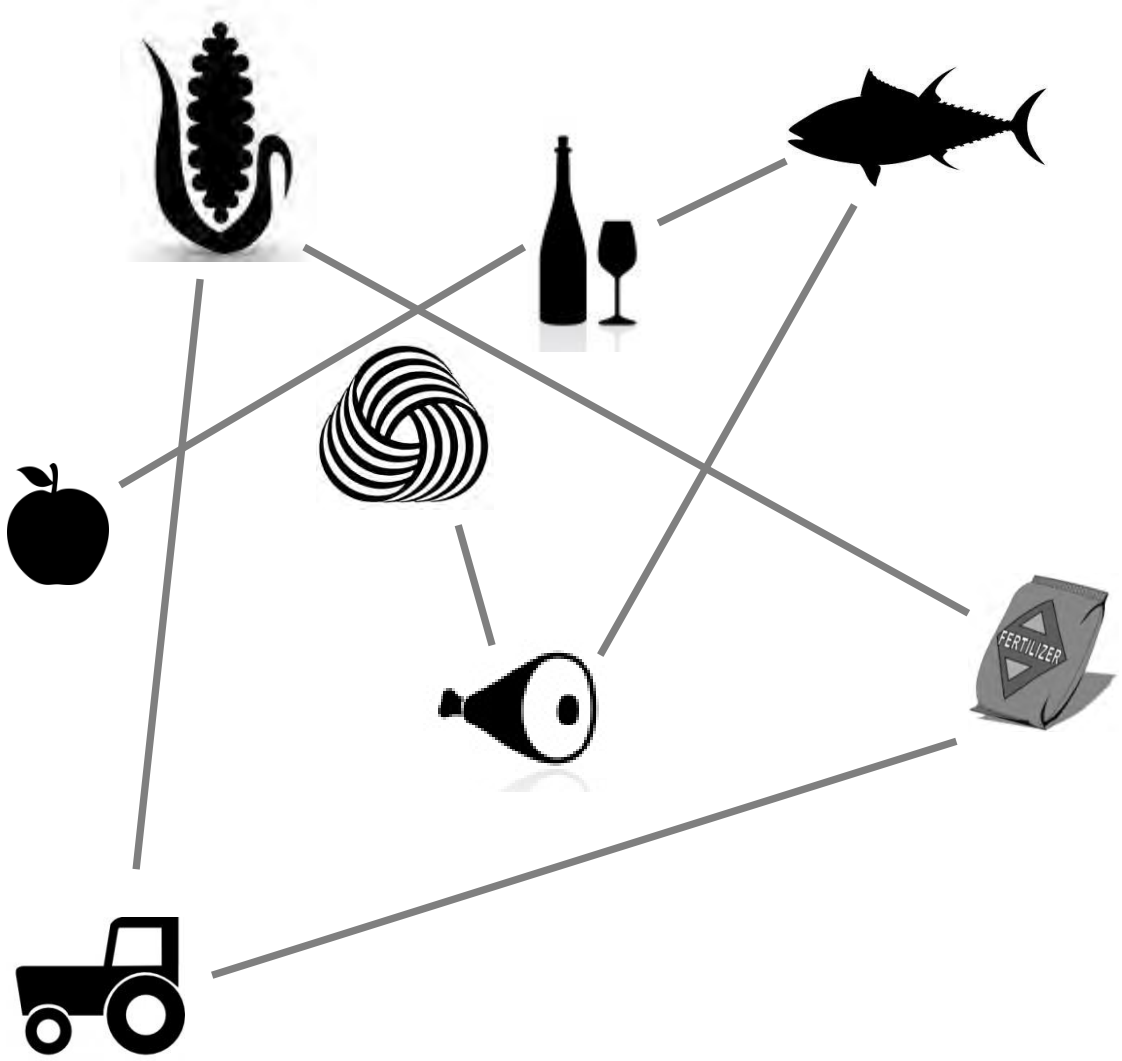
CHAPTER 5

THE AGRICULTURAL PRODUCT SPACE

Structure and South Africa's position



5.1 INTRODUCTION

This study specifically constructs a product space for the agro-complex, whereas previous applications have applied the concept to the broader economy (see Section 4.2.2). The methodological framework for the product space was presented in Section 4.2 and the analyses of the results are presented here. Firstly, this chapter analyses the structure of the product space for agro-complex, specifically by investigating some network metrics, as well as the linkages within and between the different clusters. Secondly, the position of South Africa's productive structure in the agricultural product space is determined to examine the potential for the diversification of its agro-complex. The product space presented in this chapter will form the basis for the analysis in the next chapter (six), which focuses on the identification of the country's diversification opportunities along the lines of the three strategic values.

5.2 THE AGRICULTURAL PRODUCT SPACE

The product space is a network structure that reflects the productive structure of a nation by connecting products with similar capabilities and which can be used as an industrial map for diversification. This section firstly presents some stylised facts on the underlying measure of product relatedness in the product space, namely the proximity value. Secondly, the agricultural product space is visualised. In the subsequent parts, the network's structure is analysed on the basis of individual connected network components, the position of the five clusters of the agro-complex, and the prevalence of intra-cluster linkages.

5.2.1 Proximity

From Section 4.2.3 it is clear that the proximity value is the conditional probability of any country producing good *A*, given that it also produces good *B*. For example, a proximity value of 0.2 between goods *A* and *B* implies that there is a 20 per cent chance of a country producing good *A*, given that it produces good *B*. It is assumed that the higher the proximity value, the more similar is the set of capabilities and knowledge used in the production of

both products (Hidalgo *et al*., 2007). Proximity is thus an empirical measure of product relatedness.

The matrix used to reflect the pairwise proximity between products, and which is used to construct the product space for the agro-complex, has a dimension of 1 456 by 1 456 products[31]. Hence, the maximum number of unique possible product to product proximity connections is 2 118 480. The proximity matrix revealed a total of 797 265 connections between agricultural products, which represents 38 per cent of the maximum possible connections. 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 relatedness within and between the different agricultural clusters will be discussed later in this chapter (see Section 5.2.4). 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.

A graphical representation of the proximity matrix for the 1 456 selected agricultural products is shown in Figure 5.1 below. Each column and row of this 1 456 by 1 456 matrix represents a product. Furthermore, the elements of the matrix are colour-coded in accordance with the respective proximity values. The matrix elements in green reveal a high proximity value and the elements coloured in red indicate untraded products. It is evident from the graphical representation that the degree of relatedness in the agro-complex is relatively low.

[31] Refer to Data Supplement I for a complete overview of the products used in the analysis.

Figure 5.1: Graphical representation of the proximity matrix for the agro-complex (2007 - 2011)

Source: Author's own calculations (2013)

An overview of the frequency and cumulative distribution of the proximity values between the 1 456 products is provided in Figure 5.2 below. The figure shows 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.

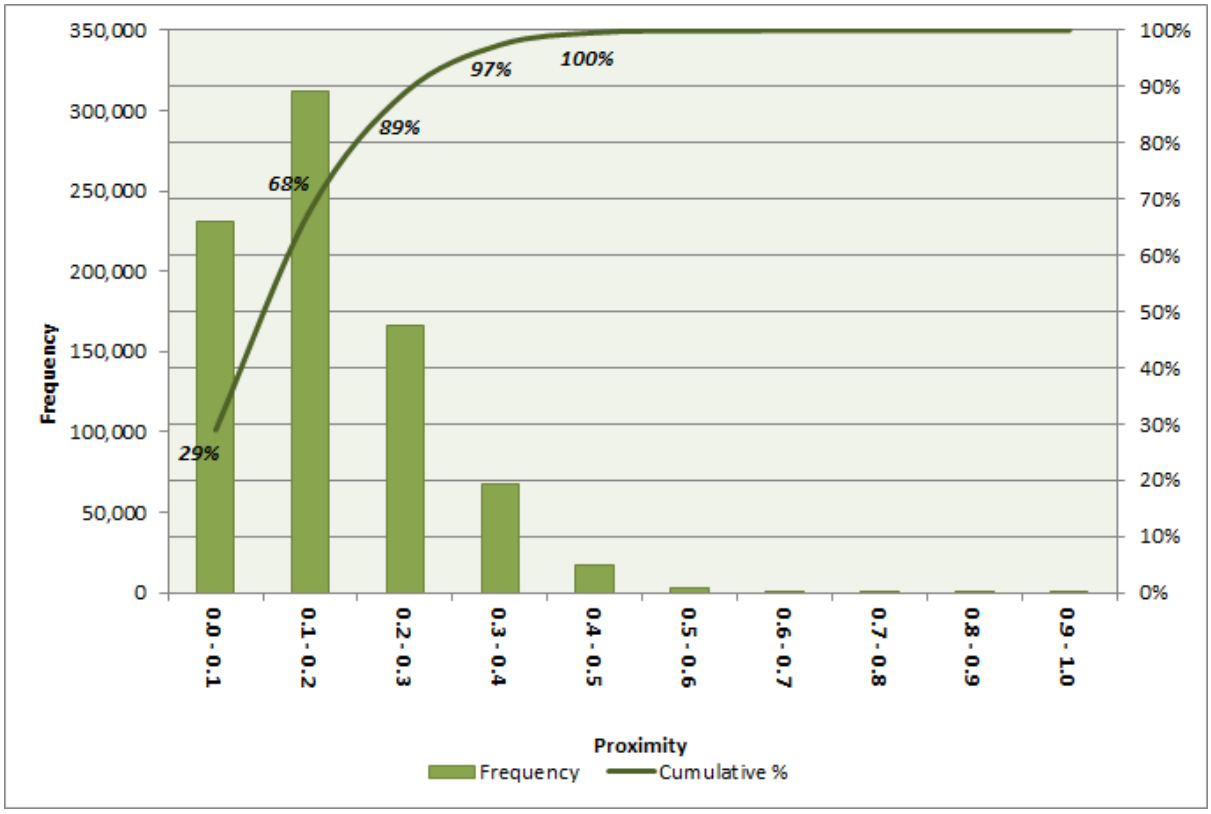


Figure 5.2: Distribution of the proximity between products in the agro-complex
Source: Author's own calculations (2013)

As discussed in Section 4.2.3, this study uses a proximity value equal to or higher than 0.55 as the threshold for identifying meaningful relationships between agricultural products. This criterion is applicable to 1 872 of the product-to-product connections, reflecting 0.23 per cent of the total 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 agricultural products with meaningful proximity values at 772. This represents 53 per cent of the total 1 456 products under investigation. Figure 5.2 above elaborates on the previous figure by showing only the distribution of the proximity values of the meaningful relationships between products in the agro-complex. These are thus the connections with a proximity value of 0.55 and higher. It is evident from the figure that the majority of these connections (73 per cent) have a proximity value of between 0.55 and 0.65. Furthermore, the figure shows that a total of 90 pair-wise product connections have a very strong degree of relatedness, with a proximity value of 0.95 or higher.

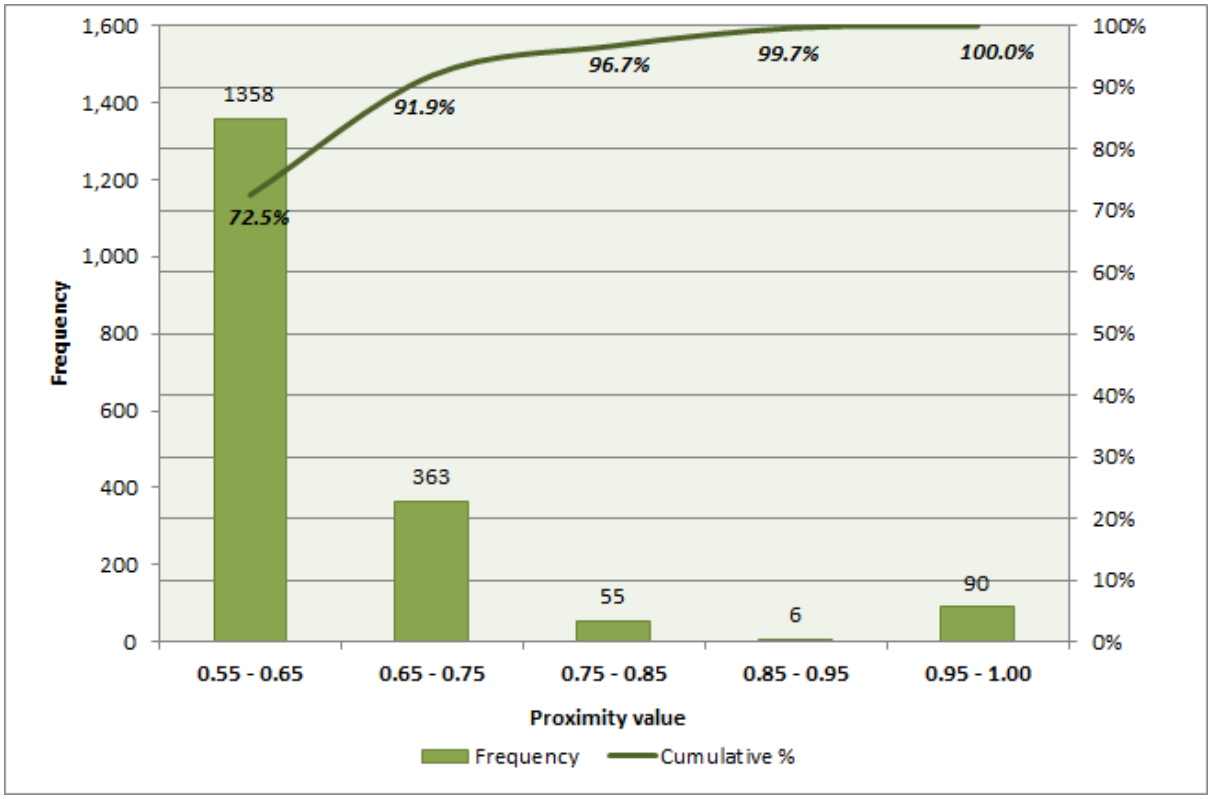


Figure 5.3: Distribution of meaningful relatedness between products in the agro-complex
Source: Author's own calculations (2013)

5.2.2 A network of relatedness

The proximity matrix is used to construct the network of the agricultural product space. The network was designed and visualised with the NodeXL software package for MS Excel. A network representation of the proximity matrix, which is called the product space, will provide insight into the structure of the degree of relatedness between products. Furthermore, it assists in studying the productive structure of a country it represents (i.e. South Arica).

Figure 5.4 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 1872 connections (i.e. links/edges). The agricultural product space was laid out as an undirected graph by using the Harel-Koren Fast Multi-scale algorithm (Harel & Koren, 2000). This algorithm is relatively fast to process and capable of drawing large force-directed and readable network graphs.

HS chapter	Description
01	Livestock
02	Meat
03	Fish
04	Diary products
05	Other animal products
06	Flowers, plants and trees
07	Vegetables
08	Fruit
09	Coffee, tea & spices
10	Cereals
11	Cereal products
12	Seeds (oilseeds, sowing seeds, oleaginous fruits)
13	Vegetable extracts and saps
14	Vegetable plaiting material
15	Animal and vegetable fats, oils
16	Preparations of meat or fish
17	Sugar and sugar products
18	Cacao and cacao products
19	Food preparations of cereal
20	Food preparations of fruit, vegetables and nuts
21	Other food preparations
22	Beverages and spirits
23	Food residues
24	Tobacco

HS chapter	Description
32,33	Essential oils, tanning and dying extracts
35	Albumins, starches and enzymes
40	Natural rubber
41	Raw hides, skins and leather
42	Articles of leather
43	Fur skins
44	Wood and articles of wood
45	Cork and articles of cork
46	Manufacturers of plaiting materials
47	Pulp of wood
48	Paper and paperboard
51	Wool
52	Cotton
53	Vegetable fibres
56	Felt, ropes, cables (of natural fibres)
57	Carpets (of natural fibres)
58,60	Woven, knitted and crocheted fabrics (of natural fibres)
61,62	Clothing and garments (of natural fibres)
63	Other textiles (of natural fibres)
87,84,82	Tractors, agricultural machinery and equipment
84	Machinery for agro-processing and food manufacturing
31	Fertilisers
38	Insecticides, pesticides and biocides
94	Wooden furniture

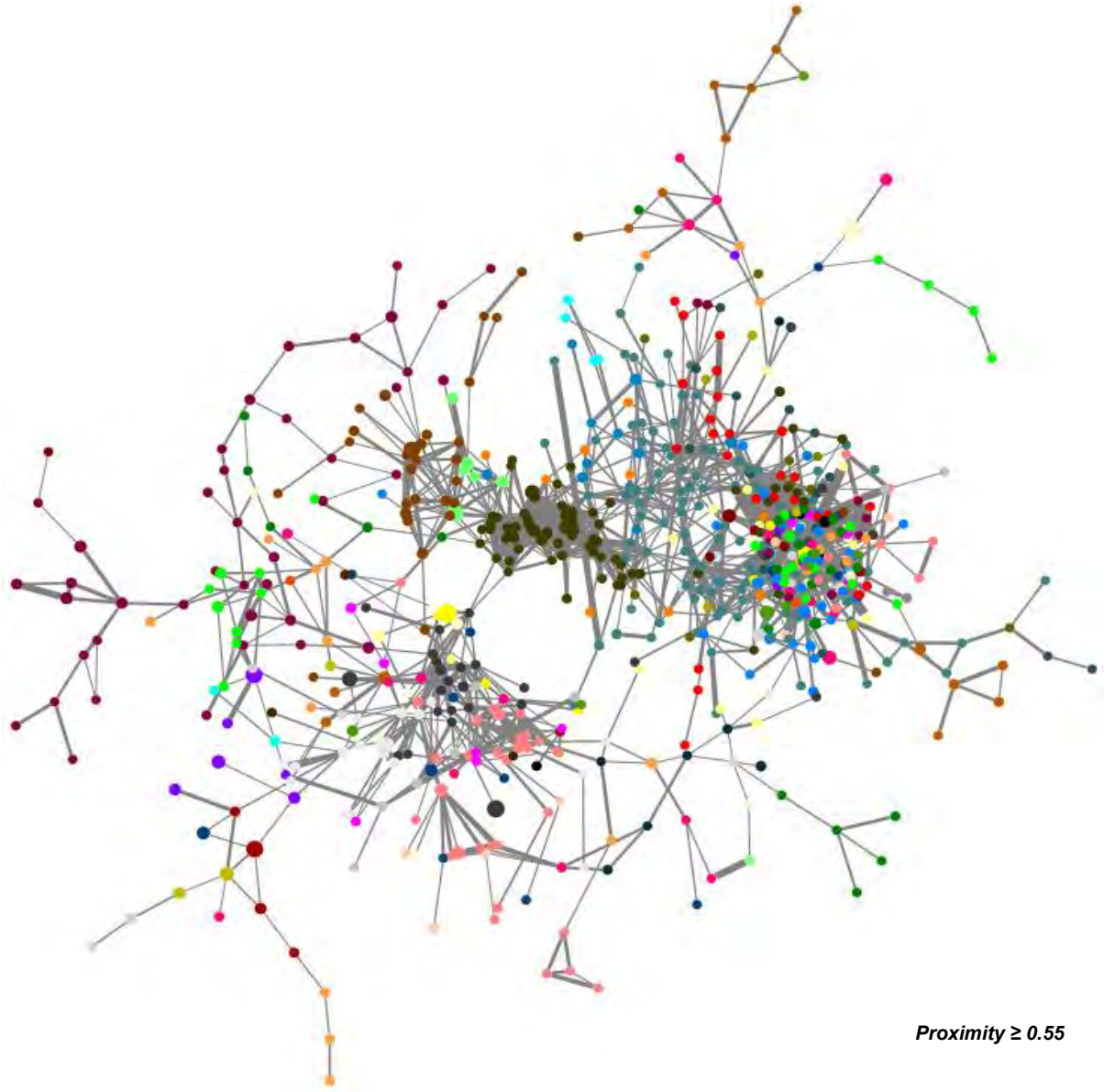


Figure 5.4: The agricultural product space (2007 – 2011)

Source: Author's own calculations (2013)

Each node in Figure 5.4 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 colour of the node is in accordance with the product's classification under the two-digit level of the Harmonised System (HS) nomenclature. As shown in the colour legend of Figure 5.4, 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.

Some of the general network metrics of the agricultural product space are shown in Table 5.1 below. The number of connected network components reflects a set of nodes (i.e. products) that is connected with each other but not to the rest of the network. The agricultural product space has a total of 76 individual connected components. Given that the maximum number of nodes and links in the largest connected network component is 540 and 1 624 respectively (see Table 5.1), the majority of the connected components in the product space consist of a relatively small number of products and links. For instance, the second largest connected component includes only 20 nodes and 86 links.

The network density is the ratio between the maximum number of links if all nodes (i.e. products) were connected with each other and the number of actual links in the product space. A density value of 0.006 is relatively low and it may thus be concluded that the agricultural product space as depicted in figure 5.4 can be classified as a sparse network.

Table 5.1: General network metrics of the agricultural product space

Network metric	
Nodes	772
Links	1 872
Individual connected network components	76
Maximum nodes in a connected network component	540
Maximum links in a connected network component	1 624
Network density	0.00629

Source: Author's own calculations (2013)

5.2.3 The structure of the agricultural product space

The metrics in Table 5.1 identified 76 different individual network components in the agricultural product space. Figure 5.5 below shows these 76 individual components of the agricultural product space. The graph confirms the presence of a single, large, connected component (see sub-graph 1) and a significant number of relatively small connected components (see sub-graphs 2 to 76). Fifty-one of the individual network components consist of only two products.

The smaller individual network components have by nature a larger degree of density. Excluding the two-product network components, the average density of the smaller components of the agricultural product space is 0.58.

Figure 5.4, in the previous section, shows that the agricultural product space is heterogeneous and characterised 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 4.2.1 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. From the graph in Figure 5.5, four relatively dense product groupings can be identified, namely cotton, textiles, meat and wood. To a lesser extent, wool and agricultural machinery can also be classified as relatively dense product groupings.

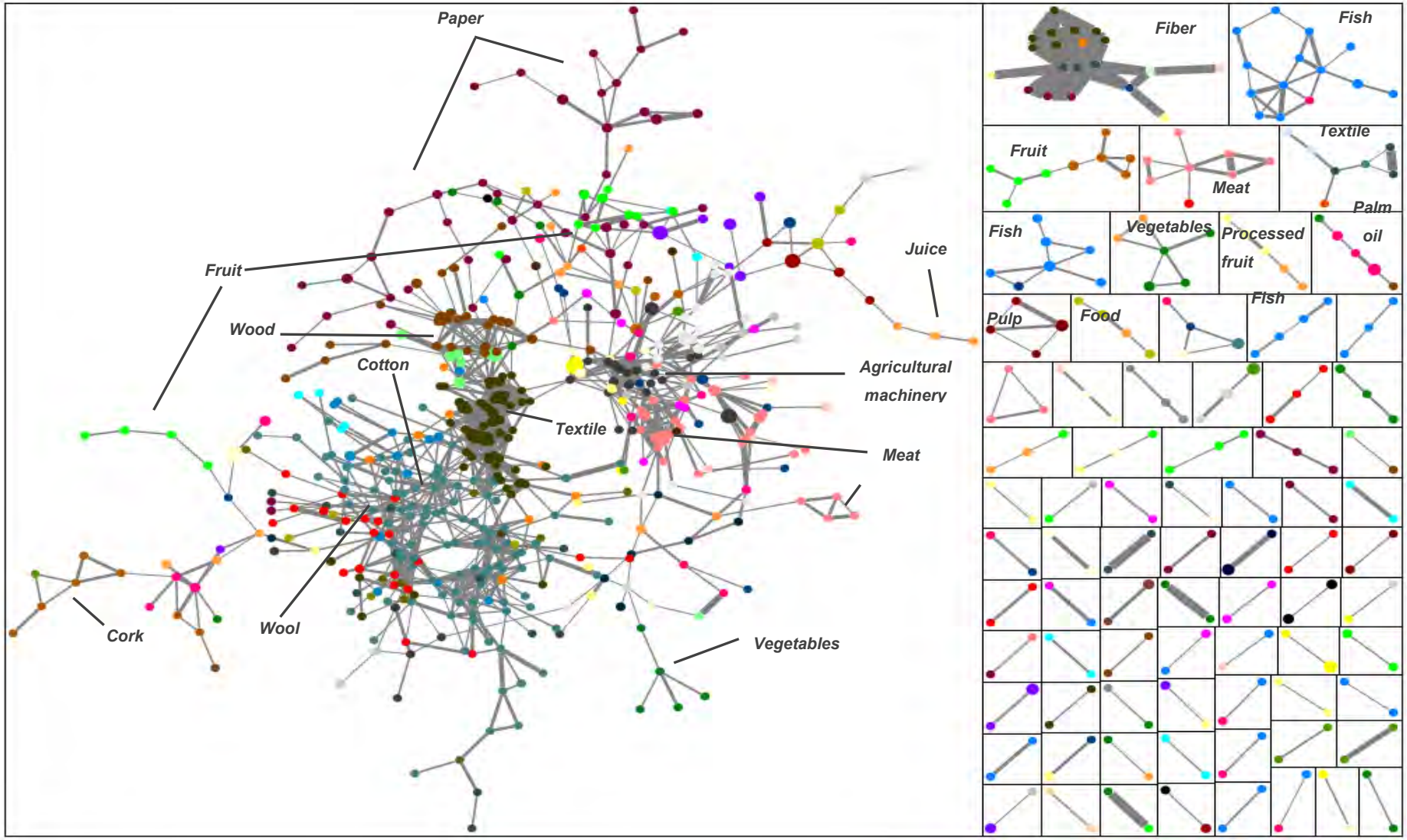


Figure 5.5: Overview of individual network components in the agricultural product space (2007-2011)

Source: Author's own calculations (2013

A variety of products are located in the less dense periphery of the agricultural product space, such as cork, vegetables, paper, and juice. Some products, like fruit for instance, have a presence in more than one location in the network. Furthermore, products located in individual network components which are not connected to the main network (see graphs 2 to 76 in Figure 5.4), include fish, vegetable fibres, palm oil, essential oils and sheep meat. Their location in the product space suggests a limited potential for capability and knowledge spill-overs from these products.

5.2.4 Agricultural product clusters

Section 3.4 introduced the aggregation of agricultural products into five broad clusters, namely primary agriculture, agro-processing food, agro-processing non-food, forestry and agricultural inputs[32]. This product clustering is based on input–output relationships, with the exception of the forestry cluster. The position of these distinguished clusters in the product space network is analysed in order to provide more insight into their connectedness (i.e. number of linkages). Hence, Figure 5.6 below shows the product space, colour coded according to the respective five clusters of the agro-complex.

Figure 5.6 shows a relative dominance of processed food products (yellow) and processed non-food products (blue). Furthermore, primary agricultural products (green) and agricultural inputs (grey) are relatively few in the product space

The connectedness within a specific cluster is determined by the number of connected individual network components, as well as the degree of density (i.e. the ratio between the actual number of links and the total number of possible links). A relatively small number of components and a high density imply a higher degree of linkages among products within a cluster. A higher number of linkages increase the opportunities for the redeployment of existing capabilities and knowledge to new production ventures within the clusters (i.e. a spill-over effect). This then determines the potential for diversification.

[32] Data Supplement I provides a complete overview of the products categorised within these five clusters.

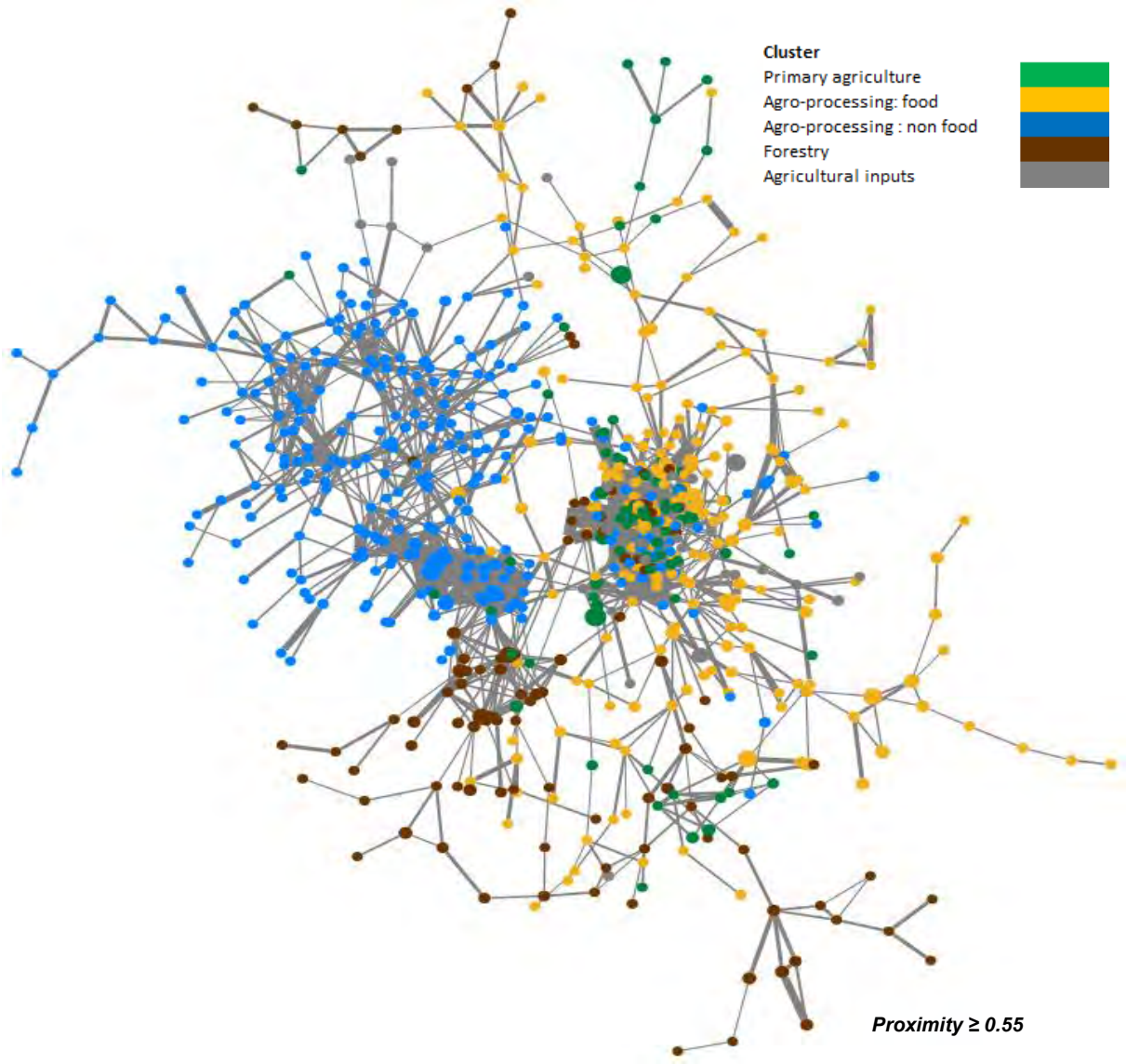


Figure 5.6: Product clusters in the agricultural product space (2007 – 2011)
Source: Author's own calculations (2013)

A summary of the characteristics of the five clusters' positions in the agricultural product space is provided in Table 5.2. It is evident from Table 5.2 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 characterised 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 5.2: Network characteristics of the five agricultural clusters

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

Source: Author's own calculations (2013)

Table 5.2 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 5.2 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 5.2). 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 5.2 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 large, ranging from milking machines to fertilisers to tractors.

It becomes evident from the analysis of Table 5.2 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. However, the number (i.e. density) of links within a cluster does not provide any information on the strength of the relatedness between products, as measured by the proximity value. Therefore, Figure 5.7 below provides an overview of the distribution of the proximity values of the links within each of the five clusters. Understandably, the figure shows a similar pattern to the aggregated proximity distribution in Figure 5.3

It is evident from Figure 5.7 that the degree of relatedness between products shows a similar distribution in all of the five clusters. In all clusters, apart from agro-processing of non-food, more than two-thirds of the respective pair-wise product connections have a proximity value that ranges between 0.55 and 0.65. Furthermore, 94 per cent of the links within the primary agriculture and agro-processing of food clusters have a proximity value of 0.75 or less. For the agro-processing of non-food cluster, this share is slightly lower (91 per cent). Furthermore, the forestry and agricultural inputs clusters have a slighter lower

share of links, below or equal to 0.75. Hence, the number of products in the agro-complex with a substantial degree of relatedness of more than 0.75 is very small.

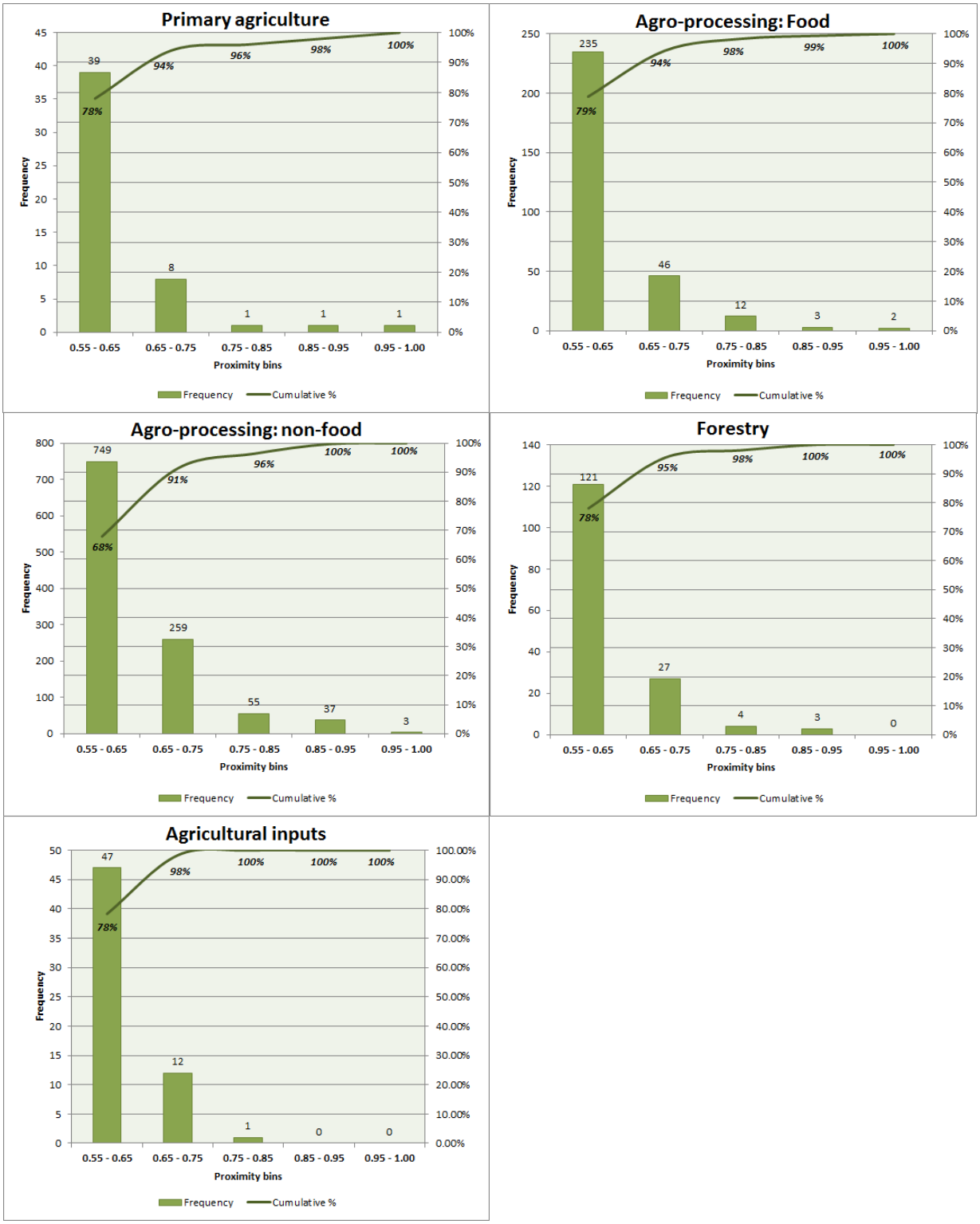


Figure 5.7: Distribution of the proximity of inter-cluster relatedness in the product space
Source: Author's own calculations (2013)

The figure shows that the relatedness within the agro-processing of non-food cluster is slightly stronger than in the other clusters. This is also reflected by the highest average proximity of 0.64 within this cluster. In comparison, the average proximities within the primary agriculture; agro-processing: food; forestry; and agricultural input clusters are 0.63, 0.62, 0.61 and 0.61, respectively.

So far, only the relatedness of products within the individual product clusters has been analysed. This has provided valuable insights into the potential for within-cluster diversification. However, the linkages between clusters by means of potential input–output relationships may also reveal diversification opportunities. This relationship is fairly evident between agricultural inputs, primary agriculture and agro-processing. However, the forestry cluster is an exception here, but will form part of the analysis. Table 5.3 shows the between-relatedness matrix of the five clusters in terms of the absolute number (top part) and the proportional (bottom part) linkages.

Table 5.3: Intra-cluster relatedness in the agricultural product space

	Agricultural inputs	Primary agriculture	Agro-processing: food	Agro-processing: non-food	Forestry
Agricultural inputs	*60*	7	54	5	2
Primary Agriculture	7	*50*	54	21	6
Agro-processing: food	54	54	*298*	22	8
Agro-processing: non-food	5	21	22	*1 103*	27
Forestry	2	6	8	27	*155*
Total intra-cluster links in the product space	**68**	**88**	**138**	**75**	**43**

(Table 5.3 continued)

	Agricultural inputs	Primary agriculture	Agro-processing: food	Agro-processing: non-food	Forestry
Agricultural inputs		8%	39%	7%	5%
Primary Agriculture	10%		39%	28%	14%
Agro-processing: food	79%	61%		29%	19%
Agro-processing: non-food	7%	24%	16%		63%
Forestry	3%	7%	6%	36%	
Intra-cluster links / total links in the product space	**53%**	**64%**	**32%**	**6%**	**22%**

Source: Author's own calculations (2013)

It is evident that the matrix in Table 5.3 is symmetric with regard to the absolute number of linkages (upper part of the table). To give some perspective, the matrix also shows the number of inter-cluster linkages for each cluster (i.e. in the darker-shaded matrix elements). The proportional linkages shown in the bottom part are calculated by dividing the number of linkages between two clusters by the total intra-cluster linkages of each cluster. For example, the number of linkages between the primary agriculture and the agro-processing of food clusters is 54, divided by the total number of intra-cluster linkages of primary agriculture, which is 88. The proportion of the intra-cluster linkages in the total linkages per cluster is given in the last row of the table.

Table 5.3 shows that the agricultural inputs and primary agriculture clusters, especially, have proportionally strong links with other clusters. The agricultural input cluster has more intra-cluster than inter-cluster links, with a large number of links especially to the agro-processing of food cluster. This cluster includes capital equipment for the agro-processing cluster (e.g. crushers, milling equipment, abattoir equipment and bakery machinery).

Of the total links of the primary agriculture cluster, 64 per cent are intra-cluster connections (see Table 5.3). Most of the intra-cluster connections of primary agriculture are with the

agro-processing of food cluster, followed by the processing of non-food cluster. This reveals relatively good forward diversification linkages from primary to secondary production.

Table 5.3 furthermore shows that agro-processing of food is more connected within its cluster than between clusters. This is reflected by the proportion of 32 per cent of intra-cluster links compared to its total links. The cluster has the most connections with primary agriculture and agricultural inputs. However, diversification opportunities within the cluster are more predominant than the diversification opportunities through backward linkages.

The agro-processing of non-food cluster is the least connected with other agricultural clusters. Only six per cent of its total linkages consists of intra-cluster links (see Table 5.3). The largest share of those intra-cluster linkages are with the forestry cluster (36 per cent), followed by agro-processing of food (29 per cent). Hence, similar to agro-processing of food, most diversification opportunities can be found from within the cluster and not through linkages with other clusters.

As expected, the intra-clusters linkages of the forestry cluster are relatively low, at only 22 per cent (see Table 5.3). Its production is relatively independent from other sectors and most input-out relationships are captured within the cluster (e.g. wood, wood pulp, and paper products). However, the cluster has a relatively strong link with the agro-processing of non-food cluster (63 per cent of its intra-cluster linkages).

The connectedness between clusters, as revealed by Table 5.3, shows some interesting patterns of relationships between clusters in the agro-complex. However, the magnitude of the intra-cluster relatedness requires some further exploration. Figure 5.8 shows the distribution of the intra-cluster proximity values for each of the five clusters.

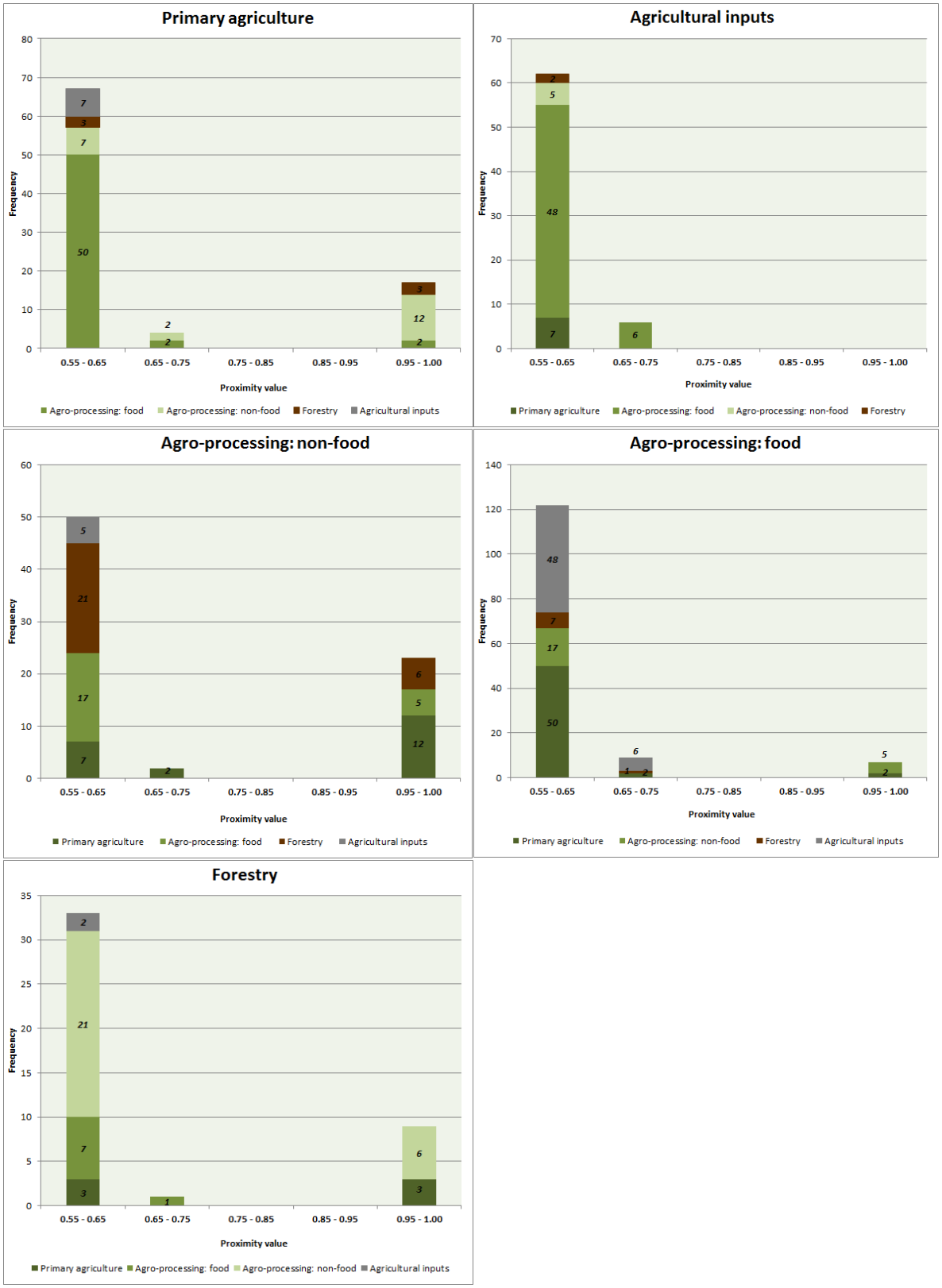


Figure 5.8: Distribution of the proximity of intra-cluster relatedness in the product space

Source: Author's own calculations (2013)

The figure reveals that the majority of the intra-cluster linkages in the agricultural product space have a proximity that ranges between 0.55 and 0.65. Hence, most of these linkages are of a moderate magnitude. However, it is also evident from Figure 5.8 that the primary agricultural and forestry clusters have several very strong linkages with the agro-processing of non-food cluster.

This section revealed a significant number of input–output linkages in the agricultural product space, although most of them had moderate proximity. To an extent, this contradicts earlier studies which found limited input–output relatedness in the product space. For instance, Hausmann, Klinger and Lawrence (2008) found that products do not tend to be strongly connected to other varieties up or down the value chain. Furthermore, Hidalgo (2011) states that input-output relationships do not generally explain proximity. It must be noted here that the findings of these authors are based on a product space constructed from products of all economic sectors, and not just for the agro-complex, as is the case in this study.

As discussed in Section 4.2, the product space measures the relatedness between products in order to identify pathways for diversification, based on the ease of transferring existing productive capabilities and knowledge. Hence, the rationale for limited input–output relationships in the product space seems obvious, as the transfer of capabilities up and downwards the supply chain is not always evident. For example, the primary production of soya beans requires a very different set of capabilities and knowledge than the processing of soya beans into oil. However, the latter cannot take place without the former.

It seems, thus, that the relatedness between products in some parts of the agro-complex is validated differently in this study than is generally assumed in the product space theory. For these specific links, the significantly strong input–output relations outweigh the degree of similarity in the required capability and knowledge set.

The previous sections provided an overview of the characteristics and structure of the agricultural product space. The next section determines South Africa's position in the

product space and the implications thereof for its diversification pathways in the agro-complex.

5.3 SOUTH AFRICA'S LOCATION IN THE AGRICULTURAL PRODUCT SPACE

It became evident in Section 5.2 that the agricultural product space has a heterogeneous structure which has implications for diversification and structural transformation of a country. Hausmann and Klinger (2006a) state that if a country produces products that are positioned in the denser part of the product space, the process of diversification and transformation is much easier as the set of acquired capabilities and knowledge can be relatively easily redeployed to the relative abundant nearby products. A country's current position in the product space (i.e. its specialisation) thus has important implications for its future economic diversification and transformation. Therefore, this section explores the location of South Africa's productive structure in the agricultural product space.

5.3.1 South Africa's specialisation in the agricultural product space

In order to determine South Africa's specialisation (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 4.2.3). The level of specialisation (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 specialisation. In order to provide a holistic picture of South Africa's agricultural production, a demarcation into four levels of product specialisation is made. These are:

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

Of the 1 456 products that comprise the agro-complex in this study, South Africa is trading 92 per cent of these products. In 859 products, or 59 per cent, the country has no specialisation, which implies that production is either non-existent or marginal and that the domestic supply thus largely depends on imports. South Africa has a low specialisation in 307 products, comprising 21 per cent of the total agro-complex. Furthermore, the country has a revealed high specialisation in 172 products, which represents 12 per cent of the agro-complex.

Figure 5.9 below shows the location of South Africa in the agricultural product space[33] for products for which the country has either a high (RTA >1) or low (RTA >0 <1) level of specialisation. 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 specialisation (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 specialisation 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 (see Section 5.2.1). 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 specialisation 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 specialisation in these products. These products comprise the best basis for diversification ventures as they have a set of well-developed, embedded productive capabilities.

[33] Note that the layout of both networks differs. The re-run of the layout algorithm after each specification of the properties of the network in NodeXL results in un-identical designs of the product space. However, the underlying structure of the agricultural product space remains the same after each re-specification.

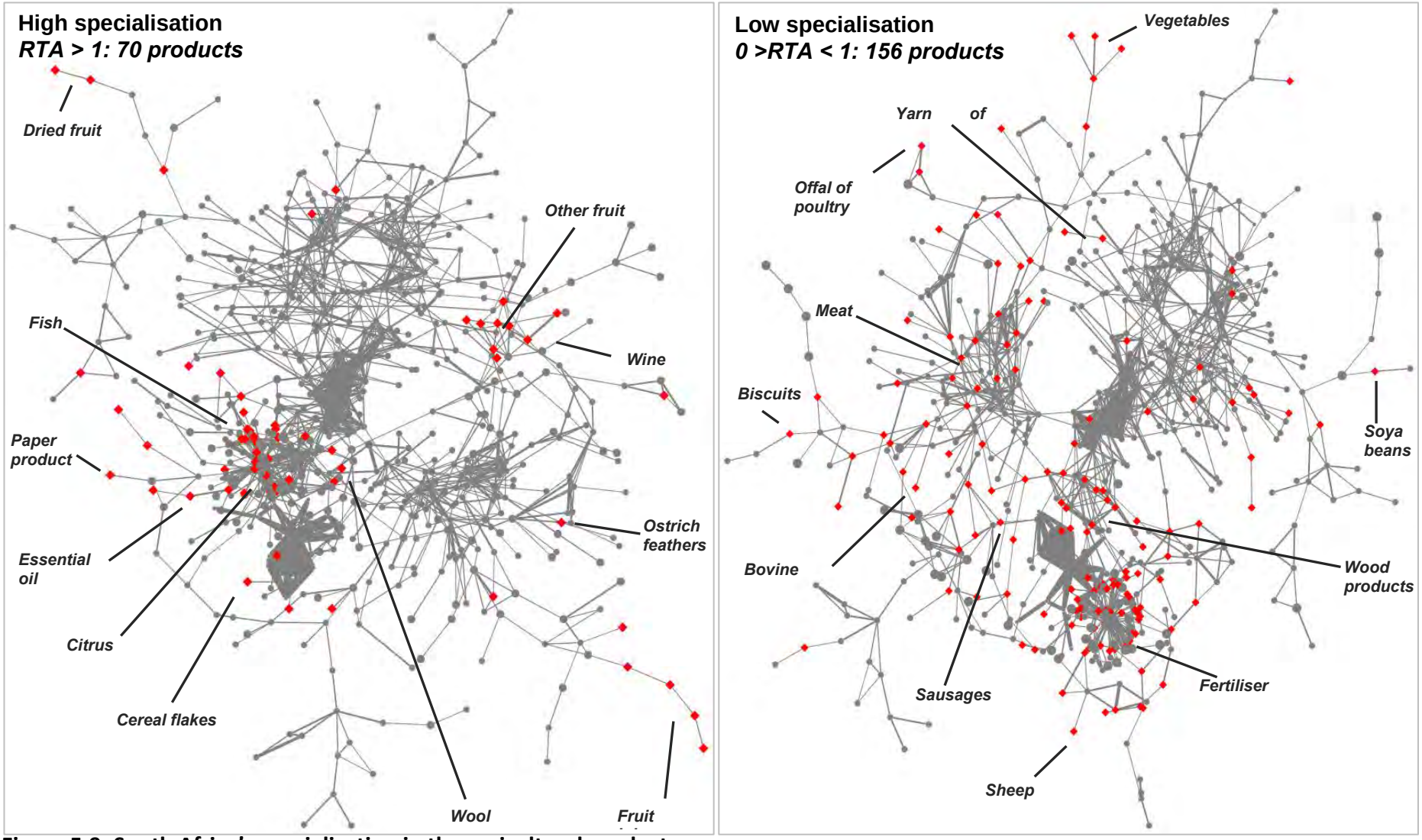


Figure 5.9: South Africa's specialisation in the agricultural product space

Source: Author's own calculations (2013)

The right pane of Figure 5.9 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 then the other group of products.

South Africa's productive structure in the agricultural product space is further analysed in Figure 5.10 below. The figure indicates the relative number of products that South Africa produces as a proportion of all products included in the clusters of the agricultural product space. It is evident from the figure that South Africa has the highest relative presence in primary agriculture, which is followed by the agro-processing of food. The country has the lowest relative presence in agricultural inputs. Looking further into the level of specialisation, its dominant position in core competencies in primary agriculture is noteworthy, whereas its core competencies in the other clusters are remarkably lower.

These stylised facts also hold 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.

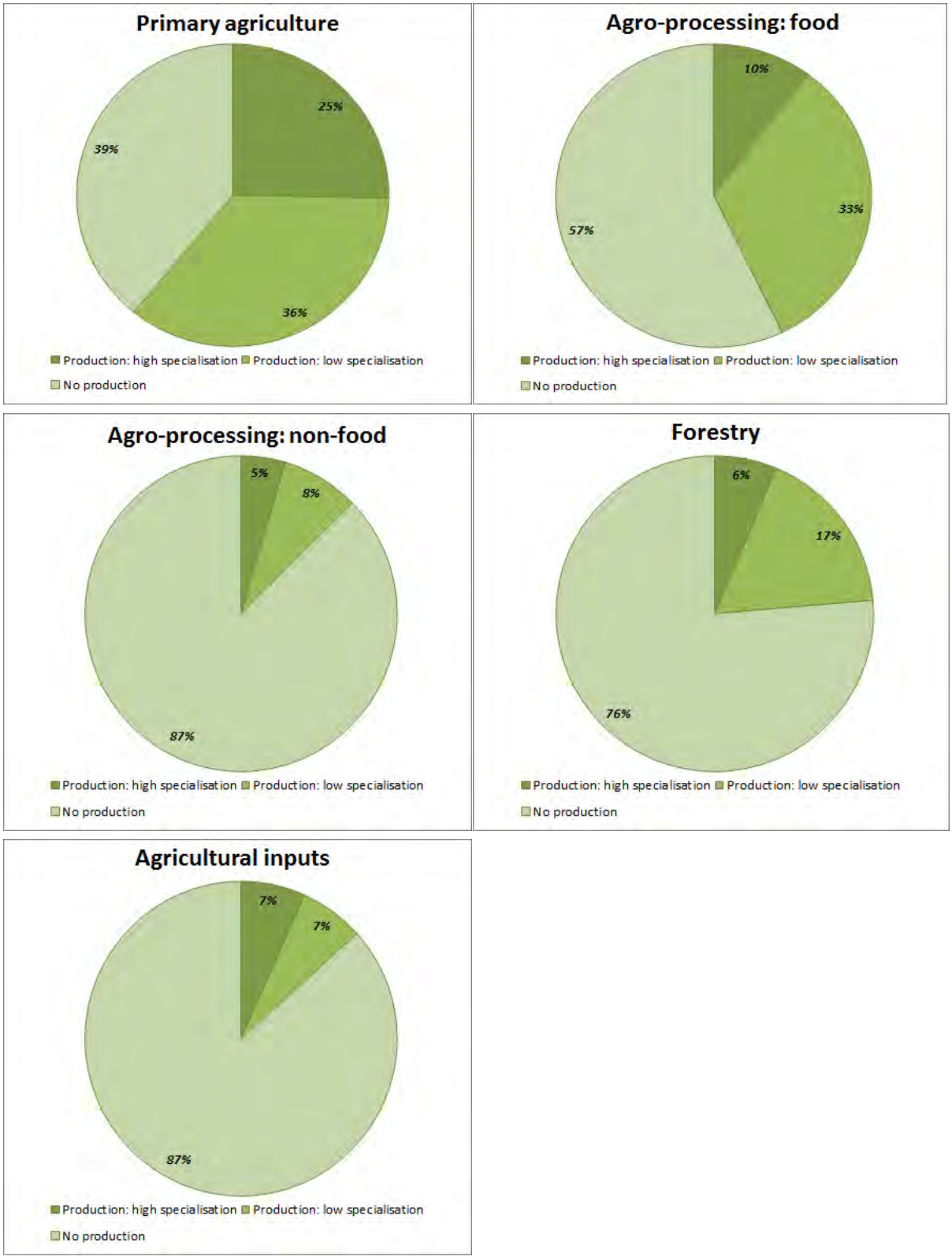


Figure 5.10: South Africa's productive structure per cluster in the agricultural product space

Source: Author's own calculations (2013)

5.3.2 South Africa's cluster relationships in the agro-complex

As was evident from Section 5.2.4, 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 5.4 below. This productive structure comprises the 70 products with a RTA >1 (i.e. a high level of revealed specialisation).

Table 5.4 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 are predominantly situated in the primary agriculture and agro-processing of food clusters. Compared to the cluster structure of the entire network (see also Table 5.3), South Africa's position in the agricultural product space 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.

Table 5.4: South Africa's inter- and intra-cluster relationships in the product space

	Agricultural inputs	Primary agriculture	Agro-processing: food	Agro-processing: non-food	Forestry
Total products	*3*	*22*	*25*	*13*	*7*
Agricultural inputs	*0*	0	0	0	0
Primary Agriculture	0	*28*	8	2	0
Agro-processing: food	0	8	*10*	2	0
Agro-processing: non-food	0	2	2	*8*	0
Forestry	0	0	0	0	*2*
Total intra-cluster links in product space	**0**	**10**	**10**	**4**	**0**
Total links	**0**	**38**	**20**	**12**	**2**

(Table 5.4 continued)

	Agricultural inputs	Primary agriculture	Agro-processing: food	Agro-processing: non-food	Forestry
Agricultural inputs	NA	0%	0%	0%	0%
Primary Agriculture	NA	74%	40%	17%	0%
Agro-processing: food	NA	21%	50%	17%	0%
Agro-processing: non-food	NA	5%	10%	67%	0%
Forestry	NA	0%	0%	0%	100%
Intra-cluster links / total links in product space	**NA**	**26%**	**50%**	**33%**	**0%**

Source: Author's own calculations (2013)

5.3.3 South Africa's products in the agricultural product space

A complete overview of the 70 products that comprise South Africa's core competencies in the agricultural product space is provided in Table A.1 in Annexure I. The table shows the respective RTA index, the value of exports, the share in global agricultural trade, the number of linkages in the product space, and the average proximity value of the linkages for each product.

Table A.1 (in Annexure I) shows that South Africa has the highest relative specialisation in chemical wood pulp, preserved apricots and fine animal hair. The table shows, furthermore, that of all the products included in the agricultural product space, South Africa earns the most foreign currency from the exports of chemical wood pulp, wine and grapes. The most globally-traded products (which is also reflected by the node size in Figure 5.4) produced by South Africa are wine, fish fillets and cane sugar. In total, these 70 products have a proportional share of 6.6 per cent in global agricultural trade for the period 2009 to 2011.

Table A.1 (in Annexure I) also provides an indication of the connectedness of South Africa's overall productive structure. About 44 per cent (31) of the products have two or more

linkages in the product space. Wine, peaches, and plums have the most, each with six linkages in the network. In terms of the strength of these linkages, Table A.1 also provides the average proximity value of the links for each product. The average proximity for all links of the 70 products is 0.61. The strongest average proximity to other products in the agricultural product space is recorded for wine, peaches and plums.

The connectedness of South Africa's current productive structure in the agricultural product space indicates the potential number of diversification opportunities for moving to nearby products in the network. Furthermore, the current level of specialisation in a product also determines the likeliness of a successful transfer of capabilities and knowledge to new production ventures.

To further analyse the connectedness of South Africa in the agricultural product space, the measure of *Centrality* (see Section 4.2.4) was calculated for each of the 70 products. A higher value of *Centrality* indicates that the product is more central in the product space and connected to a greater proportion of the 772 products. Figure 5.11 plots the *Centrality* and the *RTA* index (i.e. revealed level of specialisation) for each product for which South Africa has developed core competencies. The products in the figure are colour coded according to the respective clusters.

It is evident from Figure 5.11 that a variety of South Africa's deciduous fruits are located in the denser parts of the agricultural product space. This is remarkable, as unprocessed agricultural products in economy-wide studies have been located in the sparser parts of the product space (see Hausmann and Klinger, 2007). Furthermore, some of South Africa's processed products in the agro-complex, such as wine, fish fillets, wine lees and miscellaneous poultry meat, are also located in the denser parts. Some of the products in which South Africa has a relatively high level of specialisation, such as chemical wood pulp, fine animal hair and preserved apricots, are not so well connected in the network. In general, rich countries tend to be specialised in the denser parts of the product space (Hausmann and Klinger, 2007). Since South Africa is an upper-middle income country, it is evident that it should endeavour to reach some convergence by diversifying to new products with a higher degree of centrality.

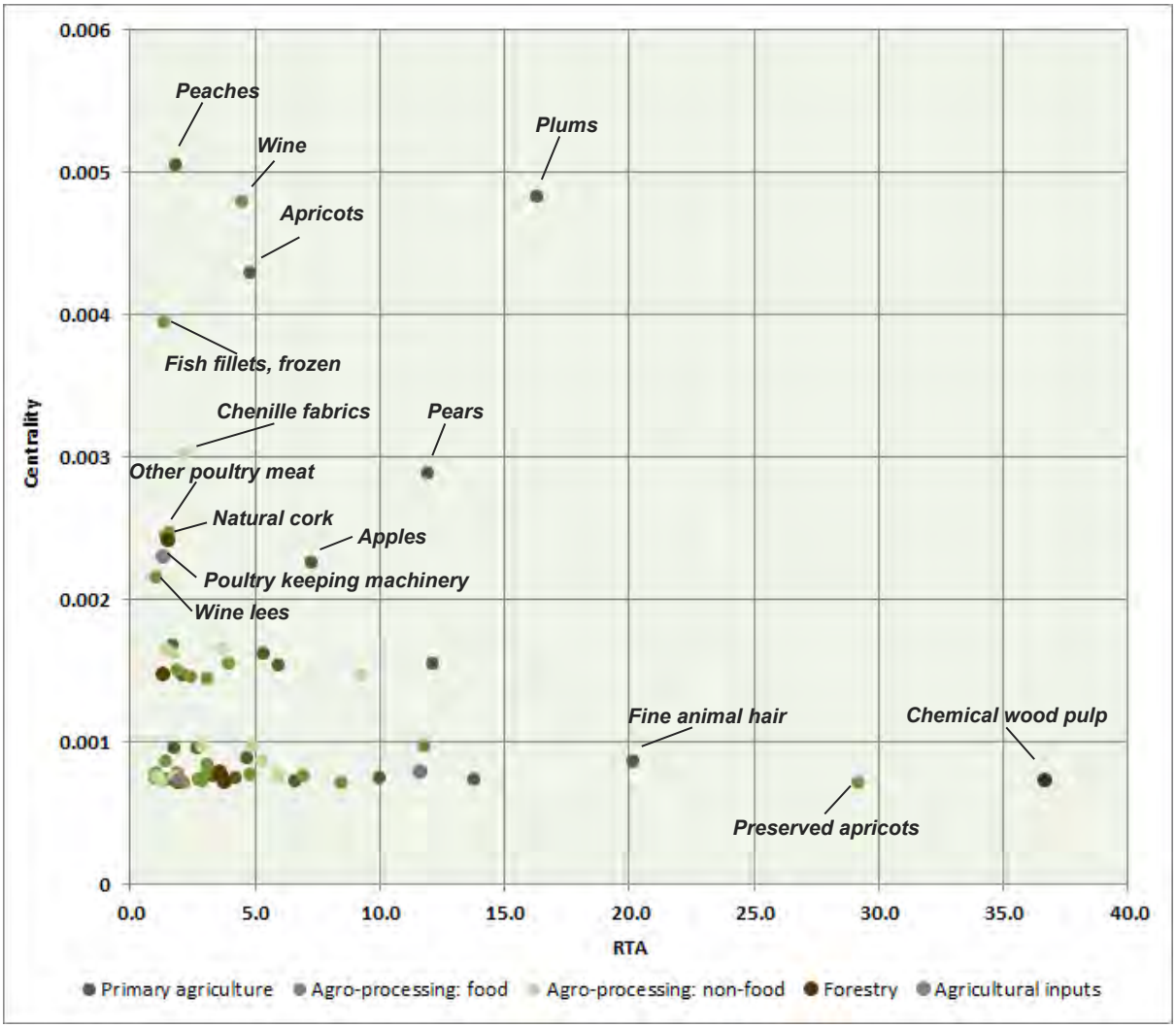


Figure 5.11: Centrality of South Africa's productive structure in the agricultural product space

Source: Author's own calculations (2013)

The 156 products in which South Africa has a relatively low level of specialisation also present a relatively lower potential for being a starting point for diversification ventures in the agricultural product space. However, cognisance 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 specialisation are depleted. Table 5.5 shows a brief comparison between South Africa's products with a high level and a low level of specialisation within the agro-complex

Table 5.5: Overview of the specialisation of South Africa's productive structure in the agricultural product space

	High level of specialisation	Low level of specialisation
Total products in agricultural product space	70	156
Share in global agricultural trade (2009 – 2011)	6.6%	13.4%
Average number of linkages in the agricultural product space	1.8	3.2
Average centrality	0.0014	0.0024

Source: Author's own calculations (2013)

It is evident from the table that South Africa will gain from improving the competencies of the products with low levels of specialisation.

5.3.4 South Africa's diversification opportunities in the agricultural product space

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 existing products. To analyse how "far" a product is located from South Africa's current productive structure, the measure of *Distance* (see Section 4.2.4) 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 5.12 below shows the *Distance* for all products 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 5.12 shows the diversification opportunities based on the core competencies of South Africa's productive structure. These 70 products comprise 9 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 specialisation. 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 5.12 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 specialisation. 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.

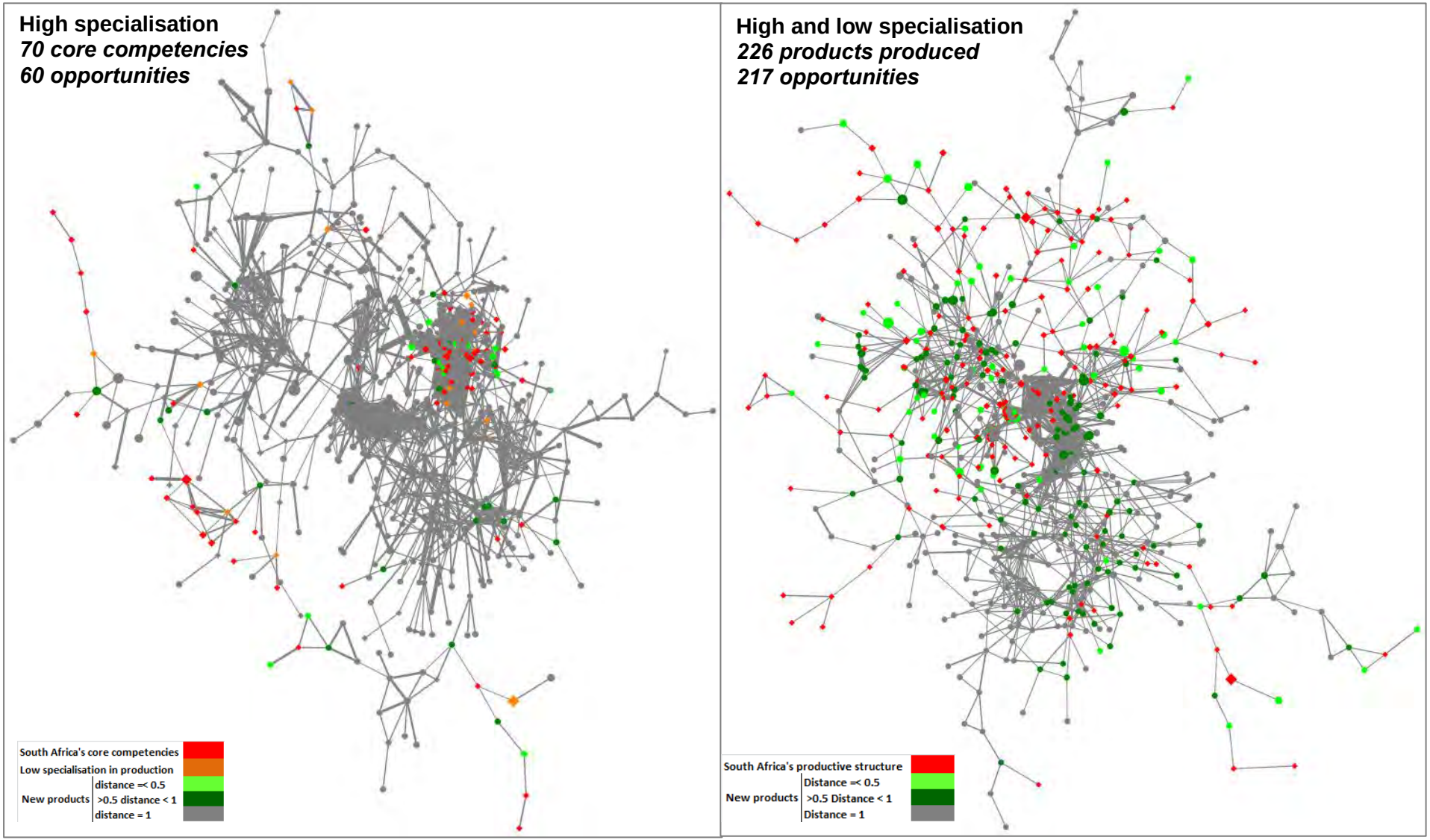


Figure 5.12: Pathways of South Africa's diversification opportunities in the agricultural product space

Source: Author's own calculations (2013)

5.4 Summary

Even based on the opportunities derived from South Africa's core competencies, there seems to be a relatively good prospect for South Africa's product diversification in the agro-complex. In this chapter it is argued that the productive capabilities for some of the products with a lower degree of specialisation are not fully developed. This makes them difficult to be transferred and redeployed to new production ventures. Hence, a number of opportunities will likely be difficult to capitalise.

Moreover, the diversification opportunities may be located in a sparse area of the network or they may be so highly related to existing products that it does not imply any innovation into new capabilities and knowledge. Therefore, these potential moves of diversifying to "new" products need to be further assessed, based on their strategic value. This value can be related to a relatively high market potential (market-driven diversification), higher labour intensity or quality (employment-driven diversification), or a higher rate of product complexity (structural transformation).

These specific avenues of diversification in the agricultural product space are analysed for South Africa in Chapter six. Furthermore, subsequent opportunities in the network may also become available as new pathways open up, following the initial round of product diversification. This will also be further explored in Section 6.3.7 in the next chapter.