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Regional trade and volatility in staple food markets in Africa

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Abstract

This paper deals with the role of regional trade in fostering the resilience of domestic food markets. Using country production and trade data from FAOSTAT database, a series of simple indicators are calculated that shed light on the potential for domestic markets stabilization through trade among African countries within Regional Economic Communities, including the Common Market for Eastern and Southern Africa (COMESA), the Economic Community of West African States (ECOWAS), and the Southern African Development Community (SADC). A regional, economy-wide multimarket model is then used to simulate changes in current productivity levels and trade costs. The findings reveal that it is possible to significantly boost the pace of regional trade expansion and thus its contribution to creating more resilient domestic food markets through modest reduction in the overall cost of trading, a similarly modest increase in crop yields, or the removal of barriers to trans-border trade.

Keywords: Production volatility, cross-border trade, domestic food market stabilization, regional integration

JEL classification: F14, F17, Q17, Q18

1. Introduction

Recent studies indicate relatively strong trade performance in general by Africa as a whole and a number of individual countries in global markets (Bouet et al; 2014) as well as in continental and major regional markets (Badiane et al; 2014). The increased competitiveness has in general translated into higher shares of regional markets in total exports by the different groupings. Relatively faster growth in demand in continental and regional markets, compared to global markets, has also boosted export performance by African countries. For instance, during the second half of the last decade, the share of African exports in global markets of all goods and agricultural products in value terms has risen sharply, from 0.05 to 0.21 and from 0.15 to 0.34 percent, respectively, in line with the stronger competitive position of African exporters shown earlier.

By promoting competition and specialization in production, regional trade, similarly to global trade, can contribute to food security through its impact on long term output and productivity growth with their induced effects on employment and incomes. Where these effects are positive, trade raises the availability of food as well as the ability of affected groups to access food. Trade also helps reduce the unit cost of supplying food to local markets, lowering food prices or reducing the pace at which they rise, which in turn improves the affordability of food. Finally, trade can also help stabilize supplies in domestic food markets and reduce the associated risks for vulnerable groups.

All of the above benefits can be obtained, perhaps in larger extent, through trade with the rest of the world. For instance, one could question why a given country should pursue efforts to expand regional trade as opposed to trade in general for the purpose of stabilizing domestic food supplies, given that world production can be expected to be more stable than regional production. Several factors such as transport costs, foreign exchange availability, responsiveness of the import sector, and dietary preferences provide valid economic justification for country efforts to boost regional trade as part of a wider supply stabilization strategy that would also include increased trade with extra-regional markets. Regional and global trade should therefore be seen as complementary rather than as substitutes.

The increase in intra-African and intra-regional trade and the rising role of continental and regional markets as major destinations of agricultural exports by African countries suggest that cross-border trade flows will exert greater influence on the level and stability of domestic food supplies. The more countries find ways to accelerate the pace of intra-trade growth, the larger that influence is expected to be in the future. The current chapter examines the future outlook for intra-regional trade expansion and the implications for volatility of regional food markets. It starts with an analysis of the potential for regional trade to stabilize food markets, followed by an assessment of the scope for cross-border trade expansion. A regional trade simulation model is then developed and used to simulate alternative scenarios to boost trade and reduce volatility in regional markets.

2. Regional potential for stabilization of domestic food markets through trade

Variability of domestic production is a major contributor to local food price instability among low income countries. The causes of production variability are such that an entire region is less likely to be affected than individual countries. Moreover, fluctuations in national production tend to partially offset each other. To the extent that such fluctuations are less than perfectly correlated, food production can be expected to be more stable at the regional than at individual country levels. If that is the case, expanding cross-border trade and allowing greater integration of domestic food markets would reduce supply volatility and price instability in these markets. Integration of regional markets through increased trade raises the capacity of domestic markets to absorb local price risks by: (i) enlarging the areas of production and consumption and thus increasing the volume of demand and supply that can be adjusted to respond to and dampen the effects of shocks; (ii) providing incentives to invest in marketing services and expand capacities and activities in the marketing sector, which raises the capacity of the private sector to respond to future shocks; and (iii) lowering the size of needed carryover stocks, thereby reducing the cost of supplying markets during periods of shortage and hence decreasing the likely amplitude of price variation.

A simple comparison of the variability of cereal production in individual countries against the regional average is carried out to illustrate the potential for local market stabilization through greater market integration. For that purpose, a trend-corrected coefficient of variation is used as a measure of production variability at the country and regional levels. Country coefficients are then normalized by dividing by the respective regional coefficients. Calculations are carried out for each of the same three regional economic groupings as above and the results are presented in Table A.1 in the annex and plotted in Figures1a – 1c below. The bars represent the normalized coefficients of variation which indicate by how much individual country production levels are more (normalized coefficient greater than 1) or less (normalized coefficient less than 1) volatile than production in the respective regions.

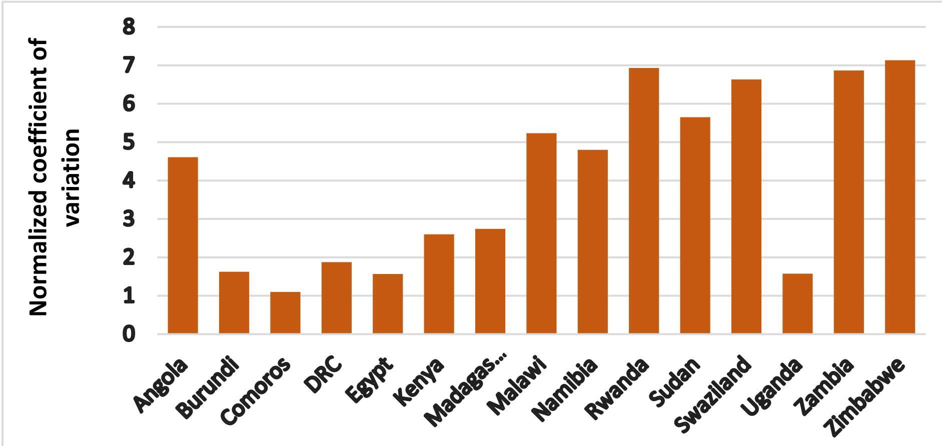

Figure 1a: COMESA cereal production instability, 1980-2010

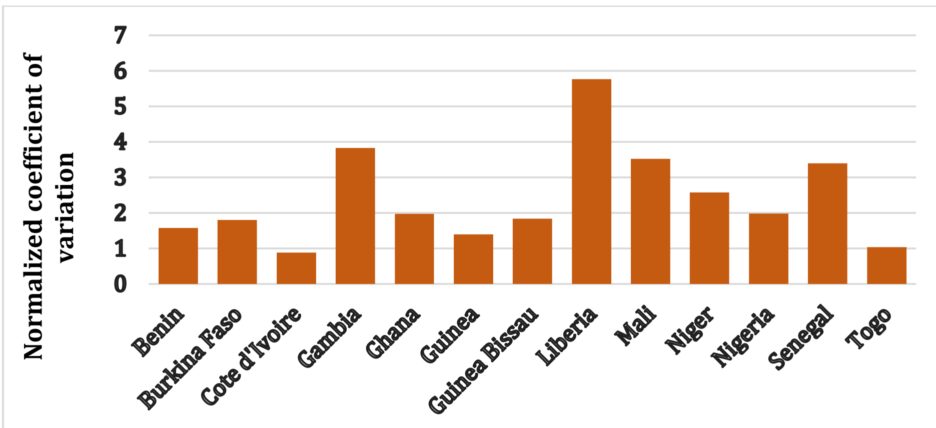

Figure 1b: ECOWAS cereal production instability

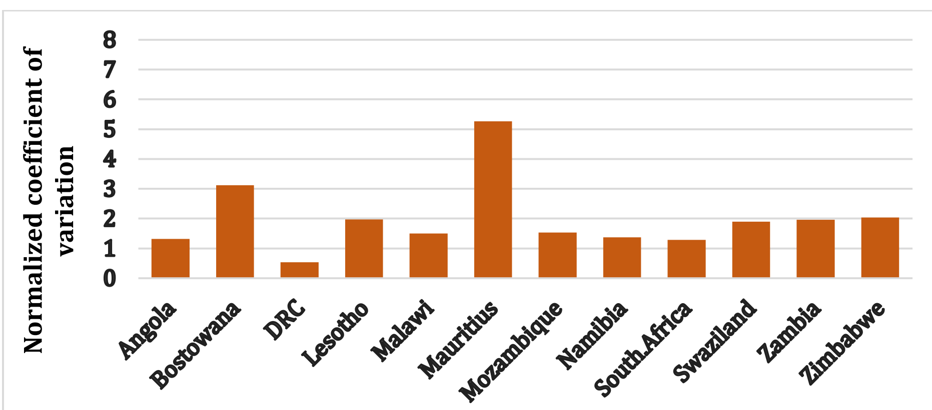

Figure 1c: SADC cereal production instability

Source: Authors' calculation. All graphs based on FAOSTAT 2014data from 1980-2010

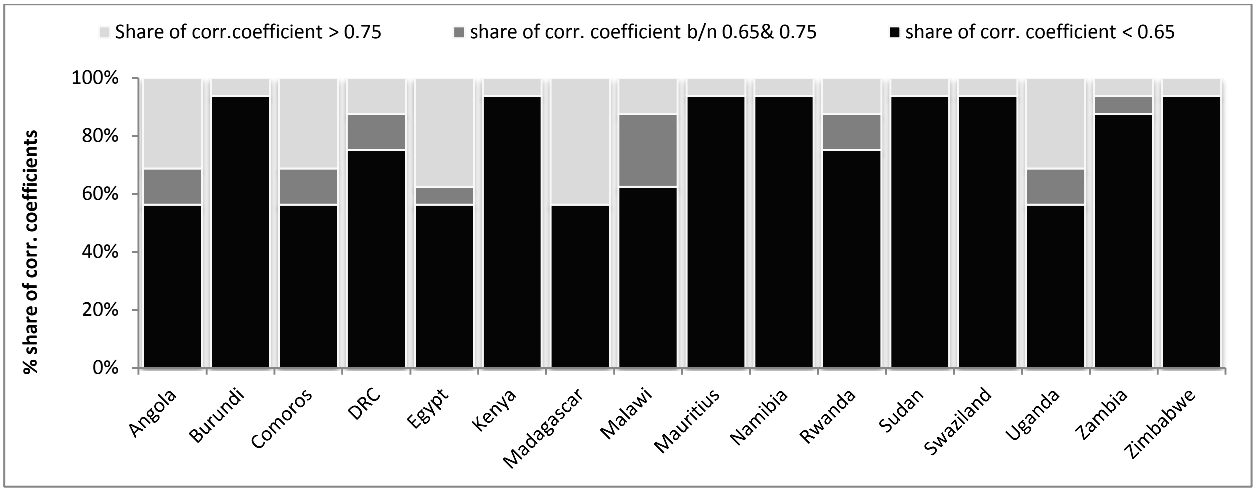

Figure 2a: Distribution of correlation coefficients, COMESA

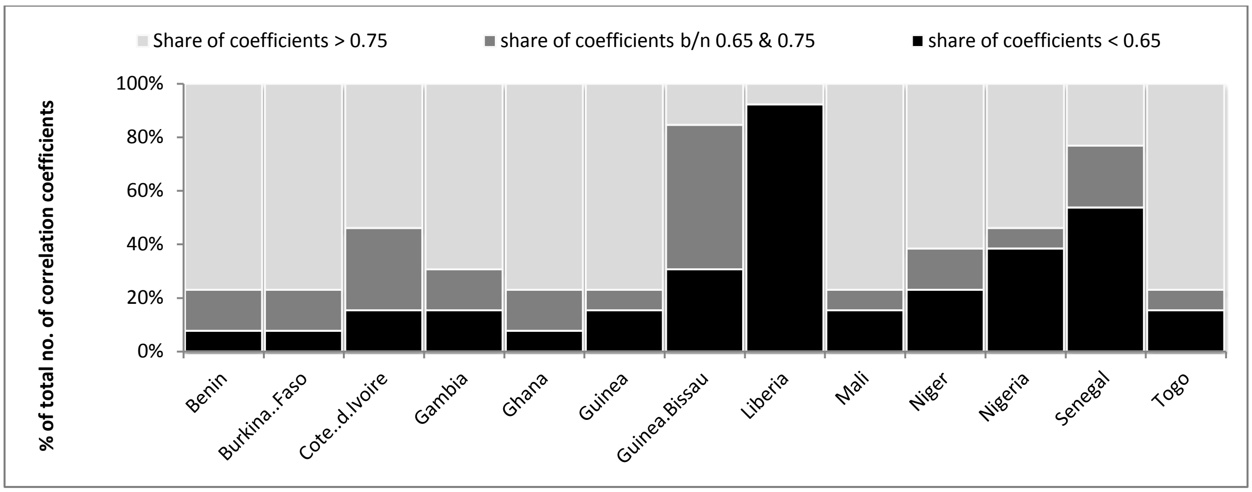

Figure 2b: Distribution of correlation coefficients, ECOWAS

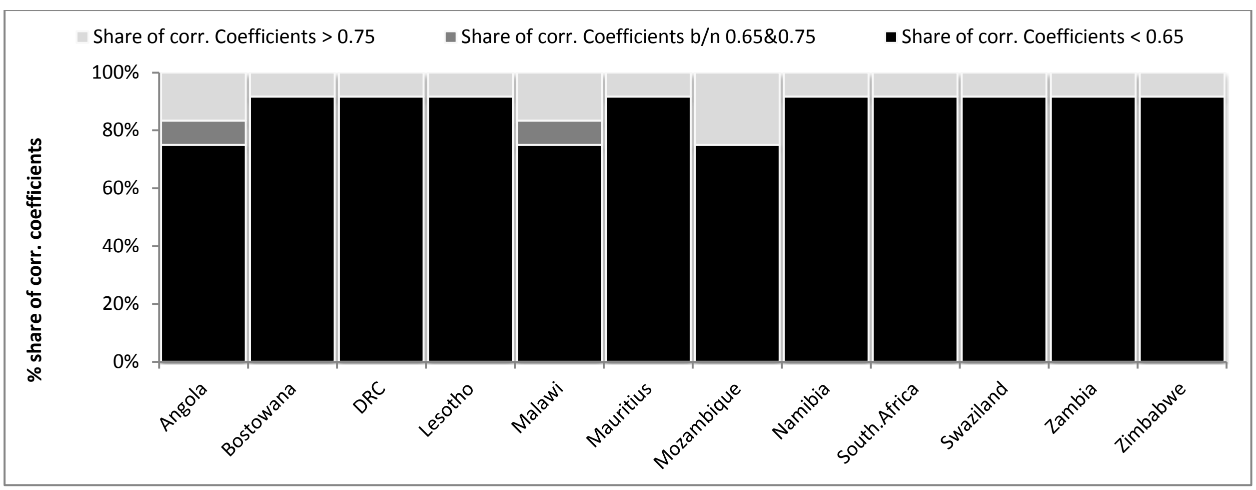

Figure 2c: Distribution of correlation coefficients, SADC

Source: Authors' calculation. All graphs based on FAOSTAT 2014data from 1980-2010

Of the three regions, SADC has the highest level of aggregate volatility with a coefficient of variation of 18.58, or more than twice and three times that of ECOWAS and COMESA, respectively. For the vast majority of countries, national production volatility is considerably larger than regional level volatility. The only exceptions are DRC in SADC and to a lesser extent Côte d'Ivoire in ECOWAS. None of the COMESA countries has production that is more stable than the regional aggregate. The COMESA countries can be divided into a relatively low volatility sub-group with normalized coefficients of less than twice the regional average, including Burundi, Comoros, DRC, Egypt, and Uganda, and a high volatility regional sub-group with volatility levels that are at least five times higher than the regional level, comprised of Malawi, Mauritius[1], Rwanda, Sudan, Swaziland, Zambia, and Zimbabwe. Between the two groups are Kenya and Madagascar with moderate levels of volatility. Most countries in SADC and ECOWAS would be in the moderate regional category, with only Botswana and Mauritius, in SADC, and Gambia, Liberia, Mali, and Senegal, in ECOWAS, showing volatility levels that are more than three times higher than the respective regional levels. The countries in the moderate and high volatility sub-groups would be the biggest beneficiaries of increased regional trade in terms of greater stability of domestic supplies.

The likelihood that a given country will benefit from the trade stabilization potential suggested by the difference between its volatility level and the regional average will be greater the more fluctuations of its production and that of the other countries in the region are weakly correlated. Figures 2 above present the distribution of correlation coefficients between individual country production levels for each regional group. For each country, the lower segment of the bar shows the percentage of correlation coefficients that are 0.65 or less, or the share of countries with production fluctuations that we define as relatively weakly correlated with the country's own production movements. The top segment represents the share of countries with highly correlated production fluctuations, with coefficients that are higher than 0.75. The middle segment is the share of moderately correlated country productions with coefficients that are between 0.65 and 0.75.

[1] Mauritius has a coefficient that is more than 18 times the regional average and is not shown on the figure for the sake of clarity.

Using the above criteria, countries in the most volatile region, SADC, have the highest concentration of weakly correlated country production levels. As seen from Figure 2c, only three countries have less than an 80 percent share of correlation coefficients below 0.65. The combination of high volatility and weak correlation suggests that countries in this region would reap the largest benefit from increased regional trade in terms of domestic market stabilization. They are followed by COMESA countries, where 60 percent of the correlation coefficients for any given country are in the below 0.65 category. In contrast, country level production levels in the ECOWAS region tend to fluctuate together more than in the other two regions, as shown by the high share of coefficients that are above 0.75. The division of the region into two nearly uniform sub-regions, Sahelian and coastal, may be an explanation. In general, however, the patterns and distribution of production fluctuations across countries in all three regions are such that increased trade could be expected to contribute to stabilizing domestic agricultural and food markets. But that is only one condition; the other being that there is actual potential to increase cross-border trade, a question that is examined in the next section.

3. The scope for specialization and regional trade expansion in agriculture

Despite recent upward trends, levels of intra-African and intra-regional trade are very low compared to other regions of the world. The share of intra-African markets in total agricultural exports by African countries was 34 percent on average between 2007 and 2011 (Badiane et al, 2014). Among the three RECs, SADC had the highest share of intra-regional trade (42 percent) and ECOWAS the lowest (6 percent). COMESA's share of intra-regional trade was 20 percent. Although SADC does much better than the other two RECs, its member countries still account for far less than half of the value of agricultural trade within the region (Badiane et al, 2014).

There may be a host of factors behind the low levels of intra-regional trade. These factors may not only make trading with extra-regional partners more attractive, they may also raise the cost of supplying regional markets from intra-regional sources. The exploitation of the regional stabilization potential pointed out above would require measures to lower the barriers to and bias against trans-border trade such as to stimulate the expansion of regional supply capacities and of trade flows across borders. This supposes that there is sufficient scope for specialization in production and trade within the sub-regions. Often, it is assumed that neighboring developing countries would exhibit similar production and trading patterns because of similarities in their resource bases, with little room for future specialization. There are, however, several factors that may lead to different specialization patterns among such countries. These factors include: (i) differences in historical investments in technologies and thus the level and structure of accumulated production capacities and skills; (ii) the economic distance to, and opportunity to trade with, distant markets; and (iii) differences in dietary patterns as well as other consumer preferences that affect the structure of local production as it responds to local demand. The relatively different patterns of specialization of Senegal compared to the rest of Sahelian West Africa or of Kenya compared to other Eastern African countries are a good illustration of the influence of these factors.

Consequently, we use a series of indicators to assess the actual degree of specialization in agricultural production and trade and whether or not there is real scope for trans-border trade expansion as a strategy to exploit the less than perfect correlation between national productions to reduce the vulnerability of domestic food markets to shocks. The first two are the production and export similarity indices through which the relative importance in every country of the production and trading of individual agricultural products is measured and ranked. The level of importance or position of each product is then compared for all relevant pairs of countries within each sub-region[2]. The indices have a maximum value of 100, which would reflect complete similarity of production or trade patterns between the considered pair of countries. The more the value of the indices tends towards zero, the greater the degree of specialization between the two countries. Index values of around 50 and below are interpreted as indicating patterns of specialization that are compatible with higher degrees of trade expansion. The results of the calculations for the three regional groupings, covering 150 products in total are presented Figures 3a and 3b below. Each bar represents the number of country pairs that falls within the corresponding range of index values. The vast majority of country pairs fall within the 0-50 range. A value of less than 60 is conventionally interpreted as compatible with higher trade exchange between the considered pair of countries. The estimated index values therefore suggest that there exists sufficient dissimilarity in current country production and trading patterns and hence scope for trans-border trade expansion in all three sub-regions.

A third indicator, the revealed comparative advantage (RCA) index, is computed to further assess the degree of trade specialization among countries within the three regions. The RCA index compares the share of a given product in a given country's export basket with that of the same product in total world exports. A value greater than 1 indicates that the considered country performs better than the world average and the higher the value is, the stronger the performance of the country in exporting the considered product. Of the nearly 600 RCA indicators estimated for various products exported by different COMESA countries, 70 percent have a value higher than 1. The total number of indicators for ECOWAS and SADC is about 450 each. The share of indictors that are higher than 1 is about the same as in the case of COMESA: 68 percent for SADC and 73 percent for ECOWAS. For each regional grouping, the 20 products

[2] See Koester, 1986.

with the highest normalized RCA index values are presented in Table 1. The normalized RCA is positive for RCA indicators that are greater than 1 and negative otherwise[3]. For very high RCA indicators, the normalized value tends towards 1.

All the products listed in the table have normalized RCA values above 0.98. The rankings reflect the degree of cross-country specialization within each REC. In ECOWAS, for instance, a total of 12 products, spread across 8 out of 15 member countries, account for the highest 20 indicators for the region. There are 13 products in that category in the case of COMESA and they come from 9 out of 19 countries. SADC has the highest number of products in that category, a total of 14, but they come from only 5 out of 15 countries. The table also illustrates the difference in degree of specialization between the three major regions. Of the top ranking products, only two (carded and combed cotton and cashew nuts in shell) are common to the ECOWAS and SADC regions. Even between COMESA and SADC, only six of the top ranking products are common to the two regions, while no common top ranking products are found between COMESA and ECOWAS. A fuller appreciation of the degree of specialization across all countries in the three regions is best obtained by looking at the RCA values for the entire set of products and countries. For instance, if countries had similar patterns of specialization, the same products would tend to rank equally high and the values of the RCA indicator for the same product would not vary significantly across countries. Similarly, if countries had similar patterns of specialization, exports would be concentrated around a few products, with substantial variation of the indicator value across products.

[3] The formula for the normalized RCA is (RCA-1)/(RCA+1).

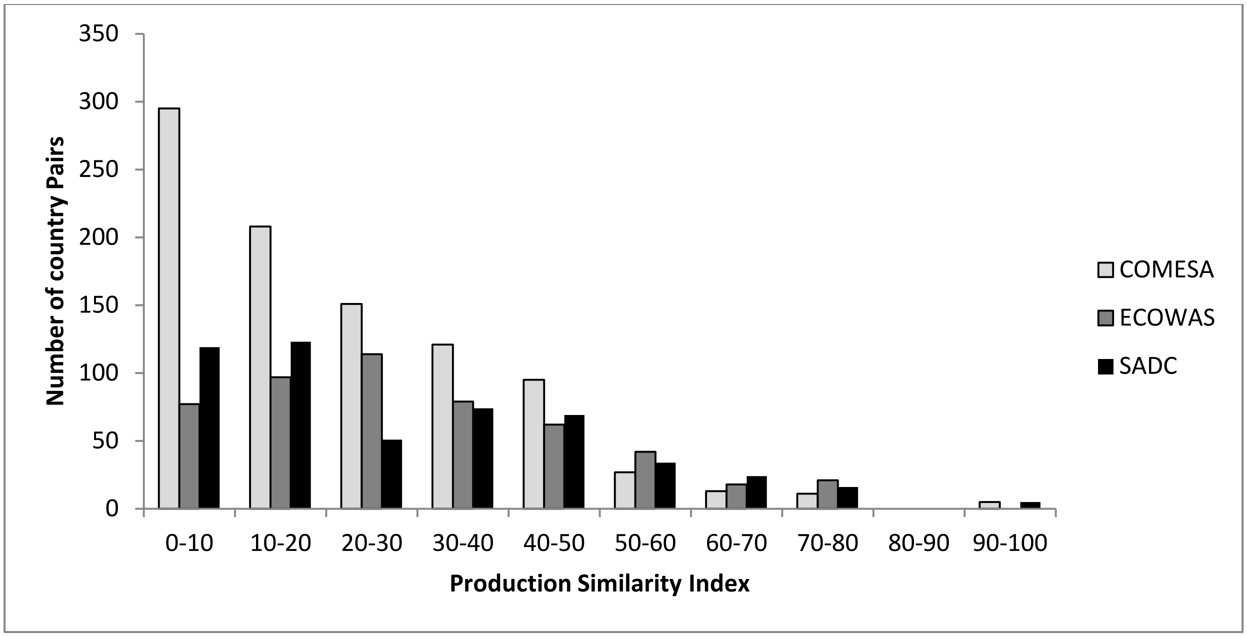

Figure 3a: Similarity of production patterns, 2007-2011

Source: Authors' calculations based on data from FAOSTAT 2014

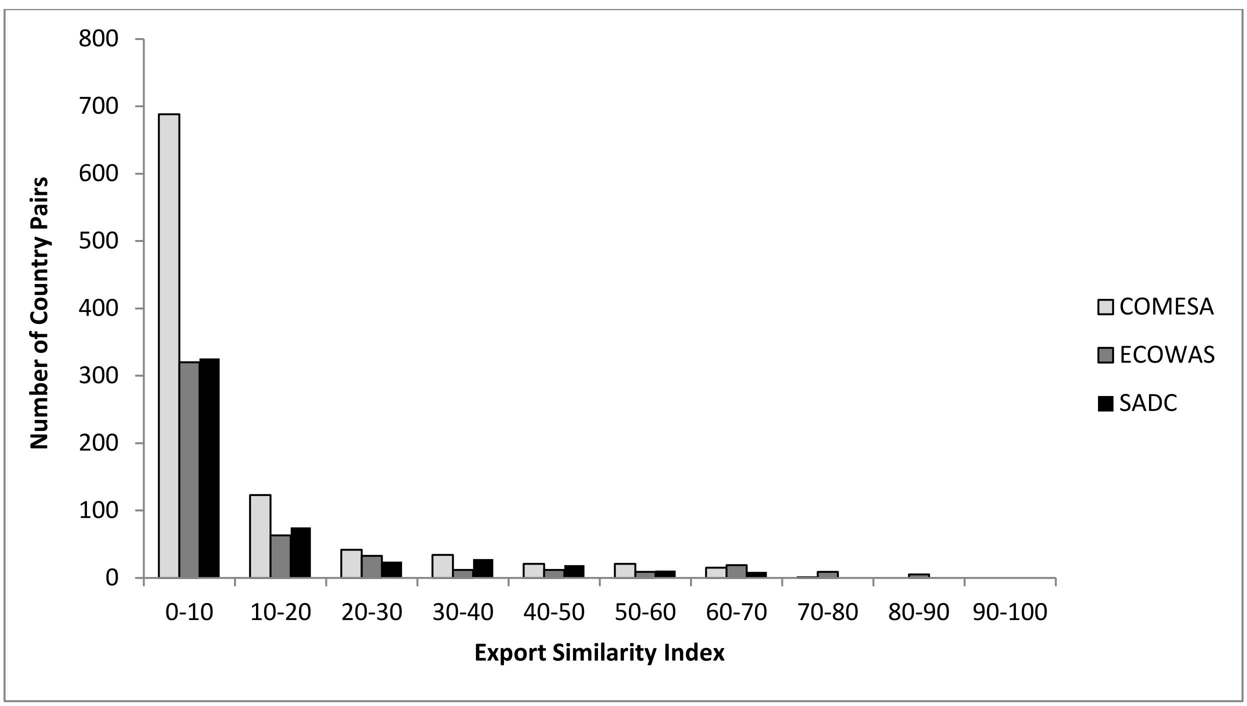

Figure 3b: Similarity of trading patterns, 2007-2011

Source: Authors' calculations based on data from FAOSTAT 2014

Table 1: Revealed Comparative Advantage indices by Region, average 2007-2011

COMESA		ECOWAS		SADC	
Commodity	**Country**	**Commodity**	**Country**	**Commodity**	**Country**
Cloves	Comoros	Cashew nuts, with shell	Guinea Bissau	Vanilla	Madagascar
Vanilla	Comoros	Cake of Groundnuts	Gambia	Cloves	Madagascar
Vanilla	Madagascar	Groundnut oil	Gambia	Coffee Husks and Skins	Tanzania
Coffee Husks and Skins	Uganda	Cashew nuts, with shell	Benin	Tobacco, unmanufactured	Malawi
Cloves	Madagascar	Groundnuts Shelled	Gambia	Cotton Carded, Combed	Malawi
Oil Essential Nes	Comoros	Cashew nuts, with shell	Gambia	Cashew nuts, with shell	Tanzania
Coffee Husks and Skins	Burundi	Groundnut oil	Senegal	Cake of Cottonseed	Zimbabwe
Sesame seed	Ethiopia	Copra	Gambia	Cake of Cottonseed	Tanzania
Skins dry Slt sheep	Ethiopia	Cake of Groundnuts	Senegal	Cotton Carded, Combed	Tanzania
Coffee Subst. Cont. Coffee	Rwanda	Cake of Cottonseed	Benin	Cloves	Tanzania
Coffee Husks and Skins	Kenya	Rubber Nat Dry	Liberia	Coffee Subst. Cont. Coffee	Malawi
Goat meat	Ethiopia	Cottonseed oil	Togo	Sesame oil	Tanzania
Cotton Carded, Combed	Uganda	Cottonseed oil	Benin	Cashew nuts, with shell	Mozambique
Sesame seed	Eritrea	Sugar beet	Gambia	Hides Nes	Zimbabwe
Tobacco, unmanufactured	Malawi	Cashew nuts, with shell	Cote d'Ivoire	Cotton Linter	Zimbabwe
Oilseeds, Nes	Ethiopia	Cotton Linter	Benin	Tobacco, unmanufactured	Zimbabwe
Broad beans, horse beans, dry	Ethiopia	Cocoa beans	Cote d'Ivoire	Cotton Linter	Malawi
Cotton Carded, Combed	Burundi	Cake of Groundnuts	Togo	Tea	Malawi
Skins dry Slt sheep	Rwanda	Cocoa Paste	Cote d'Ivoire	Cotton Waste	Malawi
Tea	Rwanda	Cocoa beans	Ghana	Peas, green	Zimbabwe

Source: Authors' calculations based on FAOSTAT 2014

An analysis of the variance of the RCA index is, therefore, carried out to test either of the above possibilities. The results of the analysis presented in Table 2 show that for the entire sample of African countries, nearly two thirds (63 percent) of the total variation of the RCA index across countries and commodities is accounted for by country-to-country variation. The balance of variation is explained by variation across products. The RCA index, like the previous two indicators, thus confirms the existence of dissimilar patterns of trade specialization in agricultural products.

So far, the analysis has established the existence of dissimilar patterns of specialization in production and trade of agricultural products among countries within and across the three major regions. Two final indicators, the Trade Overlap Indicator (TOI) and the Trade Expansion Indicator (TEI), are calculated to examine the potential to expand trade within the three blocks of countries based on current trade patterns.

They measure how much of the same product a given country or region exports and imports at the same time. The TOI measures the overall degree of overlapping trade flows for a country or region as a whole, while the TEI measures the overlapping trade flows at the level of individual products for a country or region. The results are presented in Figure 4 and Table 3. The Figure indicates that there is a considerable degree of overlapping trade flows; 25 percent for Africa as whole and as much as 40 percent for the SADC region. Normalized TOI values obtained by dividing country TOI values by the TOI value for the respective regions can be found in Badiane et al (2014). In the vast majority of cases, they are significantly less than 1. The overlapping regional trade flows must therefore be from different importing and exporting countries. In other words, some countries are exporting (importing) the same products that are being imported (exported) by other member countries in their respective groupings, but in both cases to and from countries outside the region. By redirecting such flows, countries should be able to expand trans-border trade within each of the groupings.

The TEI indicates which products have the highest potential for increased trans-border trade based on the degree of overlapping trade flows. Table 3 lists the 20 products with the highest TEI value for each of the three regions. The lowest indicator value for any of the products across the three regions is 0.41. RCA values for the same products presented in Badiane et al (2014) are all greater than 1, except for only three products: fresh fruits in ECOWAS, bananas in COMESA, and chocolate products in SADC. The fact that products with high TEI also have high RCA indicator values point to a real scope for trans-border trade expansion in all three sub-regions.

The findings above point to the existence of a real potential to expand intra-trade in all three regions beyond the levels shown in Tables 1 above, even with current production and trade patterns. The remainder of the chapter therefore analyzes the outlook for intra-trade expansion and the expected impact of volatility of regional food markets over the next 15 years. This is done by simulating alternative policy scenarios to boost intra-regional trade and comparing the effects on the level and volatility of trade flows up to 2025 to historical trends and outcomes under a baseline scenario that would continue these trends.

Table 2: Estimation of RCA variability across countries and products

Source of variance		Sequential Sum of Square	Mean squared	F	P-value	Share of variation explained
Model		1489.66	6.03	46.63	0.00	72.86%
	Countries	936.94	23.42	181.09	0.00	45.82%
	Commodities	552.44	2.68	20.73	0.00	27.02%
	Years	0.28	0.28	2.19	0.14	0.01%
Residual		555.03	0.129			27.14%
Total		2044.69	0.45			
Number of obs.	4539	R-squared 0.73		R-squared adj 0.71		

Note: The mean square (partial sum of squares /degrees of freedom) is used to compute the F-statistic and determine the significant amounts of variation. This ANOVA is without interaction terms due to the missing values from the unbalanced nature of the data. The time factor is included.

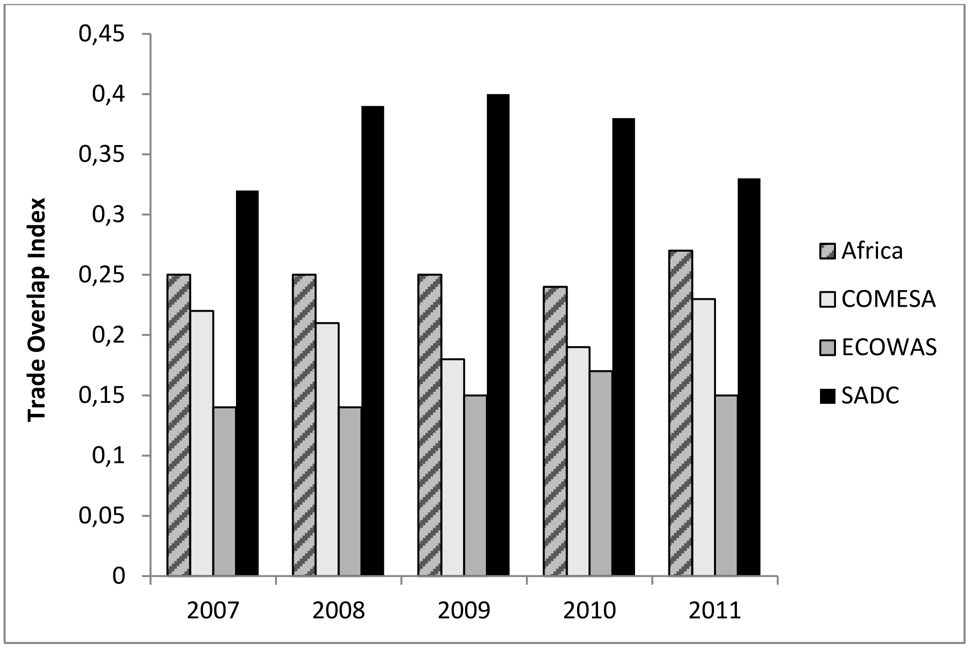

Figure 4: Trade Overlap Indicators, average 2007-2011

Source: Authors' calculations based on FAOSTAT 2014

Table 3: Trade Expansion Indicators, average 2007-2011

COMESA		ECOWAS		SADC	
Commodity	**TEI value**	**Commodity**	**TEI value**	**Commodity**	**TEI value**
Beans, dry	0.825	Tobacco products	0.926	Pepper (piper spp.)	0.919
Sugar confectionery	0.821	Fatty acids	0.763	Cake, cottonseed	0.856
Vegetables, preserved	0.819	Groundnuts, shelled	0.744	Cottonseed	0.849
Juice, fruit	0.819	Hides, cattle, wet salted	0.681	Cigarettes	0.815
Cigarettes	0.782	Coffee, extracts	0.676	Hair, fine	0.811
Spices	0.716	*Fruit, fresh*	0.620	Bran, wheat	0.797
Sugar Raw Centrifugal	0.716	Fruit, tropical fresh	0.592	Waters, ice etc.	0.783
Fruit, prepared	0.703	Cigarettes	0.573	Bran, maize	0.782
Groundnuts, shelled	0.700	Tea, mate extracts	0.535	Fruit, dried	0.776
Cake, cottonseed	0.680	Oilseeds	0.524	Sugar	0.774
Pineapples	0.677	Onions, dry	0.513	Cider etc.	0.762
Cereal preparations	0.665	Oil, cottonseed	0.510	Molasses	0.759
Anise, badian, fennel, coriander	0.655	Pepper (piper spp.)	0.479	*Juice, fruit*	0.749
Waters, ice etc.	0.655	Margarine Short	0.456	Onions, dry	0.743
Cheese, whole cow milk	0.604	Roots and tubers	0.454	Flour, cereals	0.730
Bananas	0.592	Cereal preparations	0.439	*Chocolate products*	0.723
Bran, wheat	0.586	Chickpeas	0.415	Meat, pig, preparations	0.715
Tobacco products	0.586	Vegetables fresh or dried Products	0.412	Cauliflowers and broccoli	0.712
Pepper (Piper spp.)	0.578	*Fruit, prepared*	0.412	Coconut(copra) oil	0.705
Orange Juice, single strength	0.566	Pineapple, canned	0.406	Vegetables frozen	0.697

Source: Authors' calculations based on FAOSTAT 2014

Note: Italics designate products with RCA < 1; products with high TEI but which are not being produced in the regions are included, as they relate to re-export trade. There were two in the case of COMESA and SADC and six in the case of ECOWAS.

4. The Outlook for regional cross-border trade and market volatility under alternative scenarios

The preceding analysis presents evidence showing that African countries could use increased regional trade to enhance the resilience of domestic markets to supply shocks. The high cost of moving goods across domestic and trans-border markets and outwardly biased trading infrastructure are major determinants of the level and direction of trade among African countries. A strategy to exploit the regional stabilization potential therefore has to include measures to lower the general cost of trading and remove additional barriers to cross-border trade. This section simulates the impact on regional trade flows of changes in that direction. Simulations of changes are carried out using IFPRI's regional Economy-wide Multimarket Model (EMM) described below[4].

4.1 The regional trade simulation model

Simulations of changes are carried out using IFPRI's regional Economy-wide Multimarket Model (EMM)[5]. The original model is augmented in this study to account for intra- versus extra-regional trade sources and destinations as well as informal versus formal trade costs in intra-regional trade transactions. In its original version, the EMM solves for optimal levels of supply $QX_{r\,c}$, demand $QD_{r\,c}$ and net trade (either import $QM_{r\,c}$ or export $QE_{r\,c}$) of different commodities c for individual member countries r of the modelled region.

Supply and demand balance at the national level determines domestic output prices $PX_{r\,c}$ as stated by equation (1) while equation (2) connects domestic market prices $PD_{r\,c}$ to domestic output prices taking into account an exogenous domestic marketing margin $margD_{r\,c}$. The net trade of a commodity in a country is determined through mixed complementarity relationships between producer prices and potential export quantities, and between consumer prices and potential import quantities. Accordingly, equation (3) ensures that a country will not export a commodity ($QE_{r,c} = 0$) as long as the producer price of that commodity is higher than its export parity price, where $pwe_{r\,c}$ is the country's FOB price and $margW_{r\,c}$ is an exogenous trade

[4] See Diao et al., 2007 and Nin-Pratt et al., 2010.
[5] See Diao et al., 2007 and Nin-Pratt et al., 2010.

margin covering the cost of moving the commodity from and to the border. If the domestic market balance constraint in equation (1) requires that the country exports some excess supply of a commodity ($QE_{r,c} > 0$), then the producer price will be equal to the export parity price of that commodity. Additionally, equation (4) governs any country's possibility to import a commodity, where $pwm_{r\,c}$ is its CIF price. There will be no import ($QM_{r,c} = 0$) as long as the import parity price of a commodity is higher than the domestic consumer price. If the domestic market balance constraint requires that the country imports some excess demand of a commodity ($QM_{r,c} > 0$), then the domestic consumer price will be equal to the import parity price of that commodity.

$$QX_{r\,c} + QM_{r\,c} - QE_{r\,c} = QD_{r\,c} \tag{1}$$

$$PX_{r\,c} \cdot (1 + margD_{r\,c}) = PD_{r\,c} \tag{2}$$

$$PX_{r\,c} \geq pwe_{r\,c} \cdot (1 - margW_{r\,c}) \qquad \perp \qquad QE_{r,c} \geq 0 \tag{3}$$

$$pwm_{r\,c} \cdot (1 + margW_{r\,c}) \geq PD_{r\,c} \qquad \perp \qquad QM_{r,c} \geq 0 \tag{4}$$

In the version used in this study, the net export of any commodity is modelled as an aggregate of two output varieties differentiated according to their market outlets (regional and extra-regional) while assuming an imperfect transformability between the two export varieties. Similarly, the net import of any commodity is modelled as a composite of two varieties differentiated by their origins (regional and extra-regional) while assuming an imperfect substitutability between the two import varieties.

In order to implement export differentiation by destination, the mixed complementarity relationship in equation (3) is replaced with two new equations which specify the price conditions for export to be possible to both destinations. Equation (5) indicates that for export to extra-regional market outlets to be possible ($QEZ_{r\,c} > 0$) suppliers should be willing to accept for that destination a price $PEZ_{r\,c}$ that is not greater than the export parity price. Similarly, equation (6) assures that export to within-region market outlets is possible ($QER_{r\,c} > 0$) only if suppliers are willing to receive for that destination a price $PER_{r\,c}$ that is not more than the regional market clearing price PR_c adjusted downward to account for exogenous regional trade margins $margR_{r\,c}$ incurred in moving the commodity from the farm gate to regional market. (See equation 17 below for the determination of PR_c.)

$$PEZ_{r\,c} \geq pwe_{r\,c} \cdot (1 - margW_{r\,c}) \quad \perp \quad QEZ_{r\,c} \geq 0 \tag{5}$$

$$PER_{r\,c} \geq PR_c \cdot (1 - margR_{r\,c}) \quad \perp \quad QER_{r\,c} \geq 0 \tag{6}$$

Subject to these price conditions, equations (7) – (10) determine the aggregate export quantity and its optimal allocation to alternative destinations. Equation (7) indicates that the aggregate export of a commodity by individual countries $QE_{r\,c}$ is obtained through a constant elasticity of transformation (CET) function of the quantity $QEZ_{r\,c}$ sold on extra-regional market outlets and the quantity $QER_{r\,c}$ sold on intra-regional market outlets, where $\rho^e_{r\,c}$, $\delta^e_{r\,c}$ and $\alpha^e_{r\,c}$ represent the CET function exponent, share parameter and shift parameter, respectively. Equation (8) is the first-order condition of aggregate export revenue maximization problem, given the prices suppliers can receive for the different export destinations and subject to the CET export aggregation function. It says that an increase in the ratio of intra-regional to extra-regional destination prices will increase the ratio of intra-regional to extra-regional export quantities, i.e. a shift toward the export destination that offers the higher return. Equation (9) helps identify the optimal quantities supplied to each destination; it states that aggregate export revenue at producer price of export $PE_{r\,c}$ is the sum of export sales revenues from both intra-regional and extra-regional market outlets at supplier prices, while equation (10) sets the producer price of export to be the same as the domestic output price $PX_{r\,c}$, which is determined through the supply and demand balance equation (1) as earlier explained.

$$QE_{r\,c} = \alpha^e_{r\,c} \cdot \left(\delta^e_{r\,c} \cdot QER_{r\,c}^{\rho^e_{r\,c}} + (1 - \delta^e_{r\,c}) \cdot QEZ_{r\,c}^{\rho^e_{r\,c}}\right)^{\frac{1}{\rho^e_{r\,c}}} \tag{7}$$

$$\frac{QER_{r\,c}}{QEZ_{r\,c}} = \left(\frac{PER_{r\,c}}{PEZ_{r\,c}} \cdot \frac{1 - \delta^e_{r\,c}}{\delta^e_{r\,c}}\right)^{\frac{1}{\rho^e_{r\,c} - 1}} \tag{8}$$

$$PE_{r\,c} \cdot QE_{r\,c} = PER_{r\,c} \cdot QER_{r\,c} + PEZ_{r\,c} \cdot QEZ_{r\,c} \tag{9}$$

$$PE_{r\,c} = PX_{r\,c} \tag{10}$$

Import differentiation by origin is implemented following the same treatment as described above for export differentiation by destination. Equation (4) is replaced with equations (11) and

(12). Accordingly, import from the extra-regional origin will happen ($QMZ_{r,c} > 0$) only if domestic consumers are willing to pay for the extra-regional variety a price $PMZ_{r\,c}$ that is not smaller than import parity price. Futrthermore, import from intra-regional origin is possible ($QMR_{r,c} > 0$) only if domestic consumers are willing to pay the intra-regional variety at a price $PMR_{r\,c}$ that is not smaller than the regional market clearing price PR_c adjusted upward to account for exogenous regional trade margins $margR_{r\,c}$ incurred in moving the commodity from the regional market to consumers.

$$pwm_{r\,c} \cdot (1 + margW_{r\,c}) \geq PMZ_{r\,c} \qquad \perp \qquad QMZ_{r,c} \geq 0 \tag{11}$$

$$PR_r \cdot (1 + margR_{r\,c}) \geq PMR_{r\,c} \qquad \perp \qquad QMR_{r\,c} \geq 0 \tag{12}$$

Under these price conditions, equation (13) represents aggregate import quantity $QM_{r\,c}$ as a composite of intra and extra-regional import variety quantities $QMR_{r\,c}$ and $QMZ_{r\,c}$, respectively using a constant elasticity of substitution (CES) function, with $\rho^m_{r\,c}$, $\delta^m_{r\,c}$ and $\alpha^m_{r\,c}$ standing for the CES function exponent, share parameter and shift parameter, respectively. The optimal mix of the two varieties is defined by equation (14), which is the first-order condition of aggregate import cost minimization problem, subject to the CES aggregation equation (13) and given import prices from both origins. An increase in the ratio of extra-regional to intra-regional import prices will increase the ratio of intra-regional to extra-regional import quantities, i.e. a shift away from the import origin that becomes more expensive. Equation (15) identifies the specific quantities imported from each origin. It defines total import cost at consumer price of import $PM_{r\,c}$ as the sum of intra-regional and extra-regional import costs, while equation (16) sets the consumer price of import to be the same as the domestic market price $PD_{r\,c}$, which is determined through equations (1) and (2) as earlier explained

$$QM_{r\,c} = \alpha^m_{r\,c} \cdot \left(\delta^m_{r\,c} \cdot QMR_{r\,c}^{-\rho^m_{r\,c}} + (1 - \delta^m_{r\,c}) \cdot QMZ_{r\,c}^{-\rho^m_{r\,c}}\right)^{-\frac{1}{\rho^m_{r\,c}}} \tag{13}$$

$$\frac{QMR_{r\,c}}{QMZ_{r\,c}} = \left(\frac{PMZ_{r\,c}}{PMR_{r\,c}} \cdot \frac{\delta^m_{r\,c}}{1 - \delta^m_{r\,c}}\right)^{\frac{1}{1+\rho^m_{r\,c}}} \tag{14}$$

$$PM_{r\,c} \cdot QM_{r\,c} = PMR_{r\,c} \cdot QMR_{r\,c} + PMZ_{r\,c} \cdot QMZ_{r\,c} \tag{15}$$

$$PM_{r\,c} = PD_{r\,c} \tag{16}$$

Having determined export quantities and prices by destination and import quantities and prices by origin, the regional market clearing price PR_c can now be solved. Equation (17) imposes the regional market balance constraint by equating the sum of intra-regional export supplies to the sum of intra-regional import demands, with $qdstk_c$ standing for discrepancies existing in observed aggregate intra-regional export and import quantity data in the model base year. Thus, PR_c is determined as the price that ensures the regional market balance.

$$\sum_{r} QER_{r\,c} = \sum_{r} QMR_{r\,c} + qdstk_c \tag{17}$$

The model is separately calibrated to each of the three RECs. Calibration is performed such as to replicate, for every member country within each REC, the same production, consumption and net trade data as observed for different agricultural subsectors and two non-agricultural sub-sectors in 2007–2008. Baseline trend scenarios are then constructed such that, until 2025, changes in crop yields, cultivated areas, outputs, and GDP reflect the same observed changes. Table A1 in the annex compares the calibrated agricultural and economy-wide GDP growth rates under the baseline scenario with the observed rates in recent years. Although the model is calibrated to the state of national economies seven years earlier, it reproduces closely the countries' current growth performances.

Four different scenarios are simulated using the EMM. The first is the baseline scenario described above which assumes a continuation of current trends up to 2025. It is used later as a reference to evaluate the impact of changes under the remaining three scenarios. The latter scenarios introduce the following three different sets of changes to examine their impacts on regional trade levels: a reduction of 10 percent in the overall cost of trading across the economy; a removal of all cross-border trade barriers, that is a reduction of their tariff equivalent to zero; and an across the board 10 percent increase in yields. These changes are to take place between 2008, the base year, and 2025. The change in cross-border exports is used as an indicator of the impact on intra-regional trade. In the original data, there are large discrepancies between recorded regional exports and import levels, the latter often being a multiple of the former. The more conservative export figures are therefore the preferred indicator of intra-regional trade.

4.2 Intra-trade simulation results

The results for the different regions are presented in Figures 3. The figures on the left present the results of the baseline scenarios for the three regions from 2008 to 2025. Assuming a continuation of current trends, intra-regional trade in both ECOWAS and SADC is expected to expand rapidly but with marked differences between crops. The aggregate volume of intra-regional trade in staples would approach 3 million tons in the case of ECOWAS and about half that amount in the case of SADC, if the current rates of growth in yields, cultivated areas, and income growth are sustained to 2025. Cereals would see the smallest gains, while trade in roots and tubers as well as other food crops would experience much faster growth in the case of ECOWAS. This is in line with the current structure of and trends in commodity demand and trade. While the increase in demand for roots of tubers is being met almost exclusively from local sources, the fast growing demand in cereals is heavily tilted towards rice, which is supplied from outside of the region. The two leading cereals that are traded regionally, maize and millet, therefore benefit less from the expansion of regional demand and have historically seen slower growth in trade than roots and tubers. In the case of SADC, it is particularly the rise of Angola as a main exporter of roots and tubers starting in 2013 that explains the strong boost in regional trade for that commodity. The sole exporter before was Zimbabwe with very modest quantities, hence the high rates of growth of overall regional exports.

The story is a bit different in the case of COMESA. As was already apparent from the market share analysis carried out earlier, the COMESA regional market has been the least dynamic of the three regional markets and the only one associated with a negative market effect. COMESA is the only region where member countries as a group have experienced a decline in competitiveness. The underwhelming performance is reflected in the baseline scenario. If current trends were to continue, the levels of intra-regional trade would continue to stagnate, except in the case of cereals. And even in the latter case, the decline in trade volumes would be reversed, but not enough to bring them back to their initial levels. The projected evolution of the cereals trade reflects different country dynamics and a shift in the sources of regional exports. The fall in regional trade levels at the beginning of the period is a result of continuing decline in exports from the two main traditional suppliers, Egypt and Malawi. At the same time, faster growth in several other countries, particularly Tanzania and Ethiopia, results in rising exports from these countries, starting from 2011 for Tanzania and from 2019 for Ethiopia. The result is a U-shaped pattern in COMESA cereals exports, as export declines in some countries are eventually outweighed by increases in others. The graphs in Figure 3.5b show the cumulated changes in intra-regional export levels by 2025 compared to the baselines that would result from a reduction in total trading cost, removal of trans-border trade barriers, and an increase in yields. The bars represent the proportional changes in percent and the numbers on top of the bars indicate the corresponding absolute changes in 1000 metric tons. The results invariably show considerable increases in intra-regional trade in cereals and roots and tubers, the main food crops, in response to changes in trading costs and yields. Intra-community trade levels in ECOWAS climb by between 10 and 35 percent for most products over the entire period. The volume of cereal trade increases by a cumulative total of between 200,000 and 300,000 mt for individual products and that of overall trade in staples by between 1.5 and 4.0 million tons by 2025, compared to baseline trends. Cereals seem to respond better than other products in general. It also appears that removal of trans-border barriers to trade would have the strongest impact of trade flows across the board.

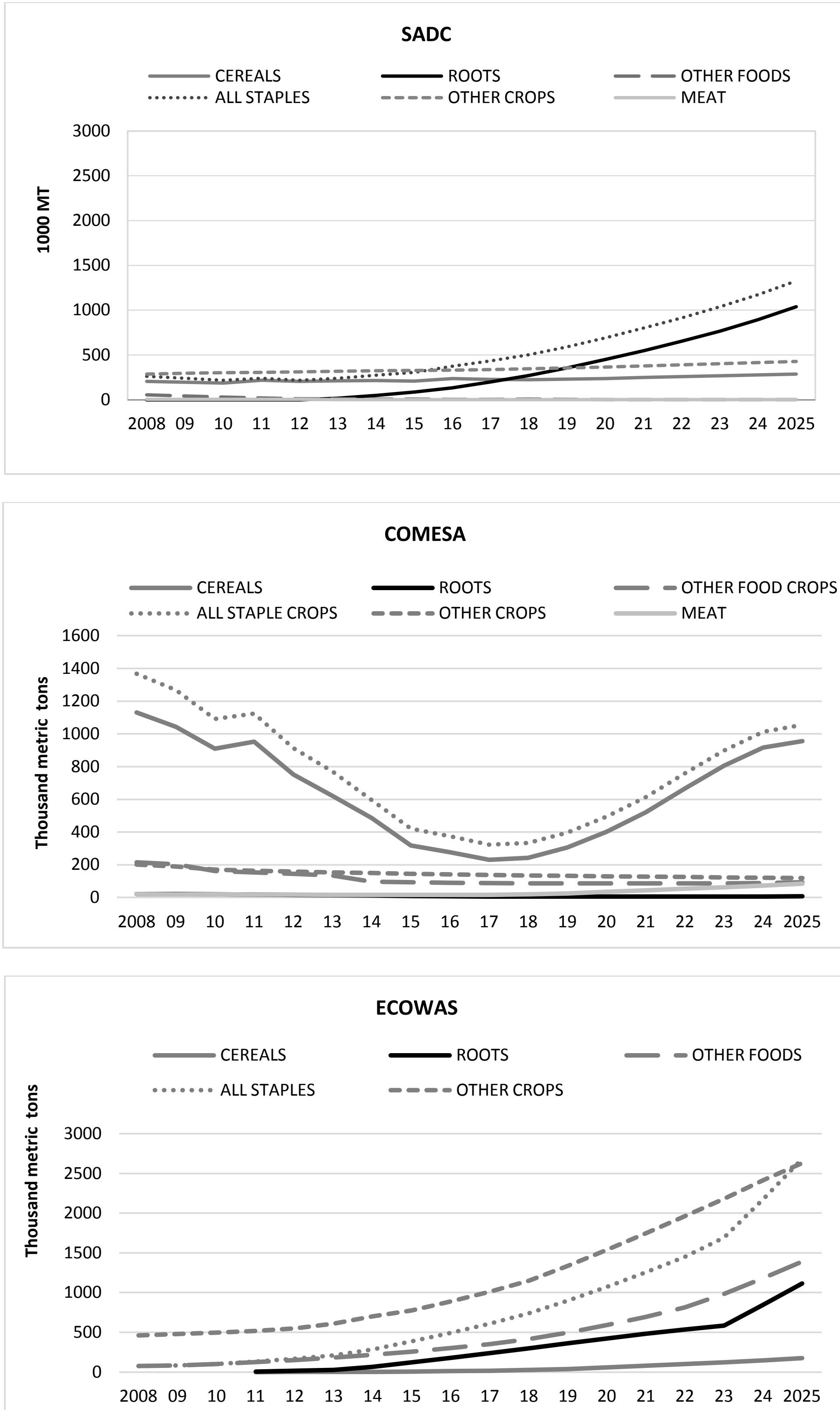

Figure 5a: Regional Exports Outlook, Baseline

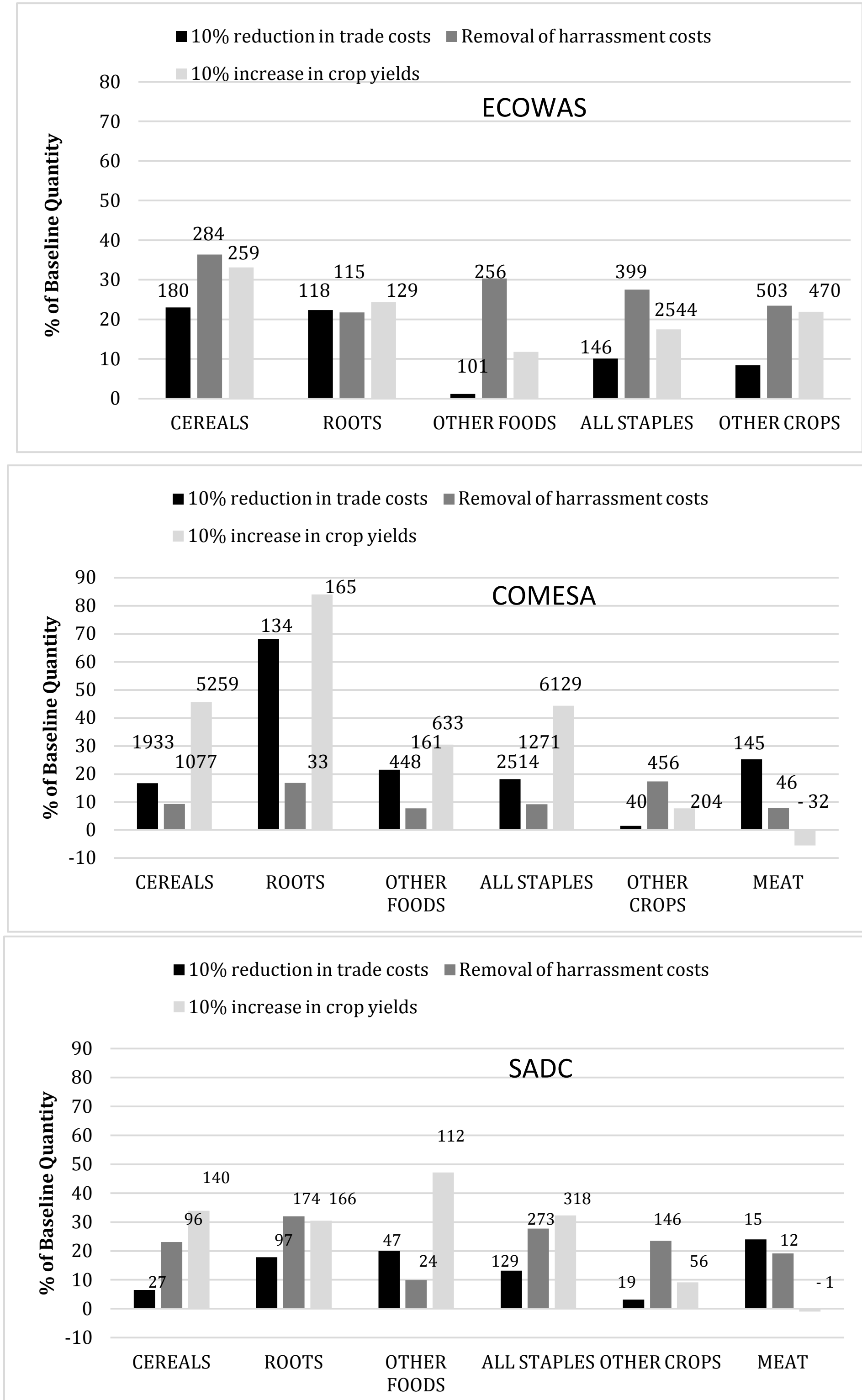

Figure 5b: Changes in Cost, Yields and Exports

Source: Authors' calculations.

Note: Figures on top of bars indicate cumulative increases in regional export supply in 1000 mt. Other crops include all or subset of the following crops: fruits and vegetables, cotton, sugar, cocoa, coffee, tea, tobacco, spices, and nuts

The COMESA region shows similar increases in overall trade in staples. Cereals trade tends to respond less in proportional terms but, because of initially higher levels, the accumulated additional volume of regional trade is much higher, ranging from 0.7 million to more than 3.0 million tons above the baseline. Also, compared to ECOWAS, intra-regional trade seems to respond more to changes in overall costs of trading and yields than to changes in cross-border barriers. This may be explained by the fact that equivalent tariffs constitute a smaller fraction of producer prices and hence changes in barriers result in smaller changes in incentives. Trade in the SADC region too seems to respond more to changes in trans-border trade barriers and yields, as in the case of ECOWAS. A 10 percent increase in yields would raise trade in staples by a cumulative volume of slightly more than 3.0 million tons by 2025 compared to the baseline scenario.

4.3 Regional market volatility under alternative policy scenarios

Under each scenario, model simulated quantities of intra-regional exports $QER_{r\,c}$ are used to estimate an index of future export volatility at country and regional levels as follows. First, a trend-corrected coefficient of variation TCV is calculated for each country, using the following formula as in Cuddy and Della Valle (1978):

$$TCV = CV \cdot \sqrt{\left(1 - \overline{R^2}\right)}$$

where CV is the coefficient of variation and $\overline{R^2}$ is the adjusted coefficient of determination of the linear trend regression obtained using the time series of aggregate quantities of intraregional exports of all staple food crops from 2008 to 2025. Then an index of regional volatility TCV_{REC} is derived for each REC as a weighted average of trend corrected coefficients of variation of its member countries with the formula

$$TCV_{REC}^2 = \sum_{i}^{n} s_i^2 \cdot TCV_i^2 + 2\sum_{i}^{n}\sum_{j}^{n} s_i \cdot s_j \cdot v_{ij} \cdot TCV_i \cdot TCV_j$$

where TCV_i and TCV_j are the trend-corrected coefficients of variation in aggregate exports of staple food crops in countries i and j, n is the number of member countries of the REC, s_i and

s_j are the shares of countries i and j in the region's overall intra-regional exports of staple food crops, and v_{ij} is the coefficient of correlation between aggregate exports of countries i and j. Finally, the coefficients of variation at country level are normalized by dividing them by the respective regional coefficients.

The historical and simulated levels of volatility of cross-border trade in food staples in the various regions under historical trends and each of the alternative scenarios are reported in Table 4. Volatility levels under historical trends are calculated based on the TradeMaps database. In Table 5, simulated volatility levels under the various scenarios are compared with the historical levels of volatility, with the difference expressed in absolute point changes. As can be seen from the figures in the two tables, volatility levels are lower under nearly all scenarios than under historical trends. The only exception is in the case of ECOWAS, where regional cross-border trade volatility decreases with a reduction of overall trading costs but rises under the removal of cross-border trade barriers or with increases in yields. The magnitude of changes are however rather small across all three scenarios. The Figures also show that under continuation of current trends of rising volumes of intra-regional trade, volatility levels in all three regions are expected to decline compared to historical trends. A better comparison is therefore to contrast changes under the two trade policy scenarios and the productivity scenario with expected volatility levels under the baseline scenario. Furthermore, the direction and magnitude of changes in the level of intra-regional trade volatility are determined by the combined effect of changes in the level of volatility as well as shares of cross-border exports by individual countries. Figure 5 below shows changes in volatility levels (x-axis) and shares of exports (y-axis) by individual countries under each of the trade and productivity scenario compared to baseline. The different dots indicate the position of different countries under the three scenarios. The tilted distribution of country positions to the left of the x-axis indicates that exports by most countries would experience a lower level of volatility under regional policies that would reduce overall cost of trading, eliminate administrative and regulatory obstacles to trans-border trade or raise yields of staple crops in member countries.

Table 4. Regional cross-border trade volatility under various scenarios

	Historical trend (1996-2012)	Baseline trend (2008-2025)	10% reduction in trade costs (2008-2025)	Removal of cross-border trade barriers (2008-2025)	10% increase in crop yields (2008-2025)
ECOWAS	0.345	0.33	0.323	0.354	0.378
COMESA	0.682	0.55	0.505	0.551	0.449
SADC	0.73	0.126	0.131	0.173	0.151

Source: Authors calculations from TradeMaps database and EMM model simulation results.

Table 5. Change in regional trade volatility under alternative scenarios (2008-2025)

	Baseline trend	10% reduction in trade costs	Removal of cross-border trade barriers	10% increase in crop yields
	Absolute point change compared to historical trend			
ECOWAS	-0.015	-0.022	0.009	0.033
COMESA	-0.132	-0.178	-0.132	-0.234
SADC	-0.604	-0.600	-0.557	-0.579

Source: Authors calculations from TradeMaps database and EMM model simulation results.

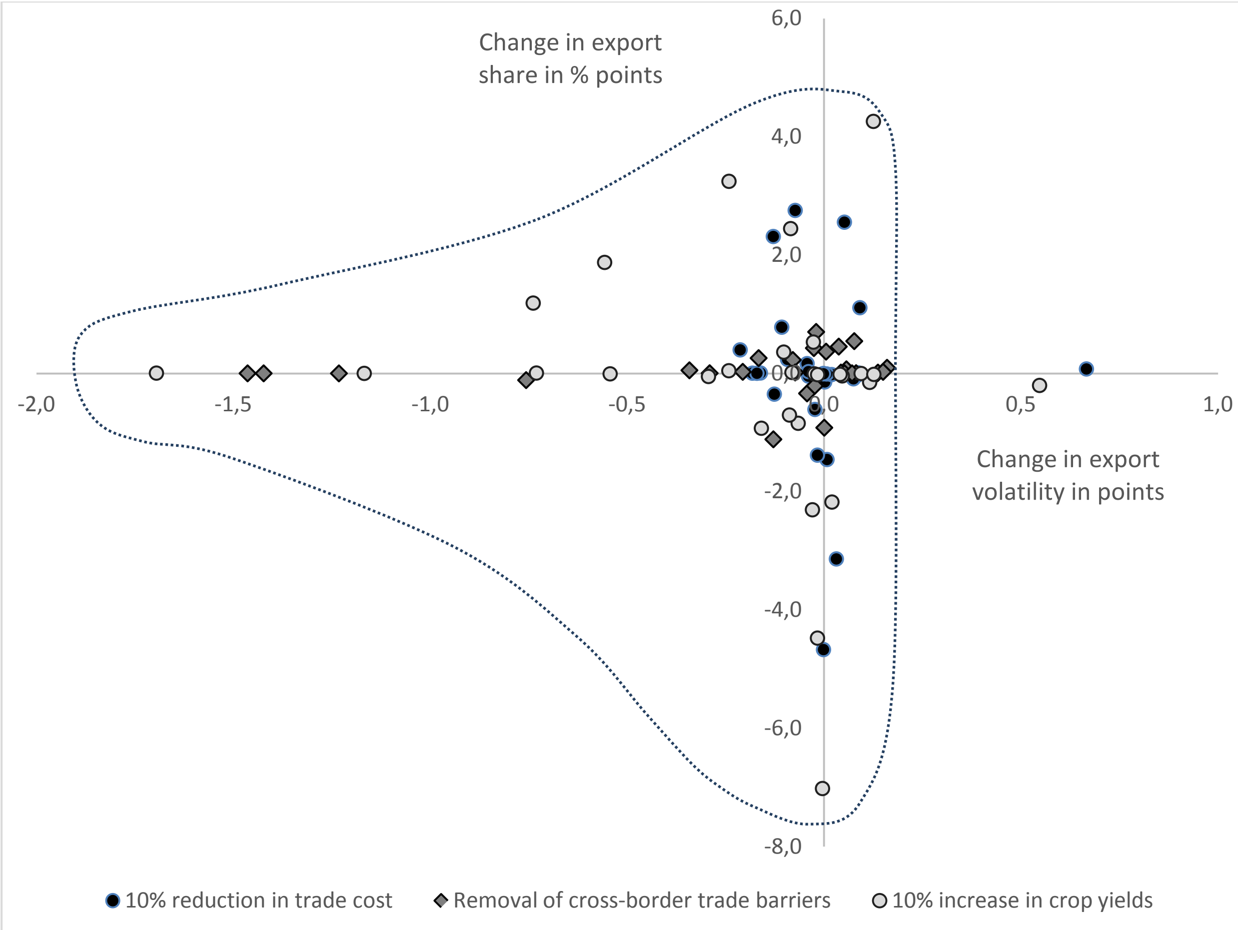

Figure 5: Changes in country export shares and volatility compared to baseline trends

The combined changes in export share and volatility for individual countries under each of the scenarios are reported in Table A2 and presented in Figures A1 to A3 in the Annex. Only countries that have exported historically are considered. Changes in country production patterns resulting from the simulated policy actions lead to changes in both the volatility as well as the level of exports and hence the shares in regional trade for each country. The magnitude and direction of these changes determine the contribution of individual countries to changes in the level of volatility in regional food markets.

5. Conclusions

The current chapter has examined the existing potential to use increased intra-regional trade among Africa’s main regional economic communities as a means to raise the resilience of domestic food markets to shocks across their member countries. The distribution and correlation of production volatility as well as the current patterns of specialization in production and trade of agricultural products across countries suggest that it is indeed possible to raise cross-border trade to reduce the level of instability of local food markets. The results of the baseline scenario indicate that continuation of recent trends would sustain the expansion of intra-regional trade flows in all three regions, particularly in the ECOWAS region. The findings also reveal that it is possible to significantly boost the pace of regional trade expansion and thus its contribution to creating more resilient domestic food markets through modest reduction in the overall cost of trading, a similarly modest increase in crop yields, or the removal of barriers to trans-border trade. More importantly, simulation results also suggest that such policy actions to promote trans-border trade would reduce volatility in regional markets and help lower the vulnerability of domestic food markets to shocks.

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Table A1: GDP and agricultural growth rates under baseline and recent trends

	Agriculture growth		GDP growth			Agriculture growth		GDP growth	
	Baseline	Trends	Baseline	Trends		Baseline	Trends	Baseline	Trends
Benin	5.23	4.85	4.84	5.13	Burundi	2.50	2.51	6.12	6.70
Burkina Faso	5.36	5.48	5.67	5.50	Comoros	2.75	2.75	3.26	2.60
Cape Verde	2.37	2.03	6.89	7.50	D. R. Congo	1.25	1.25	2.43	2.20
Chad	1.83	1.33	5.61	8.00	Djibouti	2.31	3.24	9.04	3.00
Cote d'Ivoire	2.74	2.21	3.95	3.69	Egypt	3.33	3.39	6.25	5.20
Gambia	4.53	3.96	7.00	7.19	Eritrea	5.26	5.36	5.60	2.90
Ghana	3.56	3.48	6.44	7.06	Ethiopia	6.51	6.52	9.08	8.20
Guinea	5.17	5.00	4.25	4.33	Kenya	2.42	2.17	2.03	3.40
Guinea Bissau	4.02	3.97	3.86	4.30	Libya	1.39	1.43	3.05	2.20
Liberia	2.55	2.00	4.02	5.09	Madagascar	1.99	1.98	3.18	3.90
Mali	3.70	3.26	5.24	6.26	Malawi	1.57	1.57	1.90	2.70
Mauritania	2.54	2.46	4.49	3.22	Mauritius	3.31	3.31	4.58	5.00
Niger	3.25	3.19	2.61	2.84	Rwanda	5.28	5.30	9.39	7.60
Nigeria	5.04	5.00	5.62	4.79	Seychelles	1.48	1.47	-1.89	2.30
Senegal	2.75	2.30	3.52	3.44	Sudan	2.50	2.45	6.40	7.20
Sierra Leone	4.94	4.83	6.08	5.67	Swaziland	1.03	1.11	2.85	2.60
Togo	2.31	1.63	4.54	6.66	Tanzania	4.64	4.65	7.60	6.00
					Uganda	3.01	3.01	6.51	8.10
					Zambia	1.06	0.95	3.49	6.30
					Zimbabwe	-0.51	-0.68	-0.85	1.00

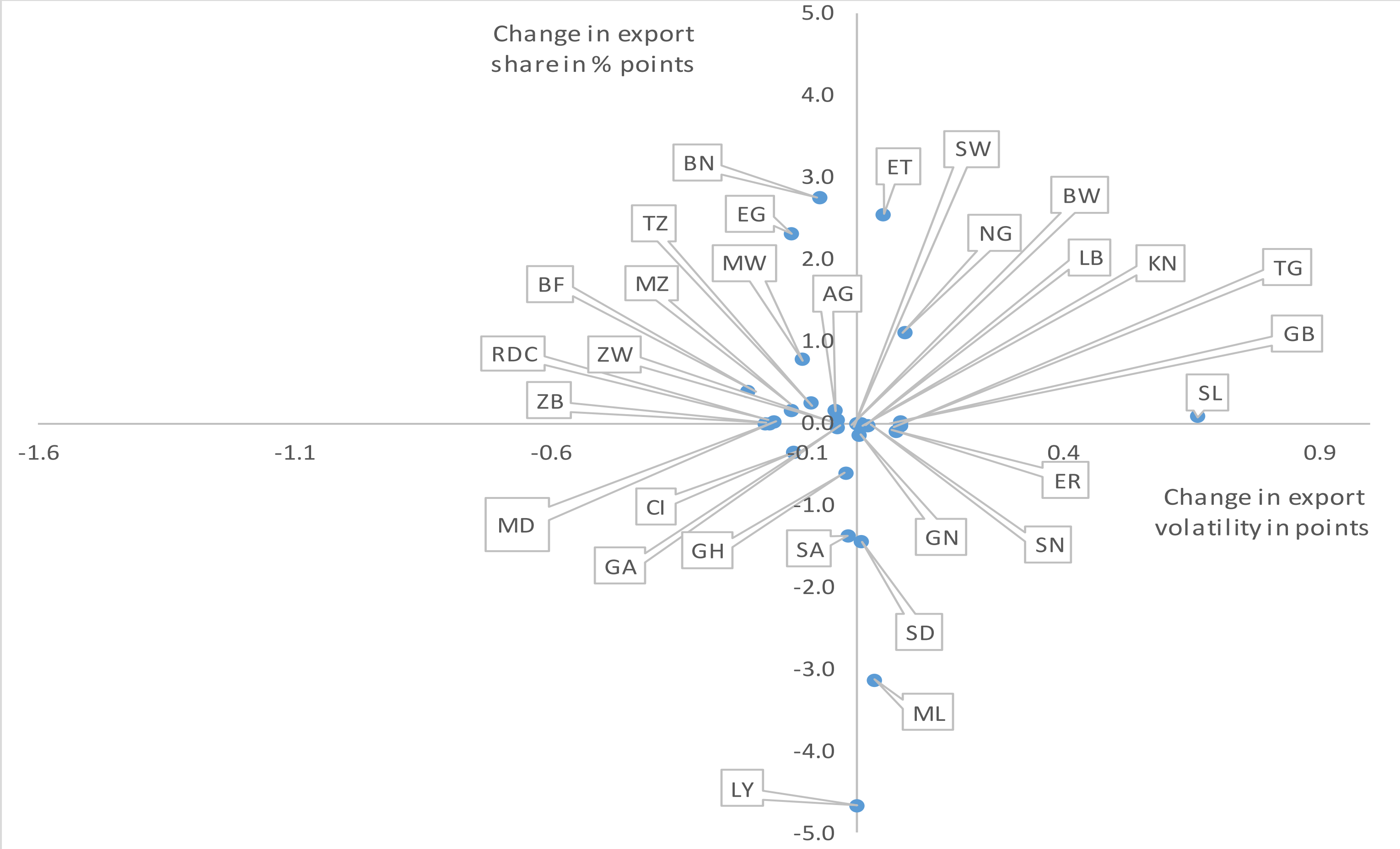
Source: Authors' calculations

Table A2. Change in volatility and share of staple exports under alternative scenarios, 2008-2025

	Change in volatility compared to baseline (points)			Change in share compared to baseline (% points)		
	10% reduction in trade cost	Removal of cross-border trade barriers	10% increase in crop yields	10% reduction in trade cost	Removal of cross-border trade barriers	10% increase in crop yields
Benin	-0.073	-0.043	-0.085	2.756	-0.338	2.448
Burkina Faso	-0.213	0.077	-0.027	0.398	0.545	0.530
Ivory Coast	-0.126	-0.026	-0.066	-0.351	0.428	-0.843
Gambia	-0.039	-0.206	-0.294	-0.047	0.026	-0.052
Ghana	-0.023	-0.079	-0.088	-0.609	0.227	-0.704
Guinea	0.002	0.160	0.116	-0.144	0.095	-0.151
Guinea Bissau	0.086	0.055	-0.082	0.009	0.005	0.016
Liberia	-0.001	0.136	0.094	-0.002	0.003	-0.002
Mali	0.031	0.057	-0.017	-3.137	0.069	-4.475
Niger	0.091	-0.129	-0.241	1.111	-1.115	3.247
Senegal	0.019	0.137	0.126	-0.020	0.014	-0.016
Sierra Leone	0.666	-0.073	-0.242	0.075	0.016	0.045
Togo	0.083	0.150	0.046	-0.038	0.026	-0.042
Egypt	-0.129	-0.020	-0.102	2.315	0.701	0.360
Eritrea	0.075	0.043	0.547	-0.091	0.014	-0.203
Ethiopia	0.052	0.005	0.125	2.557	0.368	4.261
Kenya	0.006	0.081	0.041	-0.009	0.004	-0.016
Libya	-0.001	0.001	-0.004	-4.669	-0.918	-7.018
Sudan	0.007	0.037	0.020	-1.456	0.453	-2.175
Angola	-0.043	-0.024	-0.030	0.165	-0.210	-2.306
Botswana	-0.002	0.052	-0.025	-0.003	0.001	-0.008
Congo D. Republic	-0.182	-1.232	-0.730	0.004	0.000	0.006
Madagascar	-0.162	-1.423	-1.695	0.007	0.001	0.005
Malawi	-0.107	-0.757	-0.557	0.781	-0.114	1.876
Mozambique	-0.130	-1.288	6.099	0.165	0.007	0.194
South Africa	-0.017	-0.166	-0.159	-1.382	0.258	-0.927
Swaziland	-0.002	0.071	-0.016	-0.007	0.001	-0.022
Tanzania	-0.093	-0.342	-0.739	0.237	0.052	1.189
Zambia	-0.170	-1.464	-1.168	0.002	0.001	0.000
Zimbabwe	-0.039	-0.290	-0.543	0.030	0.003	-0.008

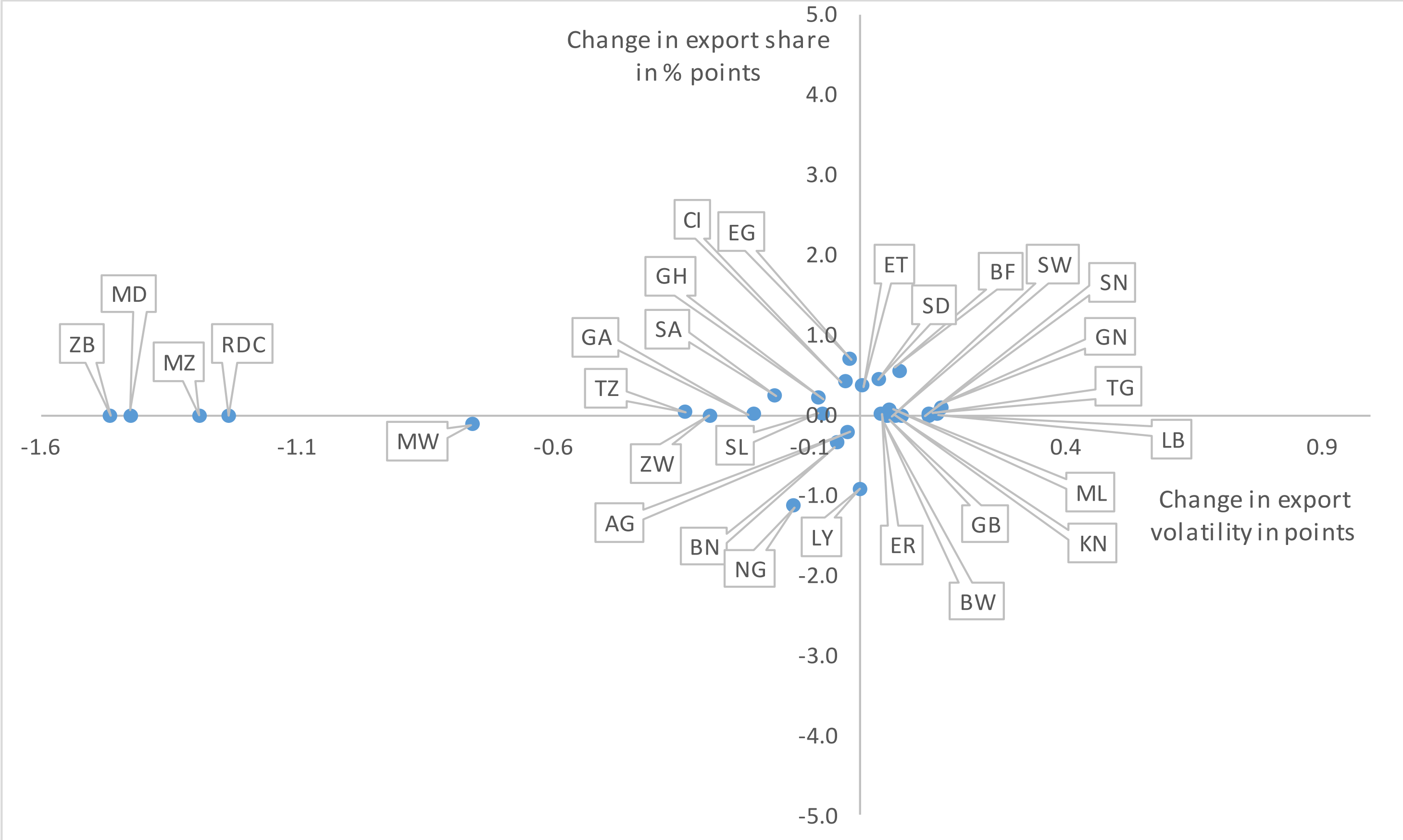
Source: Based on simulation results using Economy wide Multimarket Models of ECOWAS, COMESA and SADC regions.

Figure A1: Changes in country export share and volatility under 10% reduction in trade costs compared to baseline



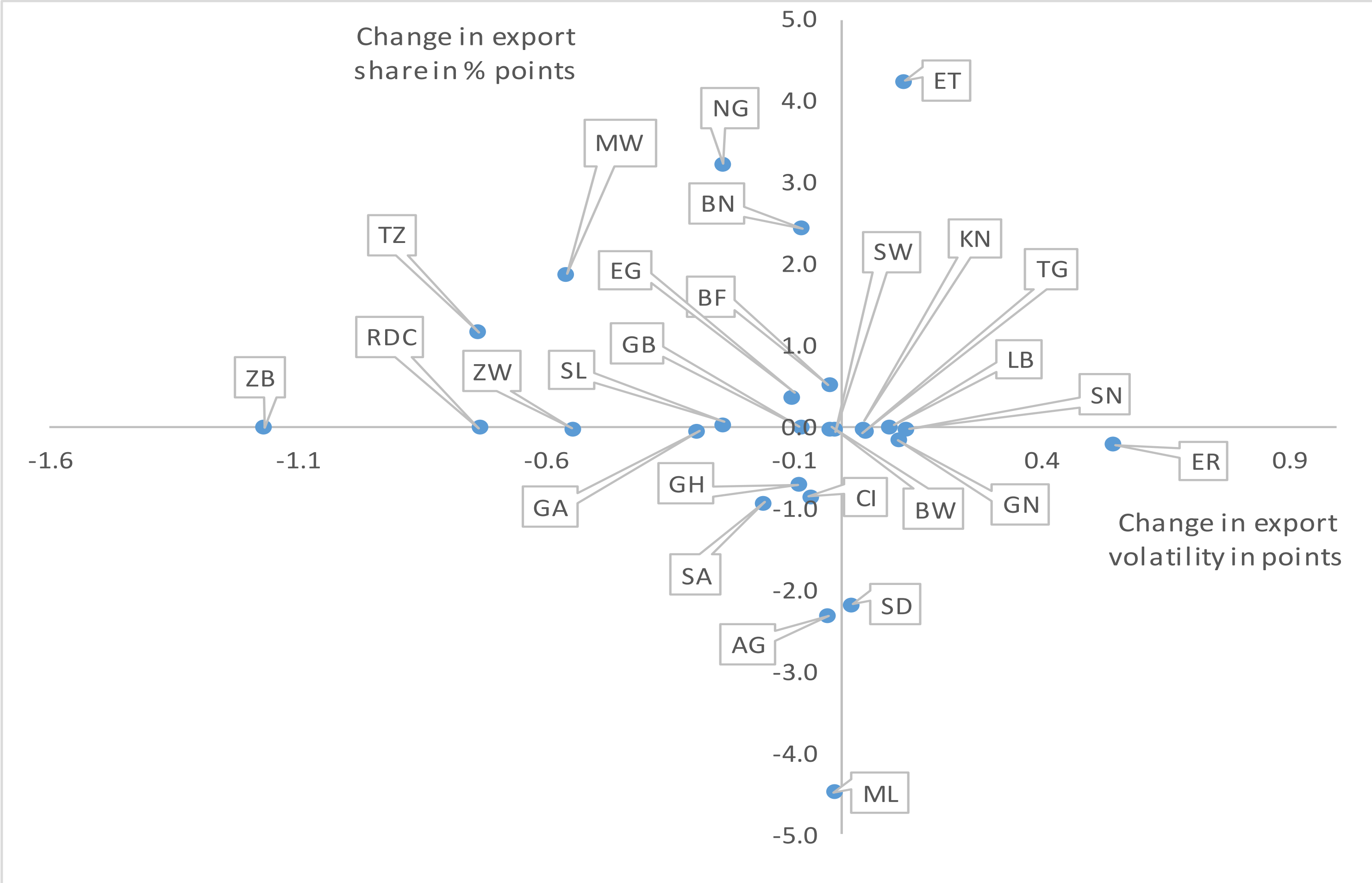
Source: Based on Table A2 above.

Figure 2: Changes in country export share and volatility under a removal of cross-border trade barriers compared to baseline



Source: Based on Table A2 above.

Figure 3: Changes in country export share and volatility under 10% increase in crop yields compared to baseline



Source: Based on Table A2 above. For the sake of clarity, values for Madagascar and Mozambique are not plotted in Figure A3 because of outliers.