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International trade and agricultural production: Evidence from the Southern African Development Community sub-region

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Southern African Development Community (SADC) countries have undertaken substantial reforms in market liberalisation policies and regional integration initiatives. Theory suggests that trade can affect output through the exploitation of comparative advantage, increasing return to scale, liberalisation policies and technology. This work investigates the impact of agricultural exports to, machinery and chemical imports from and tariffs on agricultural products by total partners to the Southern African Customs' Union, SADC, sub-Saharan Africa and the rest of the world on agricultural production. Following Hausman tests, three panel fixed-effect models are estimated. The first is for aggregate machinery imports, chemicals imports and agricultural exports. The second is for disaggregated exports and imports according to the respective destination and source regions above. The third is for aggregate imports and disaggregated tariffs implemented by the various export destination regions toward the SADC. The results agree with the theory that international trade is good for development. Agricultural market expansion through export opportunities and access to inputs are significant sources of agricultural production enhancement in the SADC region. Tariffs barriers to agricultural exports are found to be significant impediments to agricultural production. However, the disparity of effects by export destination and the insignificance of the impact of trade with the rest of Africa are worth emphasising.

Keywords: trade; agricultural production; Southern African Development Community; panel data

1. Introduction

Agriculture by reason of high employment has the capacity for greater pro-poor development. The 2008 edition of the World Development Report has highlighted this and calls for agriculture to be placed at the centre of policy attention and greater investment in developing countries' agriculture if the goals of halving poverty and hunger are to be realised. World Bank (2008) has highlighted three facts concerning agriculture's ability to enhance pro-poor growth especially in sub-Saharan Africa (SSA). Firstly, gross domestic product (GDP) growth in agriculture is four times more effective in extreme poverty reduction than GDP growth originating from other sectors. Secondly, in developing countries 75% of the poor live in (agriculture-dependent) rural areas while only 4% of official development aid goes to agriculture. Thirdly, SSA countries rely heavily on agriculture for overall growth, highly taxing the sector while allocating only 4% of total government spending to the sector. This work investigates the impact of agricultural exports to, machinery and chemical imports from and tariffs applied on agricultural products by total partners to the

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Southern African Customs' Union (SACU), Southern African Development Community (SADC), SSA and the rest of the world on agricultural production.

Significant welfare gains resulting from agricultural trade policy reforms have been documented (Hertel & Reimer, 2005; Francois & Martin, 2007). These gains generally result from the reduction of economic distance and transaction costs, price stability and technological spillovers. Expanding regional markets through regional integration can have significant effects. Regional agreements, for example, can promote collective action, thereby reducing political tensions, and can result in economies of scale in infrastructure. This can prove beneficial in a grouping of many small countries such as SSA (Staatz & Dembele, 2008). Firms' decision-making processes can be strongly affected by explicit or implicit incentives of national as well as regional trade and industrialisation policies (Stead et al., 1996). Various national and regional policies are susceptible to influencing cross-border trade and other cross-border activities through transaction costs. Generally, market structures influence output performance with possible feedback. Barriers to entry as a feature of market structure are strongly determined by tariffs. Intra-regional tariff liberalisation can lead to changes in regional market structures, affecting firms' strategies. Besides market expansion, intra-regional trade liberalisation can reduce cost associated with import of inputs and can also bring about knowledge spillover (Dion, 2004). Therefore, trade arrangements within an area like the SADC can potentially ease both demand-side and supply-side constrains, leading to output enhancement (Frankel & Cyrus, 1996; Frankel & Romer, 1999).

The member-states of the SADC[2] have very divergent levels of development. Angola, the Congo DRC, Lesotho, Malawi, Mozambique, Tanzania and Zambia are considered the least developed. South Africa, as an emerging economy, plays a strategic role in the region. With its geostrategic position and economic size, contributing 71% of the SADC GDP and 22% of its population, almost all the countries in the sub-region (especially the landlocked ones) depend on South Africa for trade and transport (using its railways, airports, seaports, road networks and other transit facilities). The poor countries of the SADC have a larger agricultural sector that supports the greatest share of employment. For instance, World Bank (2008) reports agricultural sector contribution to GDP of 38%, 32% and 48% for Malawi, Mozambique and Tanzania respectively. Hence the major export commodities are primary agricultural produce. Agricultural inputs such as machinery and fertiliser and other manufacturing goods in general are imported. The SADC trade protocol (adopted in 1996) has intensified bilateral and multilateral integration initiatives and cooperation to liberalise trade and fair competition in the production and exchange of agricultural commodities.

Since the mid-1980s, most SADC countries have undertaken substantial reforms in trade policies, culminating in market liberalisation policies and regional integration initiatives. For example, Namibia has privatised tractor and seed support services, and the agricultural boards no longer set prices nor procure agricultural products. Zambia, Malawi and Tanzania have liberalised their exchange rates, and abolished controlled pricing systems and pan-territorial and uniform pricing practices by agricultural boards. They have also eliminated other regulations such as surcharges, specific

[2]Angola, Botswana, Lesotho, Madagascar, Mozambique, Mauritius, Malawi, Namibia, Swaziland, Tanzania, South Africa, Congo DRC, Zambia and Zimbabwe.

duties, import/export permits and quantitative restrictions. Other market reforms have also been implemented, including privatisation of the crop and marketing board.

Recently, intra-SADC trade has been on the rise, although levels of exports and imports differ with countries. Although it may be expected that trade liberalisation in the SADC should enhance regional market access, pre-existing bilateral agreements or more restricted multilateral agreements in the case of the SACU[3] may remain a major channel of trade. The SACU agreement has transcended the common external tariff, free movement of goods and services, and revenue sharing formula for the establishment of a common negotiating mechanism envisaged since 2002. Specific to agriculture within the SACU is the prioritisation of policies that facilitate production, processing, and marketing of agricultural products. In this regard, the five-member SACU sub-bloc would be more strongly integrated than the general SADC with expected trade intensification.

Table 1 presents net trade changes for selected SADC countries with SACU, the rest of SADC net SACU, rest of SSA net SADC, and rest of the world net SSA between 2001 and 2006. Except for Madagascar and Mauritius, there is significant drop in agricultural export to the rest of the world for the selected countries. Except for Swaziland and Madagascar, the agricultural exports of the rest to the SADC have increased.

The main objective of this work is to: investigate the impact of trade on agricultural production. Specifically, to estimate the impact of SADC agricultural exports to the SACU, SADC, SSA and the rest of the world on agricultural production of her member countries; estimate the tariffs on agricultural goods facing the exports of SADC countries from the SACU, SADC, SSA and the rest of the world on agricultural production of member countries; and determine the role of chemicals and machinery imports from the SACU, SADC, SSA and the rest of the world on SADC member countries' agricultural production.

2. Literature review

While there is substantial literature on regional integration and trade, studies on the effect of trade on agricultural production are scarce. A body of literature has examined the role of trade on development. However, there is lack of consensus in the matter, mainly due to the possibility that openness to international trade can accelerate production through export-led incentives and imports of inputs, but also impede the growth of infant or less competitive industries through imports. Overall, openness can inhibit growth through vulnerability to international shocks (Fosu, 2001). The advent of endogenous growth theories (Lucas, 1988; Grossman & Helpman, 1991) also saw the emergence of focus on the relationship between trade and growth. These theories purport that importing countries gain knowledge through embedded new technologies in imported products, thereby increasing the competitiveness of local manufacturers.

Dion (2004) gives a review of various channels through which trade can affect output (or output growth). These are comparative advantage (classical trade theory), greater exploitation of increasing return to scale (new trade theory), new policies dismantling trade barriers (public choice and trade theory), and technology (new growth theory). In more specific terms, international trade has been thought to result in more efficient

[3]The SACU is the oldest trade arrangement of the region, dating back to 1889. The core member-states are South Africa, Lesotho, Botswana, Swaziland and Namibia.

Table 1: Changes in agricultural exports to machinery and chemical imports from the SACU, SADC, SSA and rest of the world for some SADC countries (2001 to 2006)

	Agricultural exports				Machinery imports				Chemical imports			
Country	World	SSA	SADC	SACU	World	SSA	SADC	SACU	World	SSA	SADC	SACU
Botswana	−15.82	0.09	13.40	2.33	−6.70	0.08	−0.15	6.76	−3.39	−0.03	−0.90	4.33
Namibia	−9.62	3.90	3.11	2.61	2.03	0.00	0.07	−2.09	9.49	0.14	−0.07	−9.57
Swaziland	−2.88	3.51	−0.80	0.16	15.88	0.07	2.51	−18.46	25.11	0.00	8.24	−33.35
South Africa	−2.87	−0.10	3.73	−0.75	0.22	−0.02	−0.18	0.00	0.03	0.03	−0.07	0.01
Tanzania	−5.16	3.01	1.07	1.07	−5.20	0.20	−0.15	5.15	6.09	−7.16	−0.17	1.23
Malawi	−10.82	−2.29	6.66	6.45	−8.16	−0.54	−0.90	9.60	22.54	1.13	−4.64	−19.04
Zambia	−3.42	−10.13	17.16	−3.61	12.95	−0.09	0.69	−13.55	10.20	1.12	−8.31	−3.02
Zimbabwe	−9.05	−1.60	3.20	7.46	−6.98	−0.26	0.19	7.06	−9.45	−0.14	0.83	8.75
Madagascar	0.19	0.03	−0.11	−0.11	−3.24	0.04	−0.59	3.78	1.03	0.55	−0.85	−0.72
Mozambique	−12.14	−0.39	12.46	0.06	−5.71	−0.26	1.05	4.92	−7.05	0.27	−0.19	6.96
Mauritius	3.25	−3.53	0.02	0.27	2.45	0.02	−0.01	−2.47	3.71	−0.14	0.16	−3.72

Source: Author's computation using the COMTRADE database (www.comtrade.un.org).

allocation of resources; however, the mechanisms are less clear-cut (Berg & Krueger, 2003). A number of channels identified in literature include:

- the importance of imported capital goods as inputs in production in developing countries;
- possibility of longer-term expansion at constant rather than diminishing returns due to larger market access (Ventura, 1997);
- exploitation of comparative advantage leading to high return to capital in unskilled labour-abundant developing countries;
- increased innovation and entrepreneurship due to larger market access and competition; and
- openness to ideas and innovation brought about by openness to trade.

Empirically, various authors have looked at the effect of trade on GDP. Cholksi et al. (1991) analyse the effect of trade liberalisation in 19 countries between 1946 and 1986. and establish a strong link between openness and rapid growth in export and GDP. Dollar & Kraay (2004) – classifying countries into 'globalisers' and 'non-globalisers' – show that countries of the former group recorded a stronger increase in GDP growth (1.4 to 3.8) compared with the latter (−0.1 to 0.8) in the 1990s relative to the 1980s. Also, in a panel of 71 developing countries, Coe et al. (1997) find that total factor productivity significantly relates to trading partners' stock of research and development.

Dion (2004) has used the gravity model to analyse the impact of regional trade arrangement on productivity for the European Union (EU) region in a two-stage panel regression. In the first stage, he estimates the impact of geography and membership in the EU regional trade arrangement on the flow of goods and foreign direct investment. In the second stage, he uses the gravity estimates of trade as an instrument to investigate the impact of trade on total factor productivity within the EU. Dion finds that regional economic integration through trade liberalisation and international transmission of knowledge enhances growth.

There is therefore strong evidence in favour of trade, specifically import of machinery and equipment, mediating knowledge diffusion such that the quantity of machinery and equipment imported becomes an important determinant of productivity. However, on the export side, it has been hard to establish a clear causality, given the possibility that productivity may determine exports (Roberts & Tybout, 1997). There has also been firm-level evidence from Clerides et al. (1998) for Columbia, Mexico and Morocco, and Bernard & Jensen (1999) for the United States that export growth follows productivity. However, for poorer countries, there is more to achieve from export, making a stronger case for causality running from export to productivity, without ruling out the possibility of feedback. Bigsten et al. (2005), using firm-level data for four African countries, find that firms both learn from exporting, as well as self-select for export. Kraay (1999) also finds learning effects for Chinese firms. The findings of Hallward et al. (2002) for five East Asian countries also suggest that causality can run from export market penetration to production.

The scarcity of agricultural sector experience in the above literature calls for complimentary work. The present work is designed to fit into this gap, contributing to this literature by providing evidence in a panel of 14 SADC countries. Specifically, it looks at the impact of export of agricultural produce to (as indicator of market expansion), import of chemical, machinery and equipment (as inputs containing embedded knowledge) from the SACU, SADC, SSA and rest of the world on agricultural production.

3. Methodology

The framework underlying this analysis draws on an extended type (Feder, 1983),[4] which has also been used by Pahlavani (2005) to analyse the export–GDP nexus in Iran. Consider an economy that produces for domestic use Y_d and for export Y_x using inputs K_d, L_d, M_d, and K_x, L_x, M_x respectively:

$$Y = Y_d + Y_x \tag{1}$$

Suppose the production functions F and G of both sectors are:

$$Y_d = F(K_d,\ L_d,\ M_d,\ Y_x) \tag{2}$$

$$Y_x = G(K_x,\ L_x,\ M_x) \tag{3}$$

where L and K are labour and capital, and M are intermediate imports. The inclusion of intermediate imports is motivated by the emphasis endogenous growth theories lay on knowledge spillover through imports leading to constant or increasing returns to scale (Sengupta, 1993). Equally, exports have been viewed as a considerable source of externality to the domestic production sector (Feder, 1983; Salehi-Esfahani, 1991; Ghatak et al., 1997; Pahlavani, 2005).

Differentiating the three equations with respect to time results in:

$$\dot{Y} = \dot{Y}_d + \dot{Y}_x \tag{1′}$$

$$\dot{Y} = F_K\dot{K}_d + F_L\dot{L}_d + F_M\dot{M}_d + F_Y\dot{Y}_x \tag{2′}$$

$$\dot{Y}_x = G_K\dot{K}_x + G_L\dot{L}_x + G_M\dot{M}_x \tag{3′}$$

where dots on variables denote rate of change, and F_i and G_i are marginal effects of variable i. The sum of Equations (2′) and (3′) yields:

$$\dot{Y} = F_K\dot{K}_d + F_L\dot{L}_d + F_M\dot{M}_d + F_Y\dot{Y}_x + G_K\dot{K}_x + G_L\dot{L}_x + G_M\dot{M}_X \tag{4}$$

Earlier empirical studies have demonstrated that exports contribute to GDP growth more than just the change in the volume of exports (Balassa, 1978; Tyler, 1981; Feder, 1983). Feder (1983) shows empirically that factor productivities in the export sector are higher than in the non-export sector, leading to such a higher contribution to GDP growth. Suppose the ratio of factor productivities in the export sector to those in the non-export sector differs from unity by an amount δ:

$$\frac{G_K}{F_K} = \frac{G_L}{F_L} = \frac{G_M}{F_M} 1 + \delta \tag{5}$$

[4]See also Ghatak et al. (1997), Pahlavani (2005), Sengupta (1993), and van den Berg (1997).

Under this assumption, Equation (4) becomes:

$$\dot{Y} = F_K\dot{K}_d + F_L\dot{L}_d + F_M\dot{M}_d + F_Y\dot{Y}_x + (1+\delta)F_K K_x + (1+\delta)F_L\dot{L}_x + (1+\delta)F_M\dot{M}_x \tag{6}$$

Applying Equations (5) and (3′) implies:

$$F_K\dot{K}_x + F_L\dot{L}_x + F_M\dot{M}_x = \frac{G_K}{1+\delta}\dot{K}_x + \frac{G_L}{1+\delta}\dot{L}_x + \frac{G_M}{1+\delta}\dot{M}_x = \frac{1}{1+\delta}\dot{Y}_x \tag{7}$$

Rearranging Equation (6) and considering that the total of each factor is the sum of what is allocated to both sectors gives:

$$\dot{Y} = F_K\dot{K} + F_L\dot{L} + F_M\dot{M} + \left(F_x + \frac{1}{1+\delta}\right)\dot{Y}_x \tag{8}$$

In other terms:

$$\dot{Y} = a\dot{K} + \beta\dot{L} + \gamma\dot{M} + \lambda\dot{Y}_x \tag{8′}$$

This can be likened to the neoclassical theory of economic growth. Equation (8′) has been employed in various cases for the analysis of the link between GDP, physical capital, labour, intermediate imports and exports (Pahlavani, 2005). In this work, Equation (8′) is adapted to the context of the agricultural sector for the SADC region in the following empirical specification.

3.1 Empirical specification, variables and data source

As indicated above, Feder's model presents GDP as a function of labour, and other relevant factors of production. In this work, the model in Equation (8′) is adapted for agricultural production by considering agricultural output (Y) as a function of the traditional inputs: land (N), labour (L), livestock (LS), but also machinery (MA), chemicals (C), exports (X), share of irrigated land (IR) and human capital variables. It is worth noting that not all of the machinery and chemicals imported are used in agriculture, although in this work actual imports are used in the absence of data on imports destined for agriculture.[5] Human capital variables are captured using five-year lags of enrolment rates[6] (primary school enrolment rate [PE], secondary school

[5]The assumption here is that chemicals and machinery imports can be partitioned into those that affect agriculture directly or indirectly (I_A), and those that are for non-agricultural purposes (I_{NA}). The worst-case scenario is that I_{NA} has negative effect on agricultural production. This is premised on the fact that this category of imports takes away resources from agriculture, and to the extent that land and other limiting resources are available, then the negative impact eventuates; otherwise, the effect is neutral. We argue that the negative impact is not significant in developing countries.

[6]The right proxy for educational human capital is the labour force with the necessary educational levels (primary, secondary, tertiary). However, there are hardly any data on this. To approximate this, we assume that the enrolment in the past five years directly or indirectly affects today's productivity through direct participation in the labour market, or through spillover effects in households.

enrolment rate [SE], and tertiary enrolment rate [TE]) and life expectancy (LE):

$$Y = F(N,\ L,\ LS,\ IR,\ MA,\ C,\ X,\ HC) \tag{9}$$

Three empirical models are developed for estimation, in which agricultural machinery and chemicals (fertiliser and pesticides) are proxied by machinery and transport equipment and chemical imports.[7] The first model (M1) comprises a panel of overall agricultural exports and total machinery and chemical imports together with the other control variables. The second (M2) breaks down agricultural exports, machinery and chemical imports into their respective destination and source countries – SACU, rest of SADC, rest of SSA and the rest of the World (W). The third model (M3) replaces agricultural exports to different destinations in (M2) with tariffs (TA), broken down into weighted tariffs applied by the respective exports destinations (SACU, SADC, SSA and W). Because of concerns of endogeneity between the dependent variable and agricultural exports raised in the literature, the export related variables are instrumented for by their respective one-period lags:

$$\begin{aligned} \ln y_{it} = {} & \beta_0 + \beta_1 \ln N_{it} + \beta_2 \ln L_{it} + \beta_3 LS_{it} + \beta_4 \ln MA_{it} + \beta_5 \ln C_{it} \\ & + \beta_6 \ln X_{it-1} + \beta_7 \ln PE_{it-5} + \beta_8 \ln SE_{it-5} + \beta_9 \ln TE_{it-5} \\ & + \beta_{10} \ln LE_{it} + \beta_{11} \ln IR_{it} + \eta_i + \upsilon_t + \mu_{it} \end{aligned} \tag{M1}$$

where *ln* is natural log, η is an unobserved country-specific effect, υ an unobserved time effect common across countries and μ is a serially uncorrelated error term. The model below breaks the exports and imports into destinations and source regions respectively:

$$\begin{aligned} \ln y_{it} = {} & \beta_0 + \beta_1 \ln N_{it} + \beta_2 \ln L_{it} + \beta_3 LS_{it} + \beta_{4\alpha} MAsacu_{it} + \beta_{4d} MAsadc_{it} + \beta_{4c} MAssa_{it} \\ & + \beta_{4d} MAw_{it} + \beta_{5a} Csacu_{it} + \beta_{5b} Csadc_{it} + \beta_{5c} Cssa_{it} + \beta_{5d} Cw_{it} + \beta_{6a} Xsacu_{it-1} \\ & + \beta_{6b} Xsadc_{it-1} + \beta_{6c} Xssa_{it-1} + \beta_{6d} Xw_{it-1} + \beta_7 PE_{it-5} + \beta_8 SE_{it-5} \\ & + \beta_9 TE_{it-5} + \beta_{10} LE_{it} + \beta_{11} \ln IR_{it} + \eta_i + \upsilon_t + \mu_{it} \end{aligned} \tag{M2}$$

The model (M3) below replaces agricultural exports with trade tariffs, broken down into the respective values applied by the regions (SACU, SADC, SSA and W):

$$\begin{aligned} \ln y_{it} = {} & \beta_0 + \beta_1 \ln N_{it} + \beta_2 \ln L_{it} + \beta_3 LS_{it} + \beta_{4\alpha} MAsacu_{it} \\ & + \beta_{4d} MAsadc_{it} + \beta_{4c} MAssa_{it} + \beta_{4d} MAw_{it} + \beta_{5a} Csacu_{it} \\ & + \beta_{5b} Csadc_{it} + \beta_{5c} Cssa_{it} + \beta_{5d} Cw_{it} + \beta_{6a} TAsacu_{it} \\ & + \beta_{6b} TAsadc_{it} + \beta_{6c} TAssa_{it} + \beta_{6d} TAw_{it} + \beta_7 PE_{it-5} + \beta_8 SE_{it-5} \\ & + \beta_9 TE_{it-5} + \beta_{10} LE_{it} + \eta_i + \upsilon_t + \mu_{it} \end{aligned} \tag{M3}$$

Table A1 in Appendix A presents a full list of variables, definitions, measurement and sources. Below is a brief exploration of variables used in this work, together with

[7]The most plausible option would be to get fertiliser and agricultural machinery trade; however, at bilateral trade levels, these quantities are not readily available over the reasonable span required for this analysis.

their definitions, theoretical expectations and sources. All variables are in log form. The dependent variable *y* is agricultural value added at constant 2000 US dollars.

The first sets of regressors are the variables of concern, which are trade related. Agricultural exports *X* are incorporated in Model 1 as the lag value of total exports to all trading partners (US$1000). In M2, it was broken down into various destinations – SACU as mirror exports[8] from a given SADC country by all the SACU member countries (*Xsacu*); SADC as the total value of mirror exports of SADC less that of SACU (*Xsadc*); *Xssa* as the value to SSA net total of SADC; and *Xw* as the value to the world net the total of SSA. These variables are expected to have a positive coefficient since they represent market incentives for production and also some source of positive externality. Data for these variables are obtained from the UN COMTRADE[9] database using WITS.

Imports variables are machinery and transport equipment *MA* and chemicals (C). They are broken down respectively according to source region – *MAsacu*, *MAsadu*, *MAssa*, *MAw* and *Csacu*, *Csadc*, *Cssa*, *Cw* from the SACU, SADC (net SACU), SSA (net SADC) and W (net SSA). Both sets of variables can proxy for agricultural machinery and chemicals (pesticides and fertiliser). They are also possible carriers of new technology and therefore are expected to have positive signs. These series are also from the COMTRADE database.

The tariff variables are trade-weighted values facing the various SADC countries. They are subdivided in the same way as imports and exports above; that is, into *TAsacu*, *TAsadc*, *TAssa* and *TAw*, which are respectively tariffs facing various SADC member countries from the SACU, SADC (net SACU), SSA (net SADC) and W (net SSA). These variables are trade restricting and are expected to have negative signs. They are sourced from the UNCTAD TRAINS database.[10]

The other variables are the controls. The first set is inputs: arable land (N) from World Development Indicators (WDI) 2010, labour (L – as economically active population in the agricultural sector) from the FAO dataset, livestock (LS) from the WDI 2010 and FAO dataset, share of irrigated cropland (IR), which is the ratio of irrigated land to arable land, taken from the WDI and FAO dataset. These are all expected to have positive signs. The second set is human capital related and are all taken from the WDI 2010 CD-ROM.[11] They are: primary education enrolment (PE), secondary enrolment (SE), tertiary enrolment (TE) and life expectancy at birth (LE). Five-year lags of educational variables were considered. It is expected that life expectancy will show a positive effect on productivity. Higher levels of education may not be encouraging for agricultural production because in many developing countries, higher education may take labour away from agricultural activities.

In general, the data have different spans for different countries, conditioned by the availability of trade data. Data for Mozambique, Mauritius, Malawi, Tanzania, South Africa, the Congo DRC, Zambia and Zimbabwe span 1970 to 2008; Madagascan data are from 1971 to 2008; and those of Angola from 1988 to 2008. The rest of the

[8]Mirror exports are exports of a given country measured from the viewpoint of imports from its partner countries.
[9]This is the SITC (Standard International Trade Classification – http://comtrade.un.org/), Revision 1 from 1962, but only observations from 1970 are considered, and in some cases those from 2000.
[10]http://www.unctad.info/en/Trade-Analysis-Branch/Key-Areas/Non-Tariff-Measures/
[11]http://databank.worldbank.org/data/views/variableselection/selectvariables.aspx?source=world-development-indicators

countries (Botswana, Lesotho, Namibia, and Swaziland) have data only from 2000 to 2009. The dataset used in this work is therefore an unbalanced panel.

3.2 Missing and zero observations

The datasets presented two kinds of problems. The first was missing data and the second problem was zero values, especially related to trade flows and tariff values. A number of variables had missing observations. They were either interpolated or extrapolated. This was done on assumption that the series follow a relatively smooth path over time (see Vollrath, 2007:215). Thus for a variable X, with missing value at time s, falling between two observations at time t and $t + n$:

$$X_5 = X_t + (s - t)\left(X_{t+n} - X_t\right)/n$$

Variables that recorded zero values were treated using the ad-hoc method common in trade literature. In order to avoid the problem of log of zero, a near-zero (0.00001) value was added to all such variables (Van Bergeijk & Oldersma, 1990; Wang & Winters, 1991; Raballand, 2003). Both missing values (32 data points) and zero values (38 data points) represented only less than 20% of the data.

3.3 Estimation procedure

The panel data estimation procedure is applied to the three models above. There is the choice of fixed-effect or random-effect estimation. Although there is strong reason to opt for a random model given that most of the pertinent control variables were included in the model, a Hausman test was carried out to compare both specifications and the random-effect model was chosen. The test, developed by Hausman (1978), is based on the idea that under the null hypothesis of no correlation between individual effects (η_i) and the other regressors in the model, both ordinary least squares (OLS) and generalised least squares (GLS) are consistent, but OLS is inefficient, whereas under the alternative only OLS is consistent. The test statistics indicates whether the two sets of coefficients (OLS and GLS) are significantly different.

However, when the asymptotic properties of the Hausman test are not met, the test may be inconclusive. In such a case, the alternative is to test whether η_i are distributed randomly across individuals.[12] This consists of testing whether there is significant variation of η_i across individuals. Since the variance of $\eta_i\left(\sigma_\eta^2\right)$ captures this variation, the test can be specified as: $H_0{:}\sigma_\eta^2 = 0$ against $H_0{:}\sigma_\eta^2 > 0$.

The problem of endogeneity between agricultural production and exports was dealt with using lag values of export as instruments for exports. This seems plausible, given that the causality principle[13] is based on the premise that if production causes exports, then a change in production will be followed by a change in exports (Granger, 1969; Sims, 1972). Therefore in the presence of mutual causality, using the lagged values of export would eliminate the feedback process and the bias.

[12]The random-effect model can be likened to an OLS model in which the constant term varies randomly across individuals.

[13]It is worth noting that causality here is in relation to economic theory and must not be confused with the statistical Granger causality.

4. Empirical results

The summary statistics of the variables are presented in Table 2. On average, the region faces the highest trade restrictions – as measured by trade-weighted tariffs – from the rest of SSA (33.6), followed by fellow SADC member countries excluding SACU (18.3). Agricultural exports are on average 19.75% to the SACU,[14] only 3.4% and 1.8% to the rest of SADC and SSA respectively and 75.1% to the rest of the world. As for machinery (and chemical) imports, the same tendency prevails, with 0.18% (and 0.67%) from SSA, 0.39 (and 0.86) from the SADC and 6.9% (and 12.64%) from the SACU, but 92.53 (and 85.83) from the rest of the world. This suggests that regional trade is still dominated by the SACU (Visser & Hartzenberg, 2004), although not quite considerable compared with the 75% for the rest of the world.

Pair-wise correlation coefficients show that all of the coefficients have the expected signs. All of the coefficients are significant except tertiary education and tariffs applied by SSA to agricultural products. However, in the regression results, tertiary education variable is significant while the primary education variable is not.

Out of the three models, the Hausman test rejects the null hypothesis in favour of fixed effects for Models 2 and 3. The null hypothesis could not be rejected for Model 1. The Breusch–Pagan (Lagrange Multiplier) tests suggest that the different country-specific effects vary significantly across countries for all three models. F-tests (Fui) on the state effects are also significant across the three models. Following these, three fixed-effect models (Models 1 to 3) are estimated and the results are presented in Table 3. Random-effect models have also been estimated (see Table A3 in Appendix A).

The overall model statistics (the R-squares, model F-test and the respective p values) all indicate good fit and model performance. Across all three models, the coefficients of the control variables are of the expected signs and are all significant except for the primary education variable. Concerning the trade-related variables, aggregate agricultural exports, machinery and chemical imports all have their positive theoretical expectations but the export variable is not significant. The result of Model 1 suggest that a percentage increase in machinery and chemical imports bring about 0.102% and 0.069% increases in agricultural value added respectively.

Model 2, in which exports and imports respectively are broken down into destination and source regions, suggests that agricultural exports to and machinery imports from the rest of SSA and rest of the world have a positive but insignificant effect on agricultural production. A 1% increase in exports to the SACU and the rest of SADC result in 0.017% and 0.021% increases in agricultural production respectively. The disparity of production enhancing the effect is noteworthy. This disparity may be attributed to the possible ways through which export possibilities to different destinations affect exporters' decisions. For example, export cost may be a factor. If an export possibility opens close by, with for example the increasing elimination of trade barriers[15] through regional integration, as with the SADC and SACU, there may be a greater productivity effect as we see. However, the underlying reason may be found by looking at farmers' decision-making models at firm level.

[14]These percentages are calculated as the ratio of mean exports (imports) to a specific region – SACU, net SADC, net SSA and net world – total multiplied by 100.
[15]The level of tariff and non-tariff barriers could equality affect the exports elasticity of agricultural production.

Table 2: Summary statistics

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
Agricultural VA (constant 2 000 US$)	394	1.19×10^{9}	1.15×10^{9}	1.14×10^{8}	5.02×10^{9}
Tariffs					
SACU	394	4.48×10^{0}	4.40×10^{0}	1.00×10^{-2}	2.93×10^{1}
SADC net SACU	394	1.83×10^{1}	1.25×10^{1}	1.00×10^{-2}	6.09×10^{1}
SSA net SADC	394	3.36×10^{1}	1.99×10^{1}	4.00×10^{-2}	8.67×10^{1}
World net SSA	394	1.07×10^{1}	1.53×10^{1}	1.00×10^{-2}	1.21×10^{2}
Agricultural exports					
Total	394	6.58×10^{5}	1.21×10^{6}	1.39×10^{2}	6.99×10^{6}
SACU	394	1.30×10^{5}	3.44×10^{5}	1.91×10^{-1}	1.44×10^{6}
SADC net SACU	394	2.24×10^{4}	6.57×10^{4}	1.60×10^{-2}	5.55×10^{5}
SSA net SADC	394	1.16×10^{4}	2.52×10^{4}	2.50×10^{0}	2.20×10^{5}
World net SSA	394	494 167.9	837 837.6	11.655	5 119 845
Machinery imports					
Total	394	1.14×10^{6}	3.10×10^{6}	1.00×10^{4}	2.94×10^{7}
SACU	394	7.88×10^{4}	1.57×10^{5}	1.66×10^{0}	1.06×10^{6}
SADC net SACU	394	4.43×10^{3}	9.37×10^{3}	4.81×10^{-1}	8.37×10^{4}
SSA net SADC	394	2.03×10^{3}	4.61×10^{3}	5.70×10^{-1}	4.24×10^{4}
World net SSA	394	1.06×10^{6}	3.11×10^{6}	5.72×10^{3}	2.93×10^{7}
Chemicals imports					
Total	394	3.48×10^{5}	8.52×10^{5}	7.15×10^{3}	7.37×10^{6}
SACU	394	4.40×10^{4}	6.40×10^{4}	$5.25\times10{-}^{1}$	3.25×10^{5}
SADC net SACU	394	3.00×10^{3}	5.27×10^{3}	$5.46\times10{-}^{1}$	4.42×10^{4}
SSA net SADC	394	2.34×10^{3}	4.30×10^{3}	-2.07×10^{3}	3.03×10^{4}
World net SSA	394	2.99×10^{5}	8.59×10^{5}	4.54×10^{2}	7.37×10^{6}
Other variables					
Land (ha)	394	4.49×106	3.84×10^{6}	9.90×10^{4}	1.49×10^{7}
Labour (1000 persons)	394	4.48×103	3.86×10^{3}	5.20×10^{1}	1.60×10^{4}
Livestock production index	394	8.50×101	1.92×10^{1}	3.00×10^{1}	1.36×102
Share of irrigated land	394	7.61×100	9.32×10^{0}	1.41×10^{-1}	3.06×10^{1}
Primary enrolment rate	394	9.11×101	1.98×10^{1}	4.81×10^{1}	1.39×10^{2}
Secondary enrolment rate	394	3.18×101	2.48×10^{1}	5.18×10^{0}	9.47×10^{1}
Tertiary enrolment rate	394	3.63×100	3.95×10^{0}	2.91×10^{-1}	1.72×10^{1}
Life expectancy (years)	394	5.01×101	8.17×10^{0}	3.91×10^{1}	7.33×10^{1}

The machinery imports elasticity of agricultural production is significant only for the SACU, with a magnitude of 0.022. Chemical import elasticities are all positive but insignificant for the SADC and SSA. A 1% increase in imports of chemicals from the SACU and the rest of the word results in 0.021% and 0.04% increases in agricultural production respectively.

Model 3 estimates agricultural production on disaggregated tariff measures facing SADC member countries from the SACU, SADC, SSA and the rest of the world. The coefficients are all negative but significant only for tariffs levied by SACU member

Table 3: Fixed-effect estimation results (Breusch-Pagan Statistics are for random effects)[a]

	Model 1			Model 2			Model3		
	Coefficient	SE	p	Coefficient	SE	p	Coefficient	SE	p
Constant	9.226***	1.801	0.000	12.183***	1.777	0.000	8.747***	1.695	0.000
ln *N*	0.479***	0.143	0.001	0.132	0.143	0.357	0.547***	0.133	0.000
ln *L*	0.464***	0.049	0.000	0.604***	0.060	0.000	0.383***	0.054	0.000
ln *LS*	0.160**	0.058	0.006	0.129*	0.066	0.051	0.200***	0.056	0.000
ln *IR*	0.158**	0.072	0.030	0.232***	0.075	0.002	0.166**	0.072	0.022
ln $PE_{(t-5)}$	0.200	0.092	0.230	0.100	0.093	0.285	0.013	0.078	0.867
ln $SE_{(t-5)}$	0.178**	0.015	0.000	0.189***	0.028	0.000	0.135***	0.033	0.000
ln $TE_{(t-5)}$	-0.083***	0.021	0.002	-0.099***	0.030	0.001	-0.038	0.029	0.193
ln *LE*	0.315***	0.093	0.001	0.090	0.098	0.356	0.327***	0.102	0.001
ln *X*	0.016	0.010	0.123	–	–	–	–	–	–
ln *MA*	0.102***	0.025	0.000	–	–	–	0.093***	0.024	0.000
ln *C*	0.069***	0.023	0.003	–	–	–	0.065***	0.023	0.004
ln *Xsacu*	–	–	–	0.017*	0.009	0.063	–	–	–
ln *Xsadc*	–	–	–	0.021***	0.005	0.000	–	–	–
ln *Xssa*	–	–	–	0.003	0.005	0.581	–	–	–
ln *Xw*	–	–	–	0.016	0.019	0.409	–	–	–
ln *MAsacu*	–	–	–	0.022**	0.010	0.031	–	–	–
ln *MAsadc*	–	–	–	0.012	0.008	0.110	–	–	–
ln *MAssa*	–	–	–	0.008	0.007	0.264	–	–	–
ln *MAw*	–	–	–	0.029	0.029	0.326	–	–	–
ln *Csacu*	–	–	–	0.021**	0.011	0.044	–	–	
ln *Csadc*	–	–	–	0.008	0.008	0.341	–	–	
ln *Cssa*	–	–	–	0.001	0.009	0.951	–	–	
ln *Cw*	–	–	–	0.040**	0.018	0.036	–	–	

ln *TAsacu*	–	–	–	–	–	−0.008**	0.003	0.015
ln *TAsadc*	–	–	–	–	–	−0.005	0.007	0.453
ln *TAssa*	–	–	–	–	–	−0.044	0.028	0.122
ln *TAw*	–	–	–	–	–	−0.067	0.050	0.178
Observations	360	359	374					
R^2 within	0.73	0.76	0.72					
R^2 between	0.65	0.62	0.63					
R^2 overall	0.59	0.58	0.57					
F(14, 366)	86.10(0.000)	53.02(0.000)	67.83(0.000)					
Fui(13, 366)	203.20(0.000)	82.68(0.000)	225.24(0.000)					
Hausmanχ^2	19.29(0.771)	8682.46(0.000)	1091.29(0.000)					
Breuch — Pagan[b]	903.93 (0.000)	142.32 (0.000)	759.77 (0.000)					

Note: Dependent variable: log of Agric. output (at constant 2000 US$). Variables are evaluated are three significance levels: ***1%, **5% and *10% level of significance. [a]In each model, the elasticities are given in the first column of figures, followed by the standard errors (SEs) and the probability values (p). [b]Tests for random-effect model.

countries. The model suggests that a 0.008% fall in agricultural production can result from a percentage increase in tariffs applied by SACU member countries to the rest of SADC. Trade restrictions such as tariff barriers can affect productivity in two ways. The first is through market effects, where trade barriers restrict access to market by exporting countries. The other is restrictions to imports of technology-laden goods that make learning by doing and knowledge spillover effects possible, and restriction of inputs into production.

5. Conclusion and policy recommendations

Overall, this work supports international trade as an avenue for agricultural development. Agricultural market expansion through export opportunities is a significant incentive for agricultural production enhancement in the SADC region. The strongest incentive comes from opportunities to export to the SADC and SACU. There is potential for the SADC's agricultural enhancement through trade with the rest of the world and SSA, but this is weak and insignificant, probably due to high trade cost and country-specific institutional weaknesses. Machinery imports from the SACU are a significant source of agricultural development. Again, the high cost of imports due to poor or no infrastructure may explain the insignificance of import effects from the other regions. Chemical imports from the SACU and the rest of the world enhance agricultural production. Compared with machinery, imports of chemicals can be relatively easier. The presence of South Africa in the SACU and a stronger SACU sub-regional integration is also important in explaining some of these results. Tariffs as an export restriction variable are significant impediments to agricultural production especially in the SACU.

It is important to compare these results with the corresponding random-effect estimates (Table A3 in Appendix A). GLS estimates suggest that, apart from the exports and imports variables relating to SSA net of SADC, all trade variables appear significant. Tariffs from all four trading regions also appear to significantly slow agricultural production. However, when specific country effects are taken into account, the coefficients of the trade variables lost their significance except for those relating to the SACU and chemical imports from the rest of the world. This implies that specific country conditions matter for agriculture to gain from both imports and exports. Rodrik (1998) highlights some important country-specific fundamentals on which the output enhancement ability of trade may depend. These are mainly investment in human capital, infrastructure and the establishment of credible institutions for macroeconomic management. Fosu (2001) argues that, on the other hand, appropriate trade policies may be required to get these fundamentals right, thus highlighting the possible feedback between trade policy and economic fundamentals. Although the models estimated in this work control for human capital, physical infrastructure and quality of institutions have not been accounted for. However, the fact that trade between the SADC and SSA is relatively dismal may be indicative of a more significant role of infrastructure. The SACU sub-region (and to a lesser extent the SADC) is more endowed with interstate infrastructure networks. This may partly explain the ability for greater appropriation of the trade-related agricultural development from the SACU.

In summary, this work concludes that trade openness in agricultural produce exports and imports of inputs are a source of agricultural production enhancement in the SADC. It also suggests that regional integration is a worthwhile avenue for agricultural development, but such integration must not shun existing trade openings with SSA and the rest of the world.

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Appendix A

Table A1: Variables, definitions and measurements

Variable	Definition	Measurement	Data source
y	Agricultural value added	At constant 2000 US$	WDI 2008
N	Arable land	Ha	WDI 2008
L	Labour force in agriculture	Persons	FAO database
LS	Livestock	Index	WDI 2008
IR	Share of irrigated land	Ratio	FAO
PE	Primary enrolment rate (five-year lagged)	Rate	WDI 2008
SE	Secondary enrolment rate (five-year lagged)	Rate	WDI 2008
TE	Tertiary enrolment rate (five-year lagged)	Rate	WDI 2008)
LE	Life expectancy	Years	WDI 2008
X	Export	US$1 000	UN COMTRADE
MA	Machinery	US$1 000	UN COMTRADE
Xsacu	SADC export to SACU	US$1 000	UN COMTRADE
Xsadc	SADC export to SADC	US$1 000	UN COMTRADE
Xssa	SADC export to SSA	US$1 000	UN COMTRADE
Xw	SADC export to rest of the World	US$1 000	UN COMTRADE
MAsacu	Machinery import by SADC from SACU	US$1 000	UN COMTRADE
MAsadc	Machinery import by SADC from SADC	US$1 000	UN COMTRADE
MAssa	Machinery import by SADC from SSA	US$1 000	UN COMTRADE
MAw	Machinery import by SADC from rest of the World	US$1 000	UN COMTRADE
Csacu	Chemical import by SADC from SACU	US$1 000	UN COMTRADE
Csadc	Chemical import by SADC from SADC	US$1 000	UN COMTRADE
Cssa	Chemical import by SADC from SSA	US$1 000	UN COMTRADE
Cw	Chemical import by SADC from rest of the world	US$1 000	UN COMTRADE
TAsacu	Tariffs imposed by SACU member states to those of SADC	Trade weighted values	UNCTAD TRAINS
TAsadc	Intra-SADC tariffs	Trade weighted values	UNCTAD TRAINS
TAssa	Tariffs imposed by SSA country member states to those of SADC	Trade weighted values	UNCTAD TRAINS
TAw	Tariffs imposed by rest of the world to SADC member states	Trade weighted values	UNCTAD TRAINS

Table A2: Pair-wise correlation coefficients

Variable	Coefficient	Significance	Variable	Coefficient	Significance
ln N	0.802	0.000	ln Xw	0.536	0.000
ln L	0.648	0.000	ln $MAsacu$	−0.396	0.000
ln LS	0.176	0.001	ln $MAsadc$	0.296	0.000
ln IR	0.177	0.000	ln $MAssa$	0.577	0.000
ln $PE_{(t\text{-}5)}$	0.249	0.099	ln MAw	0.665	0.000
ln $SE_{(t\text{-}5)}$	0.216	0.000	ln $Csacu$	−0.528	0.000
ln $TE_{(t\text{-}5)}$	−0.002	0.962	ln $Csadc$	0.276	0.000
ln LE	0.030	0.047	ln $Cssa$	0.595	0.000
ln X	0.514	0.000	ln Cw	0.691	0.000
ln MA	0.520	0.000	ln $TAsacu$	−0.033	0.010
ln C	0.514	0.000	ln $TAsadc$	−0.030	0.054
ln $Xsacu$	0.373	0.000	ln $TAssa$	−0.069	0.173
ln $Xsadc$	0.273	0.000	ln TAw	−0.272	0.000
ln $Xssa$	0.441	0.000			

Table A3: GLS estimation results (last two columns contain fixed-effect estimates without human capital)

	Model 1		Model 2		Model3		No human capital	
	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
Constant	8.131***	1.085	11.133***	0.928	8.451***	1.131	7.876***	1.904
ln *N*	0.159***	0.058	0.133***	0.046	0.102*	0.059	0.534***	0.153
ln *L*	0.257***	0.056	0.222***	0.036	0.378***	0.055	0.369***	0.053
ln *LS*	0.364***	0.116	0.361***	0.084	0.435***	0.120	0.351***	0.054
ln *IR*	0.128***	0.024	0.143**	0.021	0.116*	0.020	0.275***	0.074
ln *PE*	0.118	0.160	0.100	0.122	0.105**	0.163	–	–
ln *SE*	0.523***	0.074	0.413***	0.058	0.496***	0.071	–	–
ln *TE*	−0.249	0.049	−0.124***	0.042	−0.196***	0.048	–	–
ln *LE*	1.625***	0.183	0.702***	0.164	2.073***	0.190	–	–
ln *X*	0.211***	0.026	–	–	–	–	0.019*	0.012
ln *MA*	0.091**	0.044	–	–	0.085**	0.042	0.103***	0.027
ln *C*	0.324***	0.059	–	–	0.380***	0.063	0.080***	0.026
ln *Xsacu*	–	–	0.012	0.010	–	–	–	–
ln *Xsadc*	–	–	0.030***	0.008	–	–	–	–
ln *Xssa*	–	–	0.014	0.010	–	–	–	–
ln *Xw*	–	–	0.141***	0.019	–	–	–	–
ln *MAsacu*	–	–	0.043***	0.011	–	–	–	–
ln *MAsadc*	–	–	0.081***	0.013	–	–	–	–

(Table continued)

Table A3: Continued

	Model 1		Model 2		Model3		No human capital	
	Coefficient	**SE**	**Coefficient**	**SE**	**Coefficient**	**SE**	**Coefficient**	**SE**
ln *MAssa*	–	–	0.130	0.013	–	–	–	–
ln *MAw*	–	–	0.064*	0.045	–	–	–	–
ln *Csacu*	–	–	0.033**	0.013	–	–	–	–
ln *Csadc*	–	–	0.042***	0.014	–	–	–	–
ln *Cssa*	–	–	0.041***	0.013	–	–	–	–
ln *Cw*	–	–	0.025**	0.041	–	–	–	–
ln *TAsacu*	–	–	–	–	−0.018**	0.007	–	–
ln *TAsadc*	–	–	–	–	−0.026**	0.013	–	–
ln *TAssa*	–	–	–	–	−0.014	0.032	–	–
ln *TAw*	–	–	–	–	−0.104***	0.015	–	–
Observations	380	379	380	380				
Breuch − Pagan	903.93 (0.000)	142.32 (0.000)	759.77 (0.000)					

Note: Dependent variable: log of Agric. output (at constant 2000 US$). Variables are evaluated are three significance levels: ***1%, ** 5% and *10% level of significance