resources abundance to a given country, literature is abound with evidence that natural resources booms tend to hurt countries in which they occur. According to Stevens (2003), a larger proportion of the voluminous research on the relationship between resources abundance and general economic well-being suggests that countries rich in resources perform badly when compared to other nations and that the former groups of countries are normally cursed by their natural wealth resources. Sachs and Warner (1995) indicate that countries which are resource intensive exporters tend to have low economic growth paths compared to other non-intensive resource exporters. Osson and Fors (2004), enumerating examples of countries like Angola, Democratic Republic of Congo (DRC), and Sierra Leone, argues that rents from natural resources in these countries have increased chances of civil conflicts and wars.

Contrary to the widespread evidence of the curses inflicted on a number of countries because of abundant natural resources, Botswana’s experience is one where the natural resource diamond have been combined with human ingenuity to create human capital and knowledge innovation, thereby contributing positively to the country’s economic growth and development. In fact, the country’s economic growth trend since independence in 1966 has been remarkable. According to the country’s former president:
“It is thanks to diamonds...that we have seen our country transform from one of the poorest in the world at independence, to the middle income status that it now attained” [Former President Mogae of Botswana, 7th June 2006]¹

This is in sharp contrast to the realities which the country’s neighbour, Zambia experienced due to copper boom in the 1970s as the latter country’s former president once lamented:

“We are in part to blame, but this is the curse of being born with a copper spoon in our mouths” [Kenneth Kaunda, former President of Zambia] (Quoted in Sarraf and Jiwanji, 2001)

Overall, the resource curse mainly bedevil resource abundant countries when the resources causes an existence of a rentier predatory state where corruption, political conflict and inequalities become the norm of life, as well as leading to a situation in which economic institutions are poorly developed with human capital accumulation, entrepreneurship and innovative activities being crowded out and policy makers being more interested in resource transfers and opposed to development and modernization of the country’s economy (Auty, 2001; Gylfason, 2001; Isham et al., 2003; Lal and Myint, 1996).

¹ www.diamondfacts.org
1.1 Country brief background

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 gross domestic product (GDP) per capita of above US$11,000 as of 2008, making it an upper middle income country by World Bank classification. The country has experienced by far the highest sustainable economic growth rates in Sub-Sahara Africa (SSA) averaging 8.4% per year over the entire 1965 – 1990 period and a still-high 5.1% in the 1990-2008. Thus since its independence, the country has gone from being among the poorest countries in world to one with a greater per capita income than Turkey, Thailand, or Brazil (Todaro and Smith, 2006). In fact, it is considered the richest non-oil producing country in Africa. The country’s experience shows that with fiscal discipline and sound management, mineral wealth can be a benefit in a country that has the appropriate political development in place.

Historical economic activities indicate 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.

In terms of annual contributions (since mid-1990s to date) to the economy, the diamond sector continues to be the mainstay of the economy, accounting for above 35 per cent of the country’s gross domestic product (GDP) (a significant improvement from the less than 18 percent that the sector contributed to the country's GDP in 1975/6 (Kapunda, undated)), contributing more that 75 percent towards export revenue and 53% of Government revenues. The sector directly employs more than 6 500\(^2\) people and is considered to be the largest single employer in Botswana second to government, employing a total of 25 percent (directly and indirectly linked to diamonds) of the total labour force of the country\(^3\).

The combination of the country’s over reliance and dependence on diamond export revenues for its economic growth and development over three decades with continued economic growth is interesting given that most resource-rich countries, especially developing nations in Africa have been vulnerable to the Dutch Disease (DD). In summary, the Dutch Disease is a situation whereby a natural resource booming export sector causes relative prices in both non-tradable and service sectors to increase, with the resultant effect being the hurting of the rest of the tradable goods sector.


\(^3\) http://www.diamondfacts.org/pdfs/media/media_resources/fact_sheets/Diamonds_and_Their_Benefits_to_Africa_Fact_Sheet.pdf.
To this end, the study is motivated by the fact that literature, for instance, Sarraf and Jiwanji (2001) and Transparency International (undated) claims that Botswana has defied the resources curse and instead turned the potential curse into a blessing through good governance, among other things. The main objective of this paper is therefore to empirically investigate the validity of the DD effects on the economy of Botswana. The study will test the consequences of the diamond resource boom on the country’s manufacturing exports namely, textiles and motor vehicles; mining exports, namely copper and soda ash; and agricultural exports of meat and meat products.

The outline of the paper is as follows. The preceding section provided the introduction of the research as well as the objectives to be achieved. Section 2 will present a brief description of the DD’s core model with Section 3 reviewing existing literature. Study methodology and results are discussed in Section 4 while Section 5 provides conclusion of the research.

2.0 **The “Core Model” of the Dutch Disease**

The DD has its origin from the problems which Netherlands experienced after the discovery and exploitation of vast domestic natural gas reserves in the 1960s. These activities resulted in a shift of production factors towards the gas industry while at the same time increasing the prices of non-tradable goods and services, thus hurting all
tradable goods. The term, Dutch Disease (DD), according to Corden (1984) was however coined by The Economist of November 26, 1977.

Corden and Nearly (1982) provides the architecture of the DD model. In the model, three sectors are assumed: the Booming sector (B), the Lagging sector (L) and the Non-Tradable sector (N), with the prices of tradable products from the first two sectors determined at world markets. Capital and labour are the two factors which are employed in each of the three sectors, with capital being sector specific while labour being mobile across these sectors with the ability of equalizing wages across these sectors.

A boom in B sector normally increases total income of factors used in that sector. Corden (1984) argues that the boom in sector B can be as a result of the following three possibilities. (1) There has been a once-for-all exogenous technical improvement in B, mainly underpinned by a favourable shift in the production function toward sector B. (2) The sector experienced a windfall of discovery of new resources, for instance, increase in supply of the specific factor in question say diamond in the case of Botswana. (3) Sector B produces exclusively for the export market and there happens an exogenous increase in the price of its goods on the international market relative to the price of imports. From these three possibilities, Botswana suits case (2), thus the analysis which follows will be inclined toward this type of a boom.

Given the above three sectors, most literature categorize the DD effect into three effects: the resource movement effect, the spending effect and the exchange rate effect. The
resource movement effect is normally assumed to happen on the supply side of the economy, where it occurs when the profitable natural resource sector lures productive resources (human talent and labour, capital, public spending, etc) from other sectors, tradable or non-tradable, with the latter sectors facing reduced employment of such resources, thus resulting in them having depressed growth. In other words, the resource movement has the impact of ‘crowding out’ other sectors as the dominant oil, gas or mining industry takes priority claim on scarce resources (local capital, skills, infrastructure, and suppliers).

The spending effect which normally happens on the demand side is a direct result of the ‘windfall’ of revenues in the natural resource which leads to increased income at home, thus creating a rising demand (and thus inflation) for all goods in other sectors in the economy, both tradable and non-tradable. Given that the prices for the tradable sectors are determined by the world markets, the country’s products on the international market become uncompetitive in that sector. This situation is further aggravated by the exchange rate effect. The exchange rate effect comes into play since a huge inflow of foreign exchange from oil (or natural gas or minerals) exports result in increased demand for the domestic currency of the oil (gas or mineral) exporting country, with this increased currency demand in turn causing an appreciation of the exporting country’s real exchange rate. Due to this appreciation tradable products become relatively more expensive and less competitive both domestically and on external markets. At the same time, strong domestic currency versus other currencies will imply an increase in imports as they become relatively cheaper and affordable, resulting in domestically produced goods
being squeezed out of the market. The end result, according to Carneiro (2007) will be the withering of the agricultural, manufacturing, and other sectors of the economy, as well as potential loss of jobs in these sectors, and development of an even greater economic dependence on the oil (natural gas or mineral) industry.

Whilst voluminous literature on the subject matter has focused mostly on oil-resource exports, Al-Sabah (1988) argues that, although the DD was experienced in Netherlands in the 1960s following gas discoveries, the diseases is not however exclusive to oil-resourced countries only, but rather it has also occurred in other non-oil exporting countries. For instance, Japan’s manufacturing sector’s technological advance boom in the 1960s adversely affected less dynamic tradable sectors, including the agriculture sector. Also the booming of Swiss bonds and money exports in the 1970s resulted in real appreciation of the Swiss franc hurting the country’s traditional exports and export-competing industries.

3.0 Literature Review

Sarraf and Jiwanji (2001) carried a qualitative study on Botswana which focused, among other things on management of the country’s diamond mineral boom. The research analyzed the management of Botswana government’s budget and accumulation of international reserves, placing special investigation on the government’s control over expenditures, investment decisions, domestic investments, international investment and
management of the exchange rate and economic diversification. The study’s conclusion was that Botswana presented an illustrative case where natural resource curse was not necessarily the fate of all resource abundant countries, but rather prudent economic management helped the country to avoid the disastrous effects of the resource curse. The research also considered the country’s long term sustained economic growth underpinned by the country’s avoidance of external debt, ability to stabilize growth and encouragement of economic diversification.

A paper by Transparency International (undated) considered Botswana’s good governance and integrity of its public institutions as the main reasons why the country has managed to avoid the resource curse. The study praised the country’s national integrity system, with special emphasis on democratic accountability, judicial system, services of ombudsman and free media as some of the apparatus which have helped the government in instituting appropriate policies in handling the diamond industry and the use of the mineral’s revenues.

Budina et al (2007) investigated the possibility of the Dutch Disease and debt overhang on the growth part of Nigeria since the 1970s. The study found out that, although Nigeria experienced an oil boom, that boom failed to halt the country’s continuous stagnation in the non-oil economy of the country. After a careful examination of the macroeconomic policies over the years and government’s management of the windfall oil revenues, the study concluded that extreme volatility of national or government expenditure were the main cause behind the disappointing non-oil growth record and not the Dutch Disease.
The study argues that the country’s fiscal policies over the years did not only fail to smooth highly volatile oil income, but rather, government expenditure was even more volatile than oil income.

Stijns (2003) employed a gravity trade model to empirically test the Dutch Disease hypothesis on a number of countries. The study found strong evidence of the DD, with energy price led booms systematically tending to hurt manufacturing exports of the energy exporters.

4.0 Methodology

The study borrows from the methodology employed Stijns (2003) in which a gravity trade model was used to test the DD, but with an added specific term to represent the DD in the model. The gravity trade model borrows from Isaac Newton’s Law of Universal Gravitation which postulates that the force of attraction, \( F_{ij} \), between two separate entities \( i \) and \( j \) is a positive function of the entities’ respective masses, \( m_i \) and \( m_j \), and inversely related to the squared distance, \( d_{ij}^2 \), 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. Nevertheless, over the years, theoretical underpinnings for the gravity model equation have, according to Frankel (1998) “gone from an embarrassment of poverty of theoretical foundations to embarrassment of riches”. These theoretical justification ranges from increasing returns to scale, monopolistic competition, to factor or technological differences. Anderson (1979), Bergstrand (1985, 1989), Feenstra, Markusen and Rose (1999), and Evenett and Keller (2002) are some of the authors who provide theoretical foundations for gravity trade models.

In analyzing trade, the basic gravity trade model which has been used in empirical work over the years was original specified by Tinbergen (1962) and Pöyhönen (1963) as follows:

\[
\text{Trade}_{ij} = \alpha \frac{\text{GDP}_i^{\beta_1} \text{GDP}_j^{\beta_2}}{(D_{ij})^{\rho_1}}
\]  

(1)

where \(\text{Trade}_{ij}\) represents bi-lateral trade (exports plus imports) between country \(i\) and \(j\), while \(\text{GDP}_i\) and \(\text{GDP}_j\) denote country \(i\) and \(j\)'s respective gross domestic products. \(D_{ij}\) is used as a proxy of bi-lateral distance between the two trading countries. In the formula above, \(\alpha\) and \(\beta\)s are parameters and the sign of \(\beta_1\) and \(\beta_2\) are expected to be positive,
while that for $\beta_3$ will have a priori negative sign. Taking logarithm of equation (1), the resulting linear formulation becomes:

$$\ln(\text{Trade}_{ij}) = \alpha + \beta_1 \ln GDP_i + \beta_2 \ln GDP_j - \beta_3 \ln (D_{ij}) + \mu_{ij}$$

(2)

where $\alpha$, $\beta_1$, $\beta_2$ and $\beta_3$ are coefficients to be estimated. The disturbance error term ($\mu_{ij}$) captures random events which may have an impact on bilateral trade between the two trading countries and is assumed to be normally stationary, with mean zero and a constant variance. Thus equation (2) is the core gravity equation which has been used in all empirical studies, though with added right hand side (RHS) variables, with each RHS variable added depending on the particular facet of trade being analyzed, the objectives to be achieved and availability of data.

4.1 Estimated equation

The following gravity equation model will be estimated.

$$\ln(\text{Trade}_{ij}) = \alpha_0 + \beta_1 \ln GDP_i + \beta_2 \ln GDP_j + \beta_3 \ln D_{ij} + \beta_4 \ln P_i + \beta_5 \ln P_j + \beta_6 \text{PTA} + \beta_7 B + \beta_8 DD + \beta_9 \ln \Pi_j + \beta_{10} \ln Z_{ij} + \epsilon_{ij}$$

(3)

Where:
Trade\textsubscript{ij}, GDP\textsubscript{i}, GDP\textsubscript{j}, and D\textsubscript{ij} are as defined before;

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

PTA\textsubscript{ij} = Preferential trade arrangement between trading countries \(i\) and \(j\).

B\textsubscript{ij} = Common border between trading countries \(i\) and \(j\).

B = Common border

DD = is a diamond Dutch Disease resource boom indicator or variable

\(\Pi_j\) = importer’s inflation rate

\(Z_{ij}\) = represents other possible variables used in international trade literature

\(\alpha_0\) = a constant;

Overall, in the gravity models, trade is assumed to occur when domestic production is not equivalent to domestic demand. The GDP of Botswana measures productive capacity of the country and can be considered as a proxy for the range of product varieties available, which increase the availability of exports in that sector. The GDP of the importing country measures absorptive capacity and represents potential demand for imports. Thus, \(\beta_1\) and \(\beta_2\) are expected to have positive signs.

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 inflationary period, it means that citizens will try to avoid domestic inflation by importing (with the assumption that world import price 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 really purchasing power falls, thus resulting in a negative relationship between imports (Botswana’s exports) and inflation.

PTA\textsubscript{ijk} is a vector of specific preferential trade arrangement (PTA) dummies between Botswana and a trading partner. The PTA dummies included are for Southern African Customs Union (SACU) and Southern African Development Community (SADC). In this research, membership to a trade arrangement normally generates a significant increase in trade given that countries enter into such arrangements mostly with the aim of increasing
trade among them. Thus, coefficients of all the trade related arrangement dummies are expected to be positive.

Common border, like PTA dummies is a measure of proximity of trading partners which in turn imply that there will be relatively shorter distances when compared to far off trading partner countries, thus motivating trade. To this end, common border dummy is expected to be positively related to trade between countries.

Z$_{ij}$ represents other possible variables used in international trade literature. Whilst all trade researchers agree to the empirical gravity trade model specification where trade is the dependent variable, while GDPs and distance are the core explanatory variables; contention still exists on which other variables to be included in the extended gravity trade model. As a result of this contention, Ghosh and Yamarik (2004) used 49 variables in their gravity model though they divided into five categories: dependent, core factors, regional trading arrangements, other variables, and time dummies. As evidenced in literature, the choice of variables to include in the extended gravity models (besides the core variables) normally depends on the purpose (objectives) of the study and availability of data, among other issues.

In this study, the Dutch Disease (DD) term is defined as total net diamond export following the approach by Stijns (2003) and is mathematical driven as:

$$\text{TNEX}_{ijt} = \Sigma \text{EX}_{ijt} - \Sigma \text{EX}_{jit} = \Sigma \text{NEX}_{ijt}$$

(4)
From the theoretical exposition provided in section 3 of this study, DD is expected to hurt exports of other non-diamond products, thus a negative relationship between exports of non-diamond products and DD is expected.

4.2 Estimation Procedure

4.2.1 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:

\[ y_{it} = \alpha + X'_{it} \beta + \mu_{it}, \quad i = 1, \ldots, N; \; t = 1, \ldots, T \]  

(5)

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. \( \alpha \) is a scalar, while \( \beta \) is a \( K \times 1 \) matrix and \( X_{it} \) is the \( i^{th} \) observation on \( K \) explanatory variables. In empirical literature, most of the panel data estimations utilize a one-way error component model for the disturbances, with

\[ \mu_{it} = \mu_i + \nu_{it} \]  

(6)
where $\mu_i$ denotes the unobservable individual specific effect and $v_{it}$ denotes the remainder disturbance. In our gravity equation, $y_{it}$ (represented by trade$_{ij}$ in the actual empirical model equation (3)) will measure the value of trade between Botswana and its trading partners, whereas $X_{it}$ (in equation (5)) contain a set of variables such as respective GDPs, distance and populations. On the other hand, $\mu_i$ (in equation (6)) (or $\epsilon_{ij}$ in equation (3)) 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 $v_{it}$ (in equation (6)) is considered as a well-behaved white noise error term.

On the estimation side there are broadly two ways that can be done. Firstly, 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, thus the estimation will have one (or a single) coefficient for the $\mu_i$. If such a route is chosen, a pooled estimation will be the model implemented. The second possible option is to estimate an equation where individual country-specific effects are assumed to be present in the panel. Although the individual country-specific effects will be the most appropriate model, this study’s will however be based on the pooled model. This is necessitated by the fact that the results from the country-specific model are not statistically significant.
4.3 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 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 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 panel stationarity test and these are summarized in Table 1A of Appendix. Given that the study’s panel covers 1999 to 2006, that 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.

4.4 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 system (HS) 2 to HS 6 digits, showing the export amount in US dollars 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). The estimations are done for the period 1999 to 2006.

4.5 Results

The results from the estimated gravity models for the country’s major six exports are presented in Table 1.

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The tabulated results indicate that the coefficients of the GDPs for the importing countries are correctly and positively signed according to theory and are also statistically significant in four of the six equations. The coefficients on Botswana’s GDP is however either not significant or having a wrong negative sign in most of the equations. The coefficients on distance are negative and according to theory in all the six equations, though they are significant in only four equations.

The coefficients on the variable of interest in testing the Dutch Disease, total net diamond exports (TNEX), are positive in five of the six equations. According to the theoretical
expectations as presented in section 4.1, DD will be assumed to hurt any sectoral exports in the case where a negative coefficient on the DD variable is found in any sectoral gravity model. However, as shown in Table 1, only hides and skins exports have a negative coefficient on DD, although the coefficient is not statistically significant. On the other hand, the other five sectoral exports: copper, meat and meat products, soda and ash, textiles and vehicles have positive coefficient on DD. These positive coefficients on DD variable imply that diamond boom has not hurt exports from these five sectors. Thus, these results therefore implies that the ‘resource course” or the Dutch Disease have not affected Botswana’s exports at least for the period 1999 to 2006. Also the results confirm qualitative literature on Botswana (for instance, Sarraf (2001) and Transparency International (undated)) which says that the country has beaten the resource curse case and thus avoided the Dutch Disease.

5.0 Conclusion

The main objective of the study was to investigate whether diamond resource boom has affected manufacturing, mining and agriculture exports as predicted by the Dutch Disease (DD) theorem. The latter model clearly predicts that a resource boom always hurt a country's. Through the use of a tailor-made gravity trade model, the study tested this DD hypothesis on Botswana’s main export products. The overall results indicates that diamond boom have not negatively affected exports from copper, meat and meat products, soda and ash, textiles, vehicles and hides. Thus, one can concluded that resource curse and DD has not hurt the country’s six major exports.
Table 1: Gravity trade model results

<table>
<thead>
<tr>
<th>Product/Variable</th>
<th>Copper GDP</th>
<th>Meat and meat products</th>
<th>Soda and ash</th>
<th>Hides GDP</th>
<th>Textile</th>
<th>Vehicles GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP</td>
<td>-0.21 (-0.7)</td>
<td>0.72 (3.52)***</td>
<td>-0.19 (-1.1)</td>
<td>0.73 (5.2)***</td>
<td>0.3(2.8)***</td>
<td>0.44 (4.0)***</td>
</tr>
<tr>
<td>Botswana GDP</td>
<td>3.23 (1.7)*</td>
<td>-3.1 (-2.1)**</td>
<td>-0.38 (-0.33)</td>
<td>-1.8 (-1.7)*</td>
<td>-0.5 (-0.9)</td>
<td>0.81 (1.3)</td>
</tr>
<tr>
<td>Importer Population</td>
<td>-0.64 (-1.9)*</td>
<td>-----</td>
<td>0.08 (0.33)</td>
<td>-----</td>
<td>1.2 (10)***</td>
<td>0.68 (5.8)***</td>
</tr>
<tr>
<td>Botswana Population</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>1.6 (2.8)</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>TNE</td>
<td>0.37 (1.8)*</td>
<td>2.3 (5.8)***</td>
<td>1.52 (10.7)***</td>
<td>-0.64 (-0.87)</td>
<td>0.38(2.3)**</td>
<td>0.72 (5.6)***</td>
</tr>
<tr>
<td>Distance</td>
<td>-0.05 (-0.2)</td>
<td>-3.9 (-4.6)***</td>
<td>-2.9 (-9.3)***</td>
<td>-2.3(-5.2)***</td>
<td>-0.2 (-0.55)</td>
<td>-1.1(-3.9)***</td>
</tr>
<tr>
<td>Importer Inflation</td>
<td>0.01 (2.2)**</td>
<td>-----</td>
<td>0.01 (3.0)***</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>SACU</td>
<td>---</td>
<td>----</td>
<td>-----</td>
<td>0.08 (0.06)</td>
<td>-----</td>
<td>1.5 (2.0)**</td>
</tr>
<tr>
<td>SADC</td>
<td>-----</td>
<td>----</td>
<td>-----</td>
<td>----</td>
<td>4.2</td>
<td>-----</td>
</tr>
<tr>
<td>Common border</td>
<td>----</td>
<td>-7.5 (-3.5)***</td>
<td>-----</td>
<td>----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>R²</td>
<td>0.21</td>
<td>0.16</td>
<td>0.78</td>
<td>0.38</td>
<td>0.31</td>
<td>0.23</td>
</tr>
<tr>
<td>F-Test</td>
<td>5.6</td>
<td>6.8</td>
<td>45.8</td>
<td>15.7</td>
<td>29.5</td>
<td>18.7</td>
</tr>
</tbody>
</table>

Notes: [***], [**], [*] significant at 1%, 5%, 10% level

T-statistics in parenthesis
REFERENCES


### Table 1A: Different types of panel unit root tests statistics

<table>
<thead>
<tr>
<th>Test</th>
<th>H₀</th>
<th>Hₐ</th>
<th>Assumption of the unit root process (Common/individual)</th>
<th>Test statistic</th>
<th>When to reject H₀ and associated inference in this case</th>
</tr>
</thead>
<tbody>
<tr>
<td>Levin, Lin, Chu (LLC) (2002)</td>
<td>Each individual time series contains a unit root</td>
<td>Each time series is stationary</td>
<td>Common</td>
<td>Adjusted (standardised) t-statistic ₜᵢ on pooled regression:</td>
<td>p&lt;0.05; panel is stationary</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ₑᵢ = ₚₑᵢ,ₜᵢ₋₁ + ₑᵢ</td>
<td></td>
</tr>
<tr>
<td>Breitung (2000)</td>
<td>Each individual time series contains a unit root</td>
<td>Each time series is stationary</td>
<td>Common</td>
<td>Adjusted (standardised) t-statistic ₜᵢ on pooled regression:</td>
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</tr>
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<td>ₑᵢ = ₚₑᵢ,ₜᵢ₋₁ + ₑᵢ</td>
<td></td>
</tr>
<tr>
<td>Im, Pesaran, Shin (2003)</td>
<td>Each individual time series contains a (series specific) unit root, ₚᵢ = 0 ∀ᵢ</td>
<td>Some (but not all) of the individual series have unit roots, i.e., ₚᵢ&lt;0 for at least one i.</td>
<td>Individual</td>
<td>Weighted, standardised t-statistic on t-stats of individual ₚᵢ coefficients (individual ADF statistics)</td>
<td>p&lt;0.05; panel is stationary</td>
</tr>
<tr>
<td>ADF-Fisher (Madala &amp; Wu 1999; Choi 2001)</td>
<td>Each individual time series contains a (series specific) unit root, ₚᵢ = 0 ∀ᵢ</td>
<td>Some (but not all) of the individual series have unit roots, i.e., ₚᵢ&lt;0 for at least one i.</td>
<td>Individual</td>
<td>Combined information on p-values of individual unit root tests:</td>
<td>p&lt;0.05; panel is stationary</td>
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<td></td>
<td>ₑᵢ = ₚₑᵢ,ₜᵢ₋₁ + ₑᵢ</td>
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</tr>
<tr>
<td>PP-Fisher Madala &amp; Wu 1999; Choi 2001</td>
<td>Each individual time series contains a (series specific) unit root, ₚᵢ = 0 ∀ᵢ</td>
<td>Some (but not all) of the individual series have unit roots, i.e., ₚᵢ&lt;0 for at least one i.</td>
<td>Individual</td>
<td>Combined information on p-values of individual unit root tests:</td>
<td>p&lt;0.05; panel is stationary</td>
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<td>ₑᵢ = ₚₑᵢ,ₜᵢ₋₁ + ₑᵢ</td>
<td></td>
</tr>
<tr>
<td>Hadri (2000)</td>
<td>No unit roots in any of the series in the panel</td>
<td>All series contain unit roots</td>
<td>Common</td>
<td>Two standardised Z-statistics (based on two LM statistics, where one allows for heteroskedastisity across i)</td>
<td>p&lt;0.05; panel is non-stationary</td>
</tr>
</tbody>
</table>

**Source:** author compilation