An updated Total Factor Productivity series for South African Agriculture with improvements to official data on land, and labour measurements

University of Cape Town

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Abstract

The agricultural sector in South Africa has undergone significant shifts over the years, raising substantial concerns about food security and productivity. This comprehensive study analyses these trends and their implications to offer insights for policy formulation to address these challenges. The analysis uses historical data from 1947 to 2020 to examine output, inputs, productivity indices, and sector dynamics. It provides an in-depth exploration of the changes in agricultural composition and the factors influencing productivity, highlighting the need for nuanced policy interventions.

In this thesis, I employ the Törnqvist-Theil aggregation techniques to measure input, output, and total factor production indices. The study delves into changes in crop production, shifts in input usage, and the impacts of labour reforms and minimum wage laws. Specifically, I examine the evolving shares of high-value horticultural crops, staple food crops, and livestock within agricultural outputs. The analysis focuses on the intricate relationship between input usage, labour, and land productivity to elucidate the declining Total Factor Productivity (TFP) growth rates.

The study's significance is in identifying key trends that shape South Africa's agricultural landscape and their impact on food security, utilizing official South African agricultural data from Agricultural Abstracts and Censuses. It emphasizes the urgency of revitalizing rural development strategies and investing in agricultural research and development (R&D) for long-term productivity growth. Further, the results urge policymakers to establish incentive structures that promote sustainable farming practices while ensuring the sector keeps pace with population growth.

Moreover, the study augments the Abstract and Census data by incorporating datasets from the United States Department of Agriculture's Economic Research Service for land quantity, employing rainfed-equivalent cropland as a quality-adjusted measure. Furthermore, the labour quantity and cost index from the Post-Apartheid Labour Series are incorporated to bolster the study's analytical robustness and reliability.

Key findings reveal a notable shift from staple crops to high-value horticultural production, affecting food accessibility and affordability for low-income households. The stability of livestock production presents nuanced issues concerning dietary components and resource usage. Labour reforms and the introduction of minimum wage laws have led to decreased labour use, indicating enhanced labour productivity. Notably, the study unveils a positive impact of the minimum wage on Total Factor Productivity (TFP). The analysis showcases an average increase of 1.67% per annum in TFP from 1947 to 2020, exhibiting minimal growth during the deregulation and the new South Africa period (0.34% per annum) from 1989 to 2003, but a subsequent rise in TFP (1.06% per annum) from 2004 to 2020 following the increase in the minimum wage.

Additionally, this paper underscores concerns about declining Total Factor Productivity (TFP) growth rates and their implications for food security. It emphasizes the need for effective policy strategies to bridge the gap between population growth and TFP growth rates. It also highlights the urgent requirement to improve on data quality in agriculture in South Africa. In summary, this study offers comprehensive insights into the changing dynamics of South Africa's agricultural sector between 1947 and 2020, emphasizing critical challenges and the urgent need for effective policy interventions to safeguard food security and increase productivity.

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1. Introduction

Improving total factor productivity (TFP) in agriculture is vital for South Africa's economic development. The sector not only drives economic growth but also serves as a significant source of employment and exports. Furthermore, it plays a critical role in elevating the quality of life in rural communities by offering food security and income opportunities. According to Todaro (1969), the agriculture sector has a strong, positive impact on other sectors, creating a ripple effect that significantly contributes to the overall economy. Furthermore, Johnston and Mellor (1961) found a direct linkage between agriculture and overall economic development, implying that improving productivity in the agriculture sector can create a multiplier effect within the economy. Pollin et al. found that in South Africa, agriculture has a 27.9 multiplier, much higher than the second highest multiplier industry which is apparel and textiles at 18.2.

Theoretical debates surrounding the role of agriculture in development emerge from the observed shifts in output composition, input dynamics, and productivity trends within South Africa's agricultural sector (Black, et al., 2016). One key debate revolves around structural transformation, questioning whether the shift towards higher-value horticultural crops signifies a comprehensive transformation of the economy or merely a sectoral change within agriculture.

This leads to discussions about the trade-offs between profitability and food security, as the rise in profitable horticultural crops may come at the expense of staple foods, impacting accessibility and affordability for low-income households.

Sustainability concerns also arise, particularly regarding the potential for monocropping systems to exacerbate vulnerabilities to pests and diseases and strain natural resources like water and soil. Furthermore, the decline in labour usage raises questions about the relationship between labour productivity, employment, and development, prompting debates on how to balance increased productivity with the need for job creation, especially in rural areas.

Additionally, the role of government intervention is contested, with discussions revolving on the appropriate level of state involvement to address structural inequalities, promote sustainable practices, and stimulate productivity growth while ensuring market efficiency. Government intervention is also questioned due to the wide spread of corruption in South Africa (Vink, N., 2022).

Accurate data on agricultural productivity is crucial for policymaking, as it directly impacts the government's ability to forecast and ensure food security. Without adequate productivity, agricultural output may be insufficient to meet the needs of all inhabitants, especially considering the worsening global climate crisis, the war in Ukraine and South Africa's annual population growth of 1.527%. The decline in studies on agricultural productivity in South Africa since the 1990s is concerning, as this lack of data limits policymakers' ability to make informed decisions (Thirtle, et al., 1993b; Vink, et al., 2022). Additionally, according to Conradie, Galloway, & Renner (2021), the only sector to achieve growth since 2000 has been the dairy industry. This lack of accurate data raises further questions about the country's current level of food security. As a result, policymakers must prioritize accurate and up-to-date productivity data to inform their decision-making and ensure food security for the country's growing population.

The analysis of TFP changes in the agriculture sector provides valuable insights into the sector's efficiency and productivity over time. I start by compiling measures from several sources such as official abstracts and census data to calculate the TFP index from 1947 to 2020 and then augmenting this data with better land and labour data sources. Particularly, I would like to highlight the TFP index for the period 2010 to 2020 which has had little research attention over the last ten years. With the improvement on data collection, I was able to provide a more robust TFP index for the period and bridge it to the previous periods of data. The result is a combined, complete, and standardized dataset with which policymakers and stakeholders in the agriculture sector can use to make informed decisions to enhance the sector's productivity and ensure food security.

South Africa's post-apartheid agricultural reforms sought a more equitable and productive sector through land redistribution, improved farmworker rights, and a revamped research system. However, these policies have yielded mixed and possibly inaccurate results. Land reform struggles to empower emerging farmers due to limited funding for training and infrastructure (Black, et al., 2016). Since South Africa became a democracy in 1994, it has only converted 1% of commercial land by 1999 (Vink & Hall, 2010). This only increased to just below 4% by 2007 (Kirsten, et al., 2007).

The implementation of a minimum wage in farm labour reforms, a positive step for worker rights, has inadvertently led to job losses in the commercial agricultural sector (Conradie, 2005). The minimum wage policy has been implemented with the explicit goal of providing workers in low-paid and vulnerable occupations with a fundamental subsistence income while safeguarding them from exploitation.

However, this loss of jobs is nuanced, Bhorat, et al. (2014) suggests that prior to the law, excess labour prompted farmers to shed unskilled workers in Favor of fewer, more skilled employees. Anticipation of the law led to increased capital investment, indicating potential job losses. The timing of the law, following other legislative changes and amid land redistribution concerns, influenced farm owners' reactions. Lastly, the law resulted in workforce consolidation, with fewer part-time workers and an emphasis on skilled, permanent staff, potentially improving production efficiency. There has also been an increase in wages on average in agriculture after the introduction of the minimum wage (Bhorat, et al., 2014).

Additionally, uncertainties surrounding land claims incentivized some commercial farmers to reduce their workforce. The privatization of research institutes, intended to shift the focus towards the needs of small-scale agriculture, may have resulted in a decline in public sector research capacity and expertise. Furthermore, the privatized model may not be effectively addressing the specific challenges faced by small-scale farmers, such as access to improved seeds and farming techniques (Black, et al., 2016).

These shortcomings can have serious consequences. Without proper support, land reform risks falling short of its goals of poverty reduction and rural development. Farm labour reform, while well-intentioned, requires a more nuanced approach that balances worker rights with the economic viability of commercial farms. The effectiveness of the research reform in serving small-scale farmers also merits revaluation (Black, et al., 2016).

To improve the situation, land reform programs require increased funding to provide emerging farmers with essential technical training and infrastructure development support. Streamlining land measurement processes and addressing the root causes of rural out-migration, such as limited economic opportunities, are also crucial to create a more attractive rural environment. Farm labour reforms need to find a better balance between worker rights and economic realities. Exploring possibilities for wage subsidies or tax breaks for farms employing a certain number of workers could incentivize job creation. Re-evaluating the effectiveness of privatized research in addressing the specific challenges faced by small-scale farmers is essential. A public-private partnership model that leverages expertise from both sectors could ensure research is effectively targeted towards their needs.

A successful agricultural policy goes beyond individual reforms. South Africa needs a comprehensive rural development strategy that integrates agricultural productivity enhancement with social programs like improved education and healthcare. This strategy should aim to create a more sustainable and attractive rural environment, fostering economic opportunities and stemming out-migration. Finally, the role of state support in agriculture needs revisiting. While market forces are crucial, some level of government intervention may be necessary to address historical inequalities and promote the growth of small-scale agriculture, considering its potential for job creation and poverty reduction. This could involve targeted subsidies or loan programs specifically designed to support small-scale farmers.

However, the assessment of the effectiveness of these policies hinges upon accurate data. Therefore, prioritizing the enhancement of public sector research capacity emerges as a critical policy imperative. This enhancement is essential for facilitating informed policy adjustments aimed at improving the livelihoods of all stakeholders.

To accurately gauge the success of policies aimed at bolstering productivity, including initiatives such as land redistribution, labour reforms, and the restructuring of research systems, the availability of precise data is paramount. Enhanced data quality empowers policymakers to conduct more precise assessments of the impact of these reforms, pinpointing areas necessitating adjustments or supplementary support.

To calculate productivity accurately, this study used the Törnqvist-Theil methodology based on Ball (1985) and the recommendations from the United States Department of Agriculture's (1980) report on measuring productivity growth in the USA. It has been successfully applied in various regions which illustrates that this approach is not limited by geographical boundaries and can be effectively applied to any country.

The methodology's flexibility and universality make it a valuable tool for accurately calculating and comparing productivity across different nations and regions. This approach was first applied to the UK for the period 1967-1990 by Thirtle and Bottomley (1992), before being applied to Zimbabwe in 1993 by Thirtle et al. (1993a). In 1993, Thirtle also applied this methodology to South Africa, where he found a TFP growth rate of 1.26% p.a. for the period 1947-1991, with a structural break identified around 1965 (Thirtle, et al., 1993b).

In this context, a structural break in TFP signifies a significant shift in the agricultural production processes or technology, leading to a marked change in the efficiency and output of farming activities. Identifying such a break is crucial as it implies a notable alteration in the underlying factors influencing agricultural productivity. Breaks can result from changes in farming practices, technological advancements, policy reforms, or environmental conditions that substantially impact the efficiency and output of agricultural processes. Understanding these breaks is vital for accurate assessment, forecasting, and decision-making in agricultural economics.

Schimmelpfennig et al. (2000) expanded the index to cover data until 1996, while Thirtle et al. (2005) identified a second structural break in 1981. Liebenberg & Pardey (2012) further extended the analysis to include data until 2008, incorporating the role of black farmers during apartheid and revealing an average TFP growth rate of 1.49% per annum from 1947 to 2008. Structural breaks for the years 1970 and 1988 were identified by Liebenberg & Pardey (2010), delineating three distinct periods for study: 1947-1970 being the big push forward, the subsidized production in 1971-1988 and finally deregulation and the new South Africa from 1989-2010.

To achieve its aim of providing updated estimates of agricultural productivity in South Africa up to the year 2020, this study will use data from various sources. The most recent available census is from 2017, and the latest Agricultural Abstract, published in 2022, includes preliminary data for 2020. Another crucial objective of the study is to critically examine the data from various censuses, surveys, and Abstracts. Inter-census gaps can lead to issues with the Abstract, which relies on data from the Agricultural censuses. Therefore, it is necessary for this study to address these gaps to ensure the data used are as accurate and reliable as possible. To achieve this, the study will utilize data from the United States Department of Agriculture's Economic Research Service and the Post-Apartheid Labour Series produced by DataFirst. In addition, this analysis will account for a third structural break and add a fourth period, beginning in 2003 with the implementation of the National Minimum Wage in South Africa. As a result, the four periods examined in this study are: 1947-1970 (the big push forward), 1971-1988 (subsidized production), 1989-2003 (deregulation and the new South Africa), and 2004-2020 (National Minimum Wage).

Ensuring the accuracy and reliability of the productivity estimates is essential. This updated and revised data will provide valuable information for policymakers and stakeholders in the agriculture sector. They can make informed decisions and ensure the growth and sustainability of the sector based on this updated and reliable data. Therefore, the quality-adjustment of the data will be important.

The paper is structured as follows: the first section provides a brief review of the theory behind index construction. The second section reviews the data used in the study, followed by the construction of input and output indices. The third section presents the findings from the total factor productivity analysis and partial productivity analysis using the constructed indices. The fourth section analyses the implications of the results. Finally, a conclusion is drawn in the last section.

2. Theoretical Index creation

2.1. Brief overview of earlier index construction and calculation

Total Factor Productivity (TFP) analysis is a valuable tool for policy makers in determining the efficiency of productive activities. TFP growth, expressed through the Solow residual, encapsulates the growth in output that cannot be attributed to the use of inputs. It is computed as the ratio of outputs to inputs, highlighting the efficiency and technological progress contributing to overall output growth. In South Africa, the productivity of commercial agriculture was first measured using TFP analysis by Thirtle et al. (1993b) for the period 1947-1991. This methodology used Törnqvist-Theil aggregation techniques on aggregated output data from Laspeyres indices, which was obtained from the Abstract of Agricultural Statistics.

Sub-sectoral indices of output for horticulture, field crops, and livestock were created using Laspeyres indices, and then aggregated into a single output index using the Törnqvist-Theil procedure. The resulting index is called the Törnqvist-Theil index (Liebenberg, et al., 2015).

A productivity index is usually a measure of the quantity that is produced in relation to either the cost or quantity of inputs to produce such goods (Liebenberg, 2013). The TFP index of commercial agricultural would then be the quantity of commercial output in relation to an index of all inputs used.

A TFP index should incorporate all relevant outputs and inputs, although this could vary from one place to another depending on agro-climatic conditions. In Liebenberg's (2013) estimation it is not practically possible due to data limitations. Instead, Thirtle et al. (1993b) and Liebenberg (2013) and its subsequent refinements drew mainly on the Abstract of Agricultural Statistics which they supplemented with unpublished data series from the Department of Agriculture.

One such example from Alston et al. (2010) would be the measurement of environmental amenities from rural landscapes, as this type of output is difficult to capture in rural areas. Thus, Liebenberg (2013) argued, since most TFP indices do not capture all inputs and outputs, most total factor productivity measurements are multi-factor productivity (MFP) indices. While Liebenberg's (2013) point is well taken, the terms TFP and MFP will be used interchangeably in the remainder of this analysis.

With TFP growth defined as a Solow residual, it is evident that technical progress depends critically on the accuracy of the input and output series, and in fact Liebenberg (2013) and Liebenberg et al. (2015) all strove for more accurate input measurement. Even Thirtle et al. (1993b) noted the fallacy of just counting tractors that have grown in size and sophistication during the second half of the twentieth century and continues to do so with every passing year. Craig & Pardey (1996) quality adjusted the US tractor index and found that while the number of tractors in the United States grew from 1949 to 1991, after quality adjusted, the rate of growth of tractors is reduced by 0.4% p.a. which when corrected and led to reduced capital services, thus increasing TFP.

The total agricultural output index is crafted utilizing the Törnqvist-Theil approach, which involves a methodology that integrates Divisia aggregation in its construction. This application of the Törnqvist-Theil technique utilizes pre-aggregated groups of outputs sourced from the Abstract of Agricultural Statistics, encompassing field crops, horticulture and fruit, and animal products (Schimmelpfennig, et al., 2000).

The pre-aggregated outputs for these specific categories are structured by consolidating secondary Laspeyres indices obtained from the Abstract of Agricultural Statistics. The Laspeyres indices provide fixed-weight measures by considering base-period quantities against changing prices or quantities in subsequent periods. The subsequent step involves the application of the Törnqvist-Theil techniques, where the Divisia aggregation approach is used to aggregate these Laspeyres indices.

The Divisia aggregation method accounts for changes in both quantities and prices over time, providing a more nuanced and weighted consideration of each category's relative importance. This allows for adjustments in the index that accommodate shifting consumer preferences, price changes, or other factors affecting the significance of these categories in the agricultural output (Liebenberg, et al., 2015). The final output is a comprehensive index of total agricultural quantity, taking into account the changing dynamics within these distinct categories and their relative contributions to the overall agricultural output.

On the input side, the index is made up of land, labour, capital, and intermediate inputs. These inputs are similarly pre-aggregated from the Abstract of Agricultural Statistics, with alternative data sources where more accurate data exists (DAFF, various years). Capital inputs comprise of herds, machinery, and land and fixed improvements, while intermediate inputs are made up of packaging material, fuel, fertilizer, farm feed, remedies (for both crops and animals), and other non-farm items (Liebenberg & Pardey, 2012). These *other* items include licenses; insurance; land tax; water tax; and expenditure relating to auditing fees, banking costs, consultants, maintenance and repairs and office equipment. It should be noted that the prices for these other items are not monitored, while fuel, packaging material, fertilizer, farm feed and remedies are monitored and can be separated (Liebenberg, 2013).

The paper will follow using Thirtle et al. (1993b) using the Törnqvist-Theil procedure to update the national TFP index for South African agriculture. In the output index, all items are aggregated (Y_i) using the logarithm of two successive years of output quantities weighted by a moving average share of that output in the total output value (O_i) (Conradie, et al., 2009a). In Conradie et al. (2009a) the timing of the various census reports determined the interval between data points, but since the Abstract of Agricultural Statistics compiles annual data, the interval in this study is successive years. The weighted moving average ensures that the share of output remains current overtime, unlike a simple Laspeyres index which anchors at the beginning of the index period (Conradie, et al., 2009a). The output index is computed as follows:

$$\hat{Y} = \frac{1}{2}\sum_{i}(O_{it} + O_{it-1})\, ln\frac{Y_{it}}{Y_{it-1}} \quad (1)$$

In Equation 1 if output is aggregated up from individual commodities, $ln\frac{Y_{it}}{Y_{it-1}}$ is the quantity ratio of physical outputs which capture individual growth rates. Y_{it} is the physical quantity of output i in period t and Y_{it-1} is the same, except for period $t-1$, however if the data is not available, then real values at constant prices are used instead. The moving average weight for the output index is the first half of Equation 1, $\frac{1}{2}\sum_i(O_{it} + O_{it-1})$, which is the average of the shares of output in nominal revenue between two subsequent periods.

In this study, real values are utilized as a measure of physical quantity, which are computed using price indices obtained from various abstracts. However, the latest abstract does not offer price indices dating back to 1947. Since the latest available abstract does not provide price indices that date back to 1947, this study combines price indices from various sources, including the 1965 Abstract, the 1989 Abstract, the 2018 Abstract, the 2021 Abstract, and the 2022 Abstract, all of which are sourced from the Department of Agriculture, later known as Department of Agriculture, Forestry and Fisheries and now known as the Department of Agriculture, Land Reform & Rural Development (Department of Agriculture, various years; Department of Agriculture, Forestry and Fisheries (DAFF), various years; Department of Agriculture, Land Reform & Rural Development (DALRRD), various years). The splices are made using the geometric mean as per Hill & Fox (1996). This method ensures that the spliced series is invariant to the rescaling of the original series, making it a more reliable approach (Hill & Fox, 1996).

This proxied value works if in both Y_t and Y_{t-1} the base price P_0 is used, then they will cancel out and present a quantity ratio (Conradie, et al., 2009a). In this case, however, the output data is already a quantity commodity index (e.g. the horticulture index already incorporates different kinds of fruit and vegetables) However, due to the unavailability of complete data in the latest Abstract, the same splicing technique is employed using the aforementioned abstracts to create a quantity index of the commodity from 1947-2020. The resulting indices for horticulture, livestock, and field crops are then aggregated into a total output index using the respective shares of the three main commodity groups in the overall agricultural output.

To calculate output growth rates for say horticulture natural logs had to be taken from the published indices. Like Thirtle et al. (1993b) this study begins at the end of World War II in 1947. While Liebenberg (2013) recorded some technical progress for the first half of the twentieth century, this study anchors the output index by assuming zero growth in period 1. With the individual years' three main commodity growth rates weighted according to each group's share of total output, exponents were taken, and the index was chained using a starting value of 100 in year 1.

The input index, Equation 2, was constructed using the same logic and it multiplies the same share weighting term with a similar set of individual input growth rates. I_{it} is the share of commodity i of total input cost in period t. As with the output index, the first half $\frac{1}{2}\sum_i(I_{it}+I_{it-1})$ being the moving average weight for input I. This is the average of the shares of input in nominal cost between two subsequent periods. $\ln(\frac{X_{it}}{X_{it-1}})$ is the quantity ratio of physical inputs which capture individual growth rates. X_{it} is the physical quantity of input i in period t and X_{it-1} is the same, except for period $t-1$, however if the data is not available, then real values at constant prices are used instead.

$$\hat{X} = \frac{1}{2}\sum_i (I_{it} + I_{it-1})\ \ln(\frac{X_{it}}{X_{it-1}}) \qquad (2)$$

There were several problems with implementing Equation 2 including a lack of current land use estimates and the absence of wage data in the Abstract of Agricultural Statistics as well as poor data from Agricultural Censuses. The assumptions made and alternative sources to supplement the coverage of the Abstract forms an important part of the results of this study and are presented and discussed in the index construction section.

The Törnqvist-Theil procedure is a non-frontier and non-parametric index that measures the efficiency of inputs and outputs based on pre-aggregated data from various Abstract years sourced from DAFF. To create the Törnqvist-Theil index, the study formed the ratio of the aggregate output (Equation 1) to the exponent of the aggregate input (Equation 2) using the input and output indices. All calculations were conducted in Microsoft Excel and Stata. The input, output, and TFP data were in annual increments in natural logarithms, and additional computations were necessary to form recognizable indices. The first step was to take the exponents of the logged values, which, assuming zero growth in period 1, resulted in an index value of 1 in period 1. This value was then multiplied by 100 to begin each index with a value of 100. The third step was to chain by multiplying the value in period 1 with the unchained, exponentiated value in period 2, 3, and so on, until period n. In a final computation, the chain index value's logs were taken to regress on the year and compute annual growth rates, which may or may not be statistically significant.

3. Data, descriptive statistics and my index construction

This section outlines the methodology for index construction, data sources, and their treatment. Indices, when spliced, will utilize the geometric mean method, as described in Hill and Fox (1996). An example of this equation will appear in the output section.

South Africa's agricultural data has had inconsistencies, particularly in farm census, land use, and farm labour series. The last comprehensive farm census was conducted in 1988, while 1993 marked the final year of reported land use patterns (Vink, et al., 2022). Subsequent censuses, such as the one in 2002, suffered from sampling biases and cannot be directly compared to earlier datasets. The 2007 census had a national response rate of 58.4%, and although the 2017 census improved to a 77% response rate, the quality and coverage remain under evaluation (Vink, et al., 2022).

Labour statistics in agriculture have also seen fluctuations. Liebenberg and Pardey (2012) reported an average agricultural workforce of 1.327 million during the 2000s. However, Abstracts from different years showed varying figures. The 2005 Abstract cited 964,000 employed in 2001, and the 2009 Abstract averaged 1.125 million from 2002 to 2007 (. Recent data from the 2021 Abstract indicates a declining trend, with the average agricultural employment level from 2015-2020 at 862,000, shrinking at an annual rate of 1.42% (Vink, et al., 2022).

Over the years, the issue of land data has become increasingly problematic. In 1985, the Abstract presented a land use series titled "Number of farms and land utilization in white areas." (DAFF), 1985).

This compilation of census estimates from 1930 to 1978 provided a comprehensive overview of the situation at the time. However, subsequent editions of the Abstract only reported census findings from 1988 and a Development Bank of Southern Africa study (McKenzie, et al., 1989).

The latest edition of the Abstract (Department of Agriculture, Land Reform & Rural Development (DALRRD), 2022) now includes data from the 1996 and 2002 censuses, as well as the number of farms recorded in 2017, but has left out the Development Bank study. Liebenberg and Pardey (2012) found a slight increase in land use from the 1990s to the 2000s, which is likely based on the FAO database (Vink, et al., 2022).

The most recent reliable Agricultural Abstract available in Excel format is from the Department of Agriculture, Forestry and Fisheries is the 2018 one (DAFF, 2018). Hence, it will serve as the primary source of data before incorporating new information. While the 2021 Abstract is consistent with the 2018 Abstract, the 2022 Abstract differs in weights and employs a new base year, thereby increasing data inaccuracies (DALRRD, 2021). Whenever feasible, the percentage growth from 2019 to 2020 is derived from the 2022 Abstract (DALRRD, 2022) and then applied to the 2019 Abstract index to establish the 2020 index value.

3.1. Output

The output index consists of three separate quantity indices: field crops, horticulture, and livestock. The Törnqvist-Theil production index can be computed using two distinct methodologies: the utilization of pre-constructed indices and the direct manipulation of underlying commodity-specific price and quantity data. Each method brings forth a unique array of advantages and disadvantages.

Choosing to employ pre-constructed indices offers the advantage of leveraging readily accessible data sources, thereby streamlining the compilation process and conserving valuable time and resources. Additionally, these pre-constructed indices tend to exhibit historical consistency, a particularly beneficial trait for conducting long-term trend analyses. Furthermore, their creation is typically entrusted to experts in the field, ensuring a higher level of competence in the compilation process. Nevertheless, it is essential to acknowledge the drawbacks of relying on pre-constructed indices. This approach may result in a loss of specificity since it relies on aggregated data that may not capture the nuanced subtleties at the sub-sectoral or commodity level. Moreover, the usage of these indices might introduce bias or inaccuracies if critical data is omitted.

In contrast, the alternative approach of directly working with underlying commodity-specific price and quantity data offers a set of distinct advantages and disadvantages. This method enables a more precise and customized analysis, allowing for the capture of detailed insights at the sub-sectoral or commodity level, which is invaluable for research purposes. Researchers have full control over how they manipulate and aggregate the data, affording the flexibility necessary to align with specific research objectives. Furthermore, employing raw data enhances transparency in the research process, thus facilitating verification and replication by other researchers. However, this approach comes with its own set of challenges. Collecting, cleaning, and processing raw data can be time-consuming and resource-intensive, adding complexity to the research process. Raw data may also present quality issues, including errors and inconsistencies that require thorough validation and cleaning. Depending on data availability, gaps in historical data may arise, making long-term trend analysis a complex endeavor. There is also the issue of commodities changing over time, such as pomegranates do not show up in later abstracts and the introduction of figs later. Lastly, working with raw data may necessitate significant methodological development and data harmonization, potentially introducing biases if not managed with care.

In this study, the methodology aligns with previous work by Thirtle et al. (1993b) and Conradie et al. (2009b), both of which utilize pre-constructed quantity indices. The adoption of this methodology is substantiated by its proven utility in prior research. The output index in this study encompasses three distinct pre-constructed quantity indices: field crops, horticulture, and livestock. While the 2018 Abstract provides data stretching back to 1975 (DAFF, 2018), the creation of a comprehensive output index necessitates the incorporation of data from the 1990 Abstract (Department of Agriculture, 1990). The results of merging these diverse datasets, a process known as splicing, are detailed in Table 1 below.

Table 1: Volume of field crops indices geometrically spliced.

Year	Field crops 1974 Abstract	Field crops 1987 Abstract	Spliced field crops	Rebased to 1980
	Base 1958-1960	Base 1980		Base 1980
1947	68		44	22
1948	55		36	18
1949	62		41	20
1950	71		46	23
1951	60		39	20
1952	74		48	24
1953	80		52	26
1954	81		53	26
1955	87		57	28
1956	94		61	31
1957	87		57	28
1958	94		61	31
1959	96	41	63	31
1960	110	42	68	34
1961	118	50	77	38
1962	123	52	80	40
1963	106	56	77	38
1964	116	48	75	37
1965	111	46	71	36
1966	181	52	97	48
1967	135	86	108	54
1968	137	58	89	44
1969	147	61	95	47
1970	175	63	105	52
1971	194	82	126	63
1972	128	85	104	52
1973	225	56	112	56
1974		97	194	97
1975		88	176	88
1976		88	176	88
1977		95	190	95
1978		98	196	98
1979		96	192	96
1980		100	200	100
1981		111	222	111
1982		104	208	104
1983		90	180	90

Figure 1 illustrates the output indices for horticulture, livestock, and field crops spanning from 1947 to 2020. The data reveal a consistent upward trajectory in horticulture and fruit production, whereas livestock and field crop output demonstrate a decline. This pattern aligns with expectations, considering field crops largely rely on rainfall and are therefore more susceptible to drought events, such as those witnessed in 1983, 2005, and 2015. In comparison, irrigated horticulture and fruit cultivation demonstrate greater resilience to droughts. Additionally, the livestock index usually experiences delayed effects, as drought conditions subsequently result in reduced herd productivity (Thirtle et al., 1993b).

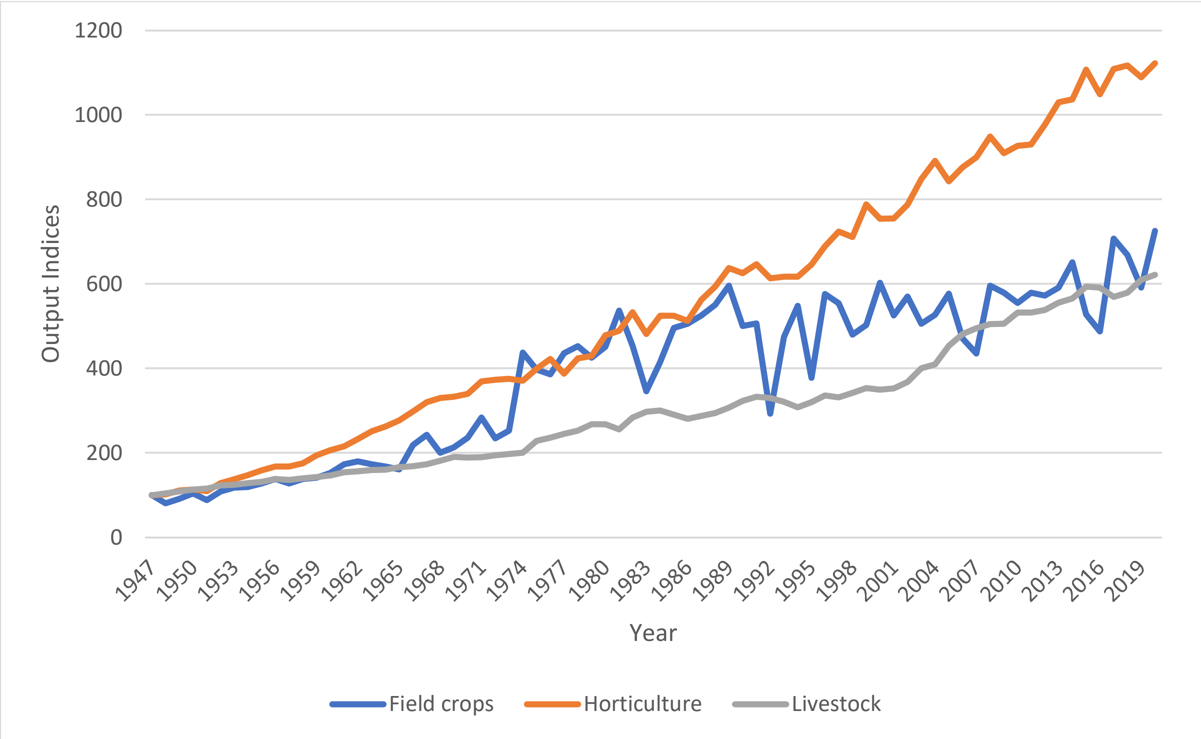

Figure 1: Volume of output indices for crops, horticulture, and livestock (1947 – 2020)

Table 2 reveals that horticulture has experienced the highest average annual growth rate of 3.2% across the whole period, corroborated by Figure 1. The primary reason for this high growth rate likely stems from the greater profitability of horticulture relative to cereal commodities. Contrary to this trend, the data for the study's fourth period indicates that livestock exhibits the highest annual growth rate at 2.08% per annum. This surge in livestock growth is potentially attributable to the dairy industry, as suggested by Conradie, Galloway, & Renner (2021). Another potential reason could be due to the return of smallholder agriculture after 1994. In comparison, field crops have seen considerable declines in output, largely due to recurring droughts since the third period, resulting in sluggish growth rates. However, the fourth period displays signs of recovery in this sector, marked by a growth rate of 1.60% per annum.

Table 2: Average annual volume output growth rates by period, 1947-2020 (%)

Year	Period	Field crops		Horticulture		Livestock		Total	
1947-2020		2.69	***	3.20	***	2.43	***	2.94	***
1947-1970	Big Push Forward	4.32	***	5.78	***	2.63	***	3.83	***
1971-1988	Subsidized Production	3.52	***	2.85	***	2.77	***	3.35	***
1989-2003	Deregulation and the New South Africa	1.07	***	2.18	***	1.32	***	1.67	***
2004-2020	National Minimum Wage	1.60	***	1.83	***	2.08	***	1.98	***

*Significance at 10%, (5)% and [1]% levels are indicated by *, (**), and [***] respectively.*

3.2. Land inputs and land prices

According to the 2022 Abstract (DALRRD, 2022), the total farming land in South Africa was estimated to be approximately 82 million hectares, based on a census conducted in 1993 and a survey in 1996. The response rates for these surveys were 67.9% and 74.2%, respectively, which are lower than the 88.4% response rate obtained from the 1988 census conducted by the Central Statistical Service (1988), where land was found to be 84 million hectares. Land data has been recorded in thousands of hectares through various censuses dating back to 1946 (Department of Agriculture, various years). However, due to the absence of data between 1996 and 2017, linear interpolation has been used to estimate the census land amounts during this period. This is due to there being no data between this time. The land estimate from the 2017 Census is also very low (Statistics South Africa, 2020). This can be seen in Figure 2 below.

In contrast, the U.S. Department of Agriculture's Economic Research Service (2022) provides quality-adjusted land data from 1961, based on Food and Agriculture Organization data. Their dataset shows an average of 15 million hectares of "rainfed-equivalent cropland," quality-adjusted using weights from Seibert & Doll (2010). An updated 2017 census estimates commercial agricultural land at 46.4 million hectares but has not been included in official Abstracts, likely due to its poor 77% response rate.

Thus, the USDA dataset is used for land and can be treated as quality-adjusted because it uses rainfed-equivalent cropland as a measure of land. The data indicates that while total land may have decreased over time, land quality has increased due to irrigation practices.

To provide a more comprehensive dataset, the census land index has been spliced with the USDA index, covering the period from 1947 to 1961. The merged data shown below in figure 2 shows a much faster decline in the census land index compared to the USDA index. This disparity is likely due to an increase in irrigated cropland, which allows for higher productivity on less land. Irrigated cropland holds 1.74 times greater value than rainfed cropland equivalent (Seibert & Doll, 2010).

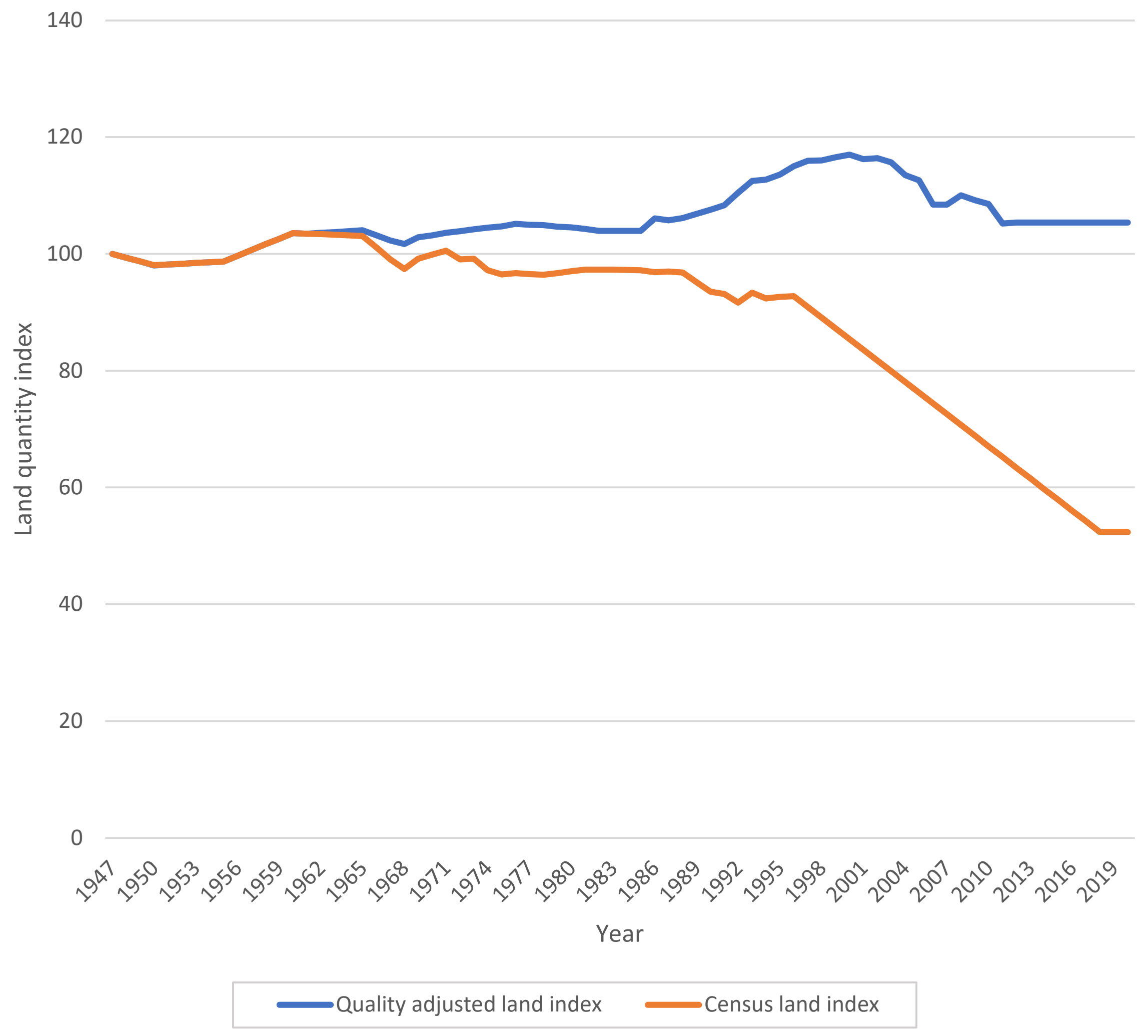

Figure 2: Index of land quantity from Agricultural Censuses and Surveys and from the USDA (1947 – 2020)

Source: Central Statistical Service (various years), USDA (2022), and Statistics South Africa (various years)

Table 3 outlines the annual average growth rates of land, measured in rainfed equivalent farmland, across different periods. The first period, spanning 1947 to 1970, displayed the strongest land growth rate at 0.26% per year, driven by the expansion of cultivated areas. The second period, from 1971 to 1988, saw a slower growth rate as land acquisition reached its peak and the emphasis shifted towards production. The third period, running from 1989 to 2003, marked an era of increased globalisation for South Africa. The removal of trade barriers possibly led to advancements in irrigation technology and an increase in irrigated farmland, thereby raising the rainfed equivalent farmland index. In contrast, the period from 2004 to 2020 showed a negative annual growth rate of -0.42%, indicating a reduction in agricultural land. Cumulatively, from 1947 to 2020, the land grew at a modest rate of 0.15% per annum, reflecting a slow expansion in South Africa's agricultural land over these 73 years.

Table 3: Average annual growth rates of land area (rainfed-cropland equivalent) 1947-2020 (%)

Years	Period	Land	
1947-2020		0.15	***
1947-1970	Big Push Forward	0.26	***
1971-1988	Subsidized Production	0.06	**
1989-2003	Deregulation and the New South Africa	0.64	***
2004-2020	National Minimum Wage	-0.42	***

*Significance at 10%, (5)% and [1]% levels are indicated by *, (**), and [***] respectively.*

To determine the weights for the land input in the index, the study utilises estimated rental value, calculated as 5% of the capital value of the land and any fixed improvements, as outlined in the Abstract (Conradie, et al., 2009b). Since the value of fixed improvements is now integrated with the land value and cannot be isolated, the calculated rental value is based on the collective worth of the land and its fixed improvements.

Figure 3 presents the land price index, serving as an informative gauge for understanding the dynamics of land values in South Africa. The index reveals an exponential increase in the price of land and fixed improvements since the subsided production period of 1971-1988. Several factors contribute to this uptick in land values, including growing demand for agricultural land, the spread of urbanisation, and the expansion of commercial farming ventures.

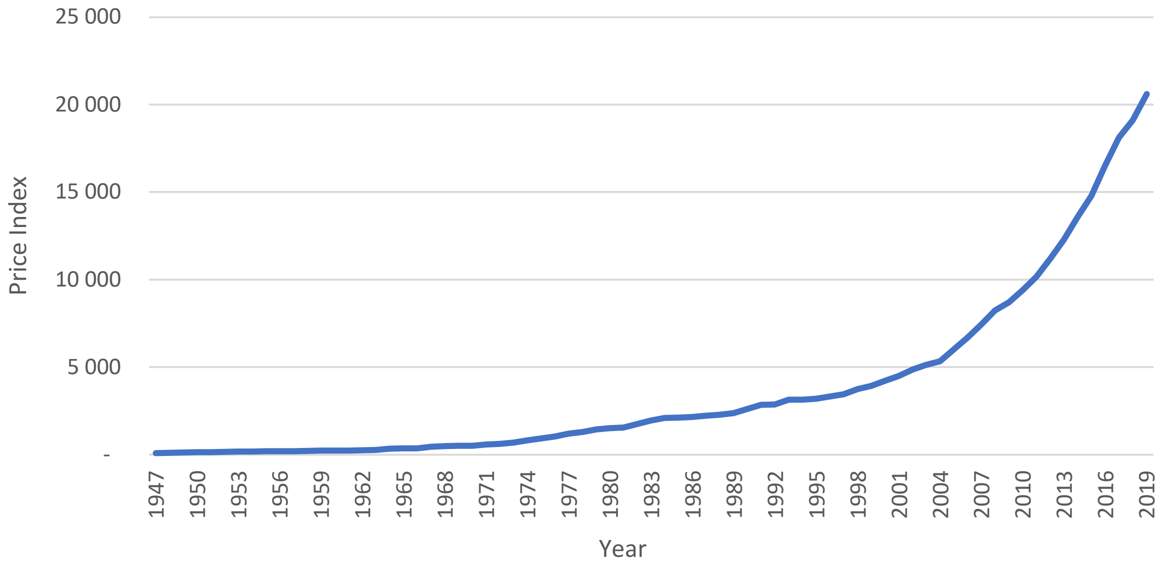

Figure 3: Nominal land price index (1947 – 2020)

3.3. Labour and wages

The Abstract of Agricultural Statistics offers limited insight into the composition of the agricultural labour force, as it does not provide specific details on categories like seasonal or casual workers. Liebenberg (2015) discovered this shortfall by comparing the Abstract with census data, revealing that seasonal labour was generally omitted in reports prior to 1965. Although census reports sometimes mentioned this category, it was not distinctly itemised in the Abstract.

Domestic servants working for households on farms are also included in the Abstract of Agricultural Statistics employment series on regular employment. Since 1947, it is reported as a separate category of labour in census reports but is reported in the Abstract of Agricultural Statistics as part of the regular employment statistics in agriculture (Liebenberg, 2013). However, the Abstract of Agricultural Statistics does not specify whether proprietor and family labour were enumerated, which introduces another source of inconsistency or lack of clarity in the measurement of the farm labour force.

The Abstract of Agricultural Statistics reports three different series for farm labour, but they overlap and have different time periods and data sources. The first series reports the number of farm employees and domestic servants on farms and ends in 1996, with updates for census years until 2007 (Vink, et al., 2022).The second series reports the economically active population at the 2-digit SIC code reported for five-year intervals from 1985 to 2001, and it is based on a different data source that dates back to the 1940s. The third series measures employment in "Agriculture, hunting, forestry and fisheries" and is based on the Labour Force Survey, which breaks down the sector's total employment into Agriculture and Other, and within Agriculture into Skilled Agricultural and Other Agricultural (Vink, et al., 2022).

Unfortunately, the data from these different series do not align well with each other, and they do not match the series used in the Liebenberg TFP index (Liebenberg & Pardey, 2010). Liebenberg and Pardey (2012) report an average agricultural workforce of 1.327 million during the 2000s, but the 2005 Abstract reports a figure of 964,000 for 2001, and the 2009 Abstract reports an average figure of 1.125 million for the period 2002 to 2007. Agricultural employment declines sharply after that period. According to the 2021 Census, the average level of agricultural employment was 862,000 in the period 2015-2020, declining by 1.42% per year over those years (Vink, et al., 2022).

The inconsistencies in the Abstract of Agricultural Statistics cast doubt on its reliability for crafting a precise labour index. As the Abstract derives its data from varying Agricultural Censuses and exhibits discrepancies in labour reporting, a more dependable approach would be to employ census data for estimating the agricultural labour force. However, even the censuses come with their set of limitations; they lack uniformity in data collection, and there are substantial data gaps, particularly starting from 1992. Figure 4 offers a more comprehensive count of the agricultural labour force, encompassing both paid and unpaid family labour as well as full-time and part-time workers, but purposefully leaves out domestic servants. Therefore, while census data might offer a more reliable avenue for labour force estimation, the persistent inconsistencies and gaps in the data underline the necessity for more robust and uniform data collection methods.

Thirtle et al. (1993b) derived a labour index for the period between 1947 and 1991 using data collected from the annual Abstracts and Censuses of agriculture as well as unpublished documents from the Department of Agriculture. They employed regression models to analyse the agricultural employment data for inter-census nodes (Liebenberg, 2013). And imputed seasonal and casual labour force as a proportion of the regular labour force. Figure 4 presents Thirtle's labour index in terms of total bodies, obtained by converting the index values.

The USDA dataset offers an index that enumerates 1000 economically active individuals in agriculture who are 15 years or older, spanning the years from 1961 to 2020. This index incorporates both employed and unpaid family labour as well as full-time and part-time workers. However, it's worth noting that the dataset lacks specifics regarding the proportion of full-time versus part-time workers, and it also does not differentiate between paid and unpaid family labour. For historical data, the index primarily relies on research by Liebenberg (2012). Additionally, it incorporates modelled estimates from the International Labour Organization (ILO) for the period after 1991 (U.S. Department of Agriculture, Economic Research Service, 2022). The ILO uses the International Standard Industrial Classification of All Economic Activities to classify worker sectors (United Nations, n.d.).

Finally, the Post-Apartheid Labour Market Series (PALMS) dataset offers a comprehensive look at South Africa's labour market from 1993 to 2019. This dataset consolidates microdata from 69 household surveys conducted by Statistics South Africa between 1994 and 2019, as well as the 1993 Project for Statistics on Living Standards and Development survey carried out by SALDRU (Kerr, et al., 2019). It combines and harmonizes data from several surveys conducted by Statistics South Africa, including the October Household Surveys (OHS) conducted from 1994 to 1999, the bi-annual Labour Force Surveys (LFS) conducted from 2000 to 2007 (including a smaller pilot survey conducted in February 2000), and the Quarterly Labour Force Surveys (QLFS) conducted from 2008 to 2019.

However, the dataset has limitations. For instance, it lacks income data for the third and fourth quarters of 2009 and from 2015 onwards. To fill this gap, the missing income data from 2015 is estimated by interpolating it to the farm census amount for 2018. Subsequently, the total remuneration is inflation-adjusted to calculate the figures for 2019 and 2020. Similarly, it echoes a similar issue present in the USDA dataset above, lacking the granularity to distinguish between part-time and full-time workers.

The PALMS dataset reveals the total number of individuals employed in the agricultural sector who are aged 15 and above. This includes both hired and unpaid family labour as well as full-time and part-time workers. To maintain consistency with other data sources, self-employed individuals are excluded. The industry code for this count is standardised to a single-digit classification code, based on the original codes from the OHS, LFS, and QLFS surveys. Furthermore, domestic workers are deliberately omitted to ensure alignment with census series. However, one of the main drawbacks of the USDA and PALMS datasets is the absence of differentiation between full-time and part-time agricultural workers.

In Figure 4, raw data from various sources such as Thirtle et al. (1993b), Agricultural Censuses, the USDA, and PALMS are plotted. A noticeable discrepancy between the USDA and census numbers and the data from Thirtle et al. (1993b) is evident for the years 1964 to 1966. This inconsistency may be due to the drought that plagued the region during this period, affecting the accuracy of data recording. Despite these fluctuations, a general trend appears consistent across data from the USDA, Thirtle et al. (1993b), and PALMS, albeit with varying magnitudes. These magnitude differences may result from the inclusion or exclusion of family labour and domestic servants in the data sets.

While the Census and USDA data points share general similarities, the continuous nature of the USDA data set offers a more streamlined comparison to the Thirtle data set. From 1993 to 2007, the PALMS dataset diverges significantly from the USDA dataset. This discrepancy might arise from variations in labour survey estimates sourced from the ILOSTAT database or perhaps from the use of an outdated model. However, from 2008 onwards, the PALMS and USDA data sets tend to align in pattern, even if the magnitudes differ.

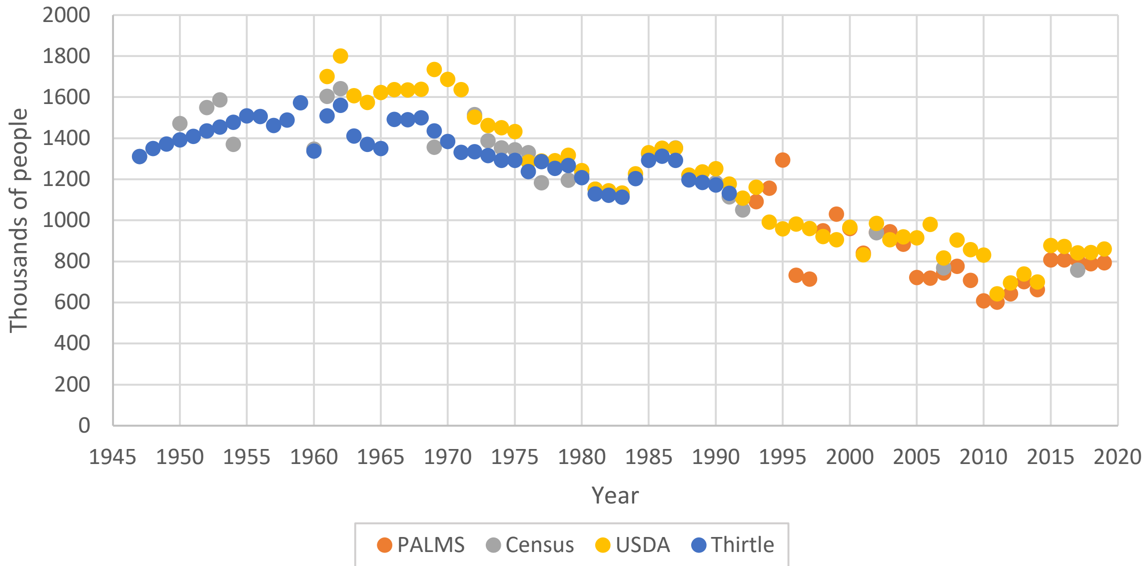

Figure 4: Scatter graph of total employment in South African Agriculture: PALMS, Agricultural Censuses, USDA and Thirtle (1947 – 2020)

Source: Thirtle et al. (1993b), Kerr, et al. (2019), USDA (2022), and DAFF (various years), DAF (various years, DALRRD (various years)

The labour index from Thirtle et al. (1993b) covering the years 1947 to 1991 was integrated with the USDA dataset using the geometric mean method, as suggested by Hill & Fox (1996). This composite labour index was further refined by incorporating PALMS data for the years 1994 to 2020. The resulting quality-adjusted labour index spans the period from 1947 to 2020. Figure 7 illustrates both the total number of agricultural labourers and their corresponding remuneration over time. An exponential growth in remuneration is evident post-2005 in the remuneration line. This is shortly after the introduction of the National Minimum Wage in 2003. The trend depicted in Figure 5 suggests a negative correlation between rising wages and overall employment in the agricultural sector. This agrees with findings by Bhorat, et al.(2014), who found that there has been an increase in agriculture wages on average. The blue line depicts the number of workers, it can be seen that workers is declining over time. This is also similar to findings by Bhorat, et al. (2014). However, this shedding of labour as mentioned before, could be due to multiple other factors, such as over employment previously, the timing of the law and finally the improvement of productivity with more permanent workers.

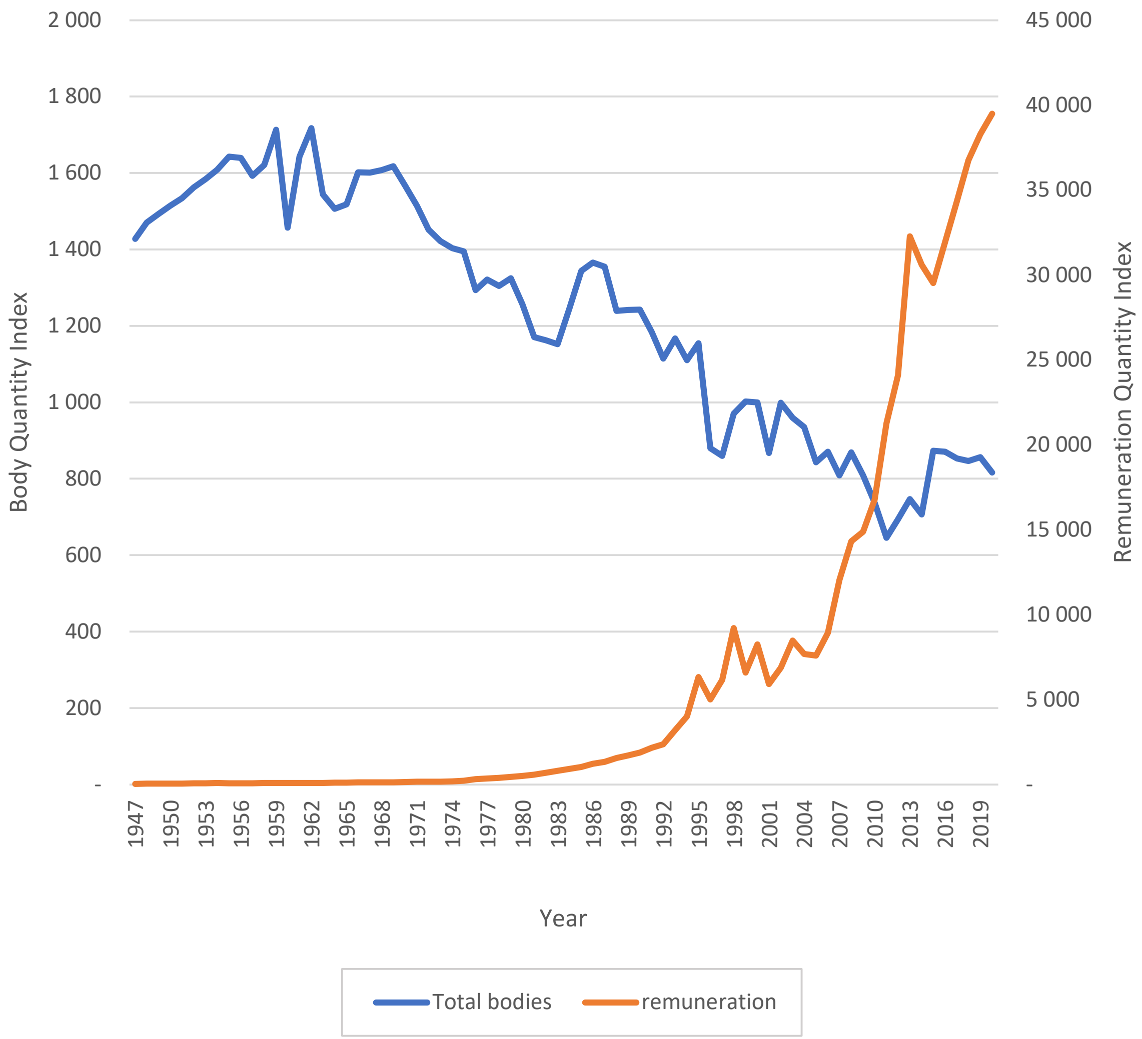

Figure 5: Trends in Agricultural Labour Force and Remuneration (1947 – 2020)

Table 4 presents the annual growth rates of total labour (excluding domestic workers) in the South African agricultural sector for the period 1947 to 2020, as well as for different sub-periods. Between 1947 and 1970, the sector experienced a slight increase in total labour of 0.26% per annum. However, from 1971 to 1988, the sector witnessed a decline in total labour of -0.86% per annum. The period between 1989 to 2003 saw a significant decline in total labour of -2.19% per annum, indicating a major restructuring and mechanization of the sector during that time. There is a large drop from 1995 to 1997 and this could be due to farmers pre-emptively reducing labour due to the end of Apartheid as well as news of the possible introduction of a minimum wage. From 2004 to 2020, the annual growth rate of total labour was -0.16% per annum, but this result is not significantly different from 0, suggesting no growth or decline in total labour with the introduction of the minimum wage. Overall, the South African agricultural sector experienced an annual decline of -1.17% in total labour from 1947 to 2020.

Table 4: average annual growth rates of labour by period, 1947-2020 (%)

Years	Period	Total Labour	
1947-2020		-1.17	***
1947-1970	Big Push Forward	0.26	*
1971-1988	Subsidized Production	-0.86	***
1989-2003	Deregulation and the New South Africa	-2.19	***
2004-2020	National Minimum Wage	-0.16	

*Significance at 10%, (5)% and [1]% levels are indicated by *, (**), and [***] respectively.*

Wages in this dataset are determined based on cash wages, salaries, and cash bonuses. Pre-1994 wage data originates from a variety of agricultural censuses. Where data was missing, estimations were made through averaging or imputations. Domestic worker wages have been excluded where possible; however, post-1985, this information is not distinctly available in the census. PALMS, which started in 1993, enables this distinction and excludes domestic workers from its calculations. It is worth noting that the 1993 wage data from PALMS appears to be an outlier compared to the 1992 and 1993 census data and shows significant divergence from PALMS data for 1994 and subsequent years. Wage data in the dataset is available up to 2015. For the period from 2015 to 2018, the missing wage data was interpolated linearly to match the 2017 Agricultural Census figure, which was then adjusted for inflation to derive total remuneration up to 2020.

3.4. Machinery and equipment

The Agricultural Abstract supplies data on machinery stock, which is then adjusted for inflation using a machinery price deflator. Following the guidelines set by the Department of Agriculture, machinery and vehicles are depreciated using the declining balance method at a consistent rate of 10% annually. This rate is applied to their estimated value at the beginning of each year, leading to a linear depreciation over a 10-year period (Liebenberg, 2013).

It's crucial to understand that the value of machinery and equipment functions as a stock variable. The index derived from this stock measures the service flow or depreciation of these assets. According to methodologies from the United States Department of Agriculture, this service flow is computed as 10% of the machinery stock's value. To this, an additional 3% interest component is incorporated, as per previous studies by Thirtle et al. (1993b) and Conradie et al. (2009a).

Gandidzanwa et al. (2019) attempted to quality-adjust machinery inputs for South African agriculture. They achieved this by treating different qualities of machinery as separate inputs. Therefore, quality adjustment effectively becomes quantity adjustment when there is sufficient disaggregation. However, it's worth noting that their study covers the years from 1995 to 2015, which is a relatively limited timeframe. Furthermore, the change in data from 1994 to 1995, as reported in their study, is significantly different and has been acknowledged as challenging to apply due to limited data availability.

For the sake of historical consistency and to address data limitations, the pre-constructed indices in the Agricultural Abstracts have been chosen to calculate capital stocks, following the methodologies outlined by Thirtle et al. (1993b) and Conradie et al. (2009b). This decision ensures that the valuation and assessment of machinery and equipment in the agricultural sector remain consistent and reliable over time.

Operating costs associated with machinery and equipment are accounted for under the category of intermediate inputs. To prevent double counting, these costs are not included in the machinery and equipment valuation.

3.5. Growth in cattle

Animals herds function as another form of capital stock requiring maintenance. Unlike machinery, these herds are depreciated at 100% upon slaughter, eliminating the need for incremental depreciation in the flow calculation. While the Abstract provides both current and constant values for these animal herds, it does not offer details on herd composition.

A pragmatic approach for calculating the herd's value is to consider the opportunity cost of holding these herds on the farm. This can be quantified as the foregone interest that could have been earned if the funds were invested elsewhere. Following the methodology outlined by Conradie et al. (2009a), a 3% interest rate is applied to the total value of livestock on commercial farms minus the value of boiler chickens, as reported in the Abstract. This rate serves as the share weight for evaluating the economic contribution of animal herds.

3.6. Intermediate inputs

Intermediate inputs consist of various components such as packing materials, fuel, fertilisers, farm feeds, animal health products, crop protection products, and other miscellaneous items. While the Abstract often doesn't specify the quantities of these inputs, when it does, the units provided are not easily comparable. For instance, fuel measurements in litres can be roughly standardised, whether diesel or petrol. In contrast, aggregating farm feeds and fertilisers presents challenges due to their diverse compositions.

In this paper, the methodology of Thirtle et al. (1993b) is adopted to estimate the quantities of these intermediate inputs. Real values will serve as proxies for these quantities, obtained by deflating the nominal values with relevant price indices available in various Abstracts.

With these input and output indices, the Törnqvist-Theil index can then be created by forming the ratio of the aggregate output (Equation 1) to the exponent of the aggregate input (Equation 2). The resulting index will then be used to examine the productivity and changes in different input indices over time. A closer examination of different input indices in relation to other inputs will provide a more detailed understanding of the drivers of productivity. This analysis will help to identify the specific factors that contribute to changes in productivity.

4. Analysis of productivity

The output and input indices developed in this study provide valuable insights into the productivity trends in South Africa's commercial agriculture sector. The analysis spans from 1947, the year South Africa started publishing its Abstracts of Agriculture, and is segmented into four significant periods. The first phase, from 1947 to 1970, is known as the "Big Push Forward," marking a time of rapid modernisation and expansion in the sector. Following that, from 1971 to 1988, the "Subsidised Production" era emerged, during which the government introduced various subsidies and incentives to stimulate production.

The next segment, from 1989 to 2003, is characterised by "Deregulation and the New South Africa," and saw major policy changes, including market deregulation and the end of apartheid, which had a profound impact on agriculture. Finally, the period from 2004 to 2020 was marked by the introduction of the "National Minimum Wage," presenting both challenges and opportunities, especially in relation to labour costs and productivity. This segmented view provides a nuanced understanding of the factors that have shaped and will continue to shape commercial agriculture in South Africa.

The calculations' outcomes will appear in Appendix E, and Table 5 will outline the average annual growth rates for the indices of output, input, and productivity. To further elucidate the behaviour of key variables over time, several figures will complement the tables. The analysis will commence with the broadest level of aggregation, exploring shifts in the aggregate Total Factor Productivity (TFP) index. This high-level examination will set the stage for an in-depth discussion on the individual components that make up the index. For a more granular perspective, Table 6 will detail the proportionate shares in the values of output and costs for the three distinct outputs, which are illustrated in Figure 8, and inputs, as represented in Figure 9. This multi-tiered approach aims to provide a comprehensive understanding of the productivity dynamics within South Africa's commercial agriculture sector.

Figure 6 visually displays the chained aggregate output and input indices alongside the Total Factor Productivity (TFP) index. The indices are comprehensively presented in Appendix E. The first column features the chained aggregate output index. The second column outlines the chained aggregate input index. The third column showcases the TFP index, which is calculated as the ratio of the chained output to the chained input index.

In addition, Table 5 aims to elaborate on the details by reporting the average share in revenue and costs. It also covers the annual growth rates of individual quantity indices for both the output and input metrics. These particulars will be graphically depicted in Figures 6 through 12.

Figure 7 provides a visual representation of the chained partial productivity indices for labour and land, enhancing the depth of result interpretation and enriching our grasp on productivity trends. These indices are also comprehensively detailed in Appendix E.

Between 1947 and 2020, the output index surged by approximately 850%, with an annual growth rate of 2.94%. In the same timeframe, the input index rose by 294%, marking an annual growth rate of 1.18%. However, these growth rates fluctuated across seven decades, as outlined in Table 5. Most of the input growth transpired during the first structural break, accelerating at an annual rate of 2.26%. This pace diminished to an average annual growth rate of 0.97% during the second structural break from 1971 to 1988. On the output side, most of the growth rate came from the first three structural breaks.

Total Factor Production (TFP) showed modest growth at 1.74% per annum throughout the entire period. During the first structural break from 1947 to 1970, TFP grew at a slightly lower rate of 1.53% per annum. However, the second structural break from 1971 to 1988 saw a more robust growth rate of 2.88% per annum. Several factors may have contributed to this trend, including government subsidies which potentially curtailed input usage, alongside a significant technological transition that characterized this era.

Expanding upon Liebenberg and Pardey's (2010) analysis, which spanned from 1947 to 2010 and was termed "1989-2010 Regulation and the New South Africa," the analysis is now extended to encompass the period from 1947 to 2020. This extension reveals a sustained robust growth in output. However, it also highlights a noticeable recovery in input during this prolonged timeframe, leading to a deceleration in total factor productivity growth over the entire period. Upon further subdivision of this timeframe into two distinct sub-periods unveils a nuanced understanding: a predominant surge in output growth is observed post-2003, contrasting with significant input increases observed from 1989 to 2003.

Between 1989 and 2003, coinciding with South Africa's deregulation, the Total Factor Productivity (TFP) growth rate experienced a notable decline to a statistically insignificant 0.31% per annum. This decline occurred during a period of considerable uncertainty as South Africa transitioned from the old government to the new. The political transition introduced significant instability and uncertainty, prompting farmers to scale back their investments. This reduction in investment was largely driven by concerns over the unpredictable regulatory environment and the potential implications for agricultural operations. As a result, the TFP growth rate stagnated during this period, reflecting the broader economic challenges and uncertainties faced by the agricultural sector amidst the transitional phase.

The period from 2003 to 2020 witnessed a rebound in TFP's growth rate to 1.06% per annum. This slower pace was primarily a result of output declines between 2014 and 2016, and further decreases from 2017 to 2019. Meanwhile, inputs have consistently risen since 2014. It is important to note that the output and input data for 2020 are significantly larger than for 2019. However, caution should be exercised as these numbers are based on preliminary data in the 2022 abstract and may contain errors.

Table 5: Average Annual growth rates in output, input, TFP, labour productivity, and land productivity, 1947- 2020 (%)

Year	Period	Output		Input		TFP		Labour productivity	land productivity
1947-2020		2.94	***	1.19	***	1.74	***	4.11	2.79
1947-1970	Big Push Forward	3.83	***	2.30	***	1.53	***		
1971-1988	Subsidized Production	3.35	***	0.49	***	2.88	***		
1989-2020	Deregulation and the New South Africa based on previous literature	2.16	***	1.10	***	1.05	***		
1989-2003	Deregulation and the New South Africa	1.67	***	1.36	***	0.31			
2004-2020	National Minimum Wage	1.98	***	0.92	**	1.07	***		

*Significance at 10%, (5)% and [1]% levels are indicated by *, (**), and [***] respectively.*

Figure 6 visually displays the chained aggregate output and input indices alongside the Total Factor Productivity (TFP) index. The indices are comprehensively presented in Appendix E. The first column features the chained aggregate output index. The second column outlines the chained aggregate input index. The third column showcases the TFP index, which is calculated as the ratio of the chained output to the chained input index.

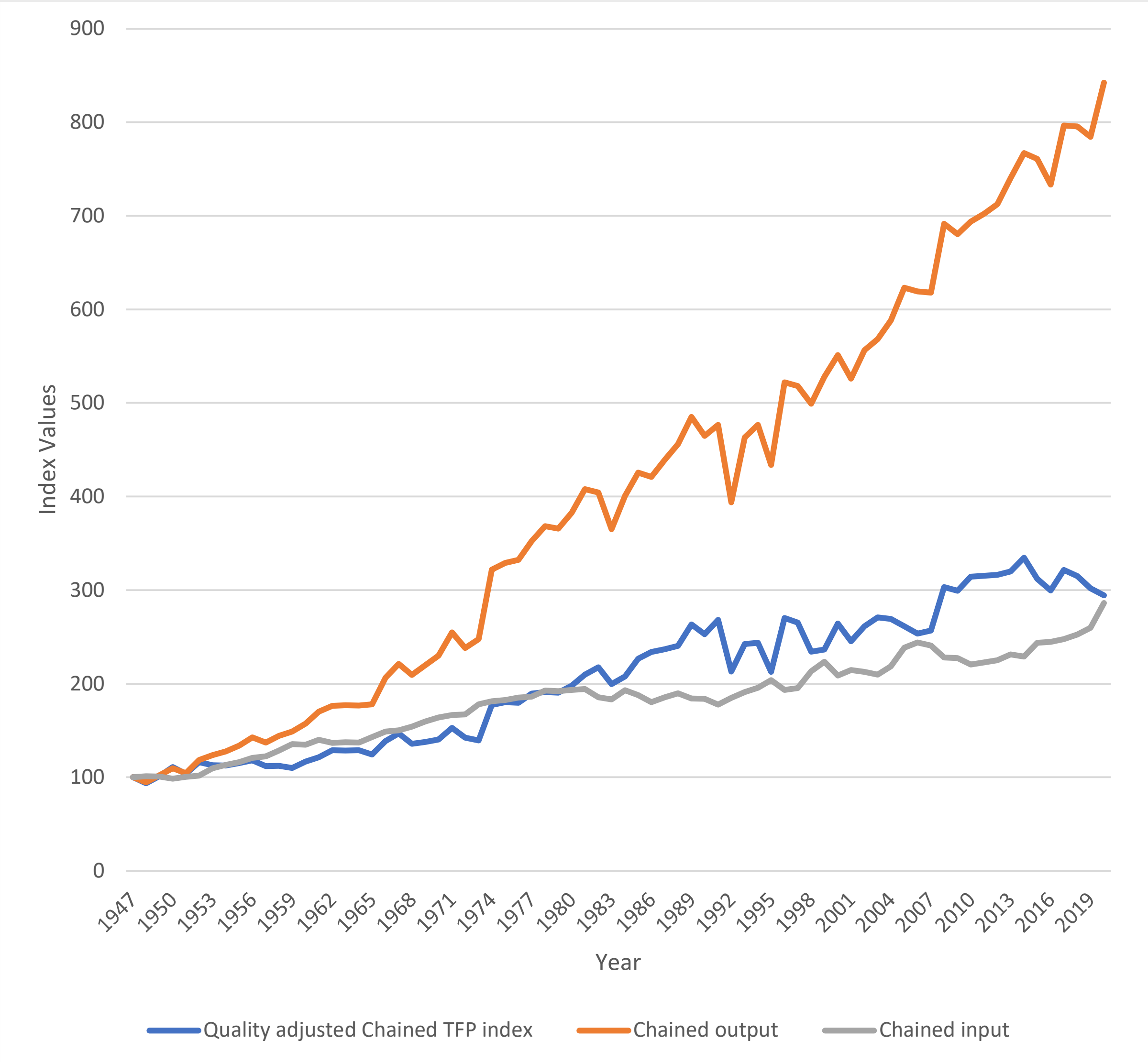

Figure 6: Divisia output, input and TFP indices (1947 – 2020)

Table 6 reveals an annual growth rate of 4.11% in the partial productivity index for labour and a 2.79% annual increase in land productivity. Notably, land productivity experiences a decline around the middle of the third period, specifically in 1992, before rebounding and resuming growth in approximately 2001. In contrast, labour productivity undergoes a significant surge starting in 1995, a trend largely maintained until 2012, after which it becomes erratic.

Table 6: Average shares in revenue and costs, and annual quantity growth rates of inputs and outputs, 1947-2020 (%)

Item	Average Share Over Period	Change In Share 1947-2020	Average Growth Rate
Outputs			
Field crops	36	40 to 26	2.69
Horticulture	20	16 to 29	3.20
Livestock	44	44 to 45	2.43
Inputs			
Labour	16	21 to 15	-1.17
Land and fixed improvements	20	29 to 6	0.15
Capital	10	12 to 6	0.09
Machinery	7	7 to 4	-0.24
Herds	3	5 to 2	0.41
Intermediate (total)	54	38 to 74	2.76
Fertilizer	7	6 to 8	1.63
Fuel	7	7 to 6	0.76
Farm feed	14	3 to 26	3.89
Remedies	4	1 to 3	5.93
Packing material	4	4 to 3	2.81
Other intermediaries	19	17 to 27	2.93

The shares of labour, land, intermediate and capital inputs sum to 100%. Then the components of the intermediate input and of the capital input again sum to 100%.

These fluctuations in productivity indices underscore the complexity of labour and land dynamics in the agricultural sector. The observed irregularity in labour productivity post-2012 and the dip in land productivity in 1992 could be indicative of underlying structural changes, market conditions, or policy interventions. Further research might be needed to pinpoint the specific factors driving these trends.

Overall, these indices are widely utilised by economists and align with the traditional belief that productivity growth in primary factors like labour and land will surpass that of Total Factor Production (TFP). This is attributed to the substitution of non-farm intermediate inputs for labour and land (Groenewald, 1964). The trend supporting this observation is clearly depicted in Figure 7. Figure 7 illustrates both the total number of agricultural labourers and their corresponding remuneration over time. An exponential growth in remuneration is evident post-2005 in the remuneration line. This is shortly after the introduction of the National Minimum Wage in 2003.

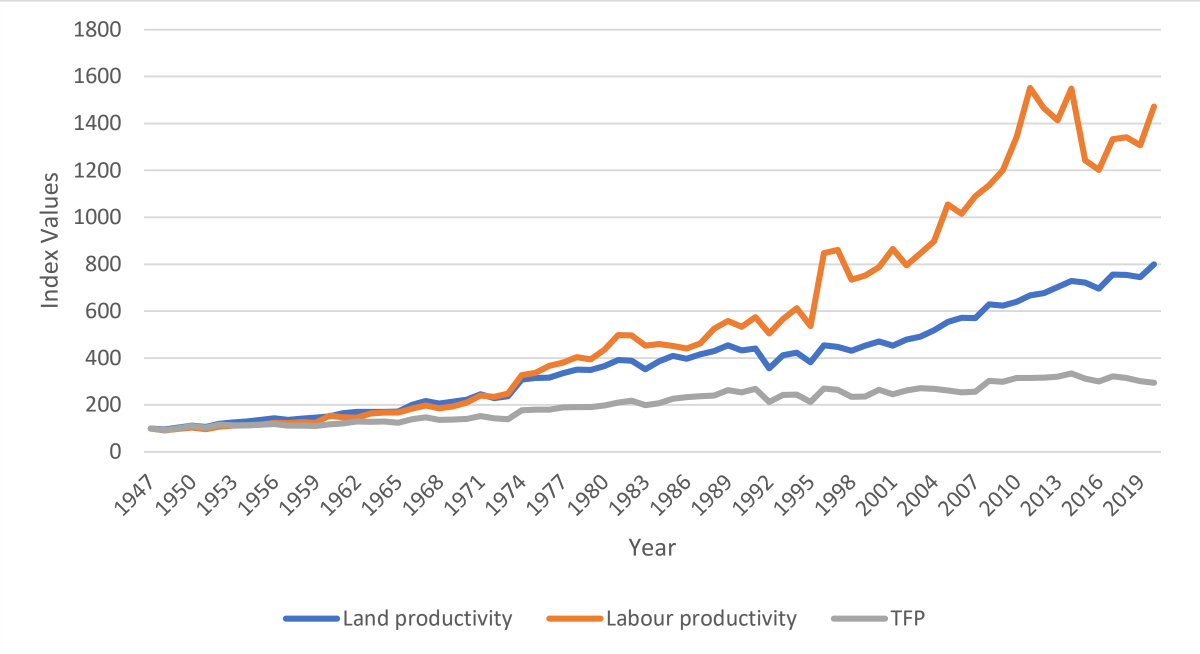

Figure 7: TFP, labour and land productivity indices (1947 – 2020)

This concludes the concise overview of the results at the highest level of aggregation. To delve into the root causes behind these aggregate changes, a more comprehensive analysis of the index components is imperative. The investigation will commence by dissecting the output, as depicted in Table 6, which disentangles it into crops, horticulture, fruit, and animal products. The growth rates for these segments were 2.69%, 3.20%, and 2.43% respectively.

The notably robust growth in horticulture and fruit has led to an expansion of their presence within the overall output, surpassing crops. This shift has historical precedence as well, highlighted by Groenewald (1965), who observed a similar trend spanning from 1945 to 1962, further intensifying over time.

Anticipated patterns emerge in these indices, aligning with the fact that field crops heavily rely on rainfall, making them susceptible to the impact of droughts, evident in occurrences such as the droughts of 1983 and 2015. Conversely, irrigated fruit and horticulture display a higher resilience. The livestock index experiences a delayed reaction due to droughts, as their effect on herd productivity becomes evident later, as noted by Thirtle et al. (1993b).

The agricultural sector has experienced significant shifts from 1947 to 2020 in both output and input compositions as can be seen above in table 6 as well as below in figure 8. In terms of output, field crops, horticulture, and livestock have exhibited varying degrees of change. Field crops saw a decline in their share from 40% to 26% but maintained a positive average growth rate of 2.69%. Conversely, horticulture's share rose from 16% to 29%, alongside a 3.20% average growth rate. Livestock remained stable, with its share moving from 44% to 45%, and an average growth rate of 2.43%.

Similarly, notable trends in key inputs emerge. There has been a strategic shift from primary inputs to non-farm intermediate and capital inputs. When focusing on intermediate inputs, two growth phases—1947-1970 and 1971-1988—exhibited annual growth rates of 4.73% and 4.02% respectively. The subsequent periods showed a slowdown, culminating in a modest annual growth rate of 1.28% in the most recent phase. Despite these variations, intermediate inputs have been the main driver of growth, maintaining an average annual rate of 2.76%.

From a cost perspective, labour and land have seen significant reductions in their proportional contribution to aggregate costs. Labour's share dwindled from 21% to 15%, paralleled by an annual average growth rate of -1.17%. The share of land and fixed improvements dropped dramatically from 29% to 6%, even though its average growth rate was a marginal 0.15%. On the capital side, livestock emerges as the primary growth driver with an average growth rate of 0.41% across the period, and an accelerated growth rate of 0.65% per annum from 2003 onwards.

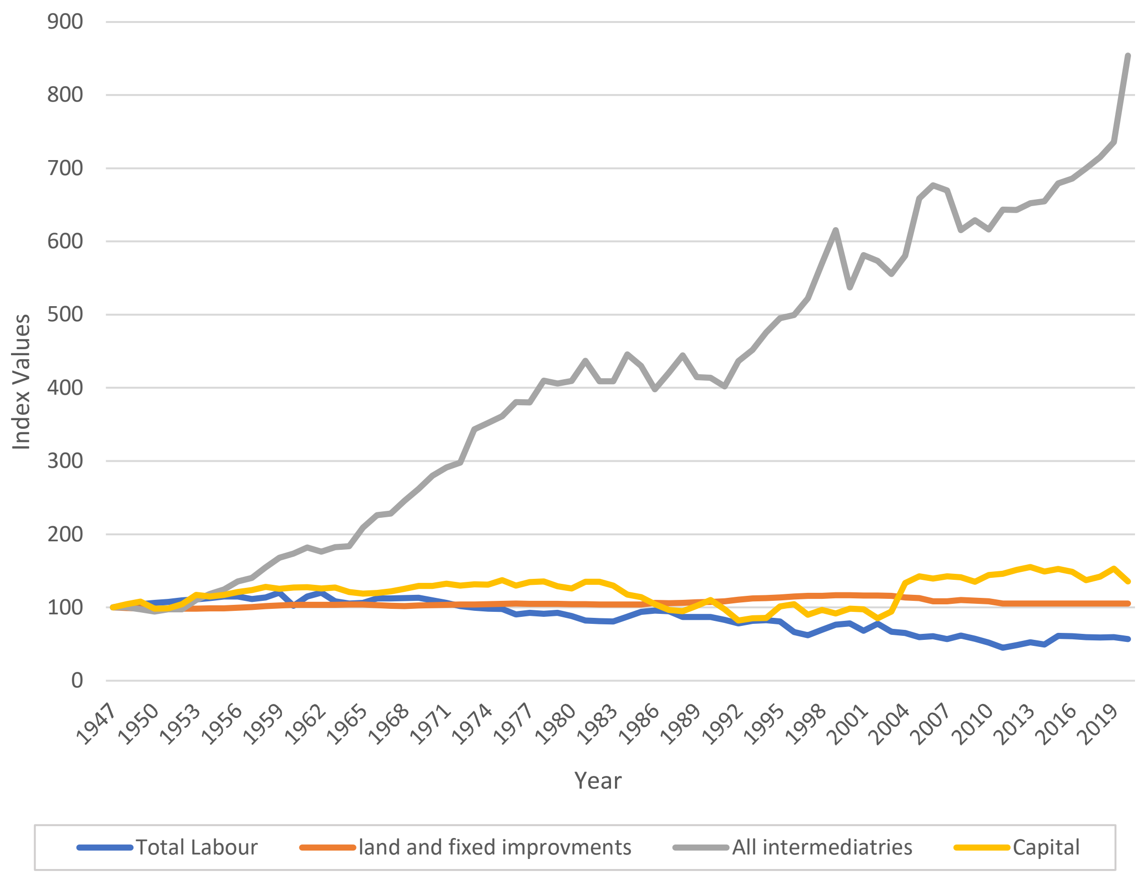

Figure 8: Divisia aggregate quantity input indices (1947 – 2020)

When looking only at labour and land and fixed improvements, the scale is now sufficient to see that the land index is growing at a steady rate of 0.27% until 2000, when only examining the primary input indices in figure 9, the scale is now sufficient to see that the land index is growing at a steady rate of 0.27% until 2000, before a dramatic decline of -0.58% per annum for the rest of the period.

The labour index is much more varied, with a rapid growth of 1.23% per annum until 1959. Labour then becomes varied until the late 1960s and begins to decline at a rate of 2.13% per annum from 1968 to 1980. This is followed by a few bad years, before a recovery around mid to late 1980s that saw labour returning to the level of the early 1970s, before declining again. From 1987 until 2020, labour decreases by a rate of 1.64% per annum.

From 1947 to the 1970s, there was an increase in the area cultivated for maize production in summer rainfall areas, as tractors were introduced into South Africa and were began to replace oxen (Thirtle, et al., 1993b). The introduction of tractors revolutionized the management of land and enabled farmers to expand their operations. This advancement was accompanied by the widespread use of fertilizers and high-yield crops, which boosted labour usage as well (Payne, et al., 1990).

After 1970, the mechanization effect continued to dominate the agricultural sector, particularly with the introduction of the combine, which significantly reduced the demand for labour during harvest time (Thirtle, et al., 1993b). This mechanization effect also allowed for cultivated land to increase as farmers were able manage larger areas of land. The phenomenon of labour leaving is not new. Day (1967) conducted research on the exodus of labour from the old South of the United States and found that it did not occur until the mechanical cotton picker was introduced. This is similar to what has happened in South Africa, where low-wage black labour stayed on the land until the introduction of the combine.

In winter rainfall areas, a similar pattern emerged, although the expansion of cultivated land was mostly completed by 1947 (Thirtle, et al., 1993b). As a result, these areas have experienced almost exclusively the machinery effect in terms of their agricultural development. With the majority of land already cultivated, the focus has shifted to the adoption of advanced machinery and technology to maximize yields and increase efficiency in the production process. The machinery effect has thus played a crucial role in driving agricultural productivity and growth in these regions.

In addition to the Pass Laws, government policies also played a significant role in shaping the agricultural industry during the apartheid era in South Africa. One of the key policies was the provision of cheap credit, negative real interest rates, and tax breaks that allowed for the rapid acquisition of capital equipment (Thirtle, et al., 1993b). This policy encouraged farmers, particularly white farmers, to invest in modern machinery and technology to improve productivity and efficiency in their operations.

Figure 9 below suggests that the social and economic costs of these policies could be considerable. The severe drought of 1981-1983 marked a turning point for the agricultural industry in South Africa. The credit and tax concessions that had previously supported the rapid acquisition of capital equipment were largely retired due to economic pressures, such as the plummeting gold price and drastic devaluation of the rand. These events had the combined effect of making labour a cheaper input relative to capital, leading to a reversal of the mechanization effect. As a result, there was a shift towards greater labour use in the agricultural sector, as farmers sought to substitute more expensive capital items with cheaper labour. The trend towards greater labour use did not last long, as the labour index fell after 1987 with the recovery from the drought and the gradual end of apartheid in the early 1990s. The end of apartheid led to the lifting of international economic sanctions against South Africa, which opened up new opportunities for trade and investment. This, combined with government policy changes, led to a reduction in tariff pressures from abroad and greater freedom of movement for labour, allowing for a more flexible and dynamic agricultural sector. As a result, farmers began to adopt a more labour-saving approach, using machinery and technology to improve efficiency and reduce costs. This will be examined in the next section.

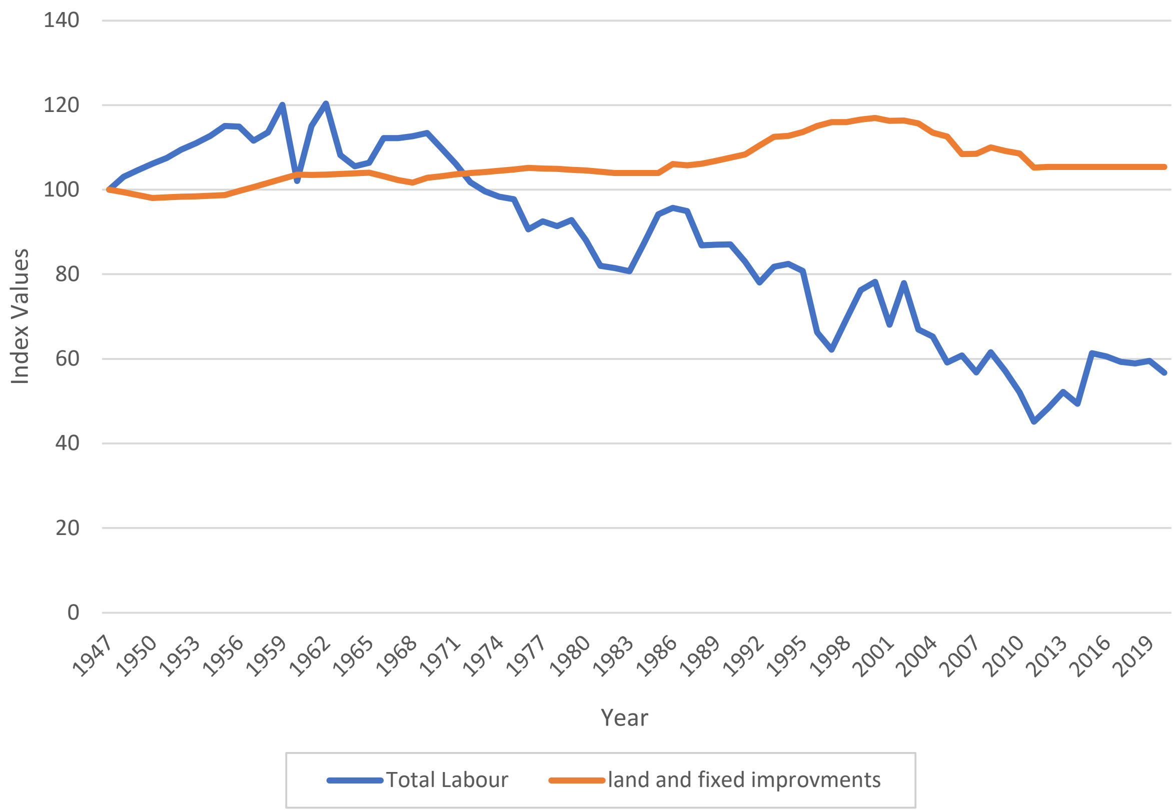

Figure 9: Divisa primary input quantity indices (1947 – 2020)

In Figure 10 below, the data suggests that the growth of the machinery index in agriculture was rapid until 1958, with an annual growth rate of 6.23%. However, from 1958 to 1981, the growth rate stabilized at a lower rate of 1.59% per annum. Subsequently, the machinery index has been declining at an average rate of 0.23% per annum since 1981. In the graph below it can also be seen that there is a sharp drop in machinery investment in 1994, this is due to commercial agriculture no longer receiving as many subsidies (Black, et al., 2016).

These trends indicate that the relative prices of inputs, particularly machinery and labour, have influenced factor substitution in agriculture. As farmers faced increased competition and pressure to improve efficiency, they substituted factors of production based on relative prices. The relationship between the machinery index and the labour index shows that as the machinery index rose, the labour index decreased, suggesting that farmers substituted labour with machinery when the relative prices of machinery were more favourable. This is due to low interest rates and tax concessions for machinery, which has now led to the overcapitalisation of agriculture (Black, et al., 2016).

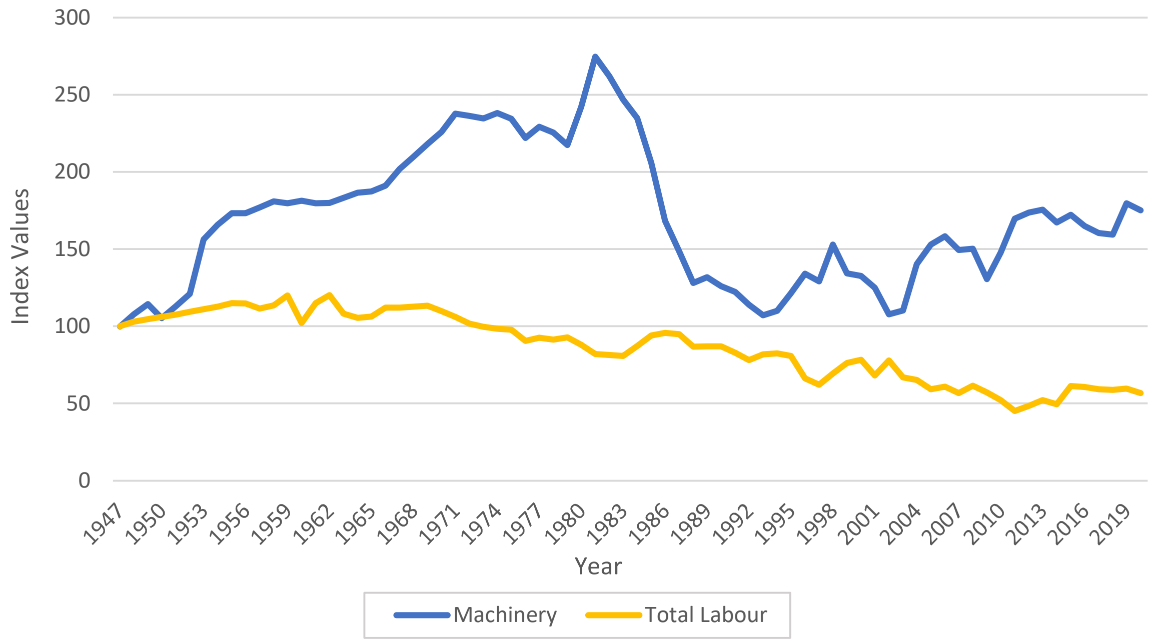

Figure 10: Machinery and labour quantity indices (1947 – 2020)

Figure 11 shows the significant increase in the use of remedies, such as dips and sprays, in the South African agricultural sector over the years. This increase was influenced by various factors, including the need to control diseases and pests, changes in agricultural practices, and advancements in technology. From the late 1940s to 1972, the use of remedies grew at an annual average rate of 8.87%, as farmers began to adopt new and more effective remedies to protect their crops and livestock. However, the use of these remedies increased rapidly from 1972 to 1980, with an average annual growth rate of 20.58%, likely due to the introduction of new chemical pesticides and the increasing demand for agricultural products.

In the 1990s, concerns about the environmental and health impacts of agricultural remedies led to increased regulation and restrictions on their use, causing a slowdown in their growth rate to 1.22% between 1980 and 2002. However, between 2002 and 2007, there was a resurgence in the adoption of remedies as farmers began to switch to more environmentally friendly alternatives, resulting in a growth rate of 9.73%.

In recent years, the growth rate of agricultural remedies has once again declined, with an annual decrease of -2.94% between 2007 and 2020. This trend indicates a shift towards more sustainable agricultural practices, driven by rising concerns over environmental and social impacts, as well as changing consumer preferences.

The decline in the growth rate of agricultural remedies reflects the growing awareness of the need for sustainable and eco-friendly farming practices. Farmers and consumers are increasingly recognizing the long-term benefits of adopting sustainable approaches that are less harmful to the environment and more socially responsible.

Farm feed shows a steady growth of 4.31% from 1947 to 2004, and then there is an explosive growth of 39.13% from 2004 to 2005. After which there is a steady decline from 2005 till 2014 at -4.69%. For the rest of the period, there is a moderate increase of 4.99% per annum.

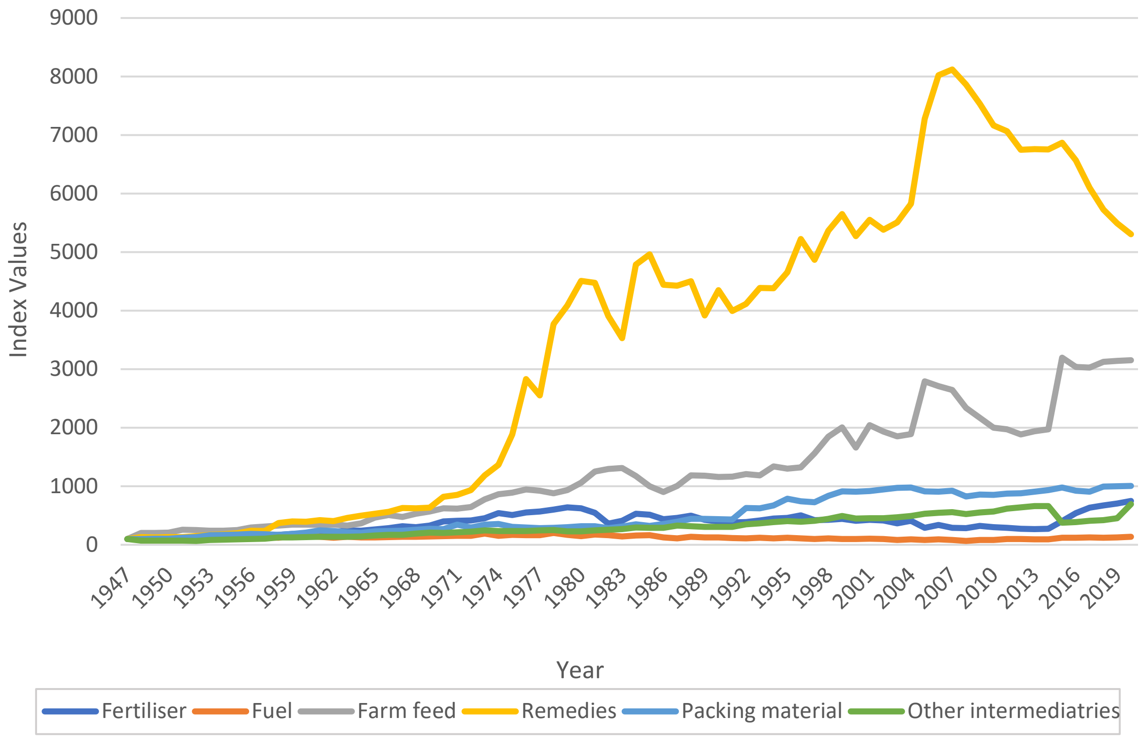

Figure 11: Divisia intermediate input quantity indices (1947 – 2020)

Figure 11 has been reproduced as figure 12 without remedies and farm feeds to show the movement of the other series.

From figure 12, it can be seen that fuel usage stays constant for the whole period, whilst packing material, fertilizers and other intermediaries show an extremely varied movement between periods. Packing material shows the largest growth, which could be the increased ability of farmers to making use of upcycling and also becoming more able to extract more from their outputs. Fertilisers also declined heavily since 1977, before increasing again from 2015 onwards.

In Table 6, an important trend to note is the significant increase in the cost share of all intermediaries, which has risen from 38% to 74% of total input costs. This is a concerning trend, as it indicates that farmers are increasingly dependent on intermediaries for their operations.

Of particular concern is the growing cost share of farm feed, which has increased from 3% to 27% of total input costs. This suggests that farmers are facing rising costs for animal feed, which can have a significant impact on their profitability. Additionally, the cost share of other intermediaries has also increased, from 16% to 28% of total input costs. It is worth noting that prices for this category are not consistently monitored, despite its significant contribution to input costs.

Overall, these trends highlight the need for greater attention to be paid to the role of intermediaries in agricultural supply chains. Farmers may benefit from increased transparency and oversight in pricing and sourcing of necessary inputs, in order to mitigate the impact of rising costs on their operations.

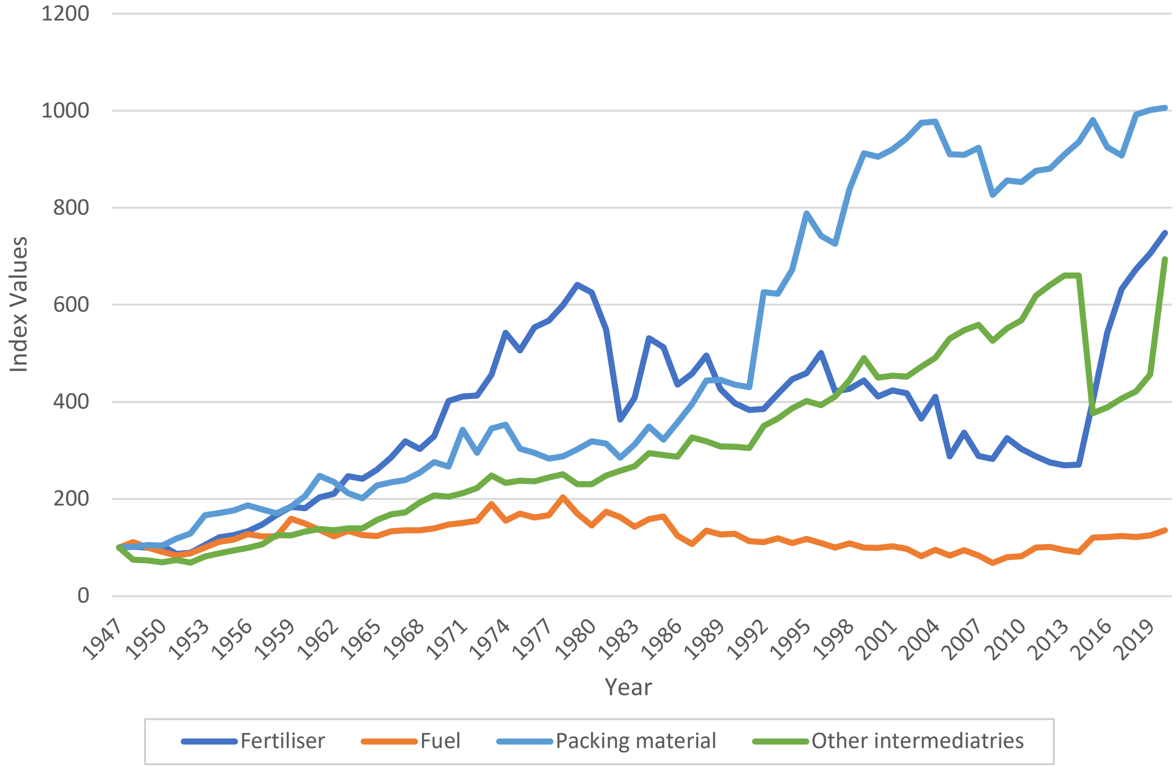

Figure 12: Average quantity indices of fertilizer, fuel, packaging materials, and other intermediaries (1947 – 2020)

5. Conclusion

The rate of agricultural output growth in South Africa has shown a notable deceleration, particularly since the 1980s, with field crop production experiencing a significant slowdown, in exchange for a higher horticulture production as it is more profitable. This trend persisted throughout the third period (1989-2003). However, there has been a recent upswing in agricultural output growth in the most recent period, with a surge in livestock growth contributing to this reversal.

The changing composition of agricultural outputs, notably the rise in higher-value horticultural crops at the expense of staple food crops and livestock, carries significant implications for food security. While horticultural crops may offer farmers higher returns and diversification opportunities, their ascendancy can also make basic staple foods less accessible and more expensive for low-income households. This is especially concerning in regions where staple foods like grains, tubers, and livestock products serve as the primary sources of nutrition.

Additionally, the shift towards higher-value crops might lead to monocropping systems, which can exacerbate vulnerability to pests and diseases, thus posing another layer of risk to food security. Furthermore, these high-value crops often require more inputs like water and fertilisers, creating stress on natural resources, which could have long-term repercussions on sustainable agriculture and, by extension, food security.

Livestock's stable share in agricultural outputs also offers a nuanced picture. While livestock provides essential nutrients and serves as a protein source, its production often requires significant land, feed, and water. A shift away from livestock production to accommodate higher-value crops could potentially limit the availability of these important dietary components, again raising concerns for food security, particularly in protein-poor diets. Intriguingly, in the latest period, livestock growth has seen a notable resurgence, possibly indicating changing consumer preferences or market demands.

In terms of input dynamics, South African agriculture has undergone significant transformations. Despite prevalent unemployment, the sector has substantially increased its use of material inputs and has continued to invest significantly in capital and intermediatory inputs. However, a notable trend is the decline in the use of labour in agriculture, which might be attributed to labour reforms introduced in 2003 with the introduction of minimum wage. This could be indicative of enhanced labour productivity resulting from these reforms, leading to increased outputs even with reduced input use.

Amidst these developments, the recent declines in the rate of total factor productivity growth are concerning. Coupled with historically low labour productivity rates in the broader African context, there arises a real concern for addressing chronic hunger and food insecurity. At least on this front in South Africa it is improving with the introduction of minimum wage. The evidence presented underscores the urgency of revitalizing rural development strategies that promote long-term productivity growth, particularly through investments in agricultural Research and Development and fostering favourable incentive structures.

The decline in the rate of total factor productivity (TFP) growth is alarming, especially when considered alongside the low labour productivity rates that have historically characterised the broader African context. This presents a critical issue for South Africa, exacerbating challenges related to chronic hunger and food insecurity. Although there have been improvements since the introduction of the minimum wage, a gap still exists. With a population growth rate of 1.527% per annum, which exceeds the TFP growth rate of 1.06% per annum, the urgency for effective strategies is amplified.

The importance of reinvigorating rural development initiatives for long-term productivity growth cannot be overstated. Prioritising investments in agricultural Research and Development (R&D) can potentially reverse the declining TFP trend. R&D leads to technological innovations and improved farming techniques, which can result in enhanced yields, optimised input usage, and a reduction in environmental impact.

While addressing the challenges facing South Africa's agricultural sector requires a multifaceted approach, establishing favourable incentive structures within the policy environment emerges as a pivotal strategy. Beyond rectifying existing shortcomings, such structures can actively promote the adoption of sustainable farming methods and innovative practices essential for long-term sectoral growth.

To achieve this, policymakers should consider implementing a range of incentives tailored to incentivize positive behaviour among farmers. Subsidies targeted at sustainable farming methods can not only alleviate financial burdens but also encourage the adoption of environmentally friendly practices. Moreover, introducing performance-based rewards tied to benchmarks related to productivity, conservation efforts, or community engagement can serve as powerful motivators for farmers to continually improve their operations.

By aligning policy incentives with the overarching goals of enhancing agricultural sustainability, productivity, and inclusivity, South Africa can foster a culture of innovation and resilience within its farming communities. These proactive measures will not only catalyse the adoption of new technologies and practices but also contribute to the broader objectives of poverty reduction, rural development, and environmental stewardship. However, the current trajectory of agricultural productivity in South Africa holds immense implications for the country's future. Policy decisions made today will significantly shape the agricultural sector for a considerable part of the century. Since the labour reform in 2004, there has been a notable decrease in input use, while outputs have grown. This indicates the potential of effective policy measures to enhance labour productivity and agricultural growth. Despite these advancements, the task of boosting productivity demands careful planning and innovative solutions to guarantee sustainable and inclusive growth within the sector.

Furthermore, there's a pressing need to address the quality of available data. Presently, numerous censuses lack essential information, and abstract data exhibits inconsistencies across different periods. Implementing quality adjustments akin to those applied to labour and land data is crucial to ensure the precision and accuracy of productivity calculations. Harmonizing and refining data sets is imperative for an accurate assessment of productivity trends.

In summary, the interplay between South Africa's growing population and sluggish TFP growth rates intensifies the food security risk. Revitalising rural development and investing in productivity-enhancing strategies are no longer just important but have become urgent necessities. These interventions must be central to policy formulation, aiming to ensure that the food production system can keep pace with population growth, thereby mitigating risks associated with chronic hunger and food insecurity.

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Appendix A: Input productivity calculation

Appendix A.1:

		Physical Quantities												Values R million Nominal							
year	Total Labour	Land & fixed (1000 hecteres Land under perm. meadows and pastures + land under perm crops	Machinery	Herds from abstract	Fertiliser	Fuel	Farm feed	Remedies	Packing material	Other intermediatries		Total wages	Land & fixed improvements	Machinery	Herds	Fertiliser	Fuel	Farm feed	Remedies	Packing material	Other intermediatries
1947	100	100	26490	59505	1963	4774	1169	80	529	5783		50,65	70,78	17,51	13,30	14,00	17,00	8,00	1,50	9,50	42,00
1948	103	99	28516	61232	1992	5287	2334	105	535	4311		52,24	78,69	21,19	13,92	14,50	20,50	16,30	2,00	10,00	32,70
1949	105	99	30274	62604	1962	4762	2358	101	555	4228		53,82	86,87	25,87	14,73	15,00	21,10	16,80	2,00	10,80	34,30
1950	106	98	27884	56478	2053	4344	2409	104	550	4011		55,41	97,94	27,86	15,51	16,00	22,00	18,00	2,20	11,00	34,90
1951	107	98	29904	55037	1703	3987	2995	106	625	4261		63,10	109,26	32,92	18,84	16,90	22,40	25,10	2,50	13,10	42,20
1952	109	98	32029	57741	1747	4207	2906	117	681	3995		70,79	119,57	36,58	21,26	17,60	24,80	27,20	3,10	14,40	41,80
1953	111	98	41392	59199	2057	4763	2790	136	879	4684		80,48	128,60	47,31	22,33	18,30	27,70	26,50	3,70	17,60	47,50
1954	113	99	43915	55001	2372	5328	2801	142	903	5089		83,35	131,11	50,39	21,64	21,10	31,20	27,00	3,80	17,90	51,80
1955	115	99	45914	54812	2462	5547	2914	157	932	5409		81,15	141,53	53,34	22,39	23,90	31,60	28,90	4,00	18,30	55,80
1956	115	100	45893	58386	2612	6083	3464	190	988	5717		73,02	141,82	55,04	25,22	26,50	36,10	34,60	5,00	19,40	60,60
1957	112	101	46897	59538	2885	5876	3630	188	943	6154		80,89	148,12	57,69	26,81	28,00	36,50	36,00	5,10	18,70	65,70
1958	114	102	47916	62123	3273	5850	3825	297	901	7242		85,00	151,39	59,81	26,74	30,80	36,80	39,00	8,10	18,70	78,20
1959	120	103	47589	60406	3602	7598	3999	316	976	7220		91,16	167,19	60,37	26,69	33,90	49,00	41,90	8,50	21,90	79,90
1960	102	104	48064	61259	3727	7287	4098	333	1012	7602		93,14	170,24	61,96	27,26	34,30	47,20	43,70	8,70	25,40	85,40
1961	115	103	47577	62076	4255	6805	4141	367	1136	7813		93,51	173,69	61,80	26,90	39,20	43,50	43,00	9,30	30,80	87,70
1962	120	104	47669	60586	4394	6139	4149	360	1057	7720		93,92	185,16	62,74	27,70	40,90	39,50	44,00	9,10	29,70	87,90
1963	108	104	48535	60744	5157	6765	3970	405	967	8036		94,33	195,46	64,86	29,35	48,00	43,20	42,20	10,40	27,00	91,40
1964	106	104	49390	54608	5032	6466	4460	443	935	8069		102,24	242,54	67,56	30,18	47,80	41,10	48,30	11,40	25,90	92,50
1965	106	104	49645	52695	5525	6571	5640	482	1009	8865		106,57	261,20	69,47	30,41	53,50	41,80	62,70	12,40	30,00	103,80
1966	112	103	50613	52539	6069	7104	6213	513	1039	9545		121,71	263,31	71,68	31,55	60,10	45,40	72,50	13,20	33,20	115,60
1967	112	102	53480	51422	6770	7193	5777	572	1057	9757		126,91	322,29	76,95	34,15	66,50	46,60	66,50	14,80	33,90	119,70
1968	113	102	55589	52432	6434	7193	6502	566	1126	10950		136,18	349,67	82,02	35,69	63,20	46,60	76,00	14,80	34,20	131,40
1969	113	103	57756	53317	7004	7424	6943	575	1221	11741		138,26	360,20	87,82	35,33	68,10	48,10	85,80	15,40	34,50	142,20
1970	110	103	59873	51493	8536	7826	7576	744	1182	11593		148,68	364,42	94,74	35,54	83,00	50,70	97,80	20,50	34,30	143,00
1971	106	104	63005	50848	8738	8010	7550	774	1517	12002		159,10	408,15	103,78	37,13	93,30	56,60	100,30	22,30	45,10	157,70
1972	102	104	62595	49032	8780	8272	7869	849	1306	12615		164,43	437,30	111,92	44,81	102,30	62,10	111,20	25,80	42,00	177,60
1973	100	104	62167	50940	9684	10101	9487	1077	1528	14091		169,76	484,67	122,01	60,06	121,50	83,40	152,40	34,10	50,90	217,90
1974	98	104	63118	49814	11531	8246	10541	1241	1563	13235		192,88	575,84	134,89	72,41	163,70	105,40	189,90	46,60	56,80	243,70
1975	98	105	62105	55870	10758	9026	10868	1717	1344	13470		230,71	656,54	165,43	77,13	213,90	132,60	214,20	81,10	60,00	301,00
1976	91	105	58795	52754	11766	8625	11537	2573	1305	13402		316,21	738,57	190,71	82,30	250,80	167,90	252,40	127,60	63,00	340,50
1977	93	105	60739	55206	12062	8845	11255	2322	1254	13851		359,04	849,35	217,88	87,19	287,80	190,10	290,60	121,20	66,00	396,50
1978	91	105	59725	56959	12729	10839	10768	3428	1275	14211		401,88	921,50	244,01	92,71	355,10	241,40	321,10	195,10	74,50	459,20
1979	93	105	57583	53430	13632	9024	11416	3717	1340	13048		457,76	1023,09	271,41	104,60	431,80	368,80	401,20	218,10	87,80	526,30
1980	88	105	64156	44267	13294	7741	12942	4099	1413	13067		507,03	1072,40	326,96	108,47	493,50	404,50	547,40	265,30	106,00	627,50
1981	82	104	72815	43161	12011	9778	14899	4170	1344	14131		581,64	1093,90	417,37	134,55	478,50	532,30	719,70	291,50	116,40	749,30
1982	81	104	69437	46621	8202	9138	15084	3566	1275	14669		694,85	1245,33	471,47	136,05	367,10	579,20	867,90	296,60	122,10	903,20
1983	81	104	65392	46337	9063	8986	13898	3222	1444	15038		808,06	1386,29	514,20	138,39	461,80	559,40	995,70	299,40	148,50	1047,10
1984	87	104	62197	39030	11641	10954	12098	4205	1583	16607		920,57	1482,63	548,65	148,99	630,50	640,70	940,40	427,90	174,80	1213,40
1985	94	104	54509	43625	10115	10710	11064	4164	1611	16403		1033,08	1498,34	588,55	167,39	730,60	788,90	936,60	528,00	188,10	1412,90
1986	96	106	44595	45285	9058	9136	10962	3708	1488	16617		1227,70	1528,98	620,22	215,75	758,40	729,00	1027,10	584,00	259,00	1650,40
1987	95	106	39349	43622	10016	8893	11743	3623	1535	19023		1343,61	1573,48	660,23	256,50	831,90	644,00	1208,30	612,50	304,30	1972,70
1988	87	106	33944	47489	9491	11408	14160	3657	1800	18703		1554,03	1621,66	697,22	312,00	977,60	867,00	1529,30	669,20	370,90	2150,80
1989	87	107	34899	53050	8167	10742	14072	3183	1806	18077		1720,83	1679,88	762,20	356,50	1004,60	1074,20	1744,90	649,30	418,90	2512,70
1990	87	108	33381	61146	7605	10827	13816	3532	1766	18022		1887,62	1849,13	807,16	365,04	1003,80	1234,30	1920,40	812,30	471,60	2793,40
1991	83	108	32410	51276	7343	9577	13893	3245	1745	17890		2167,65	2016,98	830,02	373,80	1064,80	1331,20	2139,50	873,00	492,10	3130,80
1992	78	110	30183	40705	7381	9425	14422	3340	2538	20556		2378,24	2034,48	839,68	340,70	1070,20	1423,20	2408,50	955,30	753,80	3823,50
1993	82	112	28383	44803	7972	10069	14164	3562	2526	21447		3199,12	2219,85	892,92	385,76	1243,60	1671,40	2648,60	1075,80	825,90	4375,10
1994	78	113	29126	44668	8556	9256	15938	3558	2725	22672		4020,00	2230,76	1007,19	497,16	1488,70	1666,10	3139,80	1152,80	975,50	4965,20
1995	81	114	29555	54927	8791	9963	15488	3781	3198	23557		6324,00	2262,85	1129,58	571,79	1802,20	1863,10	3267,90	1308,30	1292,00	5606,60
1996	62	115	32925	54253	9585	9226	15748	4244	3010	23067		5016,00	2347,95	1339,72	584,31	2137,40	2131,20	3826,70	1693,20	1511,00	6343,30
1997	60	116	34220	43237	8073	8474	18656	3955	2943	24104		6156,00	2445,90	1512,51	594,08	2002,10	2271,10	4962,40	1941,90	1545,20	7134,70
1998	68	116	39643	42338	8180	9150	21981	4359	3399	26075		9216,00	2649,31	1896,51	581,72	2020,40	2305,90	5935,00	2162,00	1624,70	7770,40
1999	70	117	37646	43495	8507	8451	23904	4587	3699	28751		6588,00	2779,13	1942,93	578,05	2152,20	2645,30	6740,90	2353,10	1805,30	8970,40
2000	70	117	33393	49429	7874	8409	19789	4281	3669	26382		8250,00	2986,25	2009,94	590,18	2409,30	3010,30	6906,20	2444,60	2073,20	10420,80
2001	61	116	31128	50841	8118	8681	24351	4509	3731	26617		5916,00	3185,58	2108,73	632,98	3084,70	3654,90	9302,10	2664,90	2294,30	11631,60
2002	70	116	29232	44805	7992	8215	23041	4372	3826	26511		6876,00	3437,76	2447,32	719,12	3660,50	3893,80	11174,70	2885,80	2387,40	13493,90
2003	67	116	30422	52011	7005	6961	22101	4474	3954	27706		8484,00	3635,92	2697,23	886,28	3117,40	3487,40	11249,20	2831,90	2506,70	14711,80
2004	66	113	34545	77480	7859	8068	22514	4732	3966	28771		7692,00	3783,27	3044,78	1436,48	3481,40	4380,70	11504,40	2839,20	2581,60	15565,20
2005	59	113	36798	82109	5511	7079	33295	5909	3692	31086		7584,00	4261,87	3214,71	1596,20	2617,80	3872,40	16780,70	3510,10	2407,50	16942,10
2006	61	108	39524	78049	6446	7979	32284	6513	3686	32109		8922,00	4733,21	3488,77	1861,48	3126,30	4731,80	17368,60	4031,30	2491,90	18591,40
2007	57	108	42239	82862	5528	7059	31522	6596	3746	32744		12042,00	5259,41	3755,88	2115,46	3560,10	4828,40	18850,20	4399,50	2614,50	21054,20
2008	61	110	43910	81599	5406	5781	27847	6386	3351	30811		14320,00	5839,80	4395,37	2271,71	4113,80	5838,80	20829,60	4872,60	2741,10	24525,30
2009	57	109	42660	81458	6227	6749	25881	6118	3474	32337		14880,00	6154,22	4858,13	2350,87	5317,50	6486,00	22516,60	5341,40	3063,70	28521,30
2010	52	109	39148	84972	5800	6944	23849	5818	3460	33283		16770,00	6642,94	5089,27	2549,16	5799,90	6944,40	23849,40	5818,10	3460,10	33283,40
2011	45	105	38565	80628	5504	8439	23516	5738	3552	36262		21270,00	7193,45	5554,93	2931,63	5994,10	8852,00	26314,80	6323,00	3963,90	40214,10
2012	49	105	38167	84106	5273	8559	22478	5480	3571	37554		24090,00	7910,64	6102,92	3123,69	6084,80	10425,20	28996,50	6784,30	4570,50	47430,60
2013	52	105	39051	87274	5159	7985	23112	5491	3690	38727		32280,00	8689,31	6711,37	3186,36	6268,70	10340,90	31894,80	7193,80	5043,80	52242,90
2014	50	105	39807	83892	5182	7684	23529	5486	3794	38717		30600,00	9605,23	7374,32	3460,53	6456,80	10873,20	34446,40	7625,50	5497,70	55327,00
2015	61	105	40686	85487	7707	10168	38132	5578	3977	22072		29520,00	10469,07	7944,29	3752,01	9825,80	13869,10	58228,00	8149,90	6005,00	32533,40
2016	61	105	40085	84248	10393	10293	36197	5332	3751	22771		31933,57	11692,67	8473,08	4033,80	13656,30	14708,80	59218,50	8206,10	5971,80	35454,40
2017	60	105	41089	75437	12119	10478	36067	4954	3680	23879		34347,13	12822,16	9032,56	4361,01	16469,50	15371,20	60809,60	8262,60	6307,10	38778,80
2018	59	105	41383	79830	12901	10290	37250	4650	4024	24728		36760,70	13517,36	9527,70	4624,55	17855,60	16083,10	63697,30	8319,50	7275,40	41716,90
2019	60	105	41381	83939	13522	10546	37476	4460	4060	26749		38275,24	14578,49	9844,51	4676,24	19093,50	16672,60	66333,10	8376,70	7595,50	46596,10
2020	57	105	45324	70301	14337	11462	37571	4310	4082	40711		39503,87	15671,59	11071,19	4512,77	20557,50	17264,90	69432,70	8445,90	7929,70	72960,00

Appendix A.2:

R Million Commodity shares of values

Total value	Wages perm	Land & fixed	Machinery	Herds	Fertiliser	Fuel	Farm feed	Remedies	Packing material	Other intermediatries
244,235	0,207	0,290	0,072	0,054	0,057	0,070	0,033	0,006	0,039	0,172
262,035	0,199	0,300	0,081	0,053	0,055	0,078	0,062	0,008	0,038	0,125
281,296	0,191	0,309	0,092	0,052	0,053	0,075	0,060	0,007	0,038	0,122
300,817	0,184	0,326	0,093	0,052	0,053	0,073	0,060	0,007	0,037	0,116
346,320	0,182	0,315	0,095	0,054	0,049	0,065	0,072	0,007	0,038	0,122
377,105	0,188	0,317	0,097	0,056	0,047	0,066	0,072	0,008	0,038	0,111
420,009	0,192	0,306	0,113	0,053	0,044	0,066	0,063	0,009	0,042	0,113
439,287	0,190	0,298	0,115	0,049	0,048	0,071	0,061	0,009	0,041	0,118
460,910	0,176	0,307	0,116	0,049	0,052	0,069	0,063	0,009	0,040	0,121
477,299	0,153	0,297	0,115	0,053	0,056	0,076	0,072	0,010	0,041	0,127
503,512	0,161	0,294	0,115	0,053	0,056	0,072	0,071	0,010	0,037	0,130
534,541	0,159	0,283	0,112	0,050	0,058	0,069	0,073	0,015	0,035	0,146
580,516	0,157	0,288	0,104	0,046	0,058	0,084	0,072	0,015	0,038	0,138
597,297	0,156	0,285	0,104	0,046	0,057	0,079	0,073	0,015	0,043	0,143
609,395	0,153	0,285	0,101	0,044	0,064	0,071	0,071	0,015	0,051	0,144
620,615	0,151	0,298	0,101	0,045	0,066	0,064	0,071	0,015	0,048	0,142
646,198	0,146	0,302	0,100	0,045	0,074	0,067	0,065	0,016	0,042	0,141
709,518	0,144	0,342	0,095	0,043	0,067	0,058	0,068	0,016	0,037	0,130
771,847	0,138	0,338	0,090	0,039	0,069	0,054	0,081	0,016	0,039	0,134
828,243	0,147	0,318	0,087	0,038	0,073	0,055	0,088	0,016	0,040	0,140
908,288	0,140	0,355	0,085	0,038	0,073	0,051	0,073	0,016	0,037	0,132
969,756	0,140	0,361	0,085	0,037	0,065	0,048	0,078	0,015	0,035	0,135
1015,709	0,136	0,355	0,086	0,035	0,067	0,047	0,084	0,015	0,034	0,140
1072,685	0,139	0,340	0,088	0,033	0,077	0,047	0,091	0,019	0,032	0,133
1183.458	0.134	0.345	0.088	0.031	0.079	0.048	0.085	0.019	0.038	0.133
1279.458	0.129	0.342	0.087	0.035	0.080	0.049	0.087	0.020	0.033	0.139
1496.692	0.113	0.324	0.082	0.040	0.081	0.056	0.102	0.023	0.034	0.146
1782.125	0.108	0.323	0.076	0.041	0.092	0.059	0.107	0.026	0.032	0.137
2132.600	0.108	0.308	0.078	0.036	0.100	0.062	0.100	0.038	0.028	0.141
2529.977	0.125	0.292	0.075	0.033	0.099	0.066	0.100	0.050	0.025	0.135
2865.662	0.125	0.296	0.076	0.030	0.100	0.066	0.101	0.042	0.023	0.138
3306.498	0.122	0.279	0.074	0.028	0.107	0.073	0.097	0.059	0.023	0.139
3890.858	0.118	0.263	0.070	0.027	0.111	0.095	0.103	0.056	0.023	0.135
4459.062	0.114	0.240	0.073	0.024	0.111	0.091	0.123	0.059	0.024	0.143
5115.158	0.114	0.214	0.082	0.026	0.094	0.104	0.141	0.057	0.023	0.146
5683.797	0.122	0.219	0.083	0.024	0.065	0.102	0.153	0.052	0.021	0.159
6358.844	0.127	0.218	0.081	0.022	0.073	0.088	0.157	0.047	0.023	0.165
7128.541	0.129	0.208	0.077	0.021	0.088	0.090	0.132	0.060	0.025	0.170
7872.447	0.131	0.190	0.075	0.021	0.093	0.100	0.119	0.067	0.024	0.179
8600.533	0.143	0.178	0.072	0.025	0.088	0.085	0.119	0.068	0.030	0.192
9407.516	0.143	0.167	0.070	0.027	0.088	0.068	0.128	0.065	0.032	0.210
10749.705	0.145	0.151	0.065	0.029	0.091	0.081	0.142	0.062	0.035	0.200
11924.003	0.144	0.141	0.064	0.030	0.084	0.090	0.146	0.054	0.035	0.211
13144.740	0.144	0.141	0.061	0.028	0.076	0.094	0.146	0.062	0.036	0.213
14419.851	0.150	0.140	0.058	0.026	0.074	0.092	0.148	0.061	0.034	0.217
16027.599	0.148	0.127	0.052	0.021	0.067	0.089	0.150	0.060	0.047	0.239
18538.041	0.173	0.120	0.048	0.021	0.067	0.090	0.143	0.058	0.045	0.236
21143.205	0.190	0.106	0.048	0.024	0.070	0.079	0.149	0.055	0.046	0.235
25428,313	0,249	0,089	0,044	0,022	0,071	0,073	0,129	0,051	0,051	0,220
26930,762	0,186	0,087	0,050	0,022	0,079	0,079	0,142	0,063	0,054	0,238
30565,886	0,201	0,080	0,049	0,019	0,066	0,074	0,162	0,064	0,053	0,233
36161,931	0,255	0,073	0,052	0,016	0,056	0,064	0,164	0,060	0,045	0,215
36555,307	0,180	0,076	0,053	0,016	0,059	0,072	0,184	0,064	0,049	0,245
41100,724	0,201	0,073	0,049	0,014	0,059	0,073	0,168	0,059	0,050	0,254
44475,786	0,133	0,072	0,047	0,014	0,069	0,082	0,209	0,060	0,052	0,262
50926,290	0,135	0,067	0,048	0,014	0,072	0,076	0,219	0,057	0,047	0,265
53607,822	0,158	0,068	0,050	0,017	0,058	0,065	0,210	0,053	0,042	0,274
56309,027	0,137	0,067	0,054	0,026	0,062	0,078	0,204	0,050	0,046	0,278
62787,373	0,121	0,068	0,051	0,025	0,042	0,062	0,262	0,056	0,038	0,270
69346,795	0,129	0,068	0,050	0,027	0,045	0,068	0,250	0,058	0,036	0,268
78479,654	0,153	0,067	0,048	0,027	0,045	0,062	0,240	0,056	0,033	0,268
89748,068	0,160	0,065	0,049	0,025	0,046	0,065	0,232	0,054	0,031	0,273
99489,713	0,150	0,062	0,049	0,024	0,053	0,065	0,226	0,054	0,031	0,287
110206,661	0,152	0,060	0,046	0,023	0,053	0,063	0,216	0,053	0,031	0,302
128611,906	0,165	0,056	0,043	0,023	0,047	0,069	0,205	0,049	0,031	0,311
145519,140	0,166	0,054	0,042	0,021	0,042	0,072	0,199	0,047	0,031	0,326
163851,932	0,197	0,053	0,041	0,019	0,038	0,063	0,195	0,044	0,031	0,319
171266,620	0,179	0,056	0,043	0,020	0,038	0,063	0,201	0,045	0,032	0,323
180296,570	0,164	0,058	0,044	0,021	0,054	0,077	0,323	0,045	0,033	0,180
193349,006	0,165	0,060	0,044	0,021	0,071	0,076	0,306	0,042	0,031	0,183
206561,662	0,166	0,062	0,044	0,021	0,080	0,074	0,294	0,040	0,031	0,188
219378,107	0,168	0,062	0,043	0,021	0,081	0,073	0,290	0,038	0,033	0,190
232041,976	0,165	0,063	0,042	0,020	0,082	0,072	0,286	0,036	0,033	0,203
267350,124	0,148	0,059	0,041	0,017	0,077	0,065	0,260	0,032	0,030	0,272

Average Commodity shares

total wage	Land & fix	Machinery	Herds	Fertiliser	Fuel	Farm feed	Remedies	Packing m	Other intermediatrie
0,207	0,290	0,072	0,054	0,057	0,070	0,033	0,006	0,039	0,172
0,203	0,295	0,076	0,054	0,056	0,074	0,047	0,007	0,039	0,148
0,195	0,305	0,086	0,053	0,054	0,077	0,061	0,007	0,038	0,123
0,188	0,317	0,092	0,052	0,053	0,074	0,060	0,007	0,037	0,119
0,183	0,321	0,094	0,053	0,051	0,069	0,066	0,007	0,037	0,119
0,185	0,316	0,096	0,055	0,048	0,065	0,072	0,008	0,038	0,116
0,190	0,312	0,105	0,055	0,045	0,066	0,068	0,009	0,040	0,112
0,191	0,302	0,114	0,051	0,046	0,068	0,062	0,009	0,041	0,116
0,183	0,303	0,115	0,049	0,050	0,070	0,062	0,009	0,040	0,119
0,165	0,302	0,116	0,051	0,054	0,072	0,068	0,010	0,040	0,124
0,157	0,296	0,115	0,053	0,056	0,074	0,072	0,010	0,039	0,129
0,160	0,289	0,113	0,052	0,057	0,071	0,072	0,013	0,036	0,138
0,158	0,286	0,108	0,048	0,058	0,077	0,073	0,015	0,036	0,142
0,156	0,287	0,104	0,046	0,058	0,082	0,073	0,015	0,040	0,140
0,155	0,285	0,103	0,045	0,061	0,075	0,072	0,015	0,047	0,143
0,152	0,292	0,101	0,044	0,065	0,068	0,071	0,015	0,049	0,143
0,149	0,300	0,101	0,045	0,070	0,065	0,068	0,015	0,045	0,142
0,145	0,322	0,098	0,044	0,071	0,062	0,067	0,016	0,039	0,136
0,141	0,340	0,093	0,041	0,068	0,056	0,075	0,016	0,038	0,132
0,143	0,328	0,088	0,039	0,071	0,054	0,084	0,016	0,039	0,137
0,143	0,336	0,086	0,038	0,073	0,053	0,080	0,016	0,039	0,136
0,140	0,358	0,085	0,037	0,069	0,050	0,076	0,016	0,036	0,134
0,138	0,358	0,086	0,036	0,066	0,048	0,081	0,015	0,035	0,138
0,137	0,347	0,087	0,034	0,072	0,047	0,088	0,017	0,033	0,137
0,137	0,342	0,088	0,032	0,078	0,048	0,088	0,019	0,035	0,133
0,131	0,343	0,088	0,033	0,079	0,048	0,086	0,020	0,035	0,136
0,121	0,333	0,084	0,038	0,081	0,052	0,094	0,021	0,033	0,142
0,111	0.323	0,079	0.040	0.087	0.057	0.104	0.024	0.033	0.141
0,108	0.315	0,077	0.038	0.096	0.061	0.103	0.032	0.030	0.139
0.117	0.300	0.076	0.034	0.100	0.064	0.100	0.044	0.027	0.138
0.125	0.294	0.076	0.031	0.100	0.066	0.101	0.046	0.024	0.136
0.123	0.288	0.075	0.029	0.104	0.070	0.099	0.051	0.023	0.139
0.120	0.271	0.072	0.027	0.109	0.084	0.100	0.058	0.023	0.137
0.116	0.252	0.072	0.026	0.111	0.093	0.113	0.058	0.023	0.138
0.114	0.227	0.077	0.025	0.102	0.097	0.132	0.058	0.023	0.144
0,118	0.216	0,082	0.025	0.079	0.103	0.147	0.055	0.022	0.153
0.125	0.219	0.082	0.023	0.069	0.095	0.155	0.050	0.022	0.162
0,128	0,213	0,079	0,021	0,081	0,089	0,144	0,054	0,024	0,167
0.130	0.199	0.076	0.021	0.091	0.095	0.125	0.064	0.024	0.175
0.137	0.184	0.073	0.023	0.090	0.092	0.119	0.067	0.027	0.186
0.143	0.173	0.071	0.026	0.088	0.077	0.124	0.067	0.031	0.201
0.144	0.159	0.068	0.028	0.090	0.075	0.135	0.064	0.033	0.205
0.144	0.146	0.064	0.029	0.088	0.085	0.144	0.058	0.035	0.205
0.144	0.141	0.063	0.029	0.080	0.092	0.146	0.058	0.036	0.212
0.147	0.140	0.059	0.027	0.075	0.093	0.147	0.061	0.035	0.215
0.149	0.133	0.055	0.024	0.070	0.091	0.149	0.060	0.041	0.228
0.160	0.123	0.050	0.021	0.067	0.089	0.147	0.059	0.046	0.237
0.181	0.113	0.048	0.022	0.069	0.084	0.146	0.056	0.045	0.235
0,219	0,097	0,046	0,023	0,071	0,076	0,139	0,053	0,048	0,228
0,217	0,088	0,047	0,022	0,075	0,076	0,135	0,057	0,053	0,228
0,194	0,084	0,050	0,021	0,072	0,077	0,152	0,063	0,053	0,234
0,228	0,077	0,051	0,018	0,061	0,069	0,163	0,062	0,048	0,224
0,218	0,075	0,053	0,016	0,057	0,068	0,174	0,062	0,047	0,230
0,190	0,074	0,051	0,015	0,059	0,073	0,176	0,062	0,050	0,249
0,167	0,072	0,048	0,014	0,064	0,078	0,189	0,060	0,051	0,258
0,134	0,070	0,048	0,014	0,071	0,079	0,214	0,058	0,049	0,263
0,147	0,068	0,049	0,015	0,065	0,071	0,215	0,055	0,047	0,270
0,147	0,068	0,052	0,021	0,060	0,071	0,207	0,052	0,046	0,275
0,129	0,068	0,053	0,025	0,052	0,070	0,236	0,053	0,042	0,273
0,125	0,068	0,051	0,026	0,043	0,065	0,259	0,057	0,037	0,269
0,141	0,068	0,049	0,027	0,045	0,065	0,245	0,057	0,035	0,268
0,156	0,066	0,048	0,026	0,046	0,063	0,236	0,055	0,032	0,271
0,155	0,063	0,049	0,024	0,050	0,065	0,229	0,054	0,031	0,280
0,151	0,061	0,048	0,023	0,053	0,064	0,221	0,053	0,031	0,294
0,159	0,058	0,045	0,023	0,050	0,066	0,211	0,051	0,031	0,307
0,165	0,055	0,043	0,022	0,044	0,070	0,202	0,048	0,031	0,319
0,181	0,054	0,041	0,020	0,040	0,067	0,197	0,045	0,031	0,322
0,188	0,055	0,042	0,020	0,038	0,063	0,198	0,044	0,031	0,321
0,171	0,057	0,044	0,021	0,046	0,070	0,262	0,045	0,033	0,252
0,164	0,059	0,044	0,021	0,063	0,076	0,315	0,044	0,032	0,182
0,166	0,061	0,044	0,021	0,075	0,075	0,300	0,041	0,031	0,186
0,167	0,062	0,044	0,021	0,081	0,074	0,292	0,039	0,032	0,189
0,166	0,062	0,043	0,021	0,082	0,073	0,288	0,037	0,033	0,195
0,156	0,061	0,042	0,019	0,080	0,068	0,273	0,034	0,031	0,237

Growth rates based on physical quantities

Labour tot	Land & fix	Machinery	Herds	Fertiliser	Fuel	Farm feed	Remedies	Packing m	Other inte
0	0	0	0	0	0	0	0	0	0
0,030	-0,006	0,074	0,029	0,015	0,102	0,692	0,273	0,010	-0,294
0,016	-0,007	0,060	0,022	-0,015	-0,105	0,010	-0,040	0,033	-0,020
0,014	-0,007	-0,082	-0,103	0,045	-0,092	0,021	0,030	-0,010	-0,053
0,012	0,001	0,070	-0,026	-0,187	-0,086	0,213	0,016	0,129	0,061
0,018	0,001	0,069	0,048	0,026	0,054	-0,030	0,100	0,085	-0,064
0,014	0,001	0,256	0,025	0,163	0,124	-0,041	0,143	0,255	0,159
0,015	0,001	0,059	-0,074	0,142	0,112	0,004	0,043	0,025	0,083
0,021	0,001	0,045	-0,003	0,038	0,040	0,039	0,095	0,032	0,061
-0,002	0,010	0,000	0,063	0,059	0,092	0,173	0,194	0,053	0,055
-0,029	0,010	0,022	0,020	0,100	-0,035	0,047	-0,009	-0,045	0,074
0,018	0,010	0,021	0,043	0,126	-0,004	0,052	0,455	-0,045	0,163
0,055	0,010	-0,007	-0,028	0,096	0,261	0,045	0,062	0,080	-0,003
-0,162	0,009	0,010	0,014	0,034	-0,042	0,024	0,052	0,037	0,052
0,120	-0,001	-0,010	0,013	0,132	-0,063	0,010	0,093	0,115	0,027
0,045	0,001	0,002	-0,024	0,032	-0,103	0,002	-0,021	-0,072	-0,012
-0,107	0,002	0,018	0,003	0,160	0,097	-0,044	0,119	-0,089	0,040
-0,025	0,001	0,017	-0,106	-0,025	-0,045	0,116	0,090	-0,034	0,004
0,008	0,001	0,005	-0,036	0,094	0,016	0,235	0,083	0,075	0,094
0,054	-0,008	0,019	-0,003	0,094	0,073	0,097	0,063	0,029	0,074
-0,001	-0,008	0,055	-0,021	0,109	0,012	-0,073	0,109	0,013	0,022
0,004	-0,006	0,039	0,019	-0,051	0,000	0,113	-0,011	0,063	0,115
0,006	0,011	0,038	0,017	0,085	0,032	0,065	0,017	0,080	0,070
-0,032	0,003	0,036	-0,035	0,193	0,053	0,087	0,253	-0,032	-0,013
-0,034	0,004	0,051	-0,013	0,023	0,023	-0,003	0,039	0,249	0,035
-0,042	0,003	-0,007	-0,036	0,005	0,032	0,041	0,093	-0,149	0,050
-0,021	0,003	-0,007	0,038	0,093	0,200	0,187	0,233	0,157	0,111
-0.013	0.003	0.015	-0.022	0.175	-0.203	0.105	0.141	0.022	-0.063
-0,006	0,002	-0,016	0,115	-0,069	0,090	0,030	0,325	-0,151	0,018
-0.076	0.004	-0.055	-0.057	0.090	-0.045	0.060	0.404	-0.029	-0.005
0.021	-0.002	0.033	0.045	0.025	0.025	-0.025	-0.103	-0.040	0.033
-0.013	0.000	-0.017	0.031	0.054	0.203	-0.044	0.389	0.017	0.026
0.016	-0.002	-0.037	-0.064	0.069	-0.183	0.059	0.081	0.050	-0.085
-0.053	-0.001	0.103	-0.188	-0.025	-0.153	0.125	0.093	0.053	0.001
-0.071	-0.003	0.127	-0.025	-0.101	0.234	0.141	0.017	-0.050	0.078
-0,007	-0,003	-0,047	0,077	-0,381	-0,063	0,012	-0,157	-0,053	0,037
-0.009	0.000	-0.060	-0.006	0.100	-0.017	-0.082	-0.101	0.125	0.025
0,078	0,000	-0,050	-0,172	0,250	0,193	-0,139	0,265	0,092	0,099
0.076	0.000	-0.132	0.111	-0.141	-0.023	-0.089	-0.010	0.018	-0.012
0.016	0.020	-0.201	0.037	-0.110	-0.159	-0.009	-0.116	-0.079	0.013
-0.008	-0.003	-0.125	-0.037	0.101	-0.027	0.069	-0.023	0.031	0.135
-0.089	0.004	-0.148	0.085	-0.054	0.249	0.187	0.009	0.160	-0.017
0.002	0.007	0.028	0.111	-0.150	-0.060	-0.006	-0.139	0.003	-0.034
0.001	0.007	-0.044	0.142	-0.071	0.008	-0.018	0.104	-0.022	-0.003
-0.048	0.007	-0.030	-0.176	-0.036	-0.123	0.006	-0.086	-0.012	-0.007
-0.060	0.019	-0.071	-0.231	0.006	-0.016	0.037	0.029	0.375	0.139
0.046	0.018	-0.061	0.096	0.077	0.066	-0.018	0.064	-0.006	0.042
-0.050	0.002	0.026	-0.003	0.071	-0.084	0.118	-0.001	0.076	0.056
0,039	0,008	0,015	0,207	0,027	0,074	-0,029	0,061	0,160	0,038
-0,272	0,013	0,108	-0,012	0,086	-0,077	0,017	0,115	-0,061	-0,021
-0,024	0,008	0,039	-0,227	-0,172	-0,086	0,169	-0,070	-0,022	0,044
0,121	0,000	0,147	-0,021	0,013	0,077	0,164	0,097	0,144	0,079
0,032	0,005	-0,052	0,027	0,039	-0,079	0,084	0,051	0,085	0,098
-0,002	0,004	-0,120	0,128	-0,077	-0,005	-0,189	-0,069	-0,003	-0,086
-0,142	-0,007	-0,070	0,028	0,031	0,032	0,207	0,052	0,017	0,009
0,141	0,001	-0,063	-0,126	-0,016	-0,055	-0,055	-0,031	0,025	-0,004
-0,041	-0,006	0,040	0,149	-0,132	-0,166	-0,042	0,023	0,033	0,044
-0,025	-0,019	0,127	0,399	0,115	0,143	0,019	0,056	0,003	0,038
-0,103	-0,008	0,063	0,058	-0,355	-0,131	0,391	0,222	-0,071	0,077
0,032	-0,038	0,071	-0,051	0,157	0,120	-0,031	0,097	-0,002	0,032
-0,073	0,000	0,066	0,060	-0,154	-0,123	-0,021	0,013	0,016	0,020
0,071	0,014	0,039	-0,015	-0,022	-0,200	-0,124	-0,032	-0,111	-0,061
-0,072	-0,008	-0,029	-0,002	0,141	0,155	-0,073	-0,043	0,036	0,048
-0,091	-0,006	-0,086	0,042	-0,071	0,029	-0,082	-0,050	-0,004	0,029
-0,133	-0,031	-0,015	-0,052	-0,052	0,196	-0,014	-0,014	0,026	0,086
0,071	0,001	-0,010	0,042	-0,043	0,014	-0,045	-0,046	0,005	0,035
0,074	0,000	0,023	0,037	-0,022	-0,069	0,023	0,002	0,033	0,031
-0,056	0,000	0,019	-0,040	0,004	-0,033	0,013	-0,001	0,023	0,000
0,212	0,000	0,022	0,019	0,397	0,280	0,483	0,017	0,047	-0,562
-0,003	0,000	-0,015	-0,015	0,299	0,012	-0,052	-0,045	-0,053	0,031
-0,021	0,000	0,025	-0,110	0,154	0,013	-0,004	-0,074	-0,019	0,047
-0,008	0,000	0,007	0,057	0,063	-0,013	0,032	-0,063	0,089	0,035
0,012	0,000	0,000	0,050	0,047	0,025	0,006	-0,042	0,009	0,079
-0,048	0,000	0,091	-0,177	0,053	0,083	0,003	-0,034	0,005	0,420

Appendix A.3:

						Share weighted growth							
Wages tot	Land & fix	Machinery	Herds	Fertiliser	Fuel	Farm feed	Remedies	Packing m	Other intermediatrie		in logs	exponenti	chained TF
0	0	0	0	0	0	0	0	0	0		0	1	100
0,0060	-0,0019	0,0056	0,0015	0,0008	0,0075	0,0328	0,0019	0,0004	-0,0436		0,0112	1,0113	101,1264
0,0030	-0,0020	0,0052	0,0012	-0,0008	-0,0080	0,0006	-0,0003	0,0014	-0,0024		-0,0021	0,9979	100,9157
0,0027	-0,0021	-0,0076	-0,0054	0,0024	-0,0068	0,0013	0,0002	-0,0004	-0,0063		-0,0219	0,9784	98,7326
0,0023	0,0004	0,0066	-0,0014	-0,0095	-0,0059	0,0144	0,0001	0,0048	0,0072		0,0190	1,0191	100,6227
0,0034	0,0004	0,0066	0,0027	0,0012	0,0035	-0,0022	0,0008	0,0033	-0,0075		0,0122	1,0122	101,8537
0,0026	0,0004	0,0269	0,0014	0,0074	0,0082	-0,0028	0,0013	0,0102	0,0178		0,0733	1,0761	109,6025
0,0029	0,0004	0,0067	-0,0038	0,0065	0,0077	0,0003	0,0004	0,0011	0,0096		0,0318	1,0323	113,1436
0,0038	0,0004	0,0051	-0,0002	0,0019	0,0028	0,0024	0,0008	0,0013	0,0073		0,0257	1,0260	116,0852
-0,0003	0,0030	-0,0001	0,0032	0,0032	0,0067	0,0117	0,0019	0,0023	0,0069		0,0384	1,0392	120,6328
-0,0046	0,0029	0,0025	0,0010	0,0055	-0,0026	0,0034	-0,0001	-0,0018	0,0095		0,0157	1,0158	122,5422
0,0028	0,0028	0,0024	0,0022	0,0071	-0,0003	0,0038	0,0058	-0,0017	0,0225		0,0475	1,0486	128,4988
0,0088	0,0027	-0,0007	-0,0013	0,0056	0,0200	0,0032	0,0009	0,0029	-0,0004		0,0416	1,0425	133,9635
-0,0254	0,0027	0,0010	0,0006	0,0020	-0,0034	0,0018	0,0008	0,0015	0,0072		-0,0112	0,9888	132,4697
0,0186	-0,0003	-0,0010	0,0006	0,0081	-0,0051	0,0008	0,0015	0,0054	0,0039		0,0323	1,0328	136,8178
0,0069	0,0003	0,0002	-0,0011	0,0021	-0,0069	0,0001	-0,0003	-0,0036	-0,0017		-0,0040	0,9960	136,2744
-0,0159	0,0005	0,0018	0,0001	0,0112	0,0063	-0,0030	0,0018	-0,0040	0,0057		0,0046	1,0046	136,8997
-0,0036	0,0004	0,0017	-0,0047	-0,0017	-0,0028	0,0078	0,0014	-0,0013	0,0006		-0,0023	0,9977	136,5836
0,0011	0,0005	0,0005	-0,0015	0,0064	0,0009	0,0175	0,0013	0,0029	0,0125		0,0421	1,0430	142,4616
0,0076	-0,0028	0,0017	-0,0001	0,0067	0,0043	0,0082	0,0010	0,0011	0,0101		0,0378	1,0385	147,9479
-0,0001	-0,0029	0,0047	-0,0008	0,0080	0,0007	-0,0058	0,0018	0,0007	0,0030		0,0092	1,0092	149,3137
0,0006	-0,0021	0,0033	0,0007	-0,0035	0,0000	0,0090	-0,0002	0,0023	0,0154		0,0255	1,0258	153,1699
0,0009	0,0040	0,0033	0,0006	0,0056	0,0015	0,0053	0,0003	0,0028	0,0096		0,0339	1,0345	158,4479
-0,0045	0,0012	0,0031	-0,0012	0,0143	0,0025	0,0077	0,0044	-0,0011	-0,0017		0,0248	1,0251	162,4245
-0,0046	0,0014	0,0045	-0,0004	0,0018	0,0011	-0,0003	0,0007	0,0087	0,0046		0,0175	1,0177	165,2982
-0,0055	0,0010	-0,0006	-0,0012	0,0004	0,0016	0,0035	0,0018	-0,0053	0,0068		0,0025	1,0025	165,7093
-0,0025	0,0009	-0,0006	0,0014	0,0079	0,0104	0,0177	0,0051	0,0052	0,0157		0,0613	1,0632	176,1832
-0,0014	0,0009	0,0012	-0,0009	0,0151	-0,0117	0,0110	0,0035	0,0007	-0,0088		0,0095	1,0096	177,8689
-0,0007	0,0008	-0,0012	0,0044	-0,0067	0,0055	0,0032	0,0104	-0,0045	0,0024		0,0136	1,0137	180,3001
-0,0088	0,0012	-0,0042	-0,0020	0,0089	-0,0029	0,0060	0,0179	-0,0008	-0,0007		0,0146	1,0148	182,9596
0,0026	-0,0005	0,0025	0,0014	0,0025	0,0017	-0,0025	-0,0048	-0,0010	0,0045		0,0064	1,0064	184,1380
-0,0016	-0,0001	-0,0013	0,0009	0,0056	0,0142	-0,0044	0,0197	0,0004	0,0036		0,0370	1,0377	191,0774
0,0019	-0,0006	-0,0026	-0,0018	0,0075	-0,0154	0,0059	0,0047	0,0011	-0,0117		-0,0111	0,9889	188,9654
-0,0061	-0,0003	0,0077	-0,0048	-0,0028	-0,0142	0,0142	0,0057	0,0012	0,0002		0,0008	1,0008	189,1073
-0,0081	-0,0006	0,0098	-0,0006	-0,0104	0,0227	0,0186	0,0010	-0,0012	0,0112		0,0424	1,0434	197,3059
-0,0008	-0,0007	-0,0039	0,0019	-0,0302	-0,0070	0,0018	-0,0085	-0,0012	0,0057		-0,0428	0,9581	189,0467
-0,0011	0,0000	-0,0049	-0,0001	0,0068	-0,0016	-0,0127	-0,0050	0,0028	0,0040		-0,0118	0,9883	186,8282
0,0100	0,0000	-0,0040	-0,0037	0,0202	0,0176	-0,0200	0,0143	0,0022	0,0166		0,0533	1,0547	197,0488
0,0099	0,0000	-0,0100	0,0023	-0,0127	-0,0021	-0,0112	-0,0006	0,0004	-0,0022		-0,0262	0,9741	191,9460
0,0022	0,0037	-0,0147	0,0009	-0,0100	-0,0147	-0,0011	-0,0078	-0,0021	0,0024		-0,0413	0,9595	184,1781
-0,0011	-0,0005	-0,0089	-0,0010	0,0089	-0,0021	0,0085	-0,0015	0,0010	0,0272		0,0304	1,0309	189,8643
-0,0128	0,0006	-0,0100	0,0024	-0,0048	0,0186	0,0253	0,0006	0,0053	-0,0035		0,0217	1,0219	194,0245
0,0002	0,0010	0,0018	0,0033	-0,0132	-0,0051	-0,0009	-0,0081	0,0001	-0,0070		-0,0279	0,9725	188,6881
0,0001	0,0010	-0,0028	0,0041	-0,0057	0,0007	-0,0027	0,0060	-0,0008	-0,0006		-0,0007	0,9993	188,5620
-0,0071	0,0010	-0,0018	-0,0047	-0,0026	-0,0114	0,0008	-0,0052	-0,0004	-0,0016		-0,0330	0,9675	182,4429
-0,0090	0,0026	-0,0039	-0,0054	0,0004	-0,0014	0,0056	0,0017	0,0152	0,0317		0,0373	1,0380	189,3704
0,0074	0,0022	-0,0031	0,0020	0,0052	0,0059	-0,0027	0,0038	-0,0002	0,0101		0,0306	1,0311	195,2575
-0,0091	0,0002	0,0012	-0,0001	0,0049	-0,0071	0,0172	-0,0001	0,0034	0,0131		0,0238	1,0240	199,9528
0,0086	0,0007	0,0007	0,0048	0,0019	0,0056	-0,0040	0,0032	0,0078	0,0087		0,0380	1,0387	207,6988
-0,0591	0,0011	0,0051	-0,0003	0,0065	-0,0059	0,0023	0,0066	-0,0032	-0,0048		-0,0517	0,9496	197,2386
-0,0046	0,0007	0,0019	-0,0047	-0,0124	-0,0065	0,0258	-0,0045	-0,0012	0,0103		0,0048	1,0048	198,1909
0,0277	0,0000	0,0075	-0,0004	0,0008	0,0053	0,0268	0,0060	0,0069	0,0176		0,0982	1,1032	218,6445
0,0070	0,0004	-0,0027	0,0004	0,0022	-0,0054	0,0146	0,0032	0,0040	0,0225		0,0461	1,0472	228,9620
-0,0004	0,0003	-0,0061	0,0019	-0,0045	-0,0004	-0,0333	-0,0043	-0,0004	-0,0215		-0,0686	0,9337	213,7807
-0,0237	-0,0005	-0,0034	0,0004	0,0020	0,0025	0,0391	0,0031	0,0008	0,0023		0,0226	1,0229	218,6712
0,0189	0,0001	-0,0030	-0,0018	-0,0011	-0,0044	-0,0118	-0,0018	0,0012	-0,0011		-0,0048	0,9952	217,6311
-0,0059	-0,0004	0,0020	0,0023	-0,0086	-0,0117	-0,0089	0,0013	0,0015	0,0119		-0,0166	0,9835	214,0420
-0,0037	-0,0013	0,0066	0,0084	0,0069	0,0105	0,0038	0,0029	0,0001	0,0104		0,0447	1,0457	223,8201
-0,0133	-0,0005	0,0033	0,0015	-0,0184	-0,0091	0,0923	0,0118	-0,0030	0,0211		0,0857	1,0895	243,8479
0,0040	-0,0026	0,0036	-0,0013	0,0068	0,0078	-0,0080	0,0055	-0,0001	0,0087		0,0245	1,0248	249,8887
-0,0103	0,0000	0,0033	0,0016	-0,0069	-0,0080	-0,0059	0,0007	0,0006	0,0052		-0,0197	0,9805	245,0190
0,0112	0,0009	0,0019	-0,0004	-0,0010	-0,0126	-0,0293	-0,0018	-0,0036	-0,0165		-0,0512	0,9501	232,7990
-0,0111	-0,0005	-0,0014	0,0000	0,0070	0,0101	-0,0168	-0,0023	0,0011	0,0135		-0,0004	0,9996	232,6985
-0,0138	-0,0004	-0,0041	0,0010	-0,0038	0,0018	-0,0181	-0,0027	-0,0001	0,0085		-0,0316	0,9689	225,4634
-0,0211	-0,0018	-0,0007	-0,0012	-0,0026	0,0128	-0,0030	-0,0007	0,0008	0,0263		0,0089	1,0090	227,4891
0,0118	0,0001	-0,0004	0,0009	-0,0019	0,0010	-0,0091	-0,0022	0,0002	0,0112		0,0115	1,0115	230,1142
0,0135	0,0000	0,0009	0,0008	-0,0009	-0,0047	0,0055	0,0001	0,0010	0,0099		0,0261	1,0265	236,2109
-0,0104	0,0000	0,0008	-0,0008	0,0002	-0,0024	0,0035	0,0000	0,0009	-0,0001		-0,0084	0,9916	234,2370
0,0362	0,0000	0,0010	0,0004	0,0183	0,0197	0,1265	0,0007	0,0015	-0,1415		0,0629	1,0649	249,4323
-0,0005	0,0000	-0,0007	-0,0003	0,0187	0,0009	-0,0164	-0,0020	-0,0019	0,0057		0,0036	1,0037	250,3443
-0,0034	0,0000	0,0011	-0,0023	0,0116	0,0013	-0,0011	-0,0030	-0,0006	0,0088		0,0123	1,0124	253,4534
-0,0013	0,0000	0,0003	0,0012	0,0050	-0,0013	0,0094	-0,0025	0,0028	0,0066		0,0204	1,0206	258,6702
0,0020	0,0000	0,0000	0,0010	0,0038	0,0018	0,0017	-0,0015	0,0003	0,0154		0,0245	1,0248	265,0758
-0,0075	0,0000	0,0038	-0,0033	0,0047	0,0057	0,0007	-0,0012	0,0002	0,0995		0,1025	1,1079	293,6886

Appendix B: Output productivity calculation

	Indices of volume				Values R million Current				Commodity shares of values			
year	Field crops	Horticulture	Livestock		Field crops	Horticulture	Livestock		Total value	Field crops	Horticulture	Livestock
1947	18,02142	10,79396	18,79748		156,4	62,3	172,7		391,4	0,399591	0,159172	0,441237
1948	14,57615	10,99762	19,60309		131	64,4	198,5		393,9	0,332572	0,163493	0,503935
1949	16,4313	12,01592	20,40869		166,3	66,4	216		448,7	0,370626	0,147983	0,481391
1950	18,81648	12,21958	21,2143		207,9	69,9	341,1		618,9	0,335919	0,112942	0,551139
1951	15,90125	11,81226	21,75137		190	76	297,6		563,6	0,337119	0,134847	0,528034
1952	19,61155	13,84886	23,09405		249,7	84,9	339,9		674,5	0,3702	0,125871	0,503929
1953	21,20167	14,86715	23,36258		266,8	89	347,2		703	0,379516	0,1266	0,493883
1954	21,46669	15,88545	24,16819		265	93,1	340,3		698,4	0,379439	0,133305	0,487257
1955	23,05682	17,10741	24,70526		284,7	97,8	339,1		721,6	0,39454	0,135532	0,469928
1956	24,91197	18,12571	26,04794		300,4	107,5	393,6		801,5	0,374797	0,134124	0,491079
1957	23,05682	18,12571	25,51087		274,6	107,8	356,4		738,8	0,371684	0,145912	0,482404
1958	24,91197	18,94035	26,31647		302,9	108,9	333,8		745,6	0,40625	0,146057	0,447693
1959	25,44201	20,97694	26,85354		323,7	111,9	376,5		812,1	0,398596	0,137791	0,463613
1960	27,56416	22,24941	27,61842		364,8	125,5	365,3		855,6	0,426367	0,146681	0,426952
1961	31,14941	23,2471	28,92215		375,8	129	379,8		884,6	0,424825	0,145829	0,429347
1962	32,43232	25,10265	29,41658		397,7	136,8	398,7		933,2	0,426168	0,146592	0,42724
1963	31,2443	27,07586	29,93408		366,7	154,6	436,7		958	0,382777	0,161378	0,455846
1964	30,26031	28,31001	30,17845		412,4	172,7	448,8		1033,9	0,398878	0,167037	0,434085
1965	28,97772	29,86681	31,23949		407,2	181,2	487,8		1076,2	0,378368	0,16837	0,453261
1966	39,34276	32,19024	31,73149		631,2	193,3	501,1		1325,6	0,476162	0,145821	0,378018
1967	43,69582	34,56919	32,52126		503,9	196,9	510		1210,8	0,416171	0,16262	0,421209
1968	36,14915	35,62065	34,07333		527,8	217,9	534,7		1280,4	0,412215	0,170181	0,417604
1969	38,40143	35,94301	35,8718		556,3	213,6	522,7		1292,6	0,430373	0,165248	0,404379
1970	42,58073	36,63611	35,46182		700	258,7	540,7		1499,4	0,466853	0,172536	0,360611
1971	51,14835	39,82778	35,70388		826	284,7	620,2		1730,9	0,477208	0,164481	0,358311
1972	42,2998	40,2519	36,46256		623,6	331,9	857,7		1813,2	0,343922	0,183047	0,473031
1973	45,52072	40,50319	37,11953		1322,7	361,69	983,2		2667,59	0,495841	0,135587	0,368572
1974	78,84839	39,9969	37,6016		1239,6	485	1063,4		2788	0,44462	0,17396	0,38142
1975	71,53256	43,03464	42,90439		1248,1	524,7	1217,8		2990,6	0,417341	0,17545	0,407209
1976	69,54635	45,58421	44,33276		1791,8	577	1333,6		3702,4	0,483956	0,155845	0,360199
1977	78,53911	41,86292	46,06533		1942,8	667,6	1425,4		4035,8	0,481392	0,165419	0,353189
1978	81,61905	45,73681	47,5329		2052,3	769,5	1687,2		4509	0,455156	0,170659	0,374185
1979	76,60176	46,34782	50,30652		2936,4	934,4	2059,5		5930,3	0,495152	0,157564	0,347284
1980	81,30635	51,59845	50,30652		3407,4	1013,6	2603,8		7024,8	0,485053	0,144289	0,370658
1981	96,70068	52,77424	48,08774		3194,4	1270,4	3212,5		7677,3	0,416084	0,165475	0,418441
1982	81,73601	57,50962	53,33097		3072	1341,8	3467,6		7881,4	0,389778	0,170249	0,439973
1983	62,3	52	55,9		3376,8	1530,3	3867,3		8774,4	0,384847	0,174405	0,440748
1984	74,8	56,6	56,5		4718,5	1779,1	4436,3		10933,9	0,431548	0,162714	0,405738
1985	89,3	56,6	54,6		4571,9	2136,3	4672,8		11381	0,401713	0,187708	0,410579
1986	91,1	55,3	52,8		5182,4	2492,5	5673,9		13348,8	0,38823	0,186721	0,425049
1987	94,7	60,7	54		5951,4	3076,4	7148,1		16175,9	0,367918	0,190184	0,441898
1988	99,2	64,1	55,3		7545,5	3363,7	8425,6		19334,8	0,390255	0,173971	0,435774
1989	107,4	68,8	57,7		7064,9	4282,9	8850,2		20198	0,349782	0,212046	0,438172
1990	90,2	67,5	60,7		7614,7	4817	9520,7		21952,4	0,346873	0,219429	0,433697
1991	91,2	69,8	62,6		6116,2	5457,2	10553,4		22126,8	0,276416	0,246633	0,476951
1992	52,8	66,2	62		9338,9	5423,4	10961,4		25723,7	0,363047	0,210833	0,426121
1993	85,5	66,6	60,3		9990	6199,6	11972,8		28162,4	0,354728	0,220137	0,425134
1994	98,8	66,6	57,9		8661,8	7411,3	13868,2		29941,3	0,289293	0,247528	0,46318
1995	68	69,7	60,2		13305,2	8505,2	14708,9		36519,3	0,364333	0,232896	0,402771
1996	103,8	74,4	63,2		13954,3	9463,5	17040,5		40458,3	0,344906	0,233908	0,421187
1997	99,9	78,1	62,3		13237,7	10533,9	19345,8		43117,4	0,307015	0,244307	0,448677
1998	86,5	76,7	64,3		14916,2	11837,6	17915,9		44669,7	0,333922	0,265003	0,401075
1999	90,6	85,1	66,4		14428,9	12541,9	19690,1		46660,9	0,309229	0,268788	0,421983
2000	108,6	81,4	65,7		17922,7	13094,2	21168,7		52185,6	0,343441	0,250916	0,405643
2001	94,7	81,5	66,3		27191,9	15769,8	25321,3		68283	0,398224	0,230948	0,370829
2002	102,7	85	69,2		23061,2	19551,1	30319,2		72931,5	0,316204	0,268075	0,415722
2003	91,1	91,5	75,3		20519	21739	31325,5		73583,5	0,278853	0,295433	0,425714
2004	94,9	96,2	77		17751,5	20694,9	38666,2		77112,6	0,230202	0,268372	0,501425
2005	103,9	91	85,2		18601,6	20229,6	40320,9		79152,1	0,235011	0,255579	0,50941
2006	84,8	94,6	90,5		22920,1	23409,8	52205,2		98535,1	0,232608	0,237578	0,529813
2007	78,4	97,1	93		40907,2	28835,1	59422		129164,3	0,316707	0,223244	0,46005
2008	107,3	102,4	94,9		35083,7	33588,1	65895,1		134566,9	0,260716	0,249601	0,489683
2009	104,3	98,2	95,1		30453,8	33771,2	68429,9		132654,9	0,229572	0,254579	0,515849
2010	100	100	100		36611,6	36791,1	71185,5		144588,2	0,253213	0,254454	0,492333
2011	104,3	100,4	100		47679,8	41874,7	79036,6		168591,1	0,282813	0,24838	0,468806
2012	103,1	105,4	101,1		50740,6	47737,1	86146,2		184623,9	0,274832	0,258564	0,466604
2013	106,6	111,2	104,4		59431,7	53892,5	96042,4		209366,6	0,283864	0,257407	0,458728
2014	117,4	111,9	106,3		55330,9	61071,1	109045,9		225447,9	0,245427	0,270888	0,483686
2015	95,1	119,5	111,6		55784,8	73610,1	114606,3		244001,2	0,228625	0,301679	0,469696
2016	87,8	113,2	111,1		65868,9	77385	126159,1		269413	0,24449	0,287236	0,468274
2017	127,4	119,7	107		60207,5	84702,5	142922,3		287832,3	0,209176	0,294277	0,496547
2018	120,5	120,6	108,9		64187,6	85400,3	134795,1		284383	0,225708	0,3003	0,473991
2019	106,6	117,5	114,5		79028,3	92317	141216,8		312562,1	0,25284	0,295356	0,451804
2020	130,7665	121,1823	116,869		91504,2	98892,8	151922,8		342319,8	0,267306	0,28889	0,443804

Appendix B.1:

Avg commodity shares			Growth rates based on physical quantities			Share weighted growth rates			Divisia output index			
Field crops	Horticulture	Livestock	Field crops	Horticulture	Livestock	Field crops	Horticulture	Livestock	in logs	exponentiated	chained	log of chained value
0,399591	0,159172	0,441237	0	0	0	0	0	0	0	1	100	4,60517
0,366081	0,161333	0,472586	-0,21217	0,018692	0,041964	-0,07767	0,003016	0,019832	-0,05483	0,94665	94,665	4,550344
0,351599	0,155738	0,492663	0,119801	0,088553	0,040274	0,042122	0,013791	0,019841	0,075755	1,078698	102,1149	4,626099
0,353272	0,130463	0,516265	0,135545	0,016807	0,038715	0,047884	0,002193	0,019987	0,070064	1,072577	109,5261	4,696163
0,336519	0,123895	0,539587	-0,16834	-0,0339	0,025001	-0,05665	-0,0042	0,01349	-0,04736	0,953746	104,4601	4,648805
0,353659	0,130359	0,515981	0,209721	0,159065	0,059898	0,07417	0,020736	0,030906	0,125812	1,134068	118,4649	4,774617
0,374858	0,126236	0,498906	0,077962	0,070952	0,011561	0,029225	0,008957	0,005768	0,043949	1,044929	123,7874	4,818566
0,379478	0,129952	0,49057	0,012423	0,066249	0,033902	0,004714	0,008609	0,016631	0,029954	1,030408	127,5515	4,84852
0,386989	0,134418	0,478592	0,071459	0,074108	0,021979	0,027654	0,009961	0,010519	0,048134	1,049312	133,8412	4,896654
0,384669	0,134828	0,480504	0,077387	0,05782	0,052922	0,029768	0,007796	0,025429	0,062993	1,06502	142,5436	4,959648
0,373241	0,140018	0,486742	-0,07739	0	-0,02083	-0,02888	0	-0,01014	-0,03902	0,961727	137,088	4,920623
0,388967	0,145985	0,465049	0,077387	0,043963	0,031091	0,030101	0,006418	0,014459	0,050977	1,052299	144,2576	4,9716
0,402423	0,141924	0,455653	0,021053	0,102129	0,020203	0,008472	0,014495	0,009205	0,032172	1,032696	148,9742	5,003773
0,412482	0,142236	0,445282	0,080115	0,058892	0,028085	0,033046	0,008376	0,012506	0,053928	1,055409	157,2286	5,057701
0,425596	0,146255	0,428149	0,122279	0,043865	0,046125	0,052041	0,006415	0,019748	0,078205	1,081345	170,0183	5,135906
0,425496	0,14621	0,428293	0,04036	0,076793	0,016951	0,017173	0,011228	0,00726	0,035661	1,036304	176,1908	5,171567
0,404472	0,153985	0,441543	-0,03732	0,075669	0,017439	-0,01509	0,011652	0,0077	0,004258	1,004267	176,9425	5,175825
0,390827	0,164208	0,444965	-0,032	0,044573	0,00813	-0,01251	0,007319	0,003618	-0,00157	0,998432	176,665	5,174255
0,388623	0,167704	0,443673	-0,04331	0,053532	0,034555	-0,01683	0,008978	0,015331	0,007478	1,007506	177,991	5,181733
0,427265	0,157095	0,415639	0,305785	0,074916	0,015626	0,130651	0,011769	0,006495	0,148915	1,160574	206,5718	5,330648
0,446166	0,15422	0,399613	0,104941	0,0713	0,024585	0,046821	0,010996	0,009824	0,067641	1,069981	221,0279	5,398289
0,414193	0,1664	0,419406	-0,1896	0,029963	0,046621	-0,07853	0,004986	0,019553	-0,05399	0,94744	209,4107	5,344297
0,421294	0,167715	0,410991	0,060441	0,009009	0,051436	0,025464	0,001511	0,02114	0,048114	1,049291	219,7327	5,392412
0,448613	0,168892	0,382495	0,103307	0,0191	-0,01149	0,046345	0,003226	-0,0044	0,045174	1,04621	229,8865	5,437586
0,472031	0,168508	0,359461	0,183328	0,08353	0,006803	0,086537	0,014076	0,002445	0,103058	1,108555	254,8419	5,540643
0,410565	0,173764	0,415671	-0,18995	0,010593	0,021027	-0,07799	0,001841	0,00874	-0,06741	0,934816	238,2303	5,473238
0,419882	0,159317	0,420802	0,073385	0,006223	0,017857	0,030813	0,000992	0,007514	0,039319	1,040102	247,7839	5,512557
0,47023	0,154773	0,374996	0,549359	-0,01258	0,012903	0,258325	-0,00195	0,004839	0,261217	1,29851	321,7498	5,773774
0,43098	0,174705	0,394315	-0,09737	0,073203	0,131928	-0,04197	0,012789	0,052021	0,022844	1,023107	329,1843	5,796618
0,450649	0,165647	0,383704	-0,02816	0,057556	0,03275	-0,01269	0,009534	0,012566	0,00941	1,009455	332,2967	5,806028
0,482674	0,160632	0,356694	0,121603	-0,08516	0,038337	0,058695	-0,01368	0,013675	0,05869	1,060446	352,3827	5,864718
0,468274	0,168039	0,363687	0,038466	0,088503	0,031361	0,018013	0,014872	0,011406	0,04429	1,045286	368,3406	5,909008
0,475154	0,164111	0,360735	-0,06344	0,013271	0,056713	-0,03015	0,002178	0,020458	-0,00751	0,992519	365,5851	5,901499
0,490102	0,150926	0,358971	0,059604	0,107317	0	0,029212	0,016197	0	0,045409	1,046456	382,5687	5,946908
0,450568	0,154882	0,39455	0,173396	0,022531	-0,04511	0,078127	0,00349	-0,0178	0,06382	1,0659	407,78	6,010728
0,402931	0,167862	0,429207	-0,16813	0,085929	0,10349	-0,06774	0,014424	0,044419	-0,0089	0,991139	404,1667	6,001827
0,387313	0,172327	0,44036	-0,27153	-0,10071	0,047047	-0,10517	-0,01735	0,020718	-0,10181	0,903205	365,0456	5,900022
0,408197	0,16856	0,423243	0,182856	0,084765	0,010676	0,074642	0,014288	0,004519	0,093448	1,097954	400,8031	5,99347
0,416631	0,175211	0,408159	0,177184	0	-0,03421	0,07382	0	-0,01396	0,059858	1,061686	425,5271	6,053329
0,394972	0,187214	0,417814	0,019956	-0,02324	-0,03352	0,007882	-0,00435	-0,01401	-0,01047	0,98958	421,0933	6,042854
0,378074	0,188453	0,433474	0,038756	0,093171	0,022473	0,014653	0,017558	0,009741	0,041952	1,042845	439,135	6,084807
0,379086	0,182078	0,438836	0,046424	0,054501	0,023789	0,017599	0,009923	0,010439	0,037961	1,038691	456,1256	6,122768
0,370019	0,193009	0,436973	0,079422	0,070759	0,042484	0,029388	0,013657	0,018564	0,061609	1,063547	485,1109	6,184378
0,348328	0,215738	0,435935	-0,17453	-0,01908	0,050687	-0,06079	-0,00412	0,022096	-0,04281	0,95809	464,78	6,141564
0,311645	0,233031	0,455324	0,011025	0,033506	0,030822	0,003436	0,007808	0,014034	0,025278	1,0256	476,6784	6,166842
0,319731	0,228733	0,451536	-0,54654	-0,05295	-0,00963	-0,17475	-0,01211	-0,00435	-0,19121	0,825961	393,7177	5,975634
0,358887	0,215485	0,425627	0,482005	0,006024	-0,0278	0,172986	0,001298	-0,01183	0,16245	1,17639	463,1655	6,138084
0,322011	0,233833	0,444157	0,144581	0	-0,04061	0,046557	0	-0,01804	0,028517	1,028928	476,5639	6,166602
0,326813	0,240212	0,432975	-0,37359	0,045496	0,038955	-0,12209	0,010929	0,016867	-0,0943	0,910011	433,6782	6,072303
0,35462	0,233402	0,411979	0,422958	0,065256	0,048632	0,149989	0,015231	0,020035	0,185255	1,203526	521,9429	6,257558
0,325961	0,239107	0,434932	-0,0383	0,048534	-0,01434	-0,01248	0,011605	-0,00624	-0,00712	0,992909	518,2418	6,250442
0,320469	0,254655	0,424876	-0,14403	-0,01809	0,031598	-0,04616	-0,00461	0,013425	-0,03734	0,963352	499,2492	6,213105
0,321576	0,266896	0,411529	0,04631	0,103925	0,032137	0,014892	0,027737	0,013225	0,055855	1,057444	527,9281	6,26896
0,326335	0,259852	0,413813	0,181217	-0,04445	-0,0106	0,059138	-0,01155	-0,00439	0,043201	1,044148	551,235	6,312161
0,370833	0,240932	0,388236	-0,13696	0,001228	0,009091	-0,05079	0,000296	0,003529	-0,04696	0,954123	525,9458	6,265198
0,357214	0,249511	0,393275	0,081098	0,042048	0,042811	0,028969	0,010492	0,016836	0,056297	1,057912	556,4044	6,321495
0,297528	0,281754	0,420718	-0,11985	0,073688	0,084479	-0,03566	0,020762	0,035542	0,020644	1,020858	568,0101	6,342139
0,254528	0,281903	0,463569	0,040866	0,05009	0,022325	0,010402	0,014121	0,010349	0,034871	1,035487	588,1668	6,377011
0,232607	0,261976	0,505418	0,090605	-0,05557	0,101196	0,021075	-0,01456	0,051146	0,057664	1,059359	623,0796	6,434674
0,23381	0,246579	0,519612	-0,20313	0,038798	0,060348	-0,04749	0,009567	0,031358	-0,00657	0,993451	618,9993	6,428104
0,274658	0,230411	0,494931	-0,07847	0,026084	0,02725	-0,02155	0,00601	0,013487	-0,00206	0,997946	617,7279	6,426048
0,288711	0,236423	0,474866	0,313805	0,053145	0,020224	0,090599	0,012565	0,009604	0,112767	1,119372	691,4671	6,538816
0,245144	0,25209	0,502766	-0,02836	-0,04188	0,002105	-0,00695	-0,01056	0,001058	-0,01645	0,983684	680,185	6,522365
0,241392	0,254517	0,504091	-0,0421	0,018164	0,050241	-0,01016	0,004623	0,025326	0,019786	1,019983	693,7773	6,542151
0,268013	0,251417	0,48057	0,042101	0,003992	0	0,011284	0,001004	0	0,012287	1,012363	702,3546	6,554438
0,278823	0,253472	0,467705	-0,01157	0,0486	0,01094	-0,00323	0,012319	0,005117	0,014209	1,01431	712,4056	6,568647
0,279348	0,257986	0,462666	0,033384	0,053568	0,03212	0,009326	0,01382	0,014861	0,038006	1,038738	740,0024	6,606653
0,264645	0,264148	0,471207	0,096503	0,006275	0,018036	0,025539	0,001658	0,008499	0,035695	1,03634	766,8941	6,642349
0,237026	0,286284	0,476691	-0,21066	0,065711	0,048656	-0,04993	0,018812	0,023194	-0,00793	0,992106	760,84	6,634423
0,236558	0,294457	0,468985	-0,07987	-0,05416	-0,00449	-0,01889	-0,01595	-0,00211	-0,03695	0,963727	733,2421	6,597476
0,226833	0,290756	0,482411	0,37227	0,055832	-0,0376	0,084443	0,016234	-0,01814	0,082537	1,086039	796,3297	6,680013
0,217442	0,297289	0,485269	-0,05568	0,007491	0,017601	-0,01211	0,002227	0,008541	-0,00134	0,998662	795,2638	6,678674
0,239274	0,297828	0,462898	-0,12257	-0,02604	0,050145	-0,02933	-0,00776	0,023212	-0,01387	0,986225	784,309	6,664803
0,260073	0,292123	0,447804	0,20433	0,030858	0,020479	0,053141	0,009014	0,00917	0,071325	1,073931	842,2935	6,736129

Appendix C: Input quantity index from 1947 to 2020

Year	herds	Machinery and implements	Land	Fertiliser	Fuel	Farm feed	Animal health and crop protec-tion	Packing material	All intermediate goods and services	Total Labor
1947	0,745	0,508	100,000	0,713	0,356	0,684	1,881	1,795	0,726	100,000
1948	0,758	0,572	99,353	0,728	0,388	0,698	1,901	1,870	0,758	102,995
1949	0,784	0,657	98,706	0,765	0,443	0,712	1,977	1,945	0,811	104,612
1950	0,916	0,769	98,060	0,779	0,506	0,747	2,112	2,001	0,870	106,133
1951	1,141	0,847	98,184	0,993	0,562	0,838	2,361	2,095	0,990	107,464
1952	1,227	0,879	98,308	1,007	0,589	0,936	2,649	2,113	1,046	109,461
1953	1,257	0,879	98,433	0,890	0,582	0,950	2,726	2,001	1,014	110,983
1954	1,311	0,883	98,557	0,890	0,586	0,964	2,668	1,983	1,018	112,694
1955	1,362	0,894	98,681	0,971	0,570	0,992	2,553	1,964	1,032	115,071
1956	1,440	0,923	99,655	1,015	0,593	0,999	2,630	1,964	1,060	114,881
1957	1,501	0,946	100,630	0,971	0,621	0,992	2,707	1,983	1,068	111,553
1958	1,435	0,960	101,604	0,941	0,629	1,020	2,726	2,076	1,080	113,550
1959	1,473	0,976	102,578	0,941	0,645	1,048	2,688	2,244	1,107	120,016
1960	1,484	0,992	103,553	0,920	0,648	1,066	2,612	2,509	1,123	102,044
1961	1,445	0,999	103,456	0,921	0,639	1,038	2,532	2,711	1,122	115,071
1962	1,524	1,012	103,580	0,931	0,643	1,060	2,529	2,811	1,139	120,364
1963	1,611	1,028	103,736	0,931	0,639	1,063	2,566	2,792	1,137	108,164
1964	1,842	1,052	103,868	0,950	0,636	1,083	2,571	2,771	1,146	105,502
1965	1,924	1,076	104,023	0,968	0,636	1,112	2,574	2,974	1,171	106,345
1966	2,002	1,089	103,143	0,990	0,639	1,167	2,574	3,197	1,211	112,196
1967	2,213	1,107	102,271	0,982	0,648	1,151	2,589	3,206	1,227	112,139
1968	2,269	1,135	101,676	0,982	0,648	1,169	2,617	3,036	1,200	112,627
1969	2,209	1,170	102,827	0,972	0,648	1,236	2,678	2,826	1,211	113,354
1970	2,301	1,217	103,188	0,972	0,648	1,291	2,754	2,902	1,234	109,734
1971	2,434	1,267	103,601	1,068	0,707	1,328	2,882	2,974	1,314	106,064
1972	3,046	1,375	103,892	1,165	0,751	1,413	3,037	3,215	1,408	101,731
1973	3,930	1,510	104,182	1,255	0,826	1,606	3,165	3,331	1,546	99,623
1974	4,846	1,644	104,474	1,420	1,278	1,801	3,755	3,634	1,841	98,334
1975	4,602	2,049	104,727	1,988	1,469	1,971	4,724	4,465	2,235	97,743
1976	5,200	2,495	105,151	2,132	1,947	2,188	4,960	4,827	2,541	90,617
1977	5,264	2,759	104,958	2,386	2,149	2,582	5,220	5,264	2,863	92,539
1978	5,425	3,143	104,919	2,790	2,227	2,982	5,692	5,845	3,231	91,363
1979	6,525	3,626	104,669	3,167	4,087	3,514	5,867	6,555	4,033	92,793
1980	8,168	3,920	104,533	3,712	5,225	4,230	6,472	7,501	4,802	88,041
1981	10,391	4,409	104,249	3,984	5,444	4,830	6,990	8,663	5,303	81,978
1982	9,727	5,223	103,929	4,476	6,339	5,754	8,317	9,579	6,157	81,420
1983	9,955	6,049	103,929	5,096	6,226	7,164	9,292	10,284	6,963	80,693
1984	12,724	6,786	103,929	5,416	5,849	7,773	10,177	11,042	7,306	87,260
1985	12,790	8,306	103,929	7,223	7,366	8,465	12,681	11,674	8,614	94,134
1986	15,881	10,698	106,045	8,372	7,979	9,370	15,749	17,404	9,932	95,671
1987	19,600	12,907	105,726	8,306	7,242	10,289	16,904	19,824	10,370	94,920
1988	21,900	15,800	106,100	10,300	7,600	10,800	18,300	20,600	11,500	86,828
1989	22,400	16,800	106,837	12,300	10,000	12,400	20,400	23,200	13,900	86,971
1990	19,900	18,600	107,563	13,200	11,400	13,900	23,000	26,700	15,500	87,058
1991	24,300	19,700	108,336	14,500	13,900	15,400	26,900	28,200	17,500	82,946
1992	27,900	21,400	110,454	14,500	15,100	16,700	28,600	29,700	18,600	78,079
1993	28,700	24,200	112,486	15,600	16,600	18,700	30,200	32,700	20,400	81,767
1994	37,100	26,600	112,723	17,400	18,000	19,700	32,400	35,800	21,900	77,786
1995	34,700	29,400	113,576	20,500	18,700	21,100	34,600	40,400	23,800	80,895
1996	35,900	31,300	115,031	22,300	23,100	24,300	39,900	50,200	27,500	61,659
1997	45,800	34,000	115,931	24,800	26,800	26,600	49,100	52,500	29,600	60,217
1998	45,800	36,700	115,972	24,700	25,200	27,000	49,600	47,800	29,800	67,991
1999	44,300	39,700	116,533	25,300	31,300	28,200	51,300	48,800	31,200	70,199
2000	39,800	46,300	117,005	30,600	35,800	34,900	57,100	56,500	39,500	70,060
2001	41,500	52,100	116,226	38,000	42,100	38,200	59,100	61,500	43,700	60,782
2002	53,500	64,400	116,363	45,800	47,400	48,500	66,000	62,400	50,900	69,977
2003	56,800	68,200	115,680	44,500	50,100	50,900	63,300	63,400	53,100	67,197
2004	61,800	67,800	113,446	44,300	54,300	51,100	60,000	65,100	54,100	65,523
2005	64,800	67,200	112,587	47,500	54,700	50,400	59,400	65,200	54,500	59,081
2006	79,500	67,900	108,416	48,500	59,300	53,800	61,900	67,600	57,900	60,988
2007	85,100	68,400	108,451	64,400	68,400	59,800	66,700	69,800	64,300	56,676
2008	92,800	77,900	110,008	76,100	101,000	74,800	76,300	81,800	79,600	60,870
2009	96,200	87,600	109,183	85,400	96,100	87,000	87,300	88,200	88,200	56,634
2010	100,000	100,000	108,521	100,000	100,000	100,000	100,000	100,000	100,000	51,692
2011	121,200	110,800	105,209	108,900	104,900	111,900	110,200	111,600	110,900	45,255
2012	123,800	123,000	105,337	115,400	121,800	129,000	123,800	128,000	126,300	48,597
2013	121,700	132,200	105,337	121,500	129,500	138,000	131,000	136,700	134,900	52,349
2014	137,500	142,500	105,337	124,600	141,500	146,400	139,000	144,900	142,900	49,520
2015	146,300	150,200	105,337	127,500	136,400	152,700	146,100	151,000	147,400	61,191
2016	159,600	162,600	105,337	131,400	142,900	163,600	153,900	159,200	155,700	61,015
2017	192,700	169,100	105,337	135,900	146,700	168,600	166,800	171,400	162,400	59,768
2018	193,100	177,100	105,337	138,400	156,300	171,000	178,900	180,800	168,700	59,318
2019	185,700	183,000	105,337	141,200	158,100	177,000	187,800	187,100	174,200	60,021
2020	213,975	188,122	105,337	143,391	150,623	184,802	195,965	194,279	179,214	57,191

Appendix D: Data appendix

Construction of intermediaries index:

1947-1949: Abstract of Agriculture 1965, page 55, table 54a

1959-1988: Abstract of Agriculture 1989, page 95, table 95

1980-2018: Abstract of Agriculture 2018, page 94, table 100

2019-2020: Abstract of Agriculture 2022, page 95, table 100

Construction of herds index:
1947-1979: Abstract of Agriculture 1989, page 81, table 81

1960-1987: Abstract of Agriculture1989, page 88, table 88

1980-2018: Abstract of Agriculture 2018, page 89, table 95

2019-2020: Abstract of Agriculture 2022, page 95, table 100

Construction of land index:
1947-1969: Thirtle et al. 1993b

1961-2019: FAO agricultural land index for South Africa

1961-2020: USDA Agricultural land index

Construction of machinery index:
1947-1965: Abstract of Agriculture 1965, page 55, table 54a

1959-1988: Abstract of Agriculture 1989, page 92, table 92

1980-2018: Abstract of Agriculture 2018, page 92, table 98

2019-2020: Abstract of Agriculture 2022, page 92, table 98

Construction of labour index:

1947: Summary report on agricultural and pastoral production 1936-37, 1938-39, 1945-46, 1953-54, Union of South Africa, page 10

1950, 1952-1954: Summary report on agricultural and pastoral production 1936-37, 1938-39, 1945-46, 1953-54, Union of South Africa page 26, table 51

1953-1959: 1962 Census of Agriculture

1960-1971: 1971 Census of Agriculture

1972-1976: Report on agricultural and pastoral production 1976, part 1 table 1 page 1

1977, 1979-1981: 1980 Census of Agriculture, table 1

1983: 1983 Census of Agriculture, table 1

1985-1987: 1992 Census of Agriculture, table 1

1988, 1990-1996: 1994-1996 survey table 1

2002: 2002 Census of Agriculture

2007: 2007 Census of Agriculture

2017: 2017 Census of Agriculture

1994-2015: Post- Labour Apartheid series

2018-2020: imputations using inflation from World Bank

Appendix E: output, input, total factor productive, labour and land productivity indices, 1947 – 2020 (1947 = 100)

year	Output	Input	Total productivity	labour productivity	land productivity
1947	100	100	100	100	100
1948	95	101	94	92	95
1949	102	101	101	98	103
1950	110	99	111	103	112
1951	104	101	104	97	106
1952	118	102	116	108	121
1953	124	110	113	112	126
1954	128	113	113	113	129
1955	134	116	115	116	136
1956	143	121	118	124	143
1957	137	123	112	123	136
1958	144	128	112	127	142
1959	149	136	110	124	145
1960	157	135	117	153	151
1961	170	140	121	147	164
1962	176	137	129	146	170
1963	177	138	129	168	175
1964	177	137	129	170	173
1965	178	143	125	171	175
1966	207	149	139	181	197
1967	221	150	147	205	224
1968	209	154	136	190	210
1969	220	160	138	196	216
1970	230	164	140	208	222
1971	255	167	153	239	245
1972	238	167	142	243	238
1973	248	178	139	240	229
1974	322	181	177	246	231
1975	329	183	180	282	263
1976	332	185	180	307	265
1977	352	186	189	316	278
1978	368	193	191	333	290
1979	366	192	190	330	293

1980	383	193	198	360	303
1981	408	194	210	401	315
1982	404	186	218	407	319
1983	365	183	199	375	291
1984	401	193	208	381	320
1985	426	188	227	375	339
1986	421	180	234	365	329
1987	439	185	237	383	344
1988	456	190	240	435	356
1989	485	184	263	462	376
1990	465	184	253	442	358
1991	477	178	268	476	365
1992	394	185	213	418	295
1993	463	191	242	469	341
1994	477	196	244	479	350
1995	434	204	213	445	316
1996	522	193	270	653	376
1997	518	195	265	691	371
1998	499	213	234	597	357
1999	528	223	236	574	375
2000	551	209	264	584	390
2001	526	214	245	640	375
2002	556	213	261	592	396
2003	568	210	271	703	407
2004	588	218	269	747	430
2005	623	238	261	873	459
2006	619	244	254	843	473
2007	618	241	257	902	472
2008	691	228	303	931	521
2009	680	227	299	986	516
2010	694	221	314	1103	530
2011	702	223	315	1289	553
2012	712	225	316	1219	561
2013	740	231	320	1175	582
2014	767	229	335	1287	603
2015	761	244	312	1029	599
2016	733	245	300	1003	577
2017	796	248	322	1113	627
2018	795	252	315	1119	626
2019	784	260	302	1092	617
2020	842	286	294	1230	663

Appendix F: Land and labour productivity index

Land productivity	Labour productivity
100,00	100,00
95,28	91,91
103,45	97,61
111,69	103,20
106,39	97,20
120,50	108,23
125,76	111,54
129,42	113,18
135,63	116,31
143,04	124,08
136,23	122,89
141,98	127,04
145,23	124,13
151,83	154,08
164,34	147,75
170,10	146,38
170,57	163,59
170,09	167,45
171,11	167,37
200,28	184,12
216,12	197,10
205,96	185,93
213,69	193,85
222,79	209,49
245,98	240,27
229,31	234,18
237,84	248,72
307,97	327,20
314,33	336,79
316,02	366,71
335,74	380,79
351,07	403,16
349,28	393,98
365,98	434,53
391,16	497,42
388,89	496,40
351,24	452,39
385,65	459,32
409,44	452,05
397,09	440,15
415,35	462,64
429,90	525,32

454,07	557,78
432,10	533,88
440,00	574,68
356,45	504,25
411,76	566,45
422,78	612,66
381,84	536,10
453,74	846,49
447,03	860,62
430,49	734,28
453,03	752,04
471,12	786,80
452,52	865,30
478,16	795,13
491,02	845,30
518,45	897,65
553,42	1054,61
570,95	1014,95
569,59	1089,92
628,56	1135,98
622,97	1201,03
639,30	1342,15
667,58	1551,98
676,31	1465,93
702,51	1413,60
728,04	1548,67
722,29	1243,38
696,09	1201,74
755,98	1332,36
754,97	1340,68
744,57	1306,73
799,62	1472,76