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ARTICLE

Market Imperfection and Rural-Urban Effects of Agriculture and Non-Agriculture Productivity Shocks: A Dynamic CGE Model Analysis for South Africa

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ABSTRACT

This study uses a recursive dynamic Computable General Equilibrium (CGE) model focused on South Africa to explore the interconnections between strategic initiatives in agricultural and non-agricultural sectors within a rural development strategy. It assesses how different policy interventions affect agricultural growth and rural household well-being, considering two scenarios: one targeting agricultural growth and the other non-agricultural growth. It is observed that Gross Domestic Product (GDP) experiences an elevation of 1.1 percentage points above the baseline growth rate with a 1% increase in agricultural productivity. Though agriculture contributes just 2.5% to the national GDP, its projected impact on annual growth rate of 1.1 percentage points is expected to boost the economy, adding one billion rand to non-agricultural sectors. In return, non-agricultural industries positively affect agricultural growth and rural consumption. Sectors aiding rural areas include food, beverages, tobacco; mining; transport; and catering. Meanwhile, urban-favoured sectors are government, finance, business services, retail, manufacturing, health, and community services. The findings underscore two primary considerations for policymakers. Firstly, although the agricultural sector's contribution to GDP is modest, emphasizing agricultural enhancement can result in accelerated growth, improved resource allocation to the sector, and poverty alleviation, particularly when synergized with supportive non-agricultural measures.

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Secondly, growth in non-agricultural sectors does not uniformly support agricultural and rural income growth; sectors such as agro-industrial and exportable industries primarily bolster agriculture by mitigating real exchange rate appreciation.

Keywords: Agricultural Productivity; Unbalanced Growth; Dynamic Model; Food Price; South Africa

1. Introduction

An important challenge confronting the South African economy is stunted economic growth and high unemployment [1]. While the economy experienced fairly robust economic growth over the post-democratic decade averaging 3.6% (1994–2007), growth was interrupted by the Great Recession of 2008 and the economy has not recovered since then, averaging 1.1% (2008–2023) and falling to 0.6% in 2024 [2]. Compounding the situation has been the rapid yet fragmented urbanisation leading to a widening rural and urban divide with massive migration pressures – the UN-Habitat estimates South Africa's urbanisation to rise from 67% to around 80% by 2050 [3]. Tackling the dire economic challenges produced by stagnant growth, unbalanced development as well as the rural-urban migration has brought to the fore the role that agriculture can play in reigniting employment and growth through enhancing productivity. Using an agriculture-focused recursive dynamic general equilibrium model of the economy, the present study seeks to investigate the economic consequences of productivity-induced improvements in agriculture for South Africa. Our work builds on the long-established literature on agriculture's role in economic development [4–13]. However, although South Africa shares similarities with developed countries in that agriculture plays only a minor role in terms of the overall economy accounting for only about 2.5% of gross value added, the country resembles other developing countries in that agriculture is vital for national livelihoods. Thus, while agriculture's share of the gross domestic product is small, the country has committed itself to ensuring food security through agriculture growth further argue that while formal agriculture contributes no more than 6% to the income of impoverished households [14–17], it accounts for 15% to 20% of job opportunities indicating the sector's vast importance as an employer particularly for the poor. Furthermore, subsistence farming is a key activity for the impoverished in South Africa, representing 20% and 8% of employment in the lowest and the second-lowest income quintiles, respectively [17].

There is growing literature in South Africa confirming the positive role agriculture can play for poverty reduction and economic growth [18–24]. More recently, Lefophane and Kalaba used a Granger noncausality test variant to verify that increased ICT investment can enhance the growth of ten agro-processing industries in South Africa [25]. These studies have yielded important insights that our work builds on and enhance by providing an economy-wide analysis to gain a fuller picture.

We seek to offer the valuable information provided by economy-wide frameworks that encompass simultaneously agricultural and non-agricultural interventions when designing intervention strategies in agriculture as part of a rural development strategy. McDonald and Punt provide useful reviews of agriculture-focused economy-wide studies in South Africa, while Mabugu and Chitiga-Mabugu offer a survey of general computable general equilibrium (CGE) models applied to South Africa [26,27]. This study continues in the same tradition around the effectiveness (or efficacy) of agricultural support in rural development and poverty reduction strategies in South Africa. With a focus on South African agriculture, we argue that despite agriculture's modest economic footprint, boosting its productivity has the potential to galvanise economic expansion through significant direct and ripple effects, notably by reducing food prices for the most vulnerable consumers and ensuring optimal factor reallocations that can boost productivity and growth. The studies by Pauw et al. are the most closely related works to ours as they explore the impact of agricultural and food commodity price declines triggered by agricultural efficiency gains abroad on economic welfare [17]. Using a CGE model for South

Africa calibrated to 2000 data, they find that technological advances in agriculture are indeed important for overall employment. In this paper, we build on this work and extend it by using a recursive dynamic CGE model calibrated to the 2015 dataset, distinguished by its exceptional capability to facilitate urban-rural factor mobility and precisely delineate separate producer and consumer markets interlinked with trade mechanisms. By isolating representative urban and rural household cohorts and incorporating demographic growth assessments alongside food and non-food demand trends, the model addresses the complex, imperfect market integration, specifically, the disjunction between producer and consumer markets for locally produced goods. The latter feature of imperfect local product markets is an important innovation. Our findings underscore that synergies between agricultural advancement and progress in other sectors can catalyse overarching economic growth and alleviate poverty.

The rest of the paper is organised as follows. In Section 2, the agriculture CGE model used is presented, while Section 3 presents data and calibration issues. Section 4 introduces scenarios and offers an analysis of the micro and macro effects of the simulated reforms. Section 5 gives an extended discussion of the results and findings, putting into context how the simulations and findings relate to previous studies while pointing out caveats and policy directions. The conclusions are given in Section 6.

2. The Model

There are a variety of approaches to economic modelling of agriculture. Farm household models and econometric analysis are perhaps the most prevalent in instances where requisite data is available [7]. Multi-market models and CGE models have been fashionable when the research problem centers on capturing indirect and general equilibrium effects of interventions [28–32]. Given our interest of capturing the entire economic effects of interventions including intersectoral synergies, trade-offs, and linkages, a recursive dynamic CGE model is used. The rest of this section outlines the CGE model followed by a discussion of the data. For an equation and diagrammatic overview of the CGE modelling process, readers can refer to the works by Chitiga et al. and Fofana et al. [1,33].

We build on the Partnership for Economic Policy (PEP) standard CGE model of Decaluwé et al. and customise that model to fit South African realities [34], as well as making it agriculture-focused. The supply side of the model is built around a constant return to scale production technology, which is represented by a three-level nested Constant Elasticity of Substitution (CES) function. To specifically account for agriculture, the production side features 30 activities that include "Agriculture, forestry & fishing". The 'Agriculture, forestry & fishing" is mainly rural, defined by its links through income distribution and employment to rural populations. Within the three-level production nesting structure, a variety of productivity measures can be identified, such as agricultural land productivity, agricultural labour productivity, and agricultural total factor productivity (TFP). The first two measures are partial, while TFP is assumed exogenous to the model to enable its use as an intervention variable later on.

Households are divided into rural and urban categories with income derived from factor rewards (including land) and transfers. An extended linear expenditure system (ELES) demand function is used to represent the household's consumption decisions. The ELES is derived from maximising a Stone-Geary utility function with endogenous saving behaviour.

Domestic production is split between exports and domestic markets. The split is decided on the basis of sales revenue maximisation by domestic suppliers for any given output level, subject to imperfect transformability between exports and domestic sales. The latter is expressed by a constant elasticity of transformation (CET) function. All domestic market demands for a composite commodity are made up of imports and domestic output with the combination decided by cost minimisation subject to imperfect substitutability represented by a constant elasticity of substitution (CES) function. The small country assumption applies so that importers and exporters take world prices as given, i.e., infinitely elastic demand for exported products and supply for imported products at given world prices.

There are the usual system constraints imposed on markets (commodities and factors) and macroeconomic aggregates (government balances, the current account of the rest of the world, and savings and investment) that must be satisfied. Flexible relative prices equilibrate the demand and supply of domestically marketed output. Labour markets have certain imperfections. There are workers distinguished by province of origin, type of settlement, and skill level. Skilled workers are in full employment while unskilled labour is in excess supply. To model unemployment we follow the wage curve as proposed by Blanchflower and Oswald with elasticities and parameters estimated for South Africa by Kingdon and Knight [35–37]. We allow labour mobility across industries and provinces, rural and urban areas. Given the absence of empirical evidence on degree of labour mobility, this is set exogenously. Furthermore, it is assumed that urban-rural migration and remittances are affected by both economic and noneconomic drivers which are redistributed across the categories of the households using the initial distributional shares of the income of the employees and ranked between 0 when labour income is fully spent in the final location, and 1 when labour income is fully spent in the initial location. Rural and urban product markets are imperfectly integrated; that is, we model a separation between consumer and producer markets, albeit they are linked through local trade. Private services represented in the model by "Wholesale & retail trade," "Transport & storage," and "Finance & insurance" mediate the relationship between commodity and product markets. Traders maximise profit. Government savings (the difference between current government revenues and recurrent government expenditures) are a flexible residual, while all tax rates are fixed. On external markets, the real exchange rate is flexible, while foreign savings (the current account deficit or the difference between foreign currency spending and receipts) are fixed. Investment is driven by savings in the sense that it is determined by the sum of private (households and firms), public (government), and foreign (rest of the world) savings.

Finally, the dynamic setting of the model follows from Jung and Thorbecke [38]. In this setting, both producers and consumers are myopic in the sense that they make one-period utility-maximisation and profit-maximisation decisions. Thus, savings and capital accumulation negotiate the move from one period to the next. We use a standard capital accumulation formula in which savings increase the existing capital stock net of depreciation. The allocation of new investment by sector is influenced by the specific cost and return on capital of the sector. Production factors (i.e., capital and labour), final private consumption, and final public consumption are set to grow from one period to another at an exogenous fixed rate.

3. Data and Calibration

A social accounting matrix (SAM) and parameters obtained from the literature are used to calibrate the model [1]. The main data is a 2015 and 2016 SAM for South Africa; for technical documentation of the SAM, see the work by van Seventer et al. and van Seventer and Davies [39,40]. The SAM is aggregated to cover our 30 industries and disaggregated to cover the nine provinces of South Africa, two types of settlement (i.e., urban and rural), and five levels of education. It also features one capital factor account, four tax accounts (taxes on production, subsidies on production, taxes, and levies on products, and current taxes on income and wealth), 21 institutional accounts, including eighteen household categories and two capital accounts (fixed capital formation, and changes in inventories). Elasticities are obtained from existing studies on South Africa or from related literature [41,42].

We use the model and data to build the business-as-usual scenario (or the reference scenario). The business-as-usual scenario traces out a stable path and economic structure (**Figure 1**). According to the reference scenario calibrated, since the Great Recession of 2008, the national economy has been gradually slowing down. Household final consumption expenditures are noted alongside the agricultural sector's growth, which is increasing and aligning with the national economy's average growth rate of 1.8% per annum. The proportion of rural households in total expenditures remains consistent at 20%.

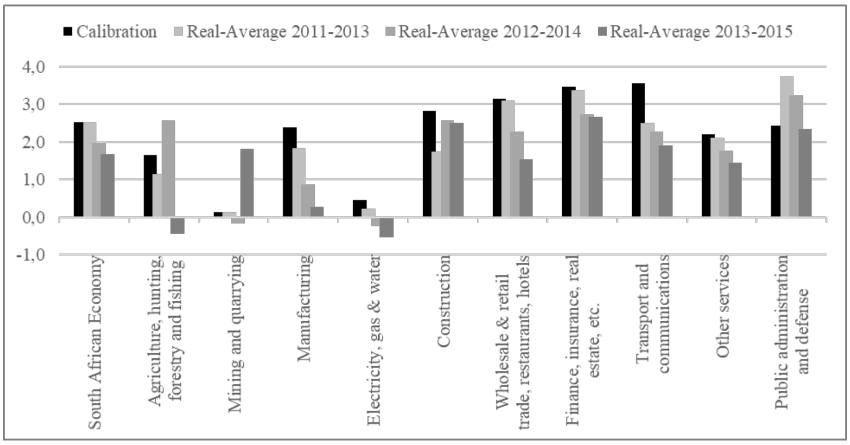

Figure 1. GDP Growth Rates (Real Versus Calibrated).

Source: Based on model simulations.

4. Results

This section examines and discusses the impacts of policy modifications utilizing the CGE model previously developed and calibrated. Once the model is calibrated over multiple years, referred to as the reference scenario mentioned earlier, two policy scenarios are evaluated in accordance with the aims of this paper: the agricultural growth policy and the non-agricultural growth policy. In every instance, we enhance the total factor productivity for both agricultural and non-agricultural sectors by 1% each year. The remainder of the section presents and analyses the outcomes of the two simulations.

4.1. Agricultural TFP Growth Results

Scenario 1 starts with an emphasis on growth driven by agriculture. In contrast to the previously described reference scenario, we boost the agricultural TFP by 1% each year. Even though the sector has a relatively small share in the economy, this swift rise in agricultural TFP yields some positive impacts on the economy. Agricultural GDP grows 1.1 percentage points more than the base-run growth (refer to **Figure 2**). According to **Table 1**, a 1% annual increase in agricultural TFP over a decade also positively affects non-agricultural sectors. Whereas agriculture GDP grows by 66% of its initial value-added, non-agricultural sectors see a 0.02% increase in base year value-added because of the intervention. Over ten years, overall GDP rises by 1.7 percentage points.

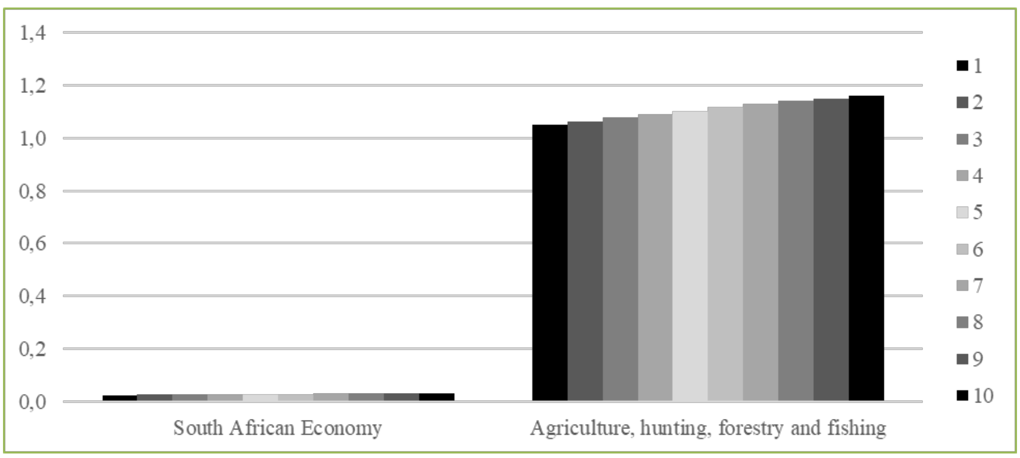

Figure 2. Annual Growth Rate Changes Over 10 Years.

Source: Based on model simulations.

Table 1. 1% TFP Increase in Agriculture to Growth, Increase in Value Added Over 10 Years, Compared to Reference.

Industry	The share in the base year of total value added (%)	10-year value added (constant base year ZAR)	10-year value added (% ratio base year value added)
Whole economy	100.0	51,657	1.7
Agriculture	2.5	50,603	65.9
Mining	9.4	−3,997	−1.4
Food	2.0	1,462	2.3
Beverages & tobacco	0.8	−248	−0.9
Petroleum, chemical, and man-made fibers	2.0	−717	−1.2
Nonmetallic minerals	0.9	−468	−1.6
Metal, machinery, and equipment	3.8	−10,060	−8.5
Other industries	2.1	167	0.3
Electricity, gas & steam	2.4	−12	0.0
Water supply	0.7	60	0.3
Building construction	3.8	777	0.7
Wholesale & retail trade	15.6	4,718	1.0
Catering & accommodation services	1.1	91	0.3
Transport & storage	6.4	42	0.0
Communication	2.6	223	0.3
Finance & insurance	7.8	−499	−0.2
Business services	13.2	2,127	0.5
Medical, dental & other health & veterinary services	2.2	866	1.3
Community, social & personal services	3.7	−528	−0.5
Government	16.9	7,051	1.3

Source: Based on model simulations.

According to **Table 2**, an increase in the agricultural growth rate results in positive outcomes for food manufacturing (2.3%), government services (1.3%), health & veterinary services (1.3%), and the wholesale and retail sectors (1.0%). Conversely, it causes negative outcomes for the metal, machinery, and equipment sector (−8.5%), nonmetallic minerals (−1.6%), mining and quarrying (−1.4%), and the petroleum, chemical, and synthetic fibers industry (−1.2%). Moreover, there are no significant changes in the catering and accommodation sectors (0.3%).

Table 2. Value Added and Welfare Changes.

Industries	Share total value added base year (%)	Welfare (ZAR constant base year)	Welfare (% ratio base year value added)
Whole Economy	100.0	51,657	1.7
Agriculture	2.5	50,603	65.9
Mining	9.4	−3,997	−1.4

Table 2. *Cont.*

Industries	Share total value added base year (%)	Welfare (ZAR constant base year)	Welfare (% ratio base year value added)
Food	2.0	1,462	2.3
Beverages & tobacco	0.8	−248	−0.9
Petroleum, Chemical and Man-made Fibres	2.0	−717	−1.2
Non-metallic minerals	0.9	−468	−1.6
Metal, machinery, and equipment	3.8	−10,060	−8.5
Other Industries	2.1	167	0.3
Electricity, gas & steam	2.4	−12	0.0
Water supply	0.7	60	0.3
Building Construction	3.8	777	0.7
Wholesale & retail trade	15.6	4,718	1.0
Catering & accommodation services	1.1	91	0.3
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Community, social & personal services	3.7	−528	−0.5
Government	16.9	7,051	1.3

Source: Based on model simulations.

Figure 3 illustrates the variations in final household consumption. Since agricultural expansion is advantageous to rural areas, final consumption rises more significantly for rural households compared to urban ones (**Figure 3**).

Figures 4 and **5** illustrate the impact on real income. While the income effect slightly favours rural areas (**Figure 4**), the rural-urban outcomes are largely influenced by price effects, which seem to be more supportive of rural regions (**Figure 5**).

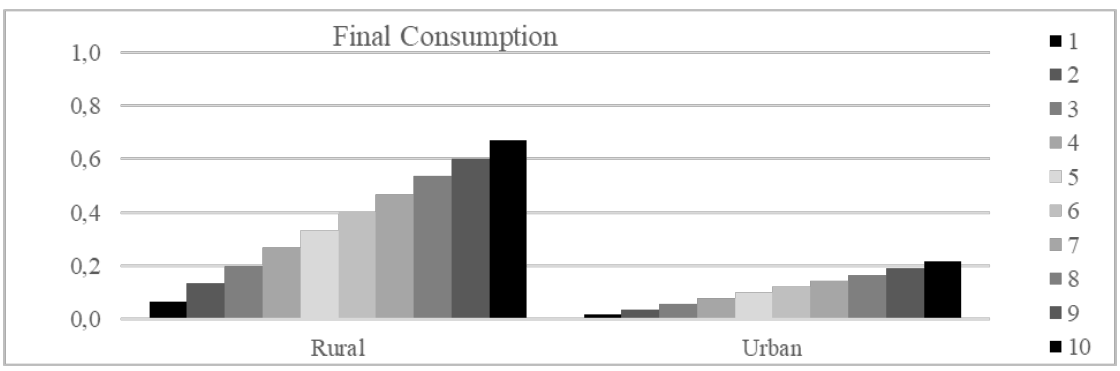

Figure 3. Final Consumption Effects.

Source: Based on model simulations.

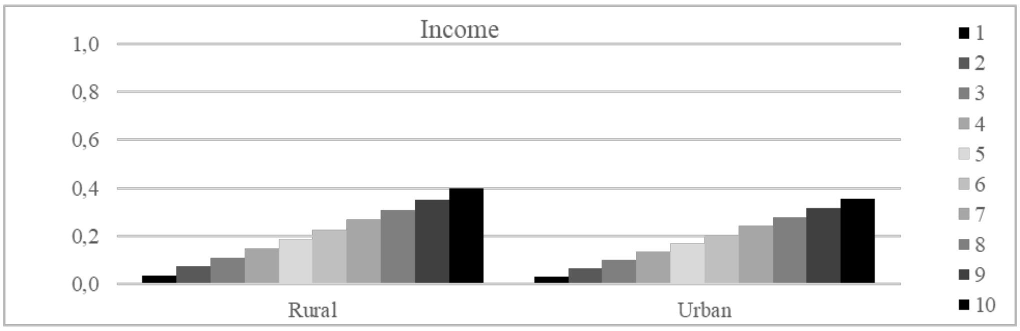

Figure 4. Household Income Changes.

Source: Based on model simulations.

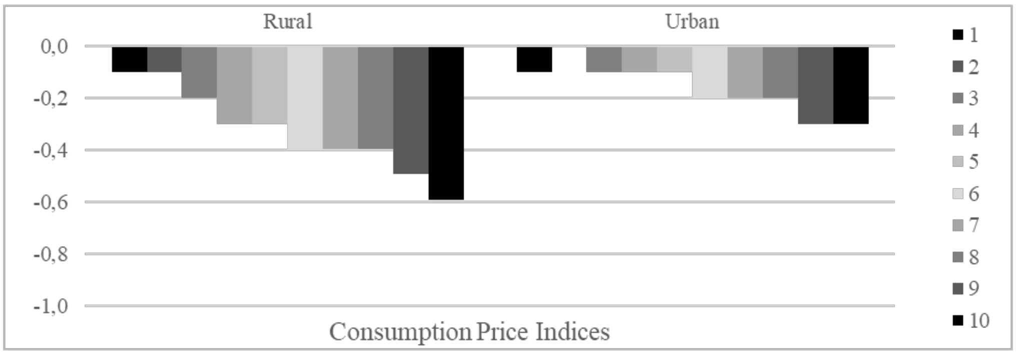

Figure 5. Consumption Price Changes.

Source: Based on model simulations.

4.2. Non-Agricultural TFP Growth Results

In Scenario 2, we focus on sectors outside of agriculture. Like in Scenario 1, we simulate a 1% annual increase in TFP over a decade. We evaluate the influence of non-agricultural sectors on agricultural growth and rural household consumption, which is a sign of rural development. If the influence is positive, the sector is considered pro-agriculture; if negative, it is considered non-pro-agriculture. Out of the 30 industries analysed, five positively affect agricultural growth, thus being pro-agriculture (**Figure 6**). These include wholesale and retail trade (input supply), food, beverage, and tobacco industries (input demand and supply), government services (input demand), financial and insurance, business services (input supply), and health and veterinary services (input supply).

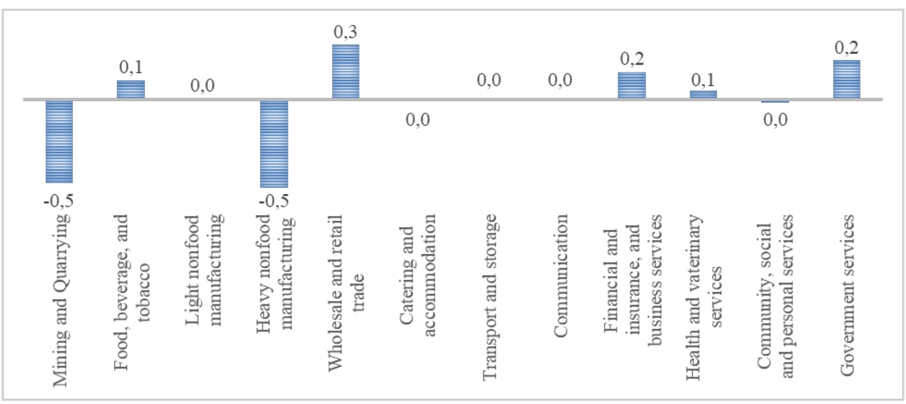

Figure 6. Agricultural Versus Non-Agricultural Growth from TFP Changes.

Source: Based on model simulations.

Certain non-agricultural industries negatively impact the agricultural sector, leading to their classification as non-pro-agriculture. The primary economic reason for this adverse effect is the appreciation of the exchange rate, which results in a decline in agricultural exports. The mining and quarrying sectors, along with the heavy manufacturing industry, are the ones with such negative impacts. According to **Figure 7**, 80% of agricultural goods are utilized for inputs and exports. Agricultural products serve as the main input for the food, beverage, tobacco, and other industries.

The agricultural industry relies primarily on these inputs (**Figure 8**): Petroleum-based chemicals and synthetic fibers; food items; metal products, machinery, and tools; transportation and logistics services; and retail and wholesale trade services.

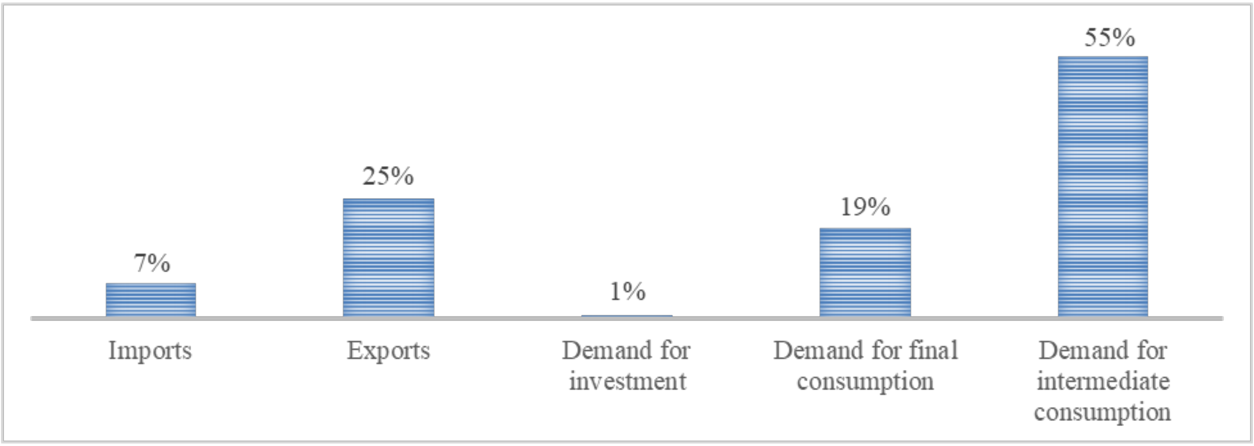

Figure 7. Agricultural Goods Demand.

Source: Based on model simulations.

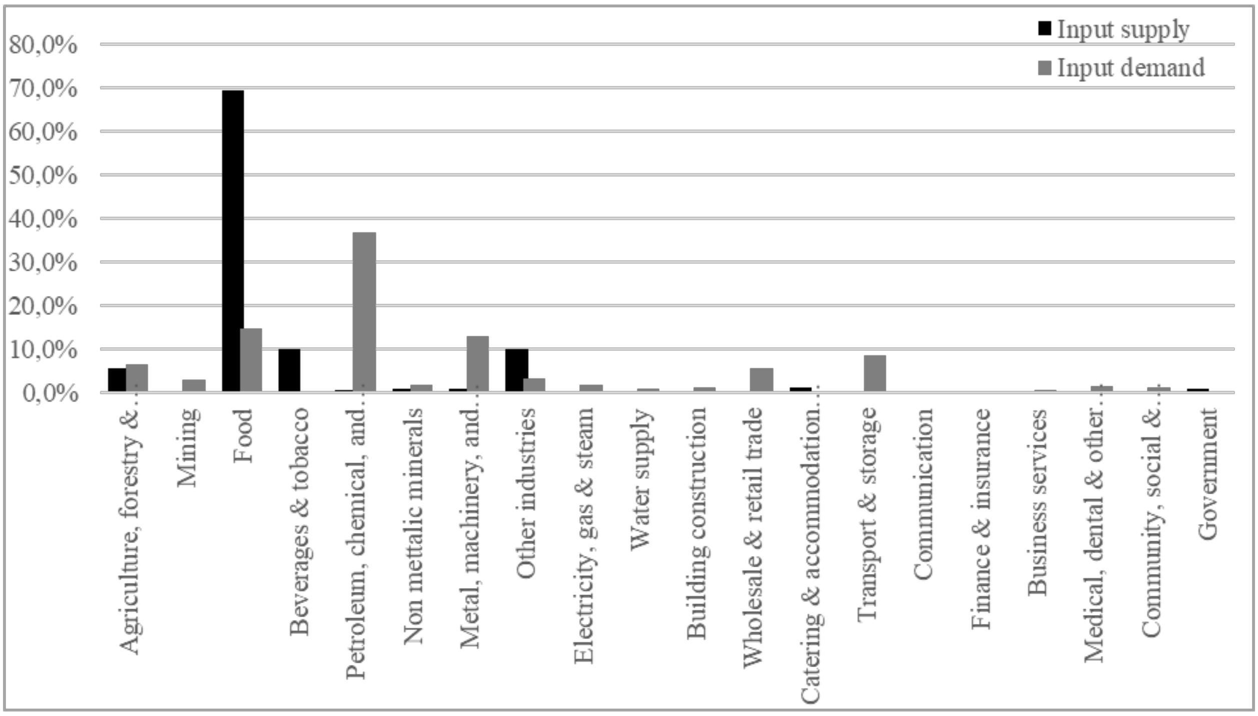

Figure 8. Agricultural Input Demand and Supply.

Source: Based on model simulations.

Besides agriculture, forestry, and fisheries, the following non-agricultural industries can be seen as pro-rural, meaning they have a positive effect on the final consumption of rural households more than urban ones (**Figure 9**): Food, beverages, and tobacco; Mining and quarrying; Transport and storage; and Catering and accommodation. Conversely, non-pro-rural industries, which affect the final consumption of urban households more than rural ones, include government services; Financial, insurance, and business services; Wholesale and retail services; Heavy manufacturing; Health and veterinary services; Community, social, and personal services; and Catering and accommodation.

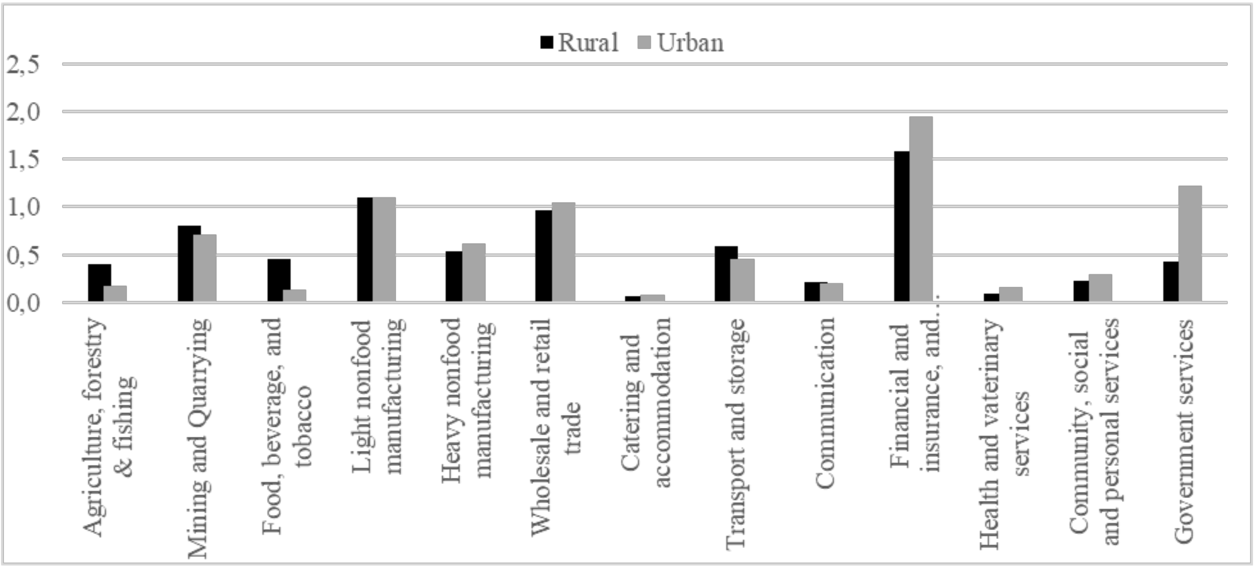

Figure 9. Industry Growth Versus Household Final Consumption.

Source: Based on model simulations.

5. Discussion

In this paper, we have developed a recursive dynamic regional CGE model for South Africa that incorporates urban-rural dichotomies and disaggregated sectors for agriculture and non-agriculture. We improve previous agricultural CGE models in South Africa using updated data and incorporating market imperfections, focusing on urban-rural labour and commodity mobility, with innovative imperfect local product markets. The model is used to evaluate how agricultural and non-agricultural productivity-induced growth impacts urban-rural migration and market differentiation. In all cases, we increase the total factor productivity for agriculture and non-agriculture by 1% annually. TFP gains can have direct and indirect effects on economic growth and well-being that operate through productivity, lower prices, employment creation, and growth linkage effects. In a general equilibrium model, TFP shocks should lead to internal changes in exports within the economy. As a result, any general equilibrium effects from the shocks have been designed to account for such changes. Although somewhat lower, our choice of 1% is comparable to 1.88% per year from 1945 to 2010 estimated by Liebenberg and Pardey [43], as well as Conradie et al. [44], who found that factor productivity grew on average by 1.22% per year during the period 1952–2002 in the Western Cape agriculture. More recently, Mosoma et al. have provided econometric estimates of TFP in the South African agricultural sector using annual time series data from 1980 to 2019 and report that TFP has fluctuated between 0.04% between 1990 and 1999 and 2.3% between 2000 and 2009 and slowed again between 2010 and 2019 compared to the previous periods [45]. In addition to this paper, Kinyondo and Chitiga applied an across-the-board TFP growth of 1% per year when analysing the general equilibrium effects of a productivity increase on the whole South African economy [46]. Comparable international measures of TFP can be found in the works by Gollin et al. [47], Minten and Barret [48], Alani [49], and Alston et al. [50].

Taken together, the results of the two simulations highlight that productivity improvements in agriculture and non-agriculture sectors could dramatically boost GDP growth. These results compare favourably to findings reported in other studies, with main nuances explained by the underlying initial economic structure captured by the input data, as well as unique model extensions highlighted earlier [12,51,52]. What is even more promising is that agricultural growth results in further improvements by fostering optimal factor reallocations towards the sector. Thus, there are positive strengthening synergies between agricultural development and progress in other sectors that can drive overall economic growth and reduce poverty. Thus, while rural areas will continue to support non-agricultural growth by providing cheap raw materials, factor input, and increasing rural incomes to expand domestic market opportunities for agriculture and non-agricultural goods, it is important in particular to avoid real exchange rate appreciation that hurts the prospects for export-orientated industries. The findings thus emphasise that collaboration between agricultural development and advancements in other sectors can boost overall economic growth and alleviate poverty. Policies must be strategically developed to achieve short, medium, and long-term goals, not only to balance immediate gains within agriculture (innovations and optimal factor reallocations) but also to incorporate strategies aimed at unlocking substantial productivity enhancements from non-agricultural export-focused industries. In the long term, it is essential to maintain a consistent alignment between agricultural strategies and broader national development goals to guarantee enduring progress and sustainability. An important empirical and policy question remains whether the adjustment toward equilibrium would be as smooth and fast as implied by the underlying elasticities in the model and what specific measures actually work to raise productivity. The recent work of Sihlobo and Aliber and Lefophane and Kalaba begins to shed useful empirical evidence on the latter issue [25,53], suggesting concrete measures to enhance the growth of the TFP for South Africa that incorporate technology (information technology, mechanical and biotechnology), export promotion, and partnerships with the private sector. Our work suggests that these interventions will be more beneficial to society as a whole if they are targeted, especially at poor farmers.

6. Conclusion

South Africa faces low growth, high unemployment, fragmented urbanisation, and migration pressures, highlighting agriculture's potential role in reviving employment and balanced growth. In this paper, we have developed a recursive dynamic regional CGE model for South Africa that incorporates urban-rural dichotomies and disaggregated sectors for agriculture and non-agriculture. The study seeks to enhance understanding of how agriculture can effectively contribute to agricultural growth, rural development, and its integration into the national economy. Specifically, it evaluates the effects of different policy interventions on agricultural growth and the well-being of rural households. Two policy scenarios are examined: one based on agricultural growth and another on non-agricultural growth. GDP sees a growth of 1.1 percentage points above the baseline growth rate. Although the overall impact of agricultural growth on the national economy is modest, accounting for only 2.5% of total GDP, an average annual growth rate of 1.1 percentage points is expected to boost the rest of the economy, particularly the non-agricultural sectors, by adding an additional value of one billion rand. Agricultural growth favours rural areas as household consumption rises more in rural households compared to urban ones, mainly due to price effects. Within the agricultural sector, the food, beverage, and tobacco industry is the only one promoting agricultural growth and rural development. Generally, non-agricultural industries positively affect agricultural growth and rural household consumption. Among the non-agricultural sectors favouring rural areas are food, beverage, and tobacco; mining and quarrying; transport and storage; and catering and accommodation. Conversely, sectors favouring urban areas include government services; financial and insurance services; business services; wholesale and retail; heavy manufacturing;

health and veterinary services; community, social, and personal services; and catering and accommodation.

The economic modelling conducted provides valuable insights into how economic growth goals could be pursued through an agricultural focus. Specifically, analysing the potential contributions of agriculture and various economy sectors has helped guide discussions on designing and prioritizing economic interventions within a rural development strategy. The results highlight two primary implications for policymakers, industry and researchers. First, despite agriculture's small contribution to GDP, a scenario focusing on agricultural enhancement can lead to faster growth, better resource allocation to the sector, and poverty reduction, especially when paired with complementary non-agricultural initiatives. Second, not all non-agricultural sector growth promotes agricultural and rural income growth; sectors like agro-industrial and exportable industries mainly support agriculture by averting real exchange rate appreciation.

These findings suggest that policy priorities and interventions must be carefully developed for the short, medium, and long term to balance immediate successes with strategies that promote significant productivity advances in agriculture. For the short to medium term, the country should focus on protecting and enhancing productive capacity by focusing on export-oriented policies, promoting private and public sector investment and improving education and skills to enable embracing of digitalisation, automation, and AI to boost productivity in and for agriculture. In the long term, aligning agricultural initiatives with national development goals is essential to secure enduring progress and sustainability.

In conclusion, certain caveats to the analysis in this paper are in order. While the modelling exercise has demonstrated how the appropriate use of economic models can contribute to agricultural development planning process and the refinement of potential agricultural development strategies, the usual caveats apply here, as with all modelling approaches: results of model simulations are indicative primarily of the size of the various direct and indirect effects, rather than a forecast or exact outcome of the scenario in general. Furthermore, results of modelling are subject to uncertainty and depend on the modelling assumptions used. Future research should focus on regional disaggregation of the model to provinces and municipalities, incorporate climate change issues, particularly those focusing on adaptation, and creatively utilise credible, frequent, real-time data in agricultural CGE frameworks.

Author Contributions

Conceptualization, R.M.; methodology, I.F., R.M. and M.C-M.; software, I.F.; formal analysis, R.M., I.F. and M.C-M.; resources, R.M., I.F. and M.C-M.; writing—original draft preparation, R.M., I.F. and M.C-M.; writing—review and editing, R.M., I.F. and M.C-M.; project administration, R.M. All authors have read and agreed to the published version of the manuscript.

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Informed Consent Statement

Not applicable.

Data Availability Statement

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Acknowledgments

Not applicable.

Conflicts of Interest

The authors declare no conflict of interest.

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