

CHAPTER 4

METHODOLOGICAL FRAMEWORK

Product space, structural transformation,
market opportunities and employment
creation

physical capital value_p = (1 - d_{pp})(1 - M_{cp}) normalised RPCI_p

$$\phi_{pp} = \frac{\sum_c M_{cp} M_{cp}}{\max(\sum_c M_{cp} | \sum_c M_{cp})} \quad RCA_p = \frac{\frac{X_p}{\sum X_p}}{\frac{\sum_p X_p}{\sum_p X_p}}$$

$$PCI_{pc} = \frac{k_{p \rightarrow n} - \bar{k}_{p \rightarrow n}}{\text{stdev} k_{p \rightarrow n}}$$

$$RMA_{cp} = \frac{\frac{I_p}{\sum I_p}}{\frac{\sum_p I_{cp}}{\sum_p I_{cp}}} \quad D_{cp} = \frac{\sum_p (1 - M_{cp}) \phi_{pp}}{\sum_p \phi_{pp}}$$

employment value_p = (1 - d_{pp})(1 - M_c) normalised LI_p



4.1 INTRODUCTION

South Africa's growth path in the agro-complex along the lines of market-driven diversification (i.e. market potential), structural transformation (i.e. upgrading) and employment creation will be determined on the basis of the country's agricultural product space. Hence, this fourth chapter will firstly provide the methodological framework for this product space in order to analyse the productive structure of the agricultural sector. Secondly, this chapter will provide a framework for analysing structural transformation (i.e. upgrade-driven diversification) in the product space. Furthermore, it will lay out the methodologies for identifying realistic opportunities for import substitution and exports in order to provide a market-driven foundation for diversification. The final section will focus on estimating the employment impacts of diversification pathways.

4.2 THE AGRICULTURAL PRODUCT SPACE

This study will construct a product space specifically for the agro-complex, where previous applications have applied the concept for the broader economy. The product space has already been briefly discussed in Sections 1.1.4. For instance, Section 1.1.4 introduced the product space as a network structure that reflects the productive structure of a nation by connecting products with similar capabilities. However, this section will elaborate further on the theoretical background, previous studies, the empirical framework, and the data used.

4.2.1 *Concepts and theoretical background*

Section 2.2.3 introduced the work by Hausmann and Klinger (2007) dealing with the concept that the production and supply of a good needs a unique set of different capabilities. Apart from factors of production (e.g. natural resources, labour and capital), these capabilities entail a wide range of aspects such as human capital, institutions, infrastructure, knowledge, supply chains, education, regulations, and technology. 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. 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. Apart from countries, Lien and Klein (2010) found that a similar diversification process is applicable at firm-level.

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.

Hidalgo *et al.* (2007) note that the patterns of specialisation of nations have previously been explained by three approaches. Firstly, by the Heckscher-Ohlin theory which stipulates that the relative proportion between factors of production (e.g. capital, labour, land, skills, infrastructure and institutions) explains why poor countries produce goods intensive in unskilled labour, and why land-rich countries produce goods that are skill- and capital-intensive. Secondly, by Romer (1986) who explained these specialisation patterns by technological differences between countries. Thirdly, by the quality ladder model of Grossman and Helpman (1991b), which assumes that there are always more advanced products that a country can move to for structural transformation.

The theory of Hausmann *et al.* (2005) analysed, for the first time, economic growth explicitly from the perspective of actual goods produced. This resourced-based approach of diversification and growth, based on related resources and capabilities, was further conceptualised 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 visualisation, the so-called "Product Space". The empirical framework of this proximity value will be presented later in Section 4.2.3. 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, social, 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.

Economic growth in the product space occurs through structural transformation by diversifying towards more sophisticated or complex products. This notion of what you exports matters for growth is thus aligned with the earlier work by Hirschman (1958) and as later empirically conceptualised by Hausmann *et al.* (2005). Section 3.7.2 has already shown the empirics of this concept for South Africa's agricultural sector.

The process of growth in the product space thus implies moving from a "poorer" part in the network to "richer" parts of the network. This movement requires a redeployment of existing capabilities, as well acquiring new ones, to goods that are different from those currently produced. Growth theories have traditionally assumed that there is always such a "new" product available, hence the structure of the product network is homogenous and unimportant. However, the product space assumes that this productive structure is heterogeneous with denser and sparser areas in which a country's orientation towards "new products" is of great importance for economic development (see also Hausmann and Klinger, 2007).

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 labour, 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.

Disaggregated product-level data on these aspects of similarity is not available and therefore an outcome-based approach is used to estimate the proximity between products



in the product space. This approach rests on the assumption that related products are more likely to be produced together, whereas products that are not similar are less likely to be produced together. Similar to the example of oranges and lemons used in Section 1.1.4, a country that has the ability to produce apples is likely able to produce pears, as these products require similar production capabilities, such as soil, climate, cold chains, agronomists, packing technologies, and inspection services. Thus, in a global context, the proximity of these products is likely to be high, whereas the proximity between apples and aircraft fuel is likely to be low or non-existent.

Hidalgo *et al.* (2007) developed a product space network based on the 775 products of the four-digit level of the Standardised International Trade Classification (SITC). Links with proximity of below 0.55 were eliminated, leaving a total of 1 525 product linkages, as depicted in Figure 4.1 below. From the figure it is evident that their product space network has a core-periphery lay out, with the core consisting of metal, machinery and chemical products, and a periphery with clusters of textile and electronic products, as well as agricultural products and natural resources in the less dense parts of the network.

Hidalgo *et al.* (2007) furthermore plotted the position of four different geographical regions in the product space. How these positions are empirically determined will be presented later in Section 4.2.3. The results show that the industrialised countries occupy the core of the product space, composed of machinery, metals and chemical products and their participation in peripheral products, such as textiles, animal and forest products, is also high. The East Asian countries are predominantly located in the electronic, garments and textile clusters of the product space, whereas Latin American countries are located further out in the periphery, with mining, agricultural and garment products. Sub-Saharan Africa has a relatively small presence in the product space, and mostly in the periphery.

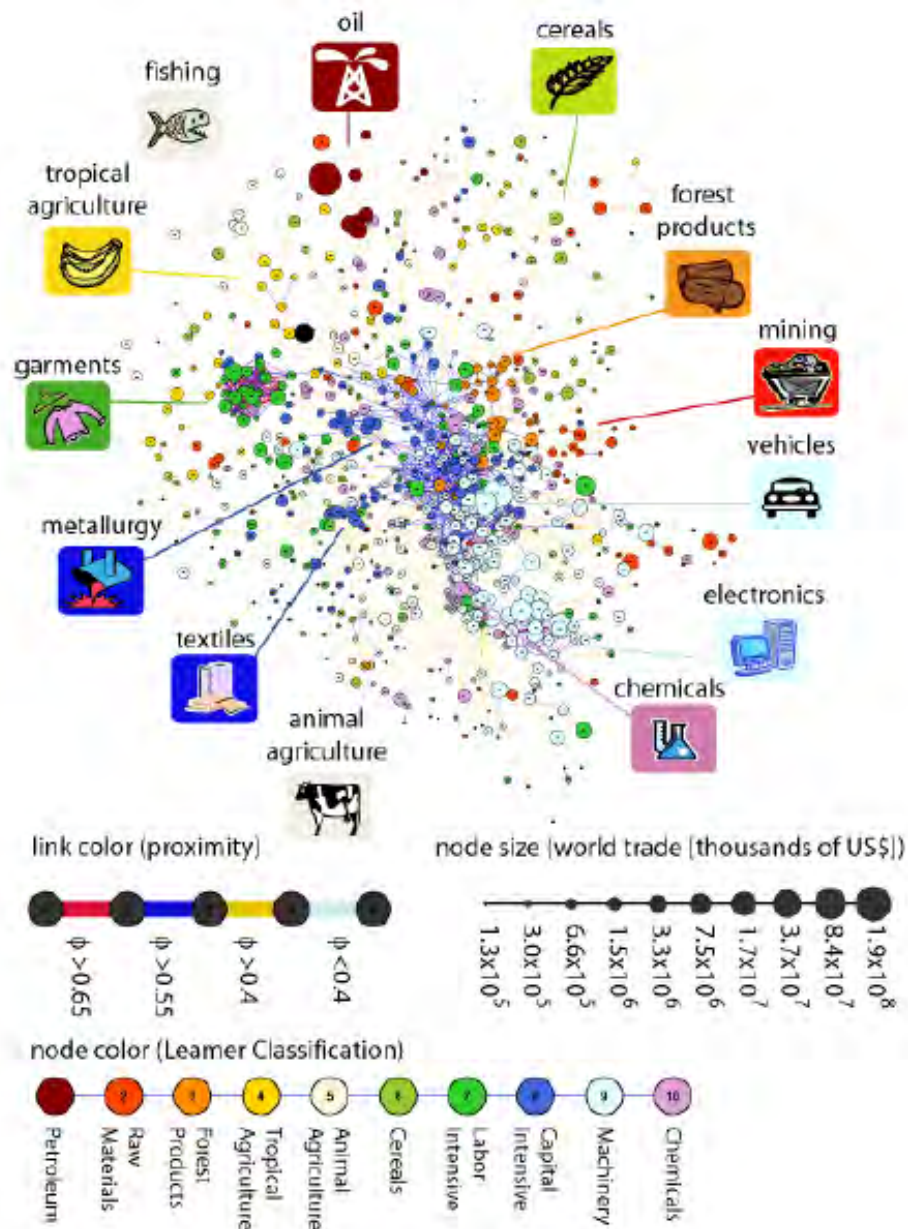


Figure 4.1: The product space network

Source: Hidalgo et al. (2007)

Hidalgo et al. (2007) also examine whether the product space structure changes over time by analysing the correlation between the relatedness of products (e.g. proximity values) for the years 1985, 1990, and 1998 – 2000. The outcomes showed that the product space appears to be stable over time. Hidalgo (2009) further explored the dynamics of time-robustness and evolution of the product space for the periods 1964 – 1966, 1974 – 1976, 1984 – 1986, 1994 – 1996, and 2003 – 2005. He found that the network remained relatively stable during this 42-year period, with the confirmation of three notable industrial trends.



Firstly, machinery products remain located in the more densely connected parts of the network. In contrast, oil and agricultural products are consistently located in the less connected periphery of the product space. Secondly, the development of the electronic sector is reflected by a shift from the periphery to a well-connected cluster in the core of the product space in the period between the 1980s and 2000s. Thirdly, the garment sector moved out of the core of the product space network in the period under investigation owing to structural transformation in East Asia by diversifying into other sectors.

Furthermore, Hidalgo *et al.* (2007) tested the assumption that countries diversified to nearby products in their product space for the period 1990 to 1995 in several ways and show that this assumption holds. This diversification pattern in the product space is also underpinned by Hausmann and Klinger (2007) who investigated this for the period 1975 to 2000.

Hidalgo *et al.* (2007) also found that the pace with which a country can diffuse through the product space by diversification largely depends on the connectedness of its current position in the product space and this pace decreases as the degree of relatedness between products (i.e. proximity) becomes higher. The latter has to do with the fact that the number of connections in the product space which have a relatively high degree of relatedness are fewer (see Section 4.2.3 for a further explanation of the calculation of proximity). Hausmann and Klinger (2006a) show that the closeness of more complex and sophisticated products, relative to a country's current location in the product space, greatly determines the pace and potential of structural transformation of that country. Furthermore, Hausmann and Klinger (2007) argue that the flexibility with which a country redeploys its capabilities from product to product also plays an important role in the rate of economic development.

The study by Hidalgo *et al.* (2007) concludes by analysing the structural transformation process by applying the metrics on sophistication developed by Hausmann *et al.* (2005) to the product space network. This analysis confirms that not all countries have equal opportunities for economic development. The poorer countries, which are predominantly located in the periphery of the product space, especially need to make large and difficult leaps in order to move to new and more sophisticated products. However, these "large



jumps” are essential for structural transformation and, hence, policies in these countries should support these jumps, rather than focusing on “dead ends” in the product space.

Although the measure of proximity is descriptive and outcome based, Hausmann and Klinger (2007) showed that it captures the underlying relationships of factor endowments and technology. They note, however, that these two dimensions are only part of the explanation, as they found that proximity is highly significant in predicting the paths of structural transformation, even after controlling for country and product characteristics.

Some studies have extended the work of the product space. Ferrarini and Scaramozzino (2011) discussed different measure for comparative advantage in order to consider net-trade flows. They furthermore incorporate vertical integration into the analysis. Kali, McGee, Reyes and Shirell (2009) investigated the relationship between small-world characteristics of the product space network and the growth-acceleration of countries.

In this study the product space network will form the basis for the analysis of South Africa’s agricultural growth path. As mentioned in Section 3.10, this pathway will be channelled along three dimensions, namely market-driven diversification (i.e. market potential), upgrading (i.e. structural transformation), and employment creation. The next section discusses earlier studies on the application of the product space methodology.

4.2.2 Earlier applications of the product space

Although the product space methodology and its theoretical foundation is relatively new, a number of authors have applied this analytical tool over the last few years. There are only two previous studies that have analysed the implications of the product space for South Africa.

Hausmann and Klinger (2006b) investigated South Africa’s export performance over the past 25 years and found that the stagnant growth in per capita exports was mainly caused by the sluggish structural transformation. Using the four-digit SITC classification as basis for their product space, they plotted the evolution of South Africa’s productive structure from 1975



to 2000. Accordingly, the study failed to look at the deeper connectedness of products that could be revealed using the six-digit HS classification of products. Nevertheless, this analysis showed that South Africa's production was predominantly positioned in the periphery, with some movements into manufacturing and steel in the 1990s, but the country showed no significant signs of structural transformation into new products and performed poorly compared to other emerging economies.

The study by Hausmann and Klinger (2006b) also briefly touched on the potential role of agriculture in South Africa's growth. It acknowledged the resource limitations of the sector that was also discussed in Section 3.2 of this study, but overlooked the production potential of agricultural land, as has since been determined in the National Development Plan (NPC, 2011) and BFAP (2011), as discussed in Section 3.9. The study further argued that the agricultural sector cannot provide the full answer to South Africa's employment and growth challenges but that it has an important role to play. Hausmann and Klinger (2006b) show that this role can be further enhanced by improving the output per worker, as well as the number of workers per hectare in the sector, as South Africa performs comparatively moderately in these aspects. The local resource limitations for agricultural production pose opportunities for agricultural innovation, as seen in Egypt, Peru and Israel, they argue. The study concludes by stating that attracting greenfield foreign investments may be the key in spurring structural transformation in South Africa.

The second study that uses the product space for its analysis of South Africa's economic growth was conducted by Dube, Hausmann and Rodrik (2007). They note that South Africa's export performance has been dismal, as its real exports per capita was at the same level in 2007 as in 1960. Against this background, the study analyses why South Africa could not maintain its economic dynamism and to move quickly into new sectors. Although the study acknowledges that some new sectors have emerged over time, these could not compensate for the decline in gold mining. Hence, the study analyses the historical evolution of South Africa in the product space since 1975, as well as some associated metrics, to conclude that the pace of structural transformation is slow owing to the country's poor positioning in the network. This is the result of the country's resource-based production structure, which is



not well-connected to other products in the product space, and which is attributable to its unique set of capabilities and its location in the periphery of the network.

Hidalgo (2011) used the product space at HS6 level, for the first time, to study the productive structures and potential of Kenya, Mozambique, Rwanda, Tanzania, and Zambia. The respective productive structures of each country in the network are examined both from the Revealed Comparative Advantage (RCA) view and an export value view. The former is used to measure how good a country is in producing a good and the latter measures the concentration of exports. The countries are all characterised by having products of a relatively low sophistication and which are located in the periphery of the product space. A third view of the product space, namely the opportunity view, introduces and shows how close or far new products are located from its current productive structure. Hidalgo (2011) found that most opportunities for diversification in the product space were located in the agricultural sector. The study also simulated the effects of economic integration of the five countries by combining the productive structures in the product space. This revealed a number of complementarities between the countries, with most opportunities in the agricultural, food, textile and garment sectors. The study concludes that these opportunities for diversification can only be capitalised by implementing institutional incentives that help hedge the risk of developing new agricultural products.

A study by Abdon and Felipe (2011) uses the product space to map the evolution of the productive structure of Sub-Saharan Africa (SSA) and to identify the opportunities for growth and diversification in Ethiopia, Mozambique, Nigeria and Senegal. They calculated these opportunities by estimating the closest products in their product space with the highest level of sophistication via the measure of PRODY, which was discussed in Section 3.7.2.

The study uses the less disaggregated product space at the four-digit level of the SITC and plots the evolution productive structure of the SSA countries in three subgroups according to their endowment and location for the period from 1962 to 2007. They found that the productive structure of the resource-rich countries in SSA had barely changed in the last 45 years and that these countries remain the exporters of very few products. The land-locked



countries in SSA managed to diversify to new products in the periphery of the product space, but did not succeed in diversifying into the well-connected products in the core. The coastal countries in SSA showed the most progress in diversifying into new products, particularly the garment sector. Compared to the evolution of the positioning in the product space of East Asia, South Asia and Latin America, SSA (unsurprisingly) performed relatively poorly. The study argues that those remarkable evolutions in East Asia, South Asia and Latin America were partly policy and partly market driven.

Abdon and Felipe (2011) argue further that, owing to the high “standardness” of the products produced in SSA, meaning that the products are exported by many other countries and use similar capabilities, the sophistication or complexity of their export baskets is low. Up to the early 1980s the level of export sophistication in SSA was similar to that of East Asia but began to diverge thereafter. The majority of SSA countries are classified as countries in a “low-product trap” and South Africa is categorised as being in a “mid-product trap” according to the respective level of product sophistication. Getting out of this trap is not an easy challenge and involves information and coordination of externalities, argue Abdon and Felipe (2011).

The product space model was used in the development of a national export strategy for Malawi (Ministry of Industry and Trade, Malawi, 2012). The strategy applies the product space to identify economic clusters for prioritisation. Outside Africa, the product space has also been applied to analyse the diversification opportunities in the Philippines (Bayudan-Dacuycuy, 2012) and in Latvia (Vītola and Dāvidsons, 2008). For Turkey, the product space was used to develop a regional based export promotion strategy (Caglar, 2011). Cirera *et al.* (2012) investigated the firm behaviour and the introduction of new exports in Brazil and analysed the proximity value between products as a determinant of firm-level diversification. They found that most diversification took place in related activities (see Section 2.5.4 for a more in-depth discussion of this study). A study by Huberty and Zachmann (2011) applied the product space to analyse the positioning and linkages of green products in order to inform the EU’s industrial policy on these goods.



Only one major study has applied the product space approach specifically to the agricultural sector. Ulinwenga and Badibanga (2012) analysed the long-term structural transformation of the aggregated African agricultural sector for the period 1962 to 2008 by using the product space in the less-detailed SITC classification. They found that the structural transformation in Africa is mainly driven by non-agricultural products and that transformation in African agriculture is moving more slowly and less balanced than that in Brazil.

4.2.3 *Limitations and extensions of the methodology*

One of the mayor drawbacks of the product space methodology is that a number of products may be excluded from the network due to their limited relatedness with other products. A threshold is applied to include only those products in the network that have a relative high degree of relatedness with at least one product. Therefore, some products in which a country has specialised do not feature within the product space as they do not embed much scope for the transfer of capabilities to “new” production ventures. Furthermore, some of the “non-connected” products which are currently not produced by a country may still have high potential for exports and increasing the economic complexity.

Another, although rather small, limitation of the methodology is the risk of irrelevant product relatedness within the product space network. The relatedness of products is calculated by the pairwise probability that a country exports a product given that it also exports another product (see also section 4.2.4). This may accidentally result in connections for which the direct horizontal or vertical productive relationship between products is not evident. If applicable, this study flags the product connections as either direct or indirect.

The transfer of productive capabilities between related products is seen as the basis for diversification pathways within the product space network. It is assumed that these capabilities can be accumulated and/or developed in order to be redeployed for “new” products. However, especially within the context of primary agriculture the factors of production such as suitable land may be limited. Within the context of this study it is



therefore assumed that these limitations can only be overcome through innovation and intensification of primary agricultural production.

Since only detailed trade data and no detailed production data is available for a large range of countries the methodology assumes that if a country has a comparative advantage in exporting a product it is able to competitively produce that product. This overlooks the occurrence of inward-orientated countries that competitively produce two related products for its domestic market. Since the conditional probability of competitively exporting a product in tandem is calculated for a large set of countries it is unlikely that those few instances of competitive local supply will significantly impact the likelihood of relatedness.

The positioning of countries in the product space network is conventionally done on the basis of their respective comparative advantage in exports. As the methodology analyses a country's prospects for diversification and transformation based on its productive structure the measurement of the latter should not only be based on its specialisation in exports. This level of specialisation can be biased by re-exports. For example, the Netherlands' specialisation in the exports of mangoes is not due to the fact that it is a competitive producer but rather a competitive trade hub of re-exportation of imported mangoes produced elsewhere. Therefore, an important extension of the product space methodology in this study is that a country's productive core competencies are captured by a more inclusive measure which will be discussed in the next section.

It is evident from the previous section (4.2.2) that all of the previous studies analysed the evolution of the productive structure and structural transformation of different countries and regions over time, or identified diversification opportunities, based on proximity and the level of sophistication. Both the South African studies apply the product space in a broad sense in order to study the structural evolution of the entire productive structure of the country.

The analysis in this study departs from the point that the agro-complex (as defined in Section 3.4) has an important role to play in spurring South Africa's economic growth. The study will thus further "zoom into" the meso-level of the product space and analyse the



agricultural sector at a rather detailed level. This will mostly be done from the perspective of the five broad clusters within the agro-complex but occasionally also at product-level.

No other study has yet specifically focused on the role of the agro-complex in economic development from a product space perspective. Furthermore, this study examines the potential for the country's transformation in the agro-complex by analysing opportunities for upgrading production, import substitution, identifying realistic export opportunities (informed by a Decision Support Model, "DSM"), and by analysing prospects for employment creation. The next section will firstly lay down the empirical framework for the agricultural product space.

4.2.4 Empirical framework of 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. This probability is calculated for all countries for which trade data is available (Hausmann and Klinger, 2007).

The proximity measure used for 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).

$$\text{Min } [P\{A|B\}, P\{B|A\}] \quad (1)$$

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.

$$RCA_{cp} = \frac{\frac{X_{cp}}{\sum_c X_{cp}}}{\frac{\sum_p X_{cp}}{\sum_{c,p} X_{cp}}} \quad (2)$$

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 Yildirim, 2011):

$$M_{cp} = \left\{ \begin{array}{l} 1 \text{ if } RCA_{cp} \geq 1 \text{ in } 3 - 5 \text{ yrs;} \\ 0 \text{ otherwise} \end{array} \right\} \quad (3)$$

This matrix thus summarises which country makes what. 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):

$$\Phi_{pp'} = \frac{\sum_c M_{cp} M_{cp'}}{\max(\sum_c M_{cp} \mid \sum_c M_{cp'})} \quad (4)$$



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 visualisation 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 visualisation and analysis of complex networks.

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. The analysis in Section 3.6.2 clearly showed that a significant amount of South Africa's agricultural exports have a negative trade balance. This reveals a significant amount of re-exports and a low a level of domestic content of some of the agricultural export products. 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 (see also Section 3.5.3) 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:

$$RTA_{cp} = RCA_{cp} - RMA_{cp} \quad (5)$$

The RMA_{cp} is the Revealed Comparative Import Advantage, the counterpart of the *RCA*, and is expressed as follows:

$$RMA_{cp} = \frac{\frac{I_{cp}}{\sum_c I_{cp}}}{\frac{\sum_p I_{cp}}{\sum_{c,p} I_{cp}}} \quad (6)$$

Where I is the import of product p by country c

4.2.5 Related concepts of the product space

A number of empirical concepts related to analysing the product space have been developed. Two of the more basic concepts will be discussed here and some of the more advanced ones will be discussed later in Section 4.3.

In order to explore what products are located in the dense parts of the product space and which are located in the sparser parts, Hausmann and Klinger (2007) developed a measure of *centrality*. This measure is calculated using the proximity matrix. The centrality of product p in time t is defined as:

$$Centrality_{pt} = \frac{\sum_j \phi_{ppjt}}{J} \quad (7)$$

Where J is the maximum possible number of distance-weighted related products. This measure can be used to identify a country's product clustering in the product space. The higher the value, the more centrally (i.e. in the denser parts) is the product located in the product space.



The probability of a country producing a particular “new” product in the future depends on that product’s proximity to its current production structure. 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 mix of exports (i.e. 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:

$$D_{cp'} = \frac{\sum_{p'} (1 - M_{cp'}) \phi_{pp'}}{\sum_{p'} \phi_{pp'}} \quad (8)$$

Hausmann and Klinger (2006a) show that this measure is a highly significant predictor of shifts in a country’s productive structure in the product space. This move towards “new” products that are located close to a country’s productive structure may or may not have strategic value. Hence, these “new” products may be located in a sparse area of the product space or they may be so highly related to existing products that it does not necessitate the development or acquisition of new capabilities. Therefore, these potential moves of diversifying into “new” products need to be further assessed based on their strategic value. This value can be related to a high market potential, higher labour intensity, or a higher rate of product complexity. How this can be done will be discussed later in Sections 4.3 to 4.5.

4.2.6 Data

This study specifically analyses the development pathways at the level of the broad-defined agro-complex. Hence, the scope of the data used for the calculations of the product space network will be similar to the trade statistics used for the analysis in Chapter 3. An overview of the 1 456 products included in the analysis, as well as the classification of the five agricultural product clusters (primary agriculture, agro-processing: food, agro-processing: non-food, forestry, and agricultural inputs), is provided in Data Supplement I. These



products are also further categorised into 391 agricultural product groups according to their affiliation to the four-digit level of the Harmonised System (HS) nomenclature.

The calculations for the proximity matrix and the product space will thus be based on product-level data at the six-digit level of the 2002 version of the HS nomenclature. The export and import data are sourced from the UN Comtrade database via the interface of the World Integrated Trade Solutions (WITS).

In order to mute short-term fluctuations in agricultural trade patterns, the proximity matrix will be made time-consistent by using data from the period from 2006 to 2011 as a basis (also see Equation 3). It is generally assumed that statistical data from importers is more accurate than statistical data from exporters (Feenstra, Lipsey, Deng, Ma and Mo, 2005). Hence, the dataset build for the product space in this study uses mirror export data as reported by importers. This approach has resulted in a dataset with export statistics for a total of 121 countries.

4.3 STRUCTURAL TRANSFORMATION

As previously discussed in sections 2.2.3 and 3.7.2, what you export matters for growth (Hausmann *et al.*, 2005). Hausmann *et al.* (2005 and 2011) and Hausmann and Klinger (2007) showed that countries exporting goods associated with a higher level of complexity will grow more rapidly. Hence, this section will discuss some of the metrics used to identify structural transformation paths in the product space, based on product complexity.

4.3.1 Introduction

Hausmann and Klinger (2007) have modelled the structural transformation paths in the product space by using PRODY as the measure of the income level (i.e. sophistication or complexity) of a product. The methodology of the PRODY measure was introduced in Section 3.7.2. The study by Hausmann and Klinger (2007) found that the speed at which countries can transform and upgrade their productive structure depends on having a path



to nearby goods in the product space that have a higher PRODY (i.e. complexity). Hence, having many nearby goods is favourable for diversification, but the complexity of these nearby goods matters a great deal for structural transformation.

A number of studies have applied the measure of PRODY. Abdon and Felipe (2011) used this concept to explain SSA's poor level of diversification and its stagnant process of structural transformation. Cirera *et al.* (2012) use PRODY to explain the diversification path of Brazilian firms. A study by Vītola and Dāvidsons (2008) used the measure to study the speed of structural transformation in Latvia.

Some recent work has criticised PRODY as a measure of product-level sophistication or complexity. The PRODY of some products is irrationally high, merely because rich countries produce them. Bacon, for instance, has a higher PRODY than combustion engines (Reis and Farole, 2012). Hence, using income in the estimation of the level of sophistication or complexity makes the finding that rich countries produce "rich-country products" circular (Felipe, Kumar, Abdon and Bacate, 2012).

However, ignoring the quality of products within the HS6 level may overestimate the importance of sophisticated products in low income countries. Although these in-product differences may be relative small for agricultural and food products, ham from country x may not be of the same quality as ham from country y . In contrast to research based on PRODY, Xu (2010) showed, through a further disaggregation of products at the HS level by relative unit values, that the structure of China's exports is consistent with its development. Global production chains further complicate the analysis of the PRODY of an export basket. For instance, China's export of sophisticated computers largely depends on the imports of high-tech components from the US and the UK. Hence, the physical production of these advanced components takes place in other countries, while the assembly takes place in China, which is not captured by the PRODY measure (Brenton *et al.*, 2009).



4.3.2 Economic complexity

An improved concept used to study structural transformation and growth, and which is not based on revealed income levels, is the concept of economic complexity, as developed by Hausmann *et al.* (2011). This concept departs from the notion that the embedded knowledge of an economy is captured by its capabilities. Recall that according to the product space theory, the production of a good requires a unique combination of different capabilities (see Section 4.2.1). The differences in prosperity between countries are related to the unique capability-set each country has. Furthermore, since some capabilities are difficult to develop or acquire, countries tend to specialise.

Hausmann *et al.*, (2011) argue that the level of complexity of a country is determined by the set of useful knowledge which is embedded in it. The unique set of capabilities for each product implies that countries missing a part of the capability-set cannot produce this product. Therefore, they state that the economic complexity is reflected by the composition of a country's productive output and replicates the productive structures that occur to hold and combine knowledge. Hausmann *et al.* (2011) further argue that the enhancement of economic complexity is essential for a country to be able to hold and use a larger amount of productive knowledge. The measurement of economic complexity is derived from the mix of products (i.e. the productive structure) that a country is able to make, which will be discussed later Section 4.3.3.

Hausmann *et al.* (2011) show that a strong relationship exists between the degree of economic complexity and per capita income. Controlling for income generated from extracting activities, which revolves around geological factors rather than knowledge, they estimate that economic complexity explains about 73 per cent of the variation across the 128 countries they studied. They extended this outcome by correlating economic complexity to future economic growth. They furthermore found that countries whose levels of economic complexity are lower than what is expected from their levels of income, grow faster than those countries that are "too rich" for their current levels of economic complexity. Empirically, Hausmann *et al.* (2011) estimated that a one standard deviation increase in economic complexity leads to a long-term and additional economic growth rate



of 1.6 per cent per year. Their study shows furthermore that the channels through which economic complexity is contributing to future growth go beyond exports, openness, diversification, or country size.

South Africa ranks as 55th in the global level of economic complexity. Based on its current level of output and economic complexity, the country is expected to achieve an annual growth in GDP per capita of 2.9 per cent between 2009 and 2020, which will rank the country 41st in the world and 7th in the region. In terms of the expected growth in total GDP, Hausmann *et al.* (2011) rank South Africa as 58th, with an expected annual growth in GDP of 3.4 per cent in that same period. Given its average annual growth in GDP of 2.5 per cent for the period 1998 to 2008, South Africa's current level of economic complexity (i.e. embedded knowledge) thus allows for a 0.9 per cent improvement in economic growth. However, given the goal of a minimum of five per cent annual economic growth (see Section 3.9) the country's level of economic complexity has to be improved. Following the empirics of Hausmann *et al.* (2011), South Africa's economic complexity has to increase with one standard deviation to reach five per cent growth. This study will, therefore, estimate how much of this increase in complexity can potentially come from the agricultural sector.

Hausmann *et al.* (2011) argue that literature focusing on the causalities of growth have predominantly examined institutions, human capital and competitiveness. They argue that the concept of economic complexity shares some basics with these approaches, as more complex economies will tend to have better institutions, a more educated labour force, and a higher level of competitiveness. However, the empirical testing of the impact of these four factors of growth shows that the measurement of economic complexity is a better explanatory variable in capturing the variance of economic growth and is thus better for predicting future economic growth.

Understanding the development process of economic complexity is important for re-shifting current growth paths to higher levels. This can be done by evaluating the connectedness of a country's current productive structure with the complexity of nearby products in the product space network (see also Section 4.2). This is calculated by a measure called *opportunity value* (see Section 4.3.4). Hausmann *et al.* (2011) show that countries with



either a high or low level of complexity tend to have few opportunities available. On the contrary, countries with an intermediate level of economic complexity, like South Africa, differ significantly in their opportunities. South Africa's position in the product space implies a relatively high overall opportunity value of close to three, which is similar to Argentina, Thailand and Belgium.

4.3.3 Measurement of complexity

Although the theoretical foundation of both the concepts of sophistication and economic complexity is similar, their measurement is different. The former is based on income levels associated with the production of certain goods, whereas the latter is based on diversity and ubiquity. Diversity revolves around the number of different goods a country is able to produce. It is assumed that a country's product diversity strongly relates to the specific set of capabilities that it has. Section 4.2.1 has already discussed the concept of capabilities in light of the product space. Ubiquity revolves around the amount of capabilities required to produce a product. As more ubiquitous products tend to be more common, the amount of capabilities required are fewer. Hence, less ubiquitous products require a variety of capabilities. Hausmann *et al.* (2011) state that diversity and ubiquity are proxies for the variety of capabilities and knowledge available in a country or as required by a product.

Countries with exceptional and scarce capabilities will be able to produce products that not many other countries will be able to produce (i.e. products with a low ubiquity). If these countries, due to their unique set of capabilities, cannot make a large variety of other products, their low product ubiquity explains their low level of product diversity. However, if countries with unique capabilities are able to make a large variety of products, then it is likely that a product with a low ubiquity requires a large number of capabilities and not just a few ones. Figure 4.2 below provides a graphical representation of the concepts of diversity and ubiquity.

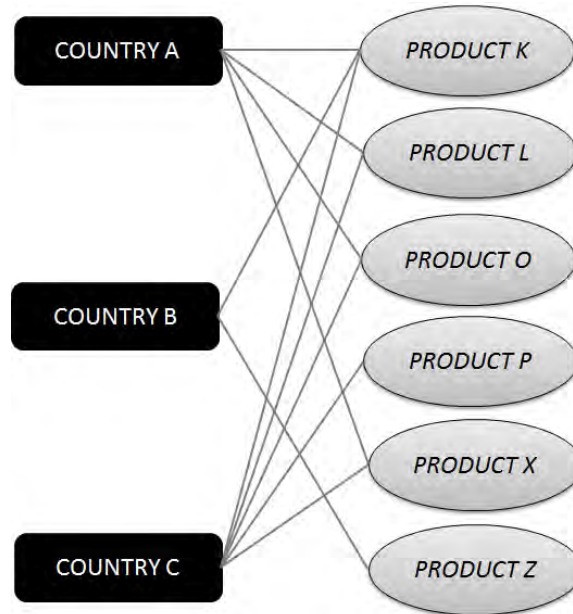


Figure 4.2: Graphical representation of diversity and ubiquity

Source: Adapted from Hausmann *et al.* (2011)

Since diversity is reflected by the number of products that a country can produce (i.e. is connected to), Figure 4.2 shows that Countries A, B and C have a diversity of 4, 2, and 5, respectively. Similarly, ubiquity is reflected by the number of countries that can produce a product (i.e. the number of countries a product is connected to). Thus, Figure 4.2 shows that Products K, L, O, P, X and Z have a ubiquity of 3, 2, 2, 1, 2 and 1, respectively.

Diversity can be used to correct for ubiquity, and vice versa, and is used by Hidalgo and Hausmann (2009) and by Hausmann *et al.* (2011) to develop a quantitative measure of complexity. For countries, this measure is called the Economic Complexity Index (ECI), and for products, this is called the Product Complexity Index (PCI). Felipe *et al.* (2012) state that the ECI is thus related to the set of capabilities of an economy and the PCI is linked to the set of capabilities required by a product. Diversity and ubiquity are thus the basis for the estimation of the two complexity measures and are defined as follows:

$$k_{c0} = \sum_{p=1}^{N_p} M_{cp} \quad (\text{diversity}) \quad (11)$$

$$k_{p0} = \sum_{c=1}^{N_c} M_{cp} \quad (\text{ubiquity}) \quad (12)$$



Where c is a country, p is a product, M_{cp} is a matrix of countries and products, $M_{cp} = 1$ if country c exports product p with revealed comparative advantage and $M_{cp} = 0$ otherwise.

Hidalgo and Hausmann (2009) developed a method of reflections by using the information embedded in ubiquity and diversity to correct for each other in order to get a robust indicator of the set of capabilities available in a country or for a product. This method of reflections starts with the estimation of Equations 11 and 12 and subsequently applies mathematical iteration where the value calculated in the one iteration is used in subsequent iteration. The iterations are defined as:

$$k_{cn} = \frac{1}{k_{c0}} \sum_{p=1}^{N_p} M_{cp} k_{pn-1} \quad (13)$$

$$k_{pn} = \frac{1}{k_{p0}} \sum_{c=1}^{N_c} M_{cp} k_{cn-1} \quad (14)$$

Where, n corresponds to the number of iterations. It is evident from the specification that the outcome of the one equation is used in the other and vice versa. Equations 13 and 14 are iterated until no additional information can be derived from the following iteration. This happens when the indicators converge to their means and can be expressed as (Poncet and Sorasta de Waldemar, 2012):

$$k_{cn} = k_{cn-2} \text{ and } k_{pn} = k_{pn-2} \quad (15)$$

For each country (i.e. k_{cn}) the even-numbered iterations result is a generalised measures of diversification and each odd-numbered iteration results is a measure of the ubiquity of exports. In contrast, for each product (i.e. k_{pn}) the even-numbered iterations are related to a product's ubiquity and the odd-numbered iterations result in a measure of diversity of countries that export the product (Abdon, Marife, Felipe and Utsav, 2010). Hence, the ECI is derived from the relative values of an even-numbered k_{cn} iteration and the PCI is derived from the relative values of an odd-numbered k_{pn} iteration. Following Poncet and Sorasta de Waldemar (2012), the ECI and PCI are defined as:



$$ECI_c = \frac{k_{c\vec{n}} - \overline{k_{c\vec{n}}}}{stdevk_{c\vec{n}}} \quad (16)$$

$$PCI_{pc} = \frac{k_{p\vec{n}} - \overline{k_{p\vec{n}}}}{stdevk_{p\vec{n}}} \quad (17)$$

A few studies have applied these concepts of complexity. Felipe et al. (2012) used these concepts to show some stylised facts on complexity and economic development. A study by Poncet and Sorasta de Waldemar (2012) studied the effects of a regionalised ECI on the economic growth in more than 200 Chinese cities and found a positive relationship.

4.3.4 Agricultural complexity

Since this study focuses on the broad agricultural sector, the measures of complexity will be applied accordingly. The ECI methodology will, therefore, be used to measure country-level agricultural complexity and henceforth be denoted as *ACI*. The *ACI* is applied to benchmark South Africa's agricultural complexity in a global perspective. Similarly, the *PCI* will be used to estimate the cluster- and product-level complexities of South Africa's agricultural sector. The calculation of the complexity measures and indicators for the agricultural sector is based on the same dataset and product scope used for the product space as discussed in Section 4.2.5.

Since this study is furthermore interested in identifying diversification pathways in the agricultural product space that enhance South Africa's structural transformation, a measure is needed to estimate the closeness to new and more complex products. This measure is called the *Opportunity value* (see Hausmann *et al.*, 2011) and quantifies a country's unexploited prospects by using the level of product complexity of products that it is not currently producing, weighted by their proximity to the country's current productive structure in the product space. The *opportunity value* can be defined as:

$$Opportunity\ value_{p_i} = (1 - d_{cp_i})(1 - M_{cp_i})PCI_{p_i} \quad (18)$$



Where p' is a product currently not exported by country c (i.e. South Africa), $d_{cp'}$ is the measurement of distance (see equation 8), and M_{cp} is a matrix containing information on the *RTA* of each country-product combination (see also equation 3). The term $1 - M_{cp}$ ensures that only products that are not currently produced by country c are counted. Furthermore, a higher total opportunity value implies that the product is in the vicinity of additional products that are more complex.

Hausmann *et al.* (2011) show that countries with a low level of complexity incline towards having few opportunities available as their productive structure is located in the sparser parts of the product space. Furthermore, countries with a high level of complexity also tend to have few opportunities since they already have a large presence in the product space and intermediate complex economies differ greatly in their number of upgrading opportunities.

Another related measure developed specifically for this study is *Opportunity outlook*. This is estimated as the closeness to more complex products that become available after diversifying to product p' . It thus reflects the potential of a subsequent increase in complexity owing to diversifying to product p' . This potential of opening up more and more complex products provides an outlook onto the long-term opportunity for structural transformation in the product space. The *Opportunity outlook* can be defined as:

$$\text{Opportunity outlook}_{p'} = (1 - d_{cp'p''}) PCI_{p''} \quad (19)$$

Where product p' is a diversification opportunity that is not currently produced and connected to product p ; p'' is a product that is connected to p' and not currently produced and not connected to current production p ; d is the measure for *Distance* between products p' and p'' .

This section discussed how to analyse structural transformation and the next section presents the methodological framework for identifying diversification opportunities, based on local and international demand.

4.4 MARKET-DRIVEN DIVERSIFICATION

4.4.1 Introduction

The outcomes of Chapter Three revealed that, for South Africa, agricultural growth from market-driven diversification can be achieved through four different channels (see Section 3.9). These channels and the methodological framework for identifying the diversification potential within each of these channels are depicted in figure 4.3 below.

This section will accordingly discuss how the products with the highest potential for diversification will be identified for each of these four channels. The identification of the diversification opportunities in channels 2 and 4 will be informed by combining the agricultural product space network and a Decision Support Model (DSM) for identifying export opportunities. This interaction provides insights into the production capabilities, as well as the international demand of the diversification opportunities for the South African agricultural sector. The product scope and level of disaggregation for this analysis is similar to that of the product space as described in Data Supplement I.

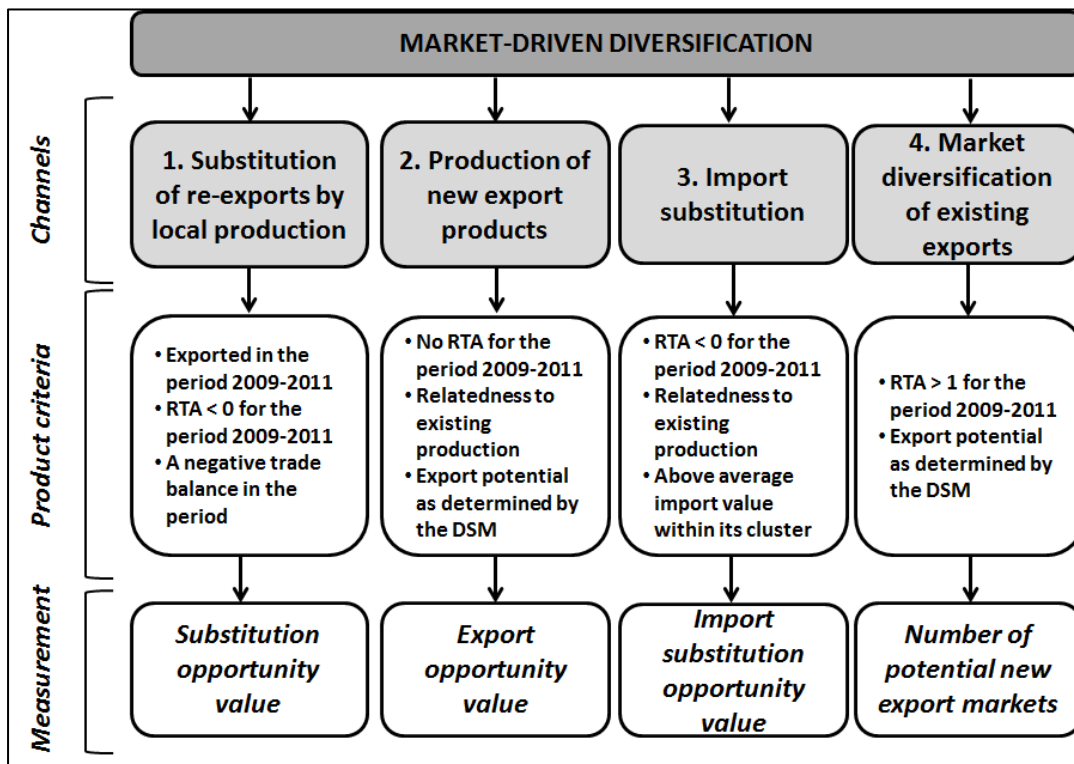


Figure 4.3: Methodological framework for market-driven diversification



This section departs from the rationale that diversification in the agricultural sector needs to take place by moving to nearby products in the product space to ensure the competitiveness of production and posits that this also needs to be driven by local and export market demand. The latter will create an economic incentive for the development or acquisition of additional capabilities required to produce “new” agricultural products in South Africa. This section will first discuss the framework of the DSM, followed by a discussion of the methodologies used for exploring the four different avenues for diversification.

4.4.2 The Decision Support Model for identifying realistic export opportunities

Processes to identify and select export opportunities for the purposes of trade expansion and diversification have been discussed in various works (Papadopoulos and Denis, 1988; Green and Allaway, 1985; Russow and Okoroafo, 1996; Papadopoulos, Chen and Thomans, 2002; Freudenberg and Paulmier, 2005a and 2005b; Shankarmahesh, Olsen and Honeycutt, 2005; Sakarya, Eckman and Hyllegard, 2007). To ensure high returns on investments, resources should be allocated to the most attractive export opportunities. Therefore, the challenge for policymakers, industry stakeholders and individual firms in South Africa lies in choosing optimal product–market combinations to support the product and market diversification of the agricultural sector. Indeed, Rahman (2003) states that the literature offers ample evidence that the main reason for export failure is poor market selection.

According to Papadopoulos and Denis (1988), there are two main approaches to international market selection, the qualitative approach and the quantitative approach. Each of these approaches can be pursued using several different models. However, the range of international market selection models will not be discussed here as they are well documented by Steenkamp, Viviers and Cuyvers (2012). In this study, the Decision Support Model (DSM), as developed by Cuyvers (1996; 2004), and refined and applied to South Africa, first by Pearson, Viviers and Cuyvers (2007) and later by Steenkamp (2011), will be used. The DSM offers the most suitable methodology for exploring realistic export opportunities for the South African agricultural sector within the product space framework as it is the only model that considers all possible product–country combinations, world-



wide, at a disaggregate product-level (i.e. the six-digit level of the HS classification). This concordance makes it relatively straightforward to link export opportunities to the productive capabilities identified in the agricultural product space. Furthermore, the model is capable of producing a list of priority products per country, and vice versa, as well as an indication of the potential export value of every identified product–country combination. Its main limitation is however that the selection of export opportunities is based on ex post data and prospected market dynamics are not considered. This may have implication for the time-robustness of the results of the DSM.

This DSM uses a sequential, four-step filtering process to identify viable product–market combinations, applying specific criteria to determine political and commercial country risk, market performance, and market accessibility. After every filtering sequence, a number of opportunities (i.e. product–country combinations) that are deemed to be not relevant are eliminated, i.e. not considered in the subsequent filters. The results emerging from the application of the DSM yield a classification of each product–market combination, based on South Africa’s current market position and characteristics of the import market.

A schematic overview of the methodological framework of the DSM is provided in Figure 4.4 below. Initially, all countries in the world are considered in the model. A synopsis of this framework is provided in this section, and a more detailed discussion of this model can be found in Steenkamp (2011).

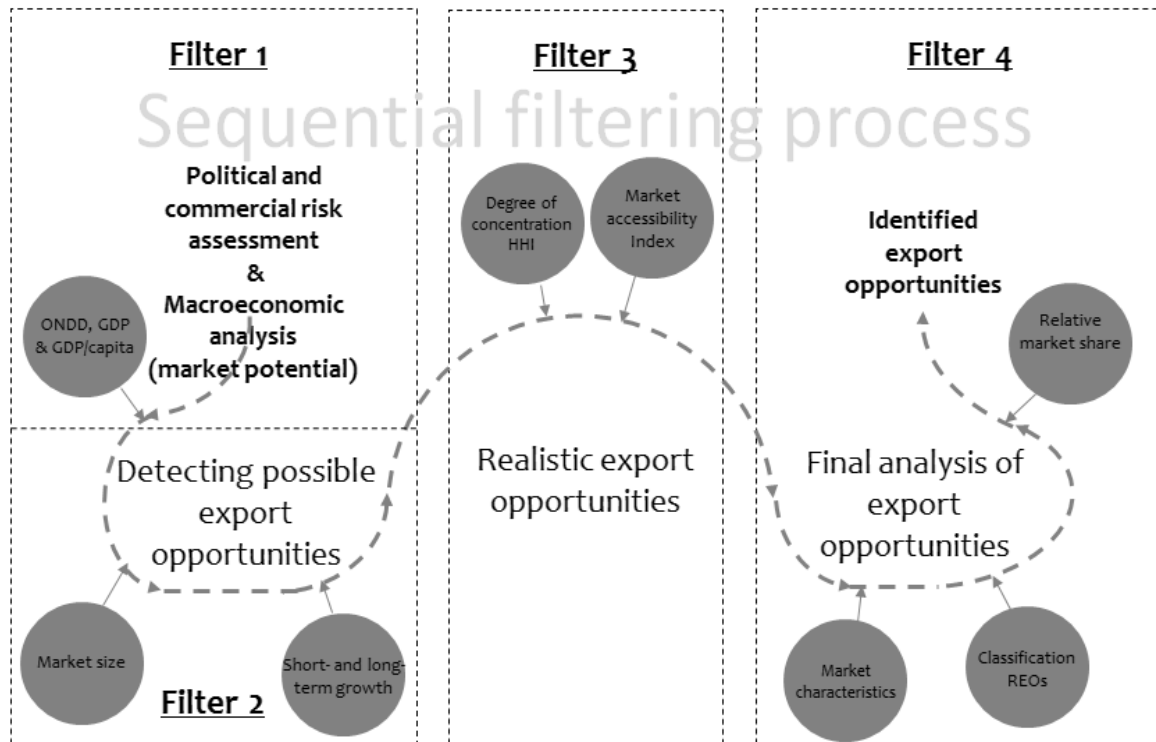


Figure 4.4: Methodological framework of the DSM

Source: Steenkamp et al. (2009)

Filter 1: Country risk and macroeconomic assessment

Filter 1 consists of two stages. Filter 1.1 arrives at scores for political and commercial risk, and eliminates countries that demonstrate relatively high risk in this regard. The political and commercial risks involved in trading with foreign countries can be analysed using variables, such as the external debt serviced as a percentage of export earnings; a country’s current account deficit as a percentage of GDP; and the extent of foreign debt relative to GDP, among others; as well as historical and prospective changes in these indicators (Cuyvers, 2004).

The rating used for this filter was sourced from the *Office National du Ducroire* (ONDD) in Belgium, and provides a risk assessment of export transactions in terms of short-, medium-, and long-term political risk, as well as the commercial risk for 240 countries. Political risk is rated from 1 to 7, where 1 indicates a low risk and 7 indicates a high risk in a specific category (term) for a particular country. Commercial risk is rated as A, B or C, where A indicates a low risk and C, a high risk. These ratings were transformed to create a single risk



rating per country, which was then used to determine a critical value to eliminate less promising export markets from the model.

Filter 1.2 arrives at scores to determine whether particular export markets are large enough and are on a sufficient growth trajectory to be lucrative export opportunities. Data on real GDP and GDP per capita, as well as growth in these indicators, was sourced from the IMF. In order to select the markets that pose relatively less risk, a cut-off point was calculated. See Cuyvers, Steenkamp and Viviers (2012) for the detail of these calculations.

Filter 2: Size and growth of import demand

Using international trade data at HS6 level for the years 2003 to 2007 from the UN Comtrade database, a categorisation system was devised for each product–country combination, based on relative short-term import growth, relative long-term import growth, and relative market (import) size. These are the proxies for the growth and size of import demand. The categories, which are shown in Table 4.1 below, were determined according to calculated cut-off values based on the growth performance and market size of each product–country combination, relative to the global averages. See Cuyvers, Steenkamp and Viviers (2012) for a detailed discussion of the calculations of these cut-off values.

Table 4.1: Categorisation of product-country combinations in Filter 2 of the DSM

Category	Short-term market growth	Long-term market growth	Relatively large market size
0	No	No	No
1	Yes	No	No
2	No	Yes	No
3	No	No	Yes
4	Yes	Yes	No
5	Yes	No	Yes
6	No	Yes	Yes
7	Yes	Yes	Yes

Source: Cuyvers (2004)



Categories 3 to 7 were considered to be potentially interesting markets for agricultural products and were selected for further analysis in the DSM. Seven countries³⁰ had no trade data and were given no further consideration.

Filter 3: Market accessibility

In Filter 3, the selected product–country combinations are further analysed in terms of their relative market accessibility for South African exporters. This level of accessibility is reliant on entry barriers which can prevent South African exporters achieving a lucrative market position in a potential export market. The DSM considers two such restrictions: the degree of market concentration (i.e. Filter 3.1) and bilateral trade restrictions (i.e. Filter 3.2).

The market concentration in Filter 3.1 is measured by the Herfindahl-Hirschman Index (HHI) which was also used in Section 3.6.1. It is assumed that if a market is highly concentrated, it will be more difficult for South African exporters to supply that market. As Cuyvers *et al.* (1995) have stated, market concentration is a larger barrier to entry into a non-growing market. Hence, a performance-dependent cut-off point for market concentration was calculated, based on the categories identified in Filter 2 (see Table 4.2 below). This ensures that a larger degree of concentration is tolerated for larger, growing markets. Please refer to Cuyvers, Steenkamp and Viviers (2012) for a discussion of the cut-off points of the HHI. The product–country combinations that showed an adequate low level of concentration were not eliminated.

In Filter 3.2 of the DSM, the potential trade restrictions faced by South Africa are determined by assigning a relative market accessibility index to each product–country combination, based on five different parameters. These five variables are summarised in Table 4.2 and their validation is further discussed in Cuyvers, Steenkamp and Viviers (2012). A weight was assigned to each parameter on the basis of a Principle Component Analysis.

³⁰ Antigua and Barbados, Bermuda, Channel Islands, Puerto Rico, San Marino and Taiwan



Table 4.2: Parameters used in the market accessibility index of the DSM

Parameter	Measurement	Weight	Data source
1. Shipping time from Durban to the main harbour (or capital for landlocked countries) in the importing country.	Days	15.9%	Freight forwarders
2. The domestic time required to ship a product to a specific importing country in terms of processing all the documents, inland transport and handling, customs clearance and inspection, and port and terminal handling.	Days	17.8%	World Bank
3. Shipping cost from Durban to the main harbour (or capital for landlocked countries) in the importing country.	USD per 40 foot reefer	16.7%	Freight forwarders
4. The domestic cost of shipping a product to a specific importing country in terms of processing all the documents, inland transport and handling, customs clearance and inspection, and port and terminal handling.	USD per 40 foot reefer	15.8%	World Bank
5. Average import tariff imposed at the border of the importing country on each products.	<i>Ad valorem</i> import tariff	5.5%	UN TRAINS
6. Logistical performance of importing country: efficiency of customs clearing processes, the quality of trade and transport infrastructure, the ease of arranging competitively priced shipments, the competence and quality of logistical services, the ability to track and trace a consignment, and the frequency with which shipments reach the consignee within the scheduled time of each importing country.	Logistical Performance Index (LPI)	10.9%	World Bank
7. Technical and non-technical trade measures for each product-country combination.	<i>Ad valorem</i> equivalents of non-tariff trade barriers	15.8%	Kee <i>et al.</i> , 2008

Source: Steenkamp (2011)

A cut-off value was calculated (see Steenkamp, 2011) to eliminate all the product–country combinations that do not show adequate levels of market accessibility.

Filter 4: Categorisation of export opportunities

In the last stage, the realistic export opportunities identified in filters 1 to 3 are prioritised and no product–country combinations are eliminated. The strength of the position in a foreign market can be derived from the relative market share (Cuyvers *et al.*, 1995). Hence, for the categorisation of each market that entered filter 4, the relative market share of South Africa for each product in each market is calculated (see Steenkamp, 2011). The other element used for categorising the product–country combination is the market performance as determined in Filter 3. Ultimately, the export opportunities are categorised in a matrix as



depicted in Table 4.3 below. A total of 20 different markets can be identified from the matrix. Hence, agricultural products in the product space which South Africa is not currently exporting, or has a very small market share of, will be categorised in cells 1 to 5.

Each of the markets requires a different type of export strategy. Cuyvers *et al.* (1995) suggest an offensive market exploration strategy for products in cells 1 to 10, an offensive market expansion strategy for products in cells 11 to 15, and a defensive market maintenance strategy for products in cells 16 to 20.

Table 4.3: Categorisation matrix of realistic export opportunities

Size and growth of importing market	Market share of South Africa			
	None or relatively small	Intermediately small	Intermediately small	Relatively high
Large product market	Cell 1	Cell 6	Cell 11	Cell 16
Growing (short- and long term) product market	Cell 2	Cell 7	Cell 12	Cell 17
Large product market with short-term growth	Cell 3	Cell 8	Cell 13	Cell 18
Large product market with long-term growth	Cell 4	Cell 9	Cell 14	Cell 19
Large product markets with short- and long term growth	Cell 5	Cell 10	Cell 15	Cell 20

Source: Cuyvers *et al.* (1995)

Filter 4 furthermore attaches a potential export value to each of the product–market combinations in order to quantify the different export opportunities. These export values are calculated by estimating South Africa’s potential market share, given the market concentration for each product–country combination (see Steenkamp, 2011). This will give an indication of the relative size of the import demand for each combination.

4.4.3 Substitution of re-exports by local production

The previous chapter revealed that although South Africa’s agricultural export basket is relatively well diversified, it consists of a significant share of re-exports. Hence, the number of export products that are produced locally needs to increase to capture more value within South Africa. The diversification of the agricultural sector by replacing re-exports with local



production must focus on products with the highest production potential. This potential is thus determined by a relatively large foreign demand and the product's closeness to South Africa's current productive structure, as revealed in the product space. These agricultural products can be identified by applying the following criteria:

- i. Exported in the period from 2009 to 2011
- ii. $RTA < 0$ in the period from 2009 to 2011
- iii. Relatedness to existing production
- iv. A negative trade balance for the period 2009 to 2011

A measure is developed to assign an opportunity value to each of the potential products. This measure is called Substitution opportunity value and is calculated as follows:

$$\text{Substitution opportunity value}_{p'} = (RE_{p'}) (1 - d_{pp'}) X_{cp'} \quad (20)$$

Where p' is a product that is not currently produced by South Africa, RE is re-export and has a value of 1 if p' is exported and has a negative trade balance and 0 otherwise, $d_{pp'}$ is the distance value (see equation 8), and X is South Africa's total exports of product p' . This measure thus reflects the distance-weighted export value of a re-exported product. A higher *Substitution opportunity value* reflects a better opportunity for local production, given the products proximity to South Africa's current production combined with a large export market.

4.4.4 Production of new export products

Growth in agricultural output can also come from producing new agricultural products for the export market. Although these products may be imported by South Africa, they are not locally produced on a large scale and are in relative high demand internationally. The identification of these products is based on the following criteria:

- i. $RTA < 0$ or no RTA (not traded) for the period 2009 to 2011
- ii. Relatedness to existing production
- iii. High realistic export potential as determined by the DSM framework.



A measure, the *Export opportunity value*, is developed to assign an opportunity value to each of the potential products and is calculated as follows:

$$\text{Export opportunity value}_{p'} = (1 - d_{pp'})PX_{p'} \quad (21)$$

Where p' is a product that is not currently produced by South Africa, $d_{pp'}$ is the distance value (see equation 8), and PX is South Africa's total potential export value as determined by the DSM. This measure thus reflects the distance-weighted potential export value for "new" and related products. A higher *Export opportunity value* reflects a better opportunity for developing new export products, given its proximity to South Africa's current production, as well as the extent of potential exports.

4.4.5 Import substitution of large imports

The reliance on imports for the local supply of some agricultural and food products (see Section 3.5.2) is cumbersome for local agricultural development in South Africa. Hence, if some of these imports could be competitively produced locally, import substitution would be a suitable pathway for agricultural development. However, Section 2.5.6 showed that a strategy of import substituting industrialisation (i.e. ISI) has not yielded the desired results in many developing regions. Similar policy endeavours in South Africa in the 1980s have also failed, owing to, among other reasons, misalignment with the country's comparative advantages. In order to ensure competitiveness, it is therefore crucial that import substituting diversification does not entail "long jumps" to products that are not close to the country's current competitive advantages in South Africa's product space network.

The products that classify for import substitution need to correspond to the following selection criteria:

- i. An RTA < 0 for the period 2009 to 2011
- ii. Relatedness to existing production
- iii. Above average import value within its cluster for the period 2009 to 2011.



A measure is developed to assign an opportunity value to each of the potential products. This measure is called *Import-substitution opportunity value* and is calculated as follows:

$$\text{Import – substitution opportunity value}_{p'} = (I_{p'} > \mu I_C)(1 - d_{pp'})I_{p'} \quad (22)$$

Where p' is a product that is not currently produced by South Africa, $I_{p'}$ are imports of product p' , μI_C is the mean value of imports within product cluster C , $d_{pp'}$ is the distance value (see equation 8), and I is South Africa's total import value of product p' . This measure thus reflects the distance-weighted potential import value for “new” and related products. A higher *Import-substitution opportunity value* reflects a better opportunity for the substitution of large imports which are closely related to South Africa's core competencies. This accordingly ensures that import-substitution only takes place in those products which likely can be competitively produced by South Africa.

4.4.6 Market diversification of existing exports

Section 3.6.3 revealed that the market reach of the intensive margin (e.g. existing exports) of South Africa's exports in the agro-complex was relatively low. Hence, there exists some potential for growth in the extensive margin from increasing exports of existing products to new markets. Agricultural export products that classify for market diversification need to correspond to the following selection criteria:

- i. An RTA > 1 (i.e. a core competency) for the period 2009 to 2011
- ii. High realistic market diversification potential as determined by the DSM framework.

The total number of additional export markets will be given for each of the identified products and they will be ranked according to their total potential export value.

This section provided some guidance for market-driven diversification and the next section investigates an important social directive for diversification in the agro-complex, namely employment creation.



4.5 EMPLOYMENT-DRIVEN DIVERSIFICATION

4.5.1 Introduction

Chapter three revealed that the primary and secondary agricultural sectors contribute six and three per cent, respectively, to total employment in South Africa (see Section 3.3.7). Although this share has been on the decline over the last few decades, this is still an important contribution. The chapter also showed that the agricultural sector has one of the highest labour multiplier of all economic sectors in South Africa (see Section 2.3.8). Furthermore, Hausmann and Klinger (2006b) show that the role of agriculture in the South African economy could be further enhanced by improving the output per worker, as well as the number of workers per hectare in the sector, as the country performs comparatively moderately.

Creating employment by growth in agriculture has a quantity and quality dimension. The quantity of employment created by diversification and structural transformation revolves around the labour absorbing capacity of the different agricultural sub-sectors. The quality of employment revolves around the level of human capital required for diversification and structural transformation. Employment creation is a second-level imperative, as the growth potential of diversification opportunities should be the foremost driver. Moreover, no employment creation will occur without substantial growth in supply and demand.

4.5.2 Labour intensity

The labour absorption of the 25 identified sub-sectors within the agro-complex will be estimated by calculating the *labour intensity*. The *labour intensity* (or *LI*) reflects the number of workers per R1 million of output and is defined as:

$$LI_s = \frac{Q_s}{Y_s} \times 10^6 \quad (23)$$

where *s* is an agricultural sub-sector, *Q* is the total employment in sector *s* and *Y* is the total output of sector *s*. Owing to differences in data classification, only a maximum number of 25



agricultural sub-sectors could be extracted. Statistics on total employment (i.e. Q) are obtained from the 2007 Quarterly Labour Survey of StatsSA (StatsSA, 2007), since that is the last survey for which detailed industry-level data at the three-digit level of the Standardised Industry Classification (SIC) is available. Data on total output (i.e. Q) is sourced from the Department of Agriculture, Forestry and Fisheries (DAFF), Quantec, StatsSA and Forestry South Africa. For consistency purposes, output statistics for 2007 are used. For interpretation, equation 23 is further normalised as follows:

$$\text{Labour intensity index}_s = \frac{LI_s - LI_{min}}{LI_{max} - LI_{min}} \quad (24)$$

where a value of close to one indicates a relative high *labour intensity* and a value of close to zero indicates a relative low *labour intensity*.

The *LI* of the 25 sub-sectors are linked to the product scope of this study in order to generate a dataset of product-level labour intensity at the HS6 level. This data is used to associate growth paths in the agricultural products space with impacts on labour intensity. The quantification of the labour intensity of unexploited prospects in the agricultural product space is measured by the *employment value*. This measure uses the level of *labour intensity* of products that South Africa is not currently producing, weighted by their proximity to the country's current productive structure in the product space. The *employment opportunity value* is defined as:

$$\text{Employment opportunity value}_{p'} = (1 - d_{pp'}) (1 - M_{cp}) \text{normalised } LI_{p'} \quad (25)$$

where p' is a product that is not currently produced by South Africa, $d_{pp'}$ is the distance value (see equation 8), and M_{cp} is a matrix containing information on the *RTA* of each product-country combination.

4.5.3 Human capital intensity

The quality of potential employment associated with growth paths in the agricultural product space can be measured by the Revealed Human Capital Index (*RHCI*), as developed



by Shirotori *et al.* (2010). A database of this index is available from UNCTAD and was also used in Section 3.7.3. The index reflects the human capital content of export products at the HS6 level, based on the average years of schooling weighted by the RCA indices of the countries producing that product. Section 3.7.3 provided an analysis of the *RHCI* for South Africa's existing agricultural exports and revealed that the gap between the human capital endowment and the intensity is relatively large for a majority of these products. Hence, to ensure export survival (see Cadot, 2010), it is important to measure the human capital requirements associated with diversifying into new products. For calculation purposes, the *RHCI* is normalised as follows:

$$\text{normalised } RHCI_p = \frac{RHCI_p - RHCI_{min}}{RHCI_{max} - RHCI_{min}} \quad (26)$$

where p is a product, and a value of close to one indicates relatively high human capital intensity, and a value of close to zero indicates relatively low human capital intensity.

The quantification of the human capital intensity of unexploited prospects in the agricultural product space is measured by the *human capital value*. This measure uses the normalised *RHCI* of products that South Africa is not currently producing, weighted by their proximity to the country's current productive structure in the product space. The *human capital opportunity value* is defined as:

$$\text{Human capital opportunity value}_{p'} = (1 - d_{pp'}) (1 - M_{cp}) \text{normalised } RHCI_{p'} \quad (27)$$

Where p' is a product that is not currently produced by South Africa, $d_{pp'}$ is the distance value (see equation 8), and M_{cp} is a matrix containing information on the *RTA* of each product–country combination.

4.6 SUMMARY

A consolidated overview of the four methodologies presented is shown in Figure 4.5 below. The figure shows the three strategic values, at the bottom, and how the diversification pathways are analysed within the product space with as ultimate goal the identification of priority products for spurring economic development and growth from the agro-complex.

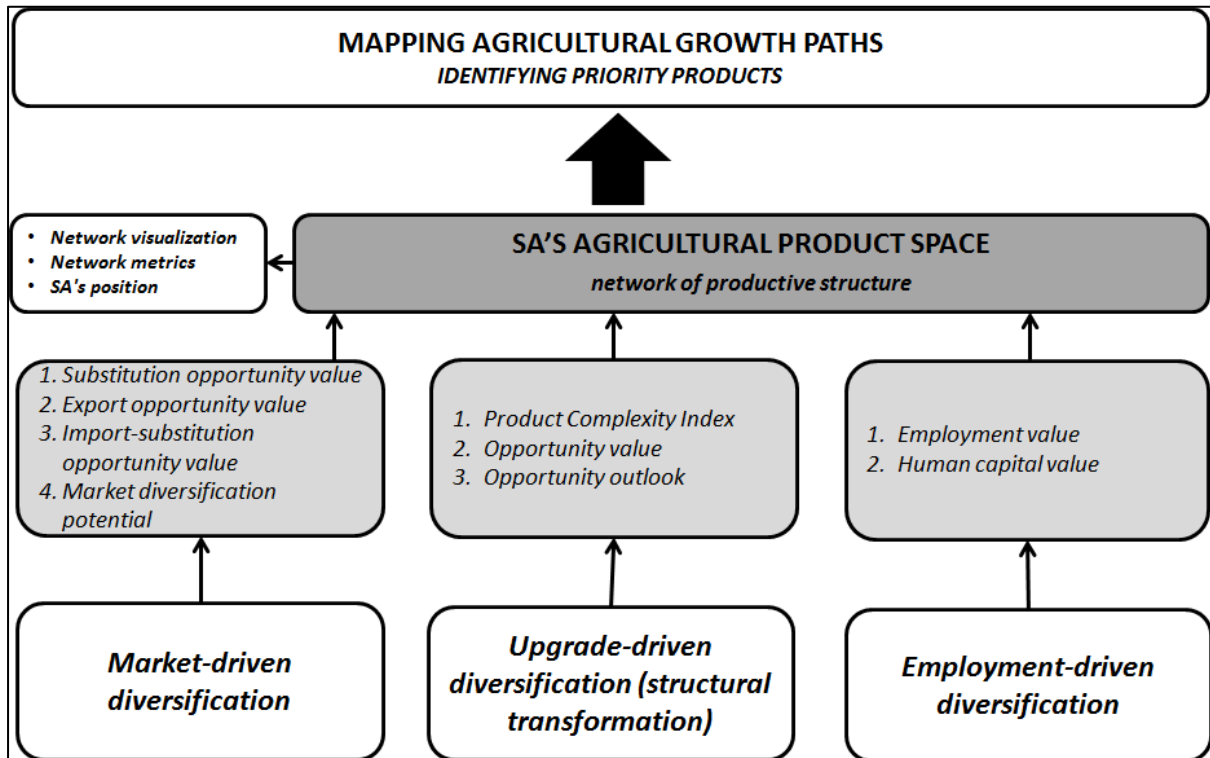


Figure 4.5: Consolidated methodological framework

The structure of the agricultural product space will be presented and analysed in the next chapter (five). This will provide an industrial map of the global agro-complex, as well as an overview of South Africa’s productive structure which subsequently determines the country’s potential diversification pathways. These pathways are presented in Chapter six along the lines of the three strategic values, namely structural transformation, market-driven diversification and employment-driven diversification.