The Agricultural Product Space: Prospects for South Africa

By

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Abstract

South Africa’s sluggish economic growth and limited structural transformation are at the core of the country’s high levels of unemployment and poverty. Why some countries are able to grow and others not has been the subject of much academic debate, with recent literature exploring the relationship between growth and a country’s productive structure. Although the magnitude of the role of agriculture in economic development is contentious within the context of an upper middle-income country, like South Africa, the sector has unmistakably a contribution to make in the much needed transformation and growth process. Therefore, this study analyses the structure of the agro-complex through the application of the ‘product space’ framework. This methodology investigates the product-level relatedness within the sector and arrives at a structure of an agricultural product space network. This structure allows potential diversification pathways to be identified which can form the basis of transformation within South Africa’s agro-complex.

Keywords: product space, South Africa, agro-complex, economic development

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1. **Introduction**

Agricultural production, and more specifically exports, will remain an important contributor towards domestic growth and ultimately poverty alleviation in South Africa. The sector is the backbone of the rural economy. Its contribution to employment and upstream- and downstream economic activities is significant. There exists vast literature that illustrates the positive relationship between agriculture and economic development (see Diao *et al.*, 2010; Kjeldsen-Kragh, 2007; Cypher and Dietz, 2004; Block and Timmer, 1994; Johnston and Mellor, 1976) as well as between trade and poverty alleviation (see Nicita *et al.*, 2011; Dollar & Kraay, 2002; Fisher, 2001; Barro, 2000). Agriculture’s role in economic development and growth is often overlooked in South Africa, as its development agenda is dominated by land reform and is not focused on advancing its production capabilities. Therefore, this study will analyse the sector’s potential development pathways specifically from the perspective of the agricultural products produced.

It is evident that the persistent poverty and unemployment in South Africa will not be eliminated by the past and current growth rates of less than three per cent. Hence, the National Planning Commission (NPC, 2011) in its National Development Plan estimates that growth rates of at least six per cent are needed. This additional growth in domestic production cannot be solely derived from current economic activities. Therefore, some structural transformation is needed in order to ensure a sustained additional increase in economic growth. Although the magnitude of the role of agriculture in economic development is contentious in the context of an upper middle-income country, like South Africa, the sector has unmistakably a contribution to make in this transformation and growth process.

Many theories, from the work of Adam Smith to the model of endogenous growth, have tried to develop a concept around the attributes of economic growth processes. Most of these growth models focus on a country’s fundamentals (e.g. factor endowments, technology, and environment), which determine a country’s productive structure and subsequently its generated wealth. However, these models fail to explain why similar countries have different specialization patterns and levels of product sophistication.

New theories of economic growth processes need to be applied to better understand the development of the agricultural sector in South Africa. One such theory was recently developed by
Hausmann, Hwang and Rodrik (2005) which states that the wealth of a nation is determined by its productive structure. This productive structure is defined by the set of products and services that a nation can supply. The most important observation of the research underpinning their theory is that what a country produces matters more for growth than how much value it extracts from this. Furthermore, as not all products have an equal level of sophistication, the income of countries is determined by its product variety and sophistication in the long run, and not by the traded value of their exports (Hausmann et al., 2005).

Hausmann and Klinger (2007) expanded this theory by arguing that the productive structure of a country is defined by the local availability of unique inputs or capabilities. They argue that these capabilities can be perceived as being specific building blocks of production. Capabilities may consist of tangible inputs, such as infrastructure and land, as well as intangible inputs, such as institutions, norms, skills and knowledge (Hidalgo and Hausmann, 2009). For instance, the production of oranges requires a certain type of soil, climatic conditions, labour skills, farming equipment, food safety standards, distribution network, and port facilities. The exact set of capabilities is unique to each product but the exchange of capabilities between products is possible. Hausmann and Klinger (2007) thus argue that each country has a unique set of capabilities and each product requires a specific combination of these capabilities.

This specific theory of economic growth and productive structure has been empirically tested by using a combination of statistical network physics and development economics (Hidalgo, Klinger, Barabási and Hausmann, 2007). This approach resulted in a network structure that connects products, based on the probability that countries export them in tandem. This “product space” assumes that similarities in capability requirements of products are expressed through co-exports (Hidalgo et al., 2007).

The product space can be seen as an industrial map of where economic development occurs. In line with the described theory, an important aspect of the economic development process is the process by which countries diversify and upgrade their productive structures. The network shows explicitly which products require similar capabilities to the ones that a country already produces (Hidalgo, 2009). The fact that countries tend to diversify towards products that are close by in the product space was demonstrated empirically by Hidalgo et al. (2007).
The main objective of this study is to analyse the potential contribution of South Africa’s broader agricultural sector, the so-called agro-complex, in the much needed economic transformation process in order to generate higher levels of growth. This is done by analysing the structure of the agro-complex within the context of the agricultural product space and determining its prospects for diversification.

The next section provides some background on the performance and structure of South Africa’s agro-complex. The third section will discuss the methodological framework for the product space analysis. The fourth section will discuss the results and the final section will provide some conclusions and recommendations for South Africa’s development agenda.

2. Performance and structure of South Africa’s agro-complex

2.1 Introduction

Although other economic sectors may play a more important role in economic growth, the contribution of South Africa’s agro-complex should not be undermined. The contribution of primary agriculture to the South African Gross Domestic Product (GDP) was 2.4 per cent in the period from 2013 (IHS Global Insight, 2014). This direct contribution may not seem impressive, but its strong forward linkages with the rest of the economy imply that approximately 60 per cent of total output in primary agriculture is used as intermediate goods in other industries (Quantec, 2014). This forward linkage is most significant with the wood, food- and beverage manufacturing sectors. Furthermore, the total contribution of the agro-processing sector to the country’s GDP was 4.0 per cent in 2013 (IHS Global Insight, 2014); adding food retailing, the total agro-food sector is likely to contribute far more than 10 per cent to GDP.

Apart from this macro-economic perspective, the sector’s contribution to economic growth also has a socio-economic dimension. Agriculture is relatively more labour intensive than other economic sectors; primary agriculture absorbs 5.3 per cent of total employment to produce a smaller percentage of GDP (IHS Global Insight, 2014). Adding employment of agro-processing activities the total share of primary and secondary agriculture amounts to nine per cent which is larger than the employment in the mining and construction sectors (IHS Global Insight, 2014). Arguably the single most important contribution of the agricultural sector to the South African economy is the adequate supply of food, which directly impacts on the welfare and productivity of its citizens.
South Africa’s agricultural sector is relatively export orientated and an important earner of foreign currency. The export-output ratio of primary agricultural products was 30 per cent in 2013, which is the third highest among South Africa’s economic sectors (Quanetc, 2014). However, some agricultural sub-sectors, such as citrus fruit, wine, deciduous fruit and leather manufacturing, have a significantly larger share of their respective production exported.

2.2 Production and exports

The long-term trends of total production in both primary and secondary agriculture (i.e. the agro-complex), reflected by the real value added, is shown in Figure 1. The real value of production within the agro-complex increased 2.6 times from 1970, to reach a total value of R112 billion by 2013. Although this performance seems significant, most other broad economic sectors performed better with regard to the real value added during the same period. For instance, total transport value added increased 5.7 times and the value added by financial services increased five times since 1971. However, the agro-complex did outperform the mining sector and construction sectors.

The annual average growth for primary and secondary agriculture was 2.7 and 2.5 per cent, respectively over the depicted period. The contribution of secondary agriculture (i.e. agro-processing) to total value added of the agro-complex did not experience a significant increase. In 1970, agro-processing contributed 58 per cent to total production of the agro-complex and by 2013 this share has only increased to 61 per cent. Hence, no significant structural changes have taken place in South Africa’s agro-complex over time in terms of capturing more value from the processing of primary agricultural products. Furthermore, the contribution of agriculture to economic growth in South Africa has been marginal since 1993. Primary agriculture specifically, only contributed 0.5 per cent to South Africa’s total economic growth from 1993 to 2012.

Another important performance indicator for the agro-complex is the growth trend of its exports. As became evident from the previous section, the agro-complex is an important earner of foreign currency. Whether this growth is sustained and has kept pace with global trends is a sound benchmark for performance from an international perspective. The graph line Figure 2 shows the trend in exports from South Africa’s agro-complex and the columns indicate the annual growth of both the country’s and global exports in the period 1993 to 2013. It is evident for the figure that the country showed stagnating growth in exports until 2002 (averaging three per cent annually) after which exports showed a significant increase (averaging 12 per cent annually from 2002 to 2013). Figure 2 shows furthermore that the trend in South Africa’s exports from the agro-complex
compares relatively well with the global trend. However, the growth-correlation coefficient of 0.72 between South Africa’s and global export growth reveals some potential for improvement.

### 2.3 Composition and diversification

The composition of South Africa’s agro-complex reveals that primary agricultural production is dominated by the poultry, maize, cattle and fruit sub-sectors. Combined these contribute 53 per cent to total primary production. Secondary agriculture (i.e. agro-processing) is dominated by food processing and beverage manufacturing. Combined these activities contribute 77 per cent to total production within agro-processing.

From a historical perspective, the most significant changes in the output-composition of crop production over the last decades where a decrease in the contribution of cereal crops countered by an increase in the contribution of fruit crops. With regard to animal production the most significant structural change over the last decades was the significant increase in the contribution of poultry production mainly at the expense of cattle production. Since 1961, the total output of South Africa’s animal production has outperformed crop production with total growth rates of 150 and 344 per cent respectively.

Figure 3 depicts the characteristics of South Africa’s productive structure in the agro-complex from a product-level and cluster perspective. This figure shows the characterization of the country’s core production competencies in terms of the product’s share in global trade (y-axis) per cluster, the product’s share in South Africa’s exports (x-axis) per cluster, as well as the proportion they represent in the total product spectrum of each of the five cluster (size of the bubble) within the agro-complex.

This elaborate analysis reveals that South Africa has built most of its core production competencies around primary agriculture. Hence, this cluster is thus relatively the most diversified as the country embeds 20 per cent of all possible primary agricultural products within its productive structure. For the other four clusters within the agro-complex, especially the agro-processing of non-food, South Africa has a more concentrated (i.e. less diversified) set of core production competencies.

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4 South Africa’s core competencies were identified by calculating the RTA index (see Section 3.2) for each product classified under the 2002 version of the Harmonized System (HS) nomenclature. Products with an RTA > 1 were classified as core competencies. The products were further categorized into five clusters of the agro-complex, namely: primary agriculture, agro-processing of food, agro-processing of non-food, forestry and agricultural inputs.
Furthermore, given the relative low share in global trade of the country’s existing core competencies within these specific clusters; there is a likely potential for broadening production.

3. A network of relatedness

This section will briefly lay out the methodological framework for determining South Africa’s position and prospects within the agricultural product space. This analytical framework consists of three steps, namely: construction of the agricultural product space network, determining South Africa’s position in the network and the identification of diversification opportunities.

3.1 Theoretical background

The theoretical underpinning of the product space has mainly been developed by Hausmann et al. (2005) and Hausmann and Klinger (2007). Hausmann and Klinger (2007) argue that the ability of a country to diversify into producing new goods depends on its current set of available capabilities (see also Section 1). Thus, countries which have built a competence (i.e. comparative advantage) in producing a certain good can use its corresponding set of capabilities in the production of new and related products that are close to its current productive structure. This process of diversification to nearby products also requires the development or acquisition of new capabilities. A drawback of the product relatedness theory is that it does not explain how these new capabilities are attained but it assumes that this is explained by institutional economics and endogenous growth models (i.e. learning-by-doing). Klinger (2007) argues that FDI could also play an important role in this matter.

This resourced-based approach of diversification and growth, based on related resources and capabilities, was thus further conceptualized by Hidalgo et al. (2007). They developed a measure for the proximity between products and used this concept to map the relatedness of products in a network visualization (i.e. the product space). In this network, products are depicted by nodes, and their relatedness, by edges. The position of a country in this network, whether in the sparser or denser parts, can predict the ease with which a country transforms itself economically. This process of structural transformation is not an endogenous process, but is led by market- and policy incentives. From the perspective of capabilities, products are not necessarily developed in sequence. For example, the fact that a country is capable of effectively producing soybeans does not imply that it is automatically an efficient producer of soybean oil. Hence, vertical linkages are as important as horizontal linkages.
The relatedness of different products, measured by the proximity and reflected by similarities in capabilities used in its production, can be caused by several possible factors:

i. the intensity of labor, land and capital (Leamer, 1984);
ii. the level of technological sophistication (Caballero and Jaffe, 1993);
iii. the inputs or outputs involved in a product’s value chain (Dietzenbacher and Lahr, 2001);
iv. necessary institutions (Rodrik, Subramanian and Trebbi, 2002); and
v. for primary agricultural products, the relatedness of products can also be attributed to similarities in agro-ecological requirements.

### 3.2 Constructing the product space

As mentioned, the relatedness of products in the product space is based on the concept that similar products require a similar set of requisite capabilities. This relatedness is measured by proximity, reflecting the likelihood that countries have a comparative advantage in both goods. This measure is developed using product-level data of exports. It is assumed that if a country has a comparative advantage in a specific product, it must have the adequate endowments and capabilities to produce that specific product. If two products require almost the same set of capabilities in their production and marketing, it would be reflected by a higher probability of the country having a comparative advantage in both those products.

The proximity measure used in the product space is the conditional probability that a given country produces product A, given that it also produces product B (e.g. P{A|B}). The conditional probability is not a symmetric measure, hence P{A|B} is not the same as P{B|A}. As the number of exporters of product A decreases, the conditional probability of exporting another good becomes closer to 1. This thus reflects the particularity of the country and not the similarity between products. For instance, if South Africa is the only global producer of litchis, then all other goods exported by South Africa, such as wool, will be closely related, when in fact they are quite different. To counter this, the minimum pair-wise conditional probability must be used as an inverse measure of distance in both directions in order to make it symmetric and more stringent (see equation 1).

\[
\text{Min} \{P\{A|B\}, P\{B|A\}\} \tag{1}
\]

The proximity measure must also be based on exports that are substantial and not just marginal. This is assured by using the revealed comparative advantage index (RCA) of Balassa (1965) (see
equation 2). If this index is larger than 1, it implies that the share of a good in the country’s exports is larger than the share of the country in global exports.

\[
RCA_{cp} = \frac{\frac{x_{cp}}{\sum_c x_{cp}}}{\frac{\sum_p x_{cp}}{\sum_{c,p} x_{cp}}}
\]

(2)

Where \(X_{cp}\) represents the exports of country \(c\) in product \(p\).

This measure is then used to build a matrix that associates each country to the product in which it has a comparative advantage. To counter annual variations in agricultural production, the RCA is calculated for five years and set at 1 if a country has a \(RCA > 1\) in three or more years. Hence, the matrix \(M_{cp}\) can be defined as follows (Hausmann, Hidalgo, Bustos, Coscia, Chung, Jimenez, Simoes and Yildrim, 2011):

\[
M_{cp} = \begin{cases} 
1 & \text{if } RCA_{cp} \geq 1 \text{ in } 3 - 5 \text{ yrs;} \\
0 & \text{otherwise}
\end{cases}
\]

(3)

This matrix thus summarises which country makes what. In order to mute short-term fluctuations in agricultural trade patterns, the proximity matrix is made time-consistent by using data from the period from 2006 to 2011 as a basis. Expanding this to the calculation of the proximity between products, which is based in the likeliness of co-exports of good \(p\) and good \(p'\), will get (Hausmann et al., 2011):

\[
\Phi_{pp'} = \frac{\sum_c M_{cp}M_{cpr}}{\max(\sum_c M_{cp} \mid \sum_c M_{cpr})}
\]

(4)

Equation 4 implies that if, for instance 25 countries export oranges, 18 countries export orange juice and 15 export both products, the proximity value between oranges and grapes is \(15/25 = 0.6\). Hence, the probability that a given country produces oranges, given that it also produces orange juice, and vice versa, is 0.6. This value thus implies that 60 per cent of the countries that export oranges also export orange juice. Furthermore, a proximity value of 0 indicates no relatedness, whereas a value of 1 indicates a very high level of product relatedness. A proximity value of 0.55 is generally assumed as a minimum and meaningful measure of the strength of relatedness between products (see Hidalgo et al., 2007; Bayudan-Dacuycuy, 2012).
The revealed proximity value between every pair of products is used to construct a proximity matrix. This matrix is then used for the network representation in order to study the structure and dynamics of the product space. The visualization of the product space in this study is done by importing the proximity matrix into NodeXL. NodeXL is an open source plug-in for Microsoft Excel developed by the Social Media Research Foundation for the visualization and analysis of complex networks. The proximity value is calculated based on trade date from 121 countries and comprises 1,456 products grouped within the five clusters of the agro-complex (see also Section 2.3). The data is sourced from the UN Comtrade database.

3.3 Determining South Africa’s productive structure

The positioning of countries in the product space is traditionally done on the basis of their respective RCA indices. This study diverts from this for the simple reason that the RCA only accounts for exports and fails to take imports in account. Since the product space aims to analyse the productive structure of a country, it is considered that the use of an alternative measure that captures the domestic content of production is a more suitable option. Hence, this study will use the index for Revealed Trade Advantage (RTA) as developed by Vollrath (1991). This index simultaneously accounts for exports and imports at product-level and is regarded as an improved reflection of the comparative advantage of local production and is thus an improved indicator for positioning countries in the product space. Owing to data constraints, in terms of limited availability of country-specific import data, it is not feasible to also use this index for the calculation of the structure of the product space network.

The RTA index is expressed as follows:

\[ RTA_{cp} = RCA_{cp} - RMA_{cp} \]  

(5)

The RMA\(_{cp}\) is the Revealed Comparative Import Advantage, the counterpart of the RCA, and is expressed as follows:

\[ RMA_{cp} = \frac{I_{cp}}{\sum_{c} I_{cp}} \frac{\sum_{p} l_{cp}}{\sum_{cp} l_{cp}} \]  

(6)

Where \( I \) is the import of product \( p \) by country \( c \)

\(^{5}\) An overview of these products is available from the authors.
3.3 Identifying diversification opportunities

The probability of a country producing a particular “new” product in the future depends on that product’s proximity to its current production structure in the product space. A country-product level indicator to measure this is distance, which reflects how “far” each product is located in relation to a country’s current production (see Hausmann et al., 2011). The measurement of Distance reflects the sum of the proximities connecting a “new” product $p'$ to all the products that country $c$ is currently not producing. This indicator is then normalised by dividing it by the sum of the proximities of all the products connected to product $p'$. If a country produces most of the exports connected to the product, the distance will be close to 0, otherwise the value will be close to 1. Distance (or $D_{cp}$) is defined as:

$$D_{cp} = \frac{\sum_{p'} (1 - M_{cp'}) \phi_{pp'}}{\sum_{p'} \phi_{pp'}}$$  \hspace{1cm} (7)

Hausmann and Klinger (2006) show that this measure is a highly significant predictor of shifts in a country’s productive structure in the product space.

4. The agricultural product space

4.1 Structure of the network

The calculation of the proximity matrix revealed a total of 797,265 connections between products within the agro-complex, which represents 38 per cent of the maximum possible connections of 2,118,480. This relatively low rate of relatedness in the agro-complex is in line with findings of previous applications of the product space (see Hidalgo et al., 2007; Bayudan-Dacuycuy, 2012). The proximity matrix furthermore revealed that a total of 1,392 products in the agro-complex have a degree of relatedness with at least one other product. This represents 96 per cent of the 1,456 products under investigation.

Analysis of the frequency and cumulative distribution of the proximity values between the 1,456 products reveals that most (39 per cent) of the pair-wise product proximities are larger than 0.1 and smaller than or equal to 0.2. It is evident that most product connections have a relatively low degree of relatedness, with 97 per cent of the proximity values being below 0.5. This study uses a proximity value equal to or higher than 0.55 as the threshold for identifying meaningful
relationships between products in the agro-complex. This criterion is applicable to 1,872 of the product-to-product connections, reflecting only 0.23 per cent of the total of 797,265 revealed connections. This threshold results, furthermore, in the exclusion of 684 products which only have proximity values with other products of below 0.55. This leaves the total number of products with meaningful proximity values at 772. This represents 53 per cent of the total of 1,456 products that comprise the agro-complex. Furthermore, the majority of these “strong” connections (73 per cent) have a proximity value of between 0.55 and 0.65. A total of 90 pair-wise product connections have a very strong degree of relatedness, with a proximity value of 0.95 or higher.

The proximity matrix is used to construct the network of the agricultural product space. As mentioned, this network representation of the proximity matrix provides insight into the degree of relatedness between products as well as the productive structure of a country. Figure 4 shows the network representation of the agricultural product space for all product connections with a proximity value of 0.55 or higher. This network thus consists of 772 products (i.e. nodes) and 1,872 connections (i.e. links/edges) and 76 individual network components. Fifty-one of these individual network components consist of only two products. The network was laid out as an undirected graph by using the Harel-Koren Fast Multi-scale algorithm (Harel and Koren, 2000). This algorithm is relatively fast to process and capable of drawing large force-directed and readable network graphs.

Each node in Figure 4 represents a product and each link represents the proximity between products. The size of the node of each product corresponds with its respective proportional value share in global trade. Hence, products with larger nodes comprise a larger share in global trade. The color of the node is in accordance with the product’s classification under the two-digit level of the Harmonized System (HS) nomenclature. As shown in the color legend of Figure 4, a total of 48 agricultural product groupings are used. The weight of the links between the nodes (i.e. products) in the product space corresponds with the respective proximity value associated with their pair-wise product connection. Hence, the higher the degree of relatedness between products, the wider the network link is between them.

Figure 4 shows that the agricultural product space is heterogeneous and characterized by a few dense cores of highly connected products and a sparser periphery of less connected products. This structure is in line with previous versions of the product space (see Hidalgo et al., 2007; Hidalgo, 2011). This structure of different densities among products reveals the amount of effort needed to create spill-overs within the agricultural sector. In the denser (i.e. better connected) parts of the
agricultural product space, the transfer of a set of acquired capabilities and knowledge between products is easier. In Section 3.1 it was discussed that countries tend to diversify to nearby products (see also Hidalgo et al., 2007; Hausmann and Klinger, 2007). Hence, in the denser parts of the network there are more nearby products, thus more opportunities to diversify. Four relatively dense product groupings can be identified within the agricultural product space, namely: cotton, textiles, meat and wood. To a lesser extent, wool and agricultural machinery can also be classified as relatively dense product groupings.

Section 2.3 introduced the aggregation of the products within the agro-complex in five broad clusters. Table 1 shows a summary of the characteristics of the five clusters’ positions in the agricultural product space. It is evident from Table 1 that primary agricultural products have relatively the lowest presence in the agricultural product space with a share of only 39 per cent of all products classified within this cluster. Primary agriculture is characterized by numerous individual network components (48) consisting of a relatively small number of products (a maximum of 7). Furthermore, the density of the cluster (0.013) is moderate. This poor connectedness may be attributed to the fact that the production of these specific products is very location-specific and often subject to specific agro-climatic conditions.

Table 1 furthermore shows that processed food products have the second largest presence in the agricultural product space, with a share of 32 per cent in the total number of nodes (i.e. products). However, the share of products located in the product space in comparison to the total number of products classified in this cluster is only 47 per cent. The degree of density (0.010) is also comparatively low. Furthermore, this cluster has a significantly larger amount of individual connected components. This lower degree of connections within this cluster points to relatively limited potential for capability and knowledge spill-overs, compared to other clusters. The relatively large heterogeneity in products (and, inter alia, in the underlying capabilities and knowledge) within this cluster lies at the foundation of these network characteristics.

With regard to the agro-processing of non-food products, Table 1 reveals that this cluster has the largest presence in the agricultural product space, with a share of 37 per cent. It is also evident from the table that a relatively large share (69 per cent) of the products classified under this cluster also features in the product space. The number of individual components within the agro-processing of non-food cluster is moderate (22). Furthermore, the total number of links and the degree of density are relatively high. This thus implies a comparatively high degree of connections within this
specific cluster. Hence, the potential for capability and knowledge spill-overs towards new ventures is very high. The underlying rationale for these network characteristics is the relatively homogenous product composition within this specific cluster, which is dominated by natural fibres and textiles.

Forestry products have a moderate presence in the agricultural product space, with a share of 14 per cent (see Table 1). About half of the possible forestry products are included in the specified network. Furthermore, the relatively high density (0.026) in this cluster reveals a good potential for capability and knowledge spill-overs to new products within the forestry cluster. Similar to the agro-processing of non-food cluster, this is also enhanced by the relatively low level of product variety within the forestry cluster.

It is clear from Table 1 that the agricultural input cluster is the smallest of the five clusters. Although a large number of agricultural inputs are located in the agricultural product space, the level of connections is the lowest. The density within this cluster is only 0.0061. Hence, transferring acquired capabilities and knowledge to new products will be more difficult. Similar to the primary agriculture cluster, the variety of products in this cluster is relatively large, ranging from milking machines to fertilizers.

It becomes evident from the analysis in Table 1 that the degree of homogeneity of the products within a cluster greatly affects its potential for diversification. This provides some insights into which clusters of the agro-complex the opportunities for diversification seem the highest in terms of the number of linkages. However, further analysis of the strength of the relatedness between products (i.e. the proximity value) is the highest in the agro-processing of non-food cluster followed by primary agriculture and the least within the agricultural input cluster.

This section has provided some stylized facts on the general structure of the agricultural product space and focused on inter-cluster relationships. The next section will specifically investigate the position of South Africa in the network and elaborate further on input-output linkages (i.e. intra-cluster relationships).

4.2 South Africa’s position

A country’s current position in the product space (i.e. its specialization) thus has important implications for its future economic diversification and transformation. In order to determine South Africa’s specialization (relative to the world) in specific products of the agro-complex, this study
applies the RTA index calculated for the period from 2009 to 2011 (see also Section 3.3). The level of specialization (or competitiveness) for each of the 1,456 products included in the agricultural product space is used to plot South Africa’s location in the agricultural product space. This will reflect the country’s current productive structure in the agro-complex of the product space. Products which are not traded by South Africa will not reveal any level of specialization. In order to provide a holistic picture of South Africa’s agricultural production, a demarcation into four levels of product specialization is made. These are:

i. RTA < 0: no revealed specialization in production (dependency on imports)
ii. 0 > RTA < 1: low revealed specialization in production
iii. RTA > 1: high revealed specialization in production (i.e. core competencies)
iv. RTA > 0: overall productive structure.

Figure 5 shows the location of South Africa in the agricultural product space for products for which the country has either a high or low level of specialization. In both panes of the figure, these products are marked in red. Furthermore, to illustrate the variety, some of these products and product groups are randomly highlighted in the figure. South Africa has a total of 70 products located in the agricultural product space in which it has developed a relatively high level of specialization (i.e. core competencies). This is proportionate to nine per cent of all products in the agricultural product space. Furthermore, 102 products in which South Africa has a high level of specialization are not included in the network. This is attributed to their relatively low level of relatedness with other products, reflected by proximity values of below 0.55. Hence, their set of capabilities and knowledge is comparatively unique, which makes the redeployment of these to “new” products relatively difficult.

The left pane in the figure shows that about half of the products with a high level of specialization are positioned in the sparser periphery of the agricultural product space. This implies a relatively lower potential for diversification than the products located in the denser and central parts of the network. For the production of these 70 products, South Africa has developed core competencies (i.e. capabilities and knowledge) which underpin its level of specialization in these products. These products comprise the best basis for diversification ventures as they have a set of well-developed, embedded productive capabilities.

The right pane of Figure 5 provides an overview of the positioning of the 156 products in the agricultural product space for which South Africa has a relatively low level of specialisation. This
represents 20 per cent of the total products included in the agricultural product space. It is evident from the graph that these products have more variety and are scattered throughout the network. Their potential for spurring further diversification opportunities is more limited as their embedded productive knowledge is less developed than the other group of products.

Table 3 shows a brief comparison between South Africa’s products with a high level and a low level of specialization within the agro-complex. It is evident from the table that South Africa will gain from improving the competencies of the products with low levels of specialization. The products in which South Africa has a relatively low level of specialization also present a relatively lower potential for being a starting point for diversification ventures in the agricultural product space. However, cognizance should be taken of these products as they will, in the process of developing competencies, also open up new opportunities in the agricultural product space. However, they should be regarded as a stimulus for “second round” diversification, after the diversification options stemming from the products in which South Africa has a high level of specialization are depleted.

Figure 3 already revealed the distribution of South Africa’s productive structure over the five clusters of the agro-complex. It became evident that it has relatively the most core competencies in primary agriculture; whereas its number of core competencies in the other clusters is remarkably lower. This pattern holds important information for South Africa’s diversification opportunities in the agro-complex. Firstly, a higher presence implies a higher variety of productive capabilities, which positively affects the number of likely linkages to “new” products. Secondly, a low presence implies a high level of unexploited potential, as the number of “new products” is relatively higher in those clusters. The structure of, and the location in, the agricultural product space ultimately determines which of these two options is more prevalent.

The connectedness between agricultural clusters in the product space reveals important information about input–output relationships. The respective inter- and intra-cluster relatedness of South Africa’s productive structure in the product space is shown in Table 3. This productive structure comprises the 70 products with a RTA >1 (i.e. the core competencies). The table shows that the amount of linkages within South Africa’s current productive structure of the agro-complex is relatively limited: a total of 72 linkages for 70 products. Furthermore, it is evident from the table that South Africa’s competencies within the agricultural product space are predominantly situated in the primary agriculture and agro-processing of food clusters. This corresponds with the country’s
overall productive structure which is presented in Figure 3. Compared to the cluster structure of the entire agricultural product space, South Africa’s position has proportionally less intra-cluster links stemming from primary agriculture. However, its intra-cluster linkages originating from the agro-processing of food and non-food are relatively higher than in the complete network. This thus implies relatively strong input–output relationships for those clusters in South Africa.

4.3 South Africa’s diversification opportunities

South Africa’s current productive structure determines its diversification pathways in the agricultural product space. These pathways develop over time as a country develops new capabilities by diversifying to new products. South Africa’s “first round” of diversification opportunities comprises moving into the production of new products that are currently linked with core competencies as its embedded productive capabilities have been fully developed. “Second round” diversification will have to originate from products with a relative low level of specialization as their productive capabilities still require further development.

To analyse how “far” a product is located from South Africa’s current productive structure, the measure of Distance (see Section 3.3) is calculated for each product in the agricultural product space. The value for Distance will be close to zero if South Africa produces most of the products connected to the product. On the other hand, the value for Distance will be equal to one if South Africa produced none of the products linked to the product.

The agricultural product space depicted in Figure 6 shows the Distance for all products in the agro-complex that South Africa is not currently producing. The products that are relatively nearby South Africa’s productive structure (marked in red) are coloured in green. More precisely, products with a Distance value of equal to or lower than 0.5 are coloured light green and products with a Distance value of between 0.5 and 1 are coloured dark green. All products that have no connection with South Africa’s current productive structure, thus which are relatively “far” are coloured grey.

The left pane in Figure 6 shows the diversification opportunities based on the core competencies of South Africa’s productive structure (i.e. products with A RTA > 1). These 70 products comprise nine per cent of the products located in the network. The figure shows that a total of 19 “new” products have a relatively short distance (<0.5) to South Africa’s core competencies. A further 23 “new” products have a slightly large distance (>0.5) and 18 products are already being produced at a low level of specialization. Hence, the total number of “novel” diversification opportunities
derived from the country’s core competencies amount to 60. This implies an opportunity ratio of 0.60 per product and 83 per cent of the network that initially remains unexploited.

The right pane in Figure 6 reveals the diversification opportunities derived from South Africa’s overall productive structure. This thus entails products in which the country has either a high or low level of specialization. These products comprise 29 per cent of the products located in the agricultural product space. The figure shows that 83 “new” products have a relatively short distance to South Africa’s total productive structure and a further 134 are located at a relatively larger distance. Hence, a total of 217 feasible diversification opportunities are derived from the country’s total product structure. This implies an opportunity ratio of 0.96 and only 43 per cent of the agricultural product space that initially remains unexploited.

The most attainable of South Africa’s diversification opportunities identified in the agricultural product space are shown in Table 4. These top 25 opportunities originate from the country’s core competencies and are so-called “low hanging fruits” in terms of transformation within the agro-complex. Most of the opportunities (14) are located in the agro-processing of food cluster followed by the primary agriculture (5). Not so surprising since South Africa’s core competencies are mainly concentrated in those clusters.

5. Conclusions and recommendations

The agricultural product space provides a good reflection of the level of relatedness and clustering within the agro-complex and provides a wide variety of potential diversification pathways. Although a number of products with little prospects for diversification were excluded, the remaining products represent a significant proportion of global trade. Section 4 provided some interesting stylized facts of the agricultural product space in a global context. Hence, the position of a country in the network will indicate more detailed perspectives for transformation. The relative low interconnectedness of the network implies a relative low level of relatedness within the agro-complex. This heterogeneity is not surprising due to the large variety of products within the agro-complex; each embedding its unique set of capabilities. However, it does limit the amount of diversification pathways in the network. Nevertheless, at cluster level some good potential for horizontal diversification was revealed. Furthermore, a significant number of network communities with a high degree of relatedness were also identified. Vertical linkages in terms of input-output relationships have great potential for increasing local value adding; an important directive in
economic development. Hence, the remarkable large number of intra-cluster linkages in the agricultural product space is a conducing condition.

About half of South Africa’s products with a high level of specialization are positioned in the sparser periphery of the agricultural product space, which seems cumbersome for diversification as the number of diversification pathways is generally more limited in those areas. However, the starting point of diversification also has important implications for successful diversification. It is envisaged that diversification ventures stemming from the country’s core competencies are more likely to succeed. Those specific embedded capabilities and knowledge are well-developed which makes the transfer to “new” and related products relatively easier. Cognizance should also be taken of the products in which South Africa currently has a low level of specialization as they will, in the process of developing competencies, also open up new opportunities in the agricultural product space. However, they should be regarded as a stimulus for “second round” diversification after the diversification options of core competencies have been depleted.

It became evident that not all of South Africa’s core competencies are located in the agricultural product space due to the fact that they don’t show a sufficient degree of relatedness with other products in the agro-complex. The relative high presence of core competencies from primary agriculture and agro-processing of food implies less unexploited potential but a relative easier transfer of capabilities to new products. The opposite is the case for the other three clusters.

South Africa’s current level of input-output relationships of its core competencies in the agricultural product space is relatively limited, compared to the total number of these linkages identified in the entire network. However, this thus provides ample opportunities to expand these and spur local value adding.

As evident from the visualization of South Africa’s position in the agricultural product space, it was estimated that the location of the country’s core competencies is predominantly in the less connected sparser parts of the network. However, there are a number of exceptions. Rich countries tend to be specialized in the denser parts of the product space. Hence, it is evident that South Africa has to reach some convergence in this relationship by diversifying to new products with a higher degree of centrality.

The overall number of identified diversification opportunities from both the core competencies (60) and the overall product structure seems sound as it amounts up to 217 products. For the country’s
core competencies an average diversification opportunity ratio of 0.60 per product was revealed. Furthermore, 83 per cent of the product space network that remains initially unexploited. Realising all diversification opportunities stemming from the overall productive would potentially leave 43 per cent of the agricultural product space unexplored.

In this study it is argued by this study that the private sector should take the lead in exploiting diversification opportunities within the agro-complex. Economic growth and development will predominantly have to come from simply selling and producing more products. Although crucial for socio-economic development, structural transformation and employment creation are secondary imperatives that will not take place without the former.

Given the above, the main question that arises from the outcomes of this study is why South African firms have not already exploited the identified diversification opportunities with favorable demand conditions. Cirera, Marin and Markwald (2012) have analyzed the patterns of firm-level diversification in Brazil. They confirm that firms tend to diversify to related products but that diminishing first-mover advantages and market failures (i.e. uncertainties) are the main constraints. Hence, business risks for South African firms have likely been too high to justify the pursuance of these existing diversification opportunities. Hence, a concerted effort between public- and private sector is needed to overcome these risks and enable “jumps” to the identified new products within the agricultural product space.
Figures

Figure 1: Long-term trend in production within South Africa’s agro-complex (1971 – 2013)
Source: Authors’ own calculations based on data from Quantec (2014)

Figure 2: Trend in exports from South Africa’s agro-complex
Note: the export value is plotted on the secondary vertical axis
Source: Authors’ own calculations based on data from UN Comtrade (2014)
Figure 3: Characteristics of South Africa’s core competencies in the agro-complex

Note: bubble size proportional to the total product-spectrum in each cluster

Source: Authors’ own calculations (2014)
Figure 4: The agricultural product space (2007 – 2011)

Source: Authors’ own calculations (2014) using NodeXL
Figure 5: South Africa’s productive structure in the agricultural product space (2007 – 2011)
Source: Authors’ own calculations (2014) using NodeXL

Figure 6: South Africa’s diversification opportunities in the agricultural product space
Source: Authors’ own calculations (2014) using NodeXL
### Tables

#### Table 1: Network characteristics of the five clusters of the agro-complex

<table>
<thead>
<tr>
<th></th>
<th>Primary agriculture</th>
<th>Agro-processing: food</th>
<th>Agro-processing: non-food</th>
<th>Forestry</th>
<th>Agricultural inputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total products in cluster</td>
<td>221</td>
<td>522</td>
<td>413</td>
<td>222</td>
<td>78</td>
</tr>
<tr>
<td>Products present in the product space</td>
<td>87</td>
<td>245</td>
<td>285</td>
<td>110</td>
<td>45</td>
</tr>
<tr>
<td>Share of total products in cluster</td>
<td>39%</td>
<td>47%</td>
<td>69%</td>
<td>50%</td>
<td>58%</td>
</tr>
<tr>
<td>Share in product space</td>
<td>11%</td>
<td>32%</td>
<td>37%</td>
<td>14%</td>
<td>6%</td>
</tr>
<tr>
<td>Links within cluster</td>
<td>50</td>
<td>298</td>
<td>1103</td>
<td>155</td>
<td>60</td>
</tr>
<tr>
<td>Connected components</td>
<td>48</td>
<td>59</td>
<td>22</td>
<td>16</td>
<td>14</td>
</tr>
<tr>
<td>Maximum products in a connected component</td>
<td>7</td>
<td>110</td>
<td>239</td>
<td>75</td>
<td>24</td>
</tr>
<tr>
<td>Density of cluster</td>
<td>0.013</td>
<td>0.010</td>
<td>0.027</td>
<td>0.026</td>
<td>0.0061</td>
</tr>
</tbody>
</table>

Source: Authors’ own calculations (2014)

#### Table 2: Overview of South Africa’s productive structure in the agricultural product space

<table>
<thead>
<tr>
<th></th>
<th>High level of specialization</th>
<th>Low level of specialization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total products in agricultural product space</td>
<td>70</td>
<td>156</td>
</tr>
<tr>
<td>Share in global agricultural trade (2009 – 2011)</td>
<td>6.6%</td>
<td>13.4%</td>
</tr>
<tr>
<td>Average number of linkages in the agricultural product space</td>
<td>1.8</td>
<td>3.2</td>
</tr>
<tr>
<td>Average centrality</td>
<td>0.0014</td>
<td>0.0024</td>
</tr>
</tbody>
</table>

Source: Authors’ own calculations (2014)

#### Table 3: South Africa’s inter- and intra-cluster relationships in the product space

<table>
<thead>
<tr>
<th></th>
<th>Agricultural inputs</th>
<th>Primary agriculture</th>
<th>Agro-processing: food</th>
<th>Agro-processing: non-food</th>
<th>Forestry</th>
</tr>
</thead>
<tbody>
<tr>
<td>SA’s core competencies</td>
<td>3</td>
<td>22</td>
<td>25</td>
<td>13</td>
<td>7</td>
</tr>
<tr>
<td>Agricultural inputs</td>
<td>NA</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Primary Agriculture</td>
<td>NA</td>
<td>74%</td>
<td>40%</td>
<td>17%</td>
<td>0%</td>
</tr>
<tr>
<td>Agro-processing: food</td>
<td>NA</td>
<td>21%</td>
<td>50%</td>
<td>17%</td>
<td>0%</td>
</tr>
<tr>
<td>Agro-processing: non-food</td>
<td>NA</td>
<td>5%</td>
<td>10%</td>
<td>67%</td>
<td>0%</td>
</tr>
<tr>
<td>Forestry</td>
<td>NA</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>Total intra-cluster links in PS</td>
<td>0</td>
<td>10</td>
<td>10</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Total links on PS</td>
<td>0</td>
<td>38</td>
<td>20</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>Intra-cluster links / total links in product space</td>
<td>NA</td>
<td>26%</td>
<td>50%</td>
<td>33%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Source: Authors’ own calculations (2014)
<table>
<thead>
<tr>
<th>HS Code</th>
<th>Product</th>
<th>Agro-complex cluster</th>
<th>Distance value</th>
</tr>
</thead>
<tbody>
<tr>
<td>30410</td>
<td>Fish fillets &amp; oth. fish meat, whether or not minced (excl. of 03.02), f...</td>
<td>Agro-processing: food</td>
<td>0.00</td>
</tr>
<tr>
<td>30490</td>
<td>Fish meat other than fillets, frozen</td>
<td>Agro-processing: food</td>
<td>0.00</td>
</tr>
<tr>
<td>50800</td>
<td>Coral &amp; sim. mats.; shells of molluscs/crustaceans/echinoderms &amp; cuttle-bon ...</td>
<td>Agro-processing: non-food</td>
<td>0.00</td>
</tr>
<tr>
<td>81010</td>
<td>Strawberries, fresh</td>
<td>Primary agriculture</td>
<td>0.00</td>
</tr>
<tr>
<td>81190</td>
<td>Fruit &amp; nuts, n.e.s., uncooked/cooked by steaming/boiling in water, frozen, ...</td>
<td>Agro-processing: food</td>
<td>0.00</td>
</tr>
<tr>
<td>90111</td>
<td>Coffee, not roasted, not decaffeinated</td>
<td>Agro-processing: food</td>
<td>0.00</td>
</tr>
<tr>
<td>120600</td>
<td>Sunflower seeds, whether or not broken</td>
<td>Primary agriculture</td>
<td>0.00</td>
</tr>
<tr>
<td>160411</td>
<td>Salmon, prepd./presvd., whole/in pieces (excl. minced)</td>
<td>Agro-processing: food</td>
<td>0.00</td>
</tr>
<tr>
<td>170310</td>
<td>Cane molasses</td>
<td>Agro-processing: food</td>
<td>0.00</td>
</tr>
<tr>
<td>200110</td>
<td>Cucumbers &amp; gherkins, prepd./presvd. by vinegar/acetic acid</td>
<td>Agro-processing: food</td>
<td>0.00</td>
</tr>
<tr>
<td>200911</td>
<td>Orange juice, frozen, unfermented &amp; not cont. added spirit, whether or not ...</td>
<td>Agro-processing: food</td>
<td>0.00</td>
</tr>
<tr>
<td>210111</td>
<td>Extracts, essences &amp; concs. of coffee</td>
<td>Agro-processing: food</td>
<td>0.00</td>
</tr>
<tr>
<td>230230</td>
<td>Bran, sharps &amp; oth. residues, whether or not in the form of pellets, derive ...</td>
<td>Agro-processing: food</td>
<td>0.00</td>
</tr>
<tr>
<td>230800</td>
<td>Vegetable mats./waste/residues/by-prods., whether or not in pellets, of a k ...</td>
<td>Agro-processing: food</td>
<td>0.00</td>
</tr>
<tr>
<td>310560</td>
<td>Mineral/chem. fertilisers cont. the 2 fertilising elements phosphorus &amp; pot ...</td>
<td>Agricultural inputs</td>
<td>0.00</td>
</tr>
<tr>
<td>320300</td>
<td>Colouring matter of veg./animal origin (incl. dyeing extracts. excl. animal ...)</td>
<td>Agro-processing: non-food</td>
<td>0.00</td>
</tr>
<tr>
<td>430160</td>
<td>Raw furskins, of fox, whole, with/without head/tail/paws</td>
<td>Agro-processing: non-food</td>
<td>0.00</td>
</tr>
<tr>
<td>450110</td>
<td>Natural cork, raw/simply prepd.</td>
<td>Forestry</td>
<td>0.00</td>
</tr>
<tr>
<td>470421</td>
<td>Chemical wood pulp, sulphite, other than dissolving grades, semi-bleached/b ...</td>
<td>Forestry</td>
<td>0.00</td>
</tr>
<tr>
<td>510129</td>
<td>Wool, not carded/combed, degreased, not carbonised, other than shorn</td>
<td>Primary agriculture</td>
<td>0.00</td>
</tr>
<tr>
<td>80920</td>
<td>Cherries, fresh</td>
<td>Primary agriculture</td>
<td>0.28</td>
</tr>
<tr>
<td>30379</td>
<td>Fish, n.e.s., frozen (excl. fillets/oth. fish meat of 03.04/livers &amp; roes)</td>
<td>Agro-processing: food</td>
<td>0.34</td>
</tr>
<tr>
<td>30342</td>
<td>Yellowfin tunas (Thunnus albacares), frozen (excl. fillets/oth. fish meat o ...</td>
<td>Agro-processing: food</td>
<td>0.46</td>
</tr>
<tr>
<td>81320</td>
<td>Prunes, dried</td>
<td>Agro-processing: food</td>
<td>0.50</td>
</tr>
<tr>
<td>91020</td>
<td>Saffron</td>
<td>Primary agriculture</td>
<td>0.50</td>
</tr>
</tbody>
</table>

*Source: Authors’ own calculations (2014)*
References


