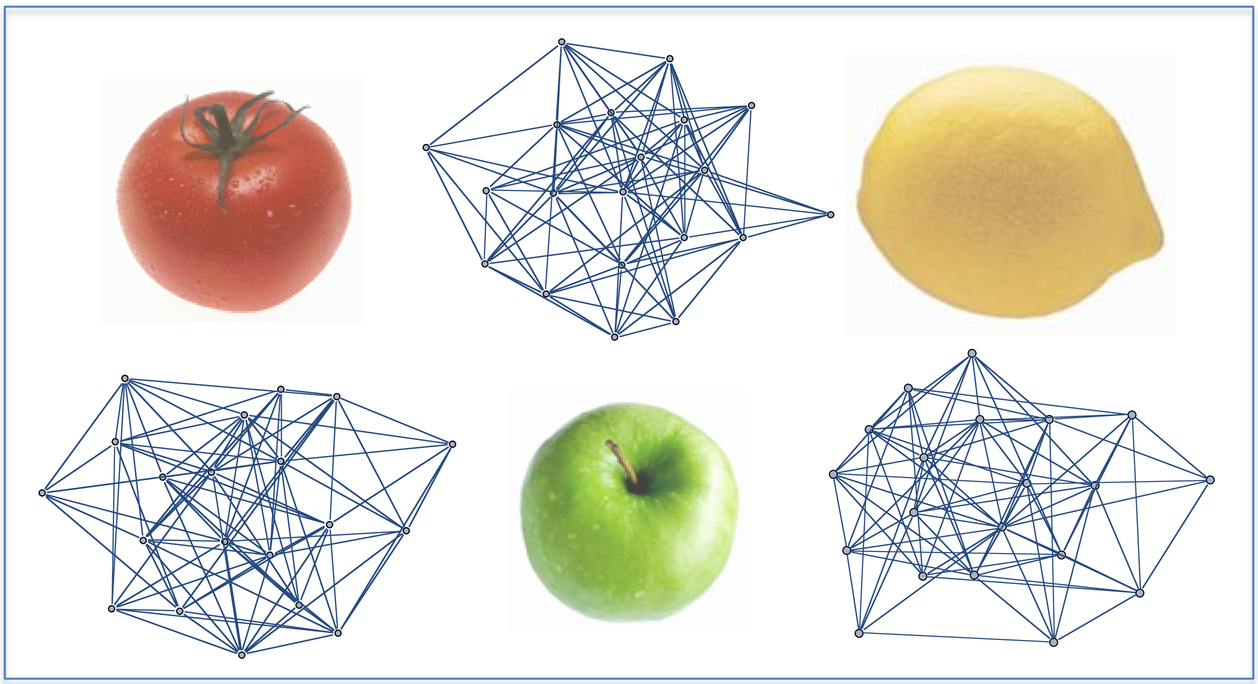
WAGENINGEN UNIVERSITY

MANAGEMENT STUDIES

INTERNATIONALIZATION IN WORLD HORTICULTURAL TRADE: A NETWORK & TRADE VOLUME ANALYSIS

MST-80424- MSc Thesis



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24 ECTS

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1. INTRODUCTION:

1.1. Trends in Agricultural Trade:

It is a commonly held opinion that agricultural trade has become more "global" in the post WWII period. In reality, the globalization of agricultural trade goes back much longer than that, starting with key storable commodities such as grains (REF) and then moving on to value added processed products[1] (REF). The history of various commodity trading companies [2](REF) is a good review of the major trends of agricultural commodity trading in especially the last century. However, this so called internationalization is not limited to grains and storable commodities; some of the major international FFV (fresh fruit vegetable) conglomerates[3] of today have their origins banana trading, which may be considered the first FFV commodity to emerge in the past century (REF). These conglomerates today trade in much more than bananas, but the industrial organization of the producer-distributer-marketer chain (followed by the retailer and consumer) is still rather fragmented and that there is a lot of activity of medium sized SMEs (REF).

It is also a widely held opinion that since the 1970s, trade in fresh fruits and vegetables have been coming up the curve and catching up with commodities, in turn they themselves becoming commodities. The increasing trend in fresh fruit and vegetable trade has been attributed to (REF):

1- Changes in consumption patterns due to health and lifestyle concerns
2- Improvement of production capacity through capital and technology injection into new regions
3- Set up of capital-intensive cold chains to enable long distance transport of fresh fruits and vegetables.

Especially since the 1980s, the FFV has been flooded with previously very little known tropical species[4] (REF). This easily gives the impression to the average Western (Europe & the US) consumer that the world is indeed becoming smaller or

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[1] Emergence of giants such as Nestle, Heinz, Campbell, Unilever among others.

[2] Bunge, Acher Daniels Midland (ADM), Cargill, Louis Dreyfus togeher control a very significant portion of global grain and agricultural commodity trade through years of internationalization and vertical and horizontal integration.

[3] Dole, Chiquita and Del Monte all have their origins in banana trade. In fact, the precursor of Chiquita, known as United Fruit Company, has been implicated in political involvement with undemocratic leaders in the so called "banana republics" of Central America- such was their power at the time (REF)

[4] Some of the previously unknown but currently available FFVs are: breadfruit, cherimoya, lychee, passion fruit, fava beans, plantain, guava, bok-choy and cassava. In addition, leafy greens such as arugula, radicchio, chicory, oak leaf and baby vegetable were previously only available for niche or ethnic markets but are now commonly available.

more “global”, but it has been noted that most of this trade takes place in a South-to-North (REF) direction, especially during the off season winter months in the North, to ensure a constant supply of year round vegetables. This is traditionally possible in Europe for some key vegetables like peppers, tomatoes etc. in Europe through controlled environment agriculture but the scope of production in greenhouses still remains rather narrow and limited to few economically feasible FFVs (REF).

In short, the consensus opinion seems to be that the trade in FFVs increased significantly in the last 5 decades, but to some [REF] it seems that the trade follows a periphery-center pattern, where the highly affluent and able consumers in the West demand a more FFVs and that distributors and suppliers turn to a few key areas of the world to ensure this supply.

In this study, we will look at the world trade in FFVs over different time periods on a “single product-total world” basis and try to understand if there are product specific differences in trade patters and if these differences can be leveraged to gain a greater understanding of the internationalization of the trade in horticultural products.

1.2. Horticultural Products vs. Commodities:

Some plant based products are categorically named “commodities” due to their storability, high volumes of trade, historical significance and inseparability from human nutrition and welfare. Most commodities like grains (wheat, rice, corn, rye) form the basis of major commodity trading companies and are an important source of economic activity through out widely integrated supply chains (Meijerink 2009) Commonly held belief is that these products are widely internationalized in that trading in them is wide spread across the all nation states. Other commoditized agricultural products include fiber crops, oil and sugar crops. However, the definition of “commoditized” agricultural products is still more of a traditional category than a formal one, mostly based on significance due to being a precursor of most processed food and industrial items.

Horticultural products, on the other hand, share other common characteristics. Traditionally, horticultural science is a part of agricultural science and deals with a subset of the total plant species that are of interest to agricultural activity. Where as traditional agronomy deals mostly with commoditized field agriculture, often relying on mechanization, large scale production, rain fed irrigation and emphasis on uniform quality, horticulture puts more emphasis on modification of individual plant behavior and architecture. This modification is often achieved thorough pruning, removal of organs, precise timing and control of development stages. In case of undesirable external conditions, horticultural crops are grown in greenhouses or entirely closed structures with near complete control over internal climate conditions such as temperature, humidity and light, through intensive use of technology and modeling of plant development and physiology. Naturally, only very high value crops can be grown in greenhouses. Some typical horticultural products include fresh fruits and vegetables, cut and pot flowers, along with some processed versions of these (ready to eat vegetables etc.) Never the less, greenhouse horticulture crops are not the norm in most regions due to already acceptable weather conditions or prohibitive costs. In addition, tree crops are usually not suitable for greenhouse production and most other horticultural products are often grown in open fields but often on smaller scales than typical agronomic crops.

Another characteristics of horticultural products is their perishability(Table 1). The level of perishability can vary significantly between species or even between different cultivars of the same species. The perishability has significant consequences on the characteristics of the supply chain required to supply the

Table 1- Perishability of Major Fruits and Vegetables - Adapted from Keyder et. al

PRODUCTS	STORAGE LIFE	
	AVERGE LIFE (WEEKS)	PERISHABILITY CATEGORY
Dates	36	4
Carrots and turnips	28	4
Garlic	26	4
Pears	18	4
Onions, dry	18	4
Kiwi fruit	16	4
Apples	16	4
Grapes	16	4
Artichokes	16	4
Cabbages and other brassicas	16	4
Lemons and limes	14	4
Cranberries	12	3
Quinces	10	3
Pumpkins, squash and gourds	10	3
Persimmons	10	3
Oranges	8.5	3
Leeks, other alliaceous veg	8	2
Grapefruit (inc. pomelos)	7	2
Avocados	4.5	2
Plums and sloes	3.5	1
Cauliflowers and broccoli	3.5	1
Tomatoes	3.5	1
Gooseberries	3.5	1
Tangerines, mandarins, clem.	3	1
Pineapples	3	1
Onions (inc. shallots), green	3	1
Peaches and nectarines	3	1
Lettuce and chicory	3	1
Plantains	3	1
Bananas	2.5	1
Cherries	2.5	1
Chillies and peppers, green	2.5	1
Other melons (inc.cantaloupes)	2.5	1
Asparagus	2.5	1
Mangoes, mangosteens, guavas	2.5	1
Currants	2.5	1
Watermelons	2.5	1
Blueberries	2	1
Apricots	2	1
Papayas	2	1
Cucumbers and gherkins	1.75	1
Spinach	1.75	1
Mushrooms and truffles	1.5	1
Peas, green	1.5	1
String beans	1.5	1
Eggplants (aubergines)	1.5	1
Strawberries	1.25	1
Beans, green	1.25	1
Figs	1.25	1
Okra	1.25	1
Raspberries	0.75	1
Sour cherries	0.75	1

products to major retail outlets. More perishable products require a different cold chain than less perishable products along with modified atmosphere storage. The important point here is that the supply chain is time sensitive and have specific requirements, which often translate to higher transportation costs. Another point to keep in mind about horticultural products is that what may be considered horticultural in one region (Bananas or olives in Northern Europe may be considered as staple food sources, such as olives in the Mediterranean or bananas in Central America. Yet another typical aspect of horticultural products is the relative lack of uniform products: biological variance is much higher and significantly different varieties of different fruits and vegetables exist, where the products are much more standardized for commodities. However, once again, this is not as true for products such as bananas or tomatoes where uniform product specification have been pushed down from the retail chains to the producer level to ensure uniform quality and higher acceptance rates to consumers (Cook 1998).

In essence, all the above mentioned criteria make it more or less a relatively subjective definition of “commoditized” or “horticultural” products.

2.RESEARCH QUESTIONS AND APPROACH

2.1 Research Aim

The literature of agricultural economics is full of analyses focusing on a single horticultural product in a limited region. Most of the analyses understandably tend to do research into either their target markets or home regions. Most of the time, the research takes either a developmental economics or trade policy perspective on certain key issues (REF, REF, REF)

On the other end of the spectrum, there are excellent papers that focus on the organization of world trade networks. Through the analysis of world level networks, these papers aim to uncover key trends in developmental stages of various parts or blocs of world trading network, often approaching the issue from a perspective of center vs. periphery, correlating these with the development and growth of these blocs. Often, major political under currents are the motivation of such research. These papers often rely on social network theory to analyze the complex trade matrices (REF,REF,REF). However, the analyses are almost never at a product level and usually focus on the total value of total world trade. Analysis at a product level, for each trading partner, for a time-series is understandably difficult due to:

- There are few sources of such data
- Often, reporters of the data are not all available at various time points for the data set. In other words, some countries start reporting the data at an earlier date than others.
- Countries often impose restriction to the trade of certain agricultural products, either due to protectionist reasons and/or health and safety

concerns. Example would be the recent ban of horticultural imports due to the e. coli infection in Northern Europe (REF)

- Wars often significantly hamper free trade
- Sometimes the amounts traded at a product level for some products are very low and are subject to changes in the weather for specific regions.

Never the less, we believe that there is significant value that can be gained from analyzing the trade on a product level basis for horticultural goods. We believe that some products are different than others due to their perishability, availability and demand. More over, the popularity of some products have increased over time either due to supply side availability and investment or an increase in demand due to changing life styles and consumer wishes. Therefore, we propose that such trends should be visible in product level analysis. In addition to trade volume analysis, we propose that the dichotomized trade network of such products also exhibit differences between products.

Another key point is that this research has the goal of being a data intensive analysis to better document the intricacies of data underlying the analysis as well as serving as a guideline for future researchers looking to further perform similar analyses. Therefore, a significant amount of time was spent cleaning and refining the data, writing code from scratch to analyze the data, filtering out problematic categories etc. There are certainly many more metrics that could be developed, especially for the network analysis data but this task is left to other students of network analysis interested in quantitative analysis of agricultural network related data.

This research neither aims to make any policy deductions nor serve as a final conclusive characterization of horticultural trade model. There are far too many variable in such a model. Availability, political and regional situations, the activity of trading blocs, protectionism will all interfere with such an analysis. Therefore, we do not try to correlate the output of our analysis with major geopolitical or economic trends. In this analysis, we strive to show that product level trade volume and trade network approaches can be valuable complementary tools to answer some basic questions about the nature and current state of world trade in horticultural foodstuffs.

2.2 Research Questions

- How have world-level trade volumes for horticultural products (fruits and vegetables) changed over time?
- What does the dichotomized global trading network for horticultural products look like?
- Can the network structure be correlated with the trading volumes? Does this information give us any information about the internationalization of horticultural production at the product and world level?
- Can information gained be used to identify opportunities for FFV trading?

2.3 Hypotheses:

- Most horticultural products increased in trade/production volumes as well as trade network density
- There are product specific differences
- Some of these product specific differences are captured in the trade network structure and can be correlated with trade volumes for these products.

3. DATA & METHODS

3.1 Data Sources & Structure

For this analysis, we will use two relatively well known and well curated data sources:

- FAO Stat Database (REF): FAO is the Food and Agriculture Organization under the United Nations. Production and data, both as value and quantities, can be pulled annually for all countries. Some of the data is projected, corrected or expected and may not be completely official. However, FAO data is widely used to analyze world trade at a high level and has significant granularity at the product level. The major problem is that cross-trade data (country A exports to country B) is only available country-by-country; in other words, it is not possible to get the data for all the countries at the same time. This is a problem, meaning that cross network analysis cannot be done.
    - Data was pulled at the world trade level
    - Import, export and production data
    - Only trading quantity (Metric Tons) was used
    - About 60 horticultural product data obtained
    - All data was pulled annually for the time period 1961-2008
    - In addition to the above, country level producer data was pulled for year 2004 only to perform additional data analysis
- UN Comtrade (REF). This is the official commodities trading database of the United Nations statistics division. All data is reported by trading partners (countries) and data is available for a significant number of commodities, including all major agricultural commodities. However, unlike the FAO database, production data is not available, only trading data can be pulled. Pulling the data is relatively streamlined and can be pulled annually for cross trading partners.
    - Data was pulled at country and product level
    - Only import data was pulled
    - Data for about 90 agricultural and horticultural products were obtained.
    - Data for 2008, 2004, 2000, 1997 & 1993 were pulled
    - Total of 480,000 lines of data were aggregated in a database file

As noted above, the data from FAO Stat service is rather straight forward. However, data from UN Comtrade is rather trickier. There are various data collection methods, two of which are the most relevant for this analysis. SITC data goes back further in time but is not granular enough; SITC1, going back to 1970s, is the most continuous data set but data is available only at a high level for about 10 groups of horticultural products. HS1 (harmonized system) is available starting from 1993 up to 2008 and it is much more granular than SITC data. However, the trade off is that it takes reporting countries some time to get up to speed; thus the number of reporters increases over time. This could be interpreted two ways:

1- The fact that the number of reporters changes over time does not matter much, assuming that the reason for the non-reporters is either that they are too small and ineffectual to matter for world trade for that specific product and/or that they are effectually out of the major world trading network. Therefore, the reporters themselves can be assumed to be "the trading network"
2- The fact that the number of reporters changes makes the time-series analysis unusable since the base is changing from year to year.

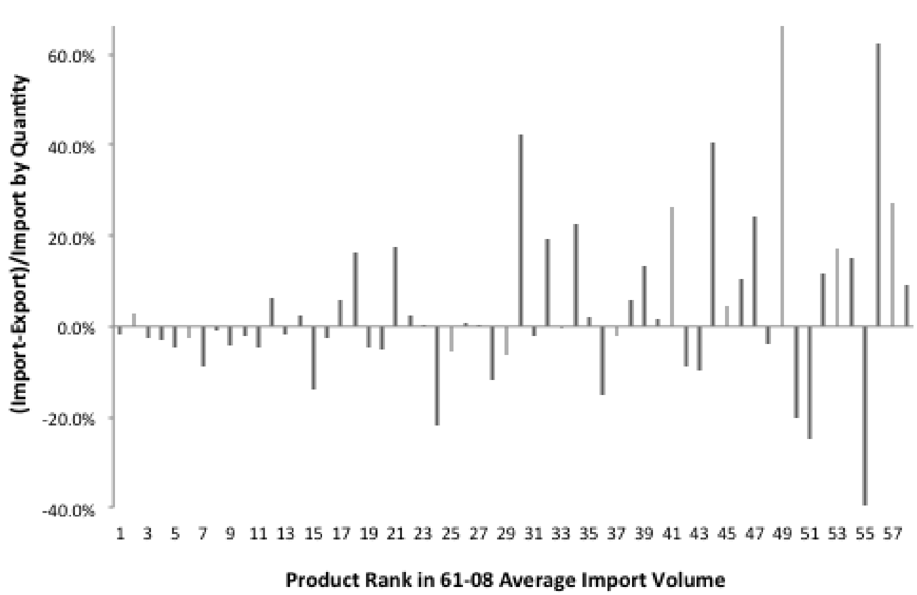
In this analysis, we are leaning towards the 1st assumption. For example, the implementation HS1 standard roughly coincides with the fall of the Berlin wall, meaning that a significant number of countries were joining the world markets along with the increasing demand of Asian countries. Therefore, the increase in the number of reporters for the data is actually a natural result of the globalization of trade in commodities. Another point to keep in mind, as explained in the section below, that rather than the exact number of trading partners and trading relationships, the structure of the network (density and degree centrality) are more important, which looks at the organization of the reporting countries. Therefore, even though the base is changing, the organization data could still be relevant. This matter is discussed in more detail in the following sections.

3.2 Data Preparation

3.2.1- FAO STAT Data

Since FAO STAT data was pulled at the total world level for the time period between 1961-2008, the initial data analysis was performed in a spreadsheet. At the world level, in an ideal case, the imports of one country should match the exports of its trading partner. Therefore export numbers

Figure 1- FAO STAT Import vs. Export Data Comparison by Product



should equal the import numbers for most products. A quick comparison was made (Table 1) and the result was that for high volume products, this was indeed true but for low volume products[5], there were sometimes significant differences in import vs. export numbers. Therefore, the first step in data analysis was to average on a product and time level the quantities traded for imports and exports. This averaged data was further used to calculate the numbers mentioned in the next section.

The FAO STAT service is comprised of different sets of databases for different types of data. For this analysis, we had to obtain both product and trade data, which reside in different databases. Therefore, the data had to be matched at the product level. Each product category had a unique identifier in both databases and these identifiers were identical in both databases. Therefore, matching of the data was performed with relative ease in a spreadsheet.

3.2.2- UN Comtrade Data

Un Comtrade data required significant preparation at a more tactical level. However, most of the preparation is due to the high throughput analysis required. As mentioned, there were more than 450 thousand rows of data. For each trading partner, the data had to be nested in lists of several layers, organized by year and commodity. Then the data was converted into a format where the functional programming language used could construct graphs (networks- as in "graph theory"). The details of this preparation need not be discussed in this text as its technicality is irrelevant. However, the code used to prepare is available (APPENDIX 5).

In addition to the tactical preparation above, some filtering out took place based on several criteria:

- Initial comparison of import quantities to the FAO Stat data resulted in a significant difference of 2X (Comtrade data was twice as high as the FAO data at the product level). This resulted in the suspicion that there was some kind of double counting going on. Detailed investigation showed that product category "0" was included in the data, which stood for "total world". This category was present both in the reporting country and its trading partner. Therefore, category "0" was filtered out and the data was compared to FAO Stat data for 2008 for several commodities as a spot check. It was found that the trading data matched FAO's trade matrix data available on FAOStat website. We proceeded with using the data for further analysis.

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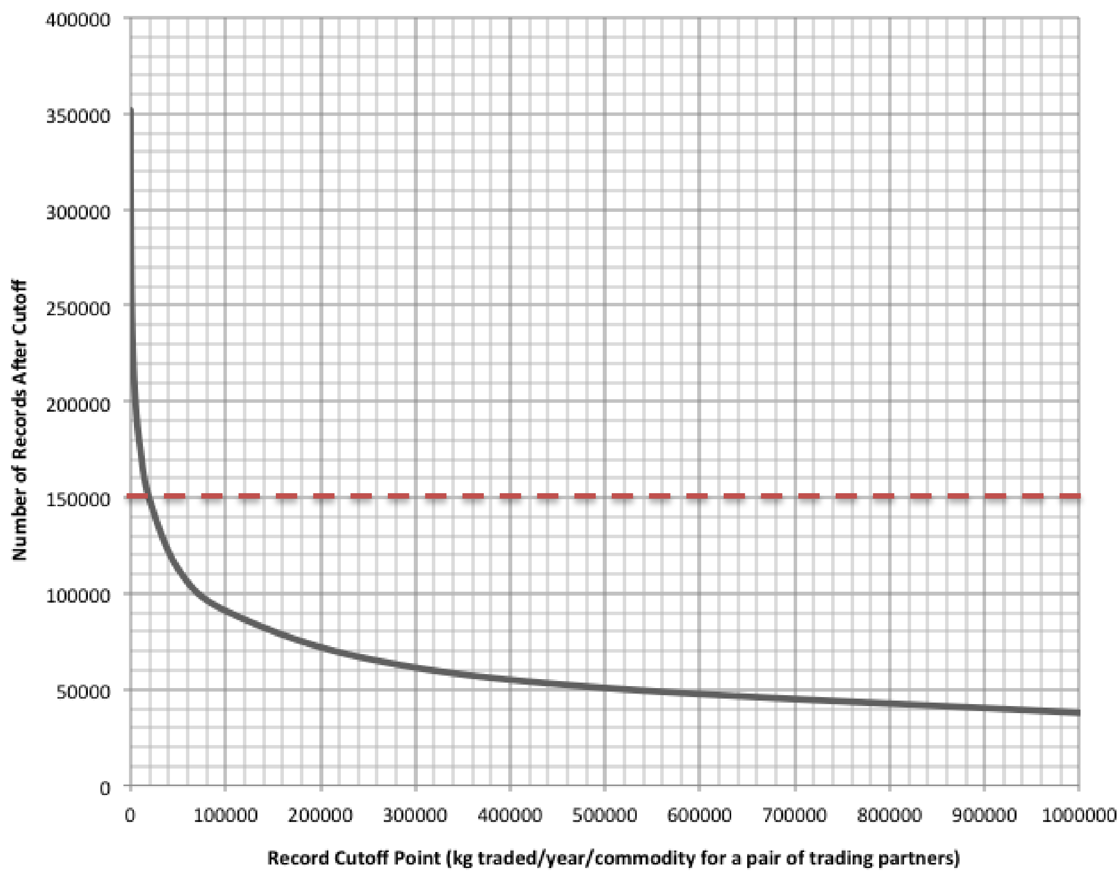
[5] To give a good perspective on Figure 1 (low traded products vs. high traded products: The average import volume by quantity of the bottom 5 products traded was 0.26% of the top 5 traded products (APPENDIX 1).

- Even though there were 450,000 rows of data, a significant portion of them were very low in trading volume (Figure 2). We picked 20,000kg (20MT) to be the minimum allowed trade level between two trading partners for several reasons: 1- 20MT is roughly the maximum allowed net weight of a container load of

Figure 2- Number of Records Left (All 5 years Total) after application of various cutoff values to each record in dataset



product (REF). 2- Any amount less than a full container load between two countries is insignificant compared to larger amounts of trade occurring between other trading partners 3- Any amount less than a container load is probably subject to significant errors in book keeping 4- Any amount less than a container load could indeed be more prone to errors due to the number of reporters changing in the data as mentioned in section 3.2.2. Therefore, we only used the data from trading partners that had more than 20MT of trade for any specific commodity for any specific year. However, it should be noted that this data in itself could actually be used to deduce certain characteristics of the network (REF). This will be discussed further in the results section.
- Due to the filtering applied, some low volume products were completely eliminated from the data set for certain years and but were present in other years. To obtain a uniform data set with the same number of products for all the years analyzed, three products were completely eliminated from the data set

(HS1 Commodity codes: #07952, #071210, #081030)[6]. Since these were low in volume and rather insignificant product, this did not have any implications for the validity of the analysis.

3.3 Analysis & Theory

Based on the data sets mentioned above, there were three sets of distinct analyses performed:

3.3.1-Trade Volume to Production Volume Analysis 1961-2008

This analysis was based on the FAO stat data. The following were calculated:

- Total production amounts by commodity, by year and by all commodities
- Total average trade (import-export) volumes by product, by year and by all commodities
- Trade to production ratios by product by year

Based on these number, higher level calculations were performed:

- Compounded annual growth rates for trade/production ratios for each product for 8-10 year periods
- Rankings per product based on all the above analyses
- A meta analysis correlating all the data calculated at product level to uncover any hidden correlations between different data sets

3.3.2-Trade Network Analysis 1993-2008

This analysis is based on the Comtrade data set. Data was grouped into by product, by year categories as a dichotomized directional graph. The following were calculated based on the text by (REF) using a functional programming language (Appendix 5):

- Number of vertices by graph (nodes or countries), by product by year
- Number of edges by graph (connections between nodes, trades) by product by year
- Density of each graph
- Out degrees for each node
- Degree centrality of each graph
- Number of records eliminated by different cutoff values for different product in different years
- Number of records eliminated at the total level for all years (Figure 2)

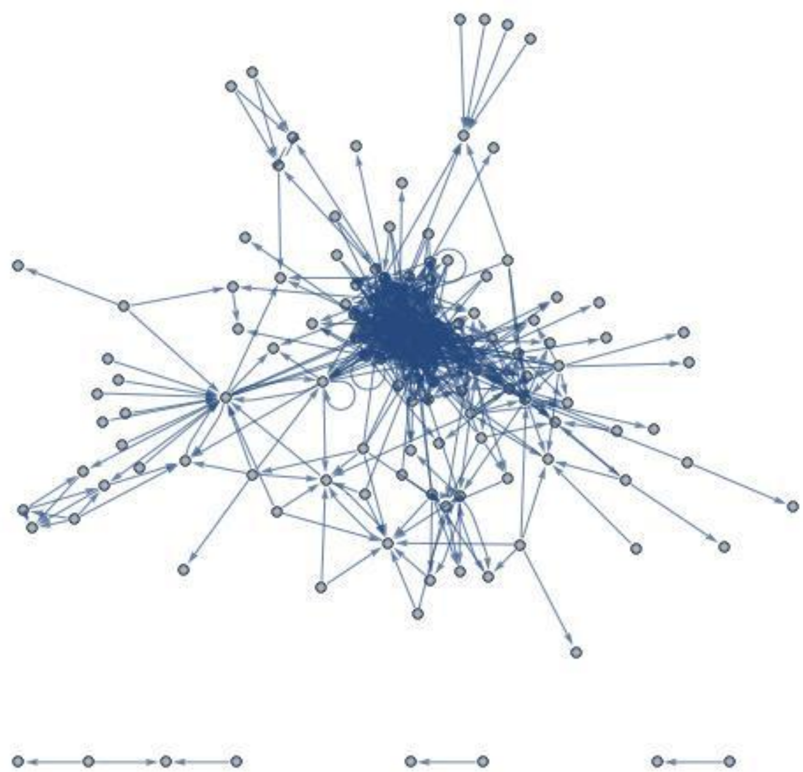
The analytical method employed for the network analysis is the branch of discrete mathematics named graph theory, also known as social network analysis. The methods applied here are discussed in the classic text by (REF); therefore all the

[6] The commodity codes #07952, #071210, #081030 refer to fresh/chilled truffles, dried potatoes (not further prepared) and fresh black/white/red currants and gooseberries

details of the theory will not be explain in depth in this analysis. However, some key facts and equations used should be noted, along with a quick summary of each metric used.

In general, graph theory concerns itself with the existence of connections between nodes, nodes being trading partners or countries in this case. The strength of connections are not of importance (the strength would be the amount traded between nodes, in this case), or rather that the analysis is possible by overlaying statistical analysis methods on top of graph theory frameworks but such level of analysis is out of scope for this research. The reduction of relationships to the existence or lack there of is called "dichotomization". Dichotomization of a network is represented in an adjacency matrix. Due to the large number of data analyzed, only an example adjacency matrix (in array plot form for easier viewing) and graphs for tomatoes for 2008 is shown. The node the arrow points to indicates the country that the origination node imports from. In other words, the out degree of a node is the number of nodes that the country imports from. As is apparent, there are a significant number of possible connections missing from both the array plot and the graph.. In this study, import data was used in general, meaning that the relationships were directional. However, since it would be uncommon for a country to import and export the same product except in cases of re-exports, the density numbers as mentioned in this study could be assumed to be double if a non-directional network is assumed. However, this would only change the absolute number but not the relative densities of graphs, so we assumed a directional network structure for all the numbers calculated.

Figure 3- 2008 World Tomato Trading Network Graph (From Comtrade Data)



The density of a directional graph is defined as:

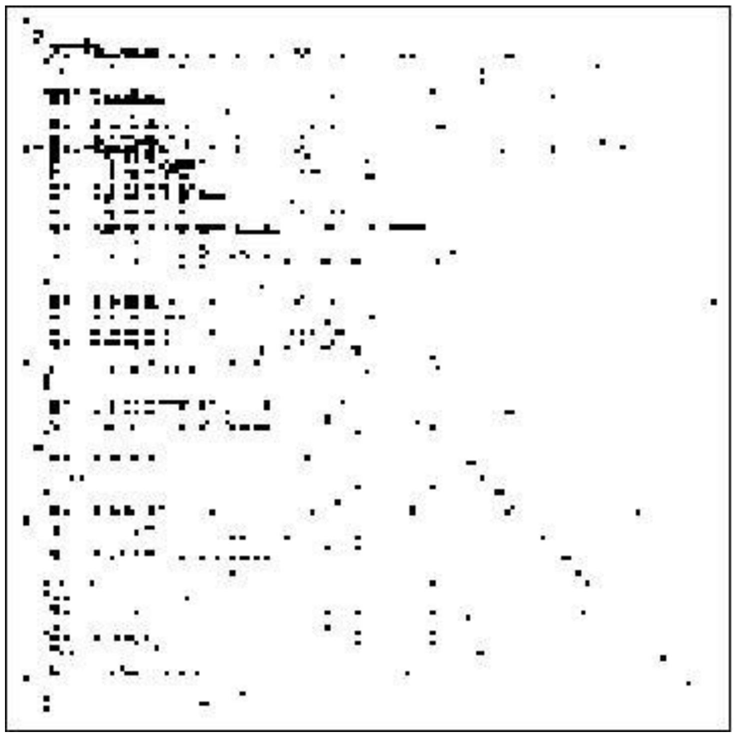
$$Density = \frac{\sum_{i=1}^{g}[C_D(n^i)]}{g(g-1)^2}$$

The degree centrality of a graph is given by:

$$C_D = \frac{\sum_{i=1}^{g}[C_D(n^*) - C_D(n^i)]}{[(g-1)^2]}$$

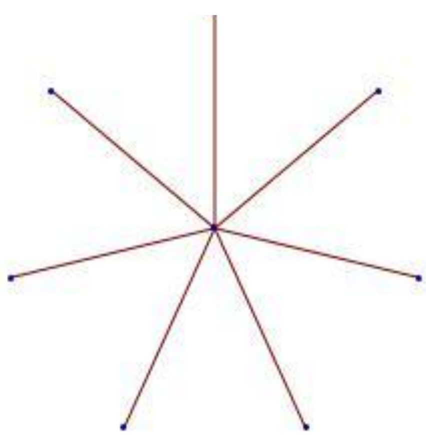
Where g is the number of nodes, $C_D(n^*)$ is the maximum vertex degree, $C_D(n^i)$ is the vertex degree of vertex n^i (the number of connections it has) and C_D is the network centrality.

Figure 4-2008 World Tomato Trading Network- Adjacency Matrix in Array Plot Form (Black squares denote a connection, nodes are listed in the same order on x and y axis)



The density of a graph can be simply explained as the number of connections existing in the graph divided by the number of possible connections. In other words, if every country in a network trades with all the other countries, then the density will be 1. This is naturally not a realistic expectation given that countries tend to specialize according to their comparative advantages and export only certain goods. In case of horticultural goods, this is even more apparent

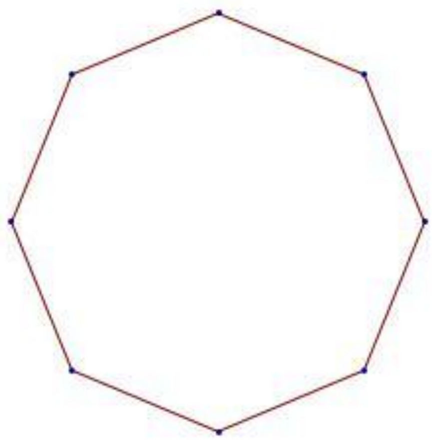
Figure 5- Star Shaped Network (Graph and Adjacency Matrix) with Degree Centrality 1



0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	1
1	1	1	1	1	1	1	0

since climactic conditions prevent the economically feasible cultivation of horticultural goods, let alone the export there of. Therefore, we would expect to see

Figure 6- Cycle Shaped Network (Graph and Adjacency Matrix) with Degree Centrality 0



0	1	0	0	0	0	0	1
1	0	1	0	0	0	0	0
0	1	0	1	0	0	0	0
0	0	1	0	1	0	0	0
0	0	0	1	0	1	0	0
0	0	0	0	1	0	1	0
0	0	0	0	0	1	0	1
1	0	0	0	0	0	1	0

a low density.

Degree centrality is a relatively simple measure to measure the concentration of a network. A star shaped network (**Fout! Verwijzingsbron niet gevonden.**) will have a degree centrality of 1, where as a circle network (**Fout! Verwijzingsbron niet gevonden.**) will have a degree centrality of 0. All other networks will fall somewhere in between.

4. RESULTS

All the results of the analysis are reported "as is" in this section. The meanings of the results are interpreted in the discussion section; we have only commented about the calculation of the numbers where required.

3.1 Trade-Production Volume Analysis

First analysis focused on the trade-to-production ratios from the FAO Stat data.

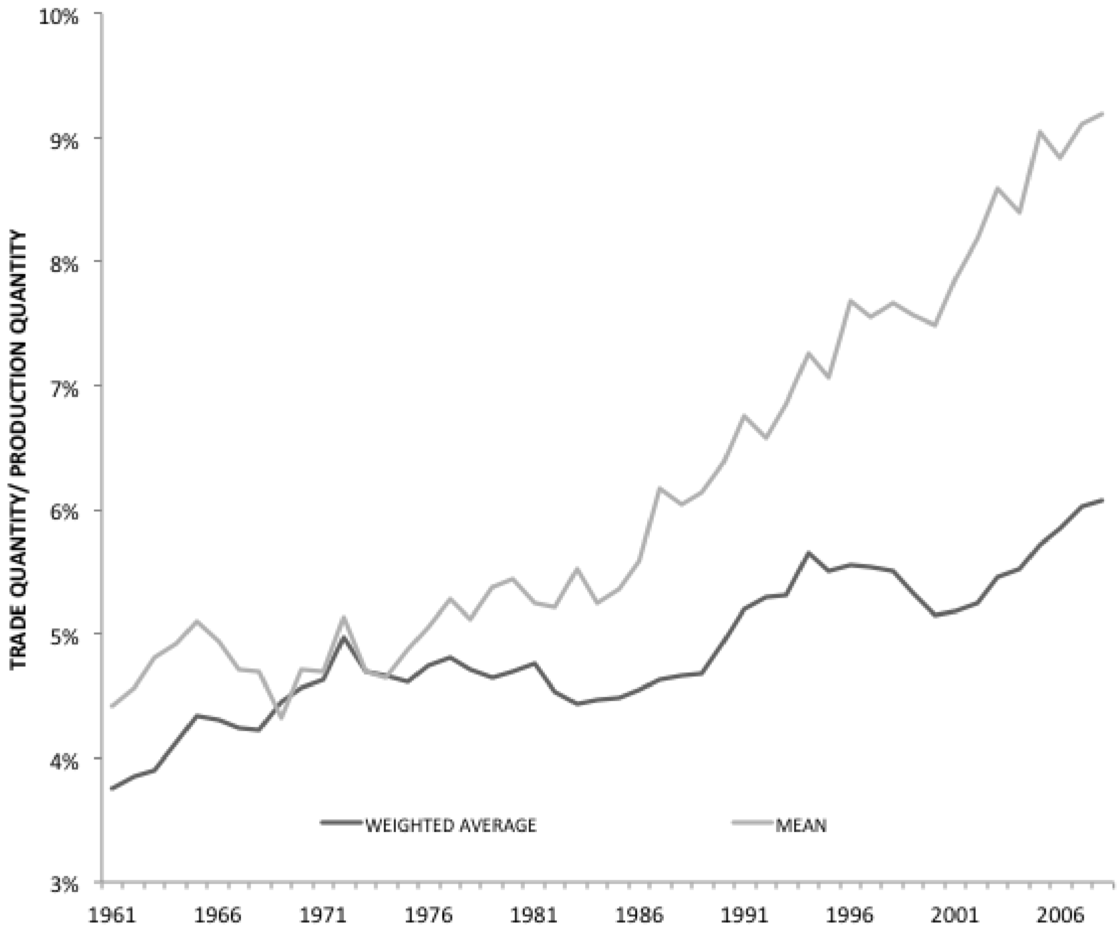
3.1.1. Trends for All Horticultural Products

The first step in the analysis was to confirm the general trends for all horticultural products. The categories used were directly from the FAO Stat database. Trade values are averages of import & export values. Total world trade includes dairy, meat, oils, fresh and dry agricultural products, among others (REF)

Figure 7- Fruits & Vegetable Trade/ Total Agricultural Trade 1961-2008 (Quantity & Value)

The second step in the analysis was to look at the trade/production trend for fruits and vegetables. The category was adapted from FOA Stat database. Weighted average puts more emphasis on the FFVs with higher trade volume, so a mean of the trade/production ratios were calculated to better reflect the trends of the typical FFV category.

Figure 8- Fruits & Vegetables Trade/Production (Quantity) Ratios 1961-2008, Weighted Average and Mean of Ratios at Product Level



3.1.2 Product Specific Analysis

The next step in the analysis was to create ranked listings of all the products analyzed by quantity produced, quantity traded for 2006-2008 period to gain a better understanding of the main items traded in world markets. This analysis allowed us to deduce information about the concentration in the trade and production of fresh fruits and vegetables. In the pages to follow, we only provide the information in a chart format for easier digestion. Detailed tables are available in the appendix.

Figure 9- 2006-2008 Average World Production (quantity) of FFVs by Product as % of Total FFV Production

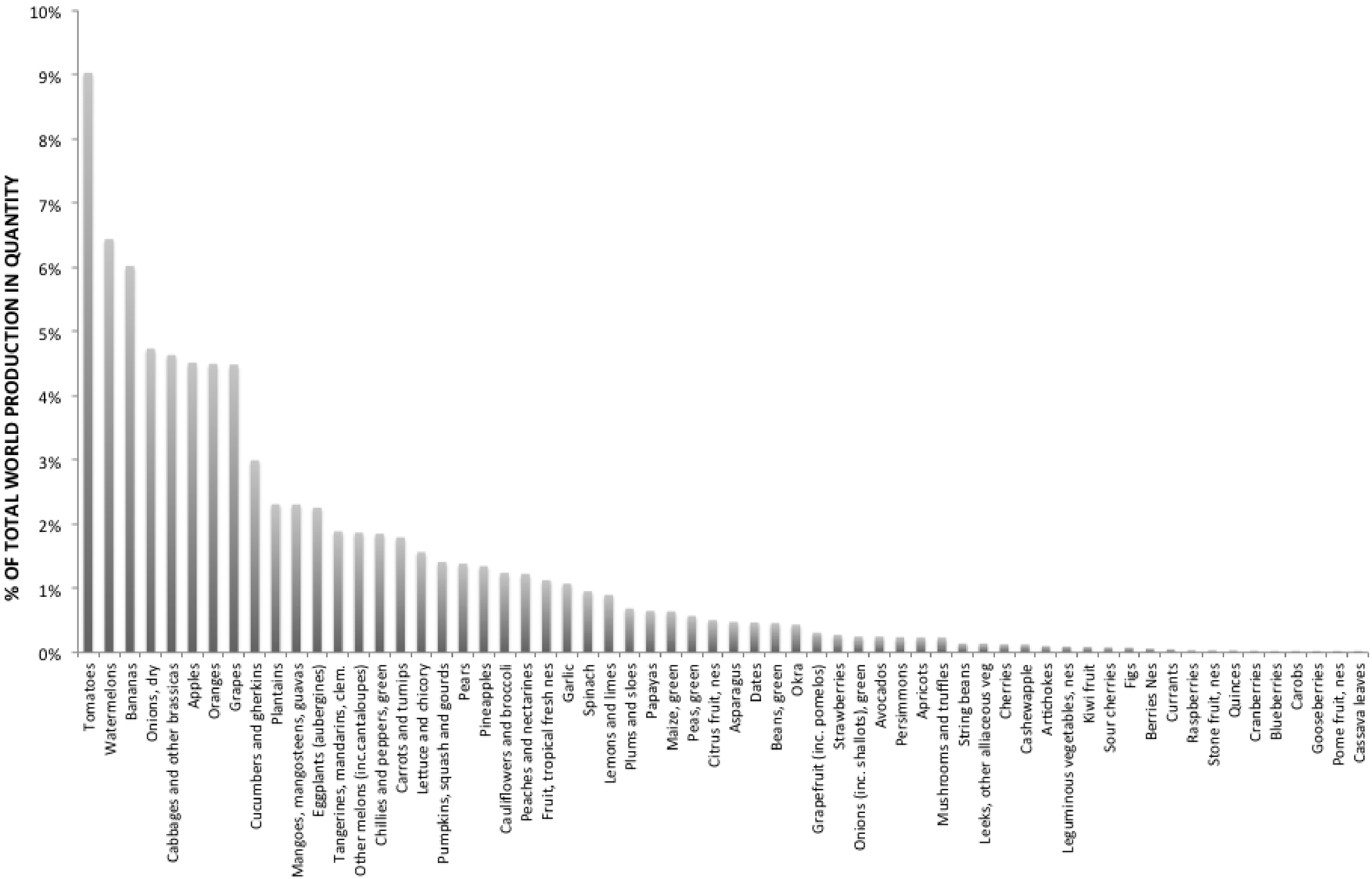


Figure 10- 2006-2008 Average World Trade (quantity) in FFVs as % of Total World FFV Trade by Product (Kiwi fruit removed due to scale)

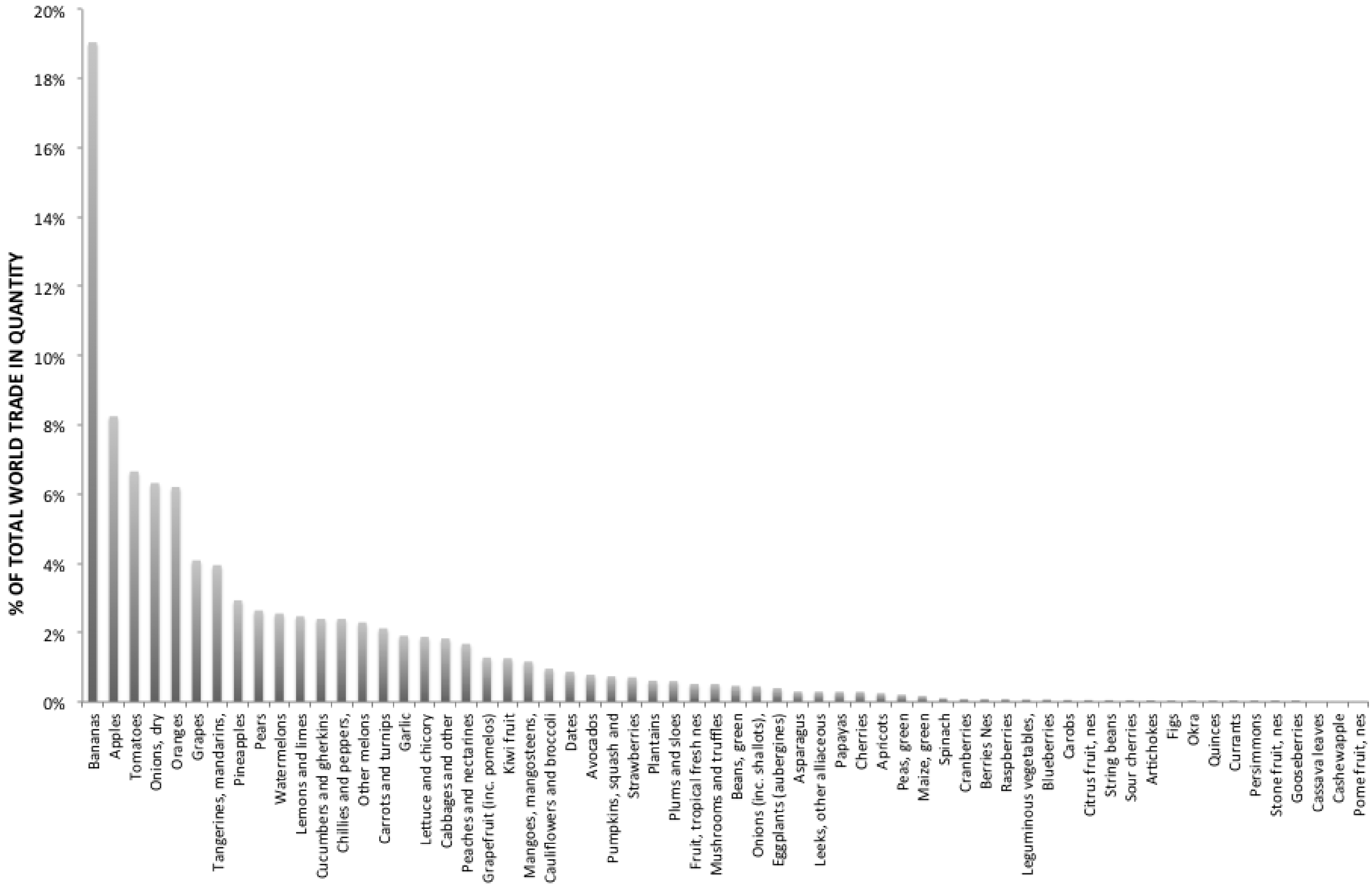
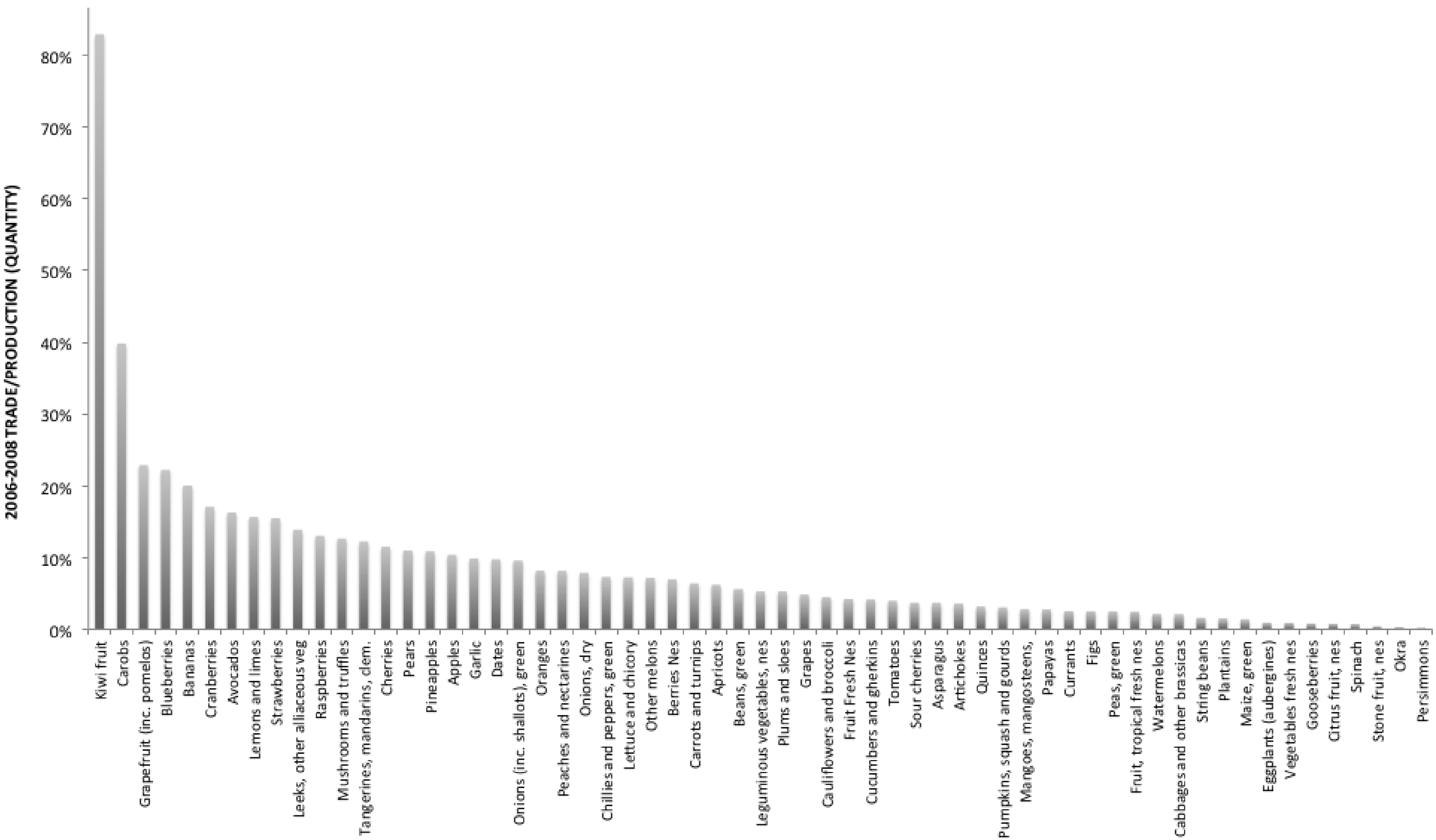


Figure 11- 2001-2008 FFV Trade/ FFV Production (Quantity)

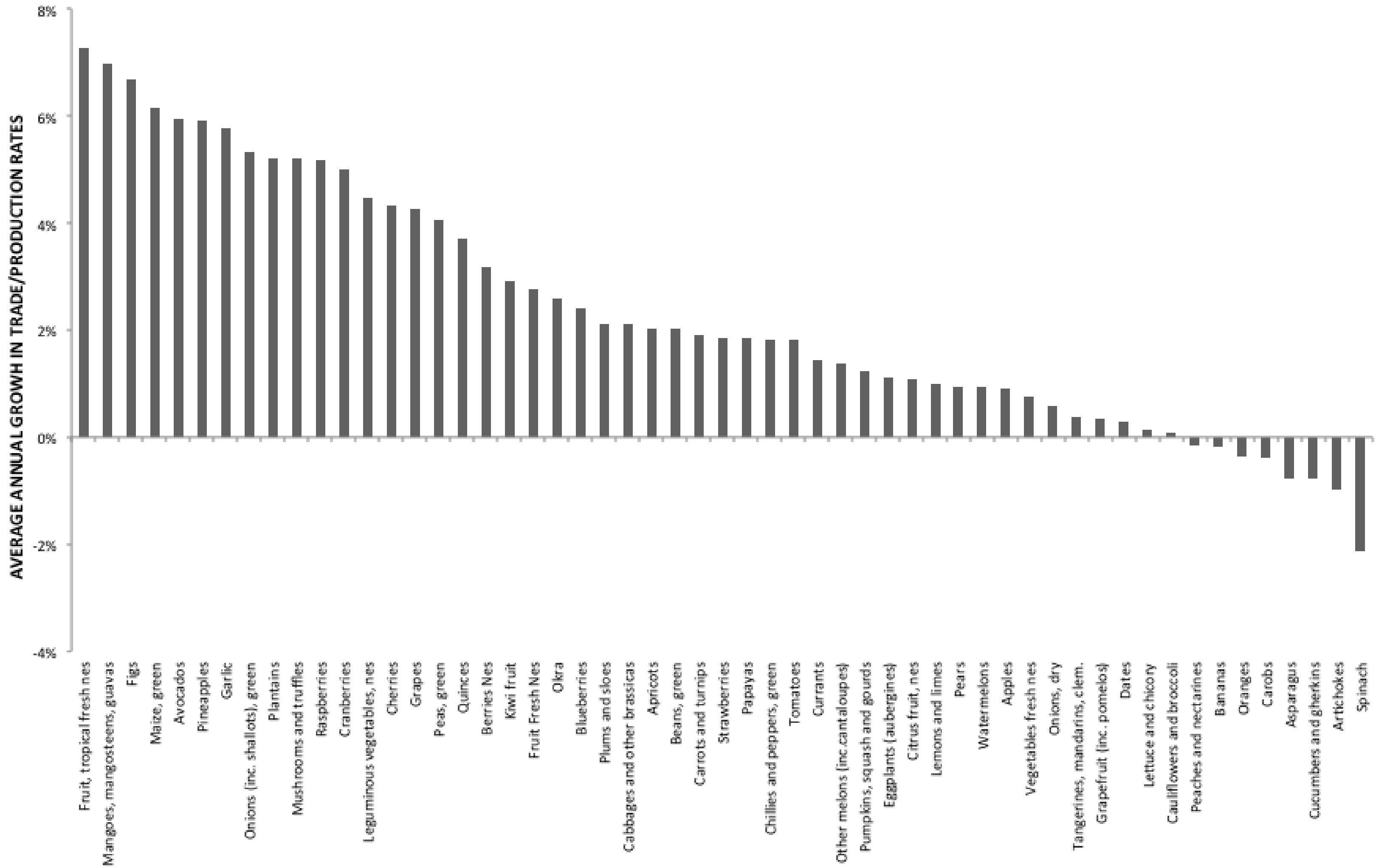


Next, some higher level analysis was performed. The following numbers were calculated from yearly and product level trade and production data:

- For 5 periods (1961-1970, 1971-1980, 1981-1990,1991-2000, 2001-2008 & 1961-2008, 1991-2008):
    - Average growth rates of trade/production ratios (Figure 11 for 1961-2008)
    - Average trade/production ratios (Figure 12&Figure 13 for 1991-2008 & 1961-2008 respectively)
- 2x2 matrix/bubble chart analysis of growth rates vs. trade/production ratios for 1991-2008 period
- Cross correlation of all the data analyzed over various time series to uncover any immediately unapparent trends. We used both Pearson and Spearman correlation tests separately (CROSS REF-APPENDIX)

These results will be further analyzed in the discussion section. For now, we report on the analysis for the recent years for this analysis. Detailed results for all time series can be found in the appendix (REF).

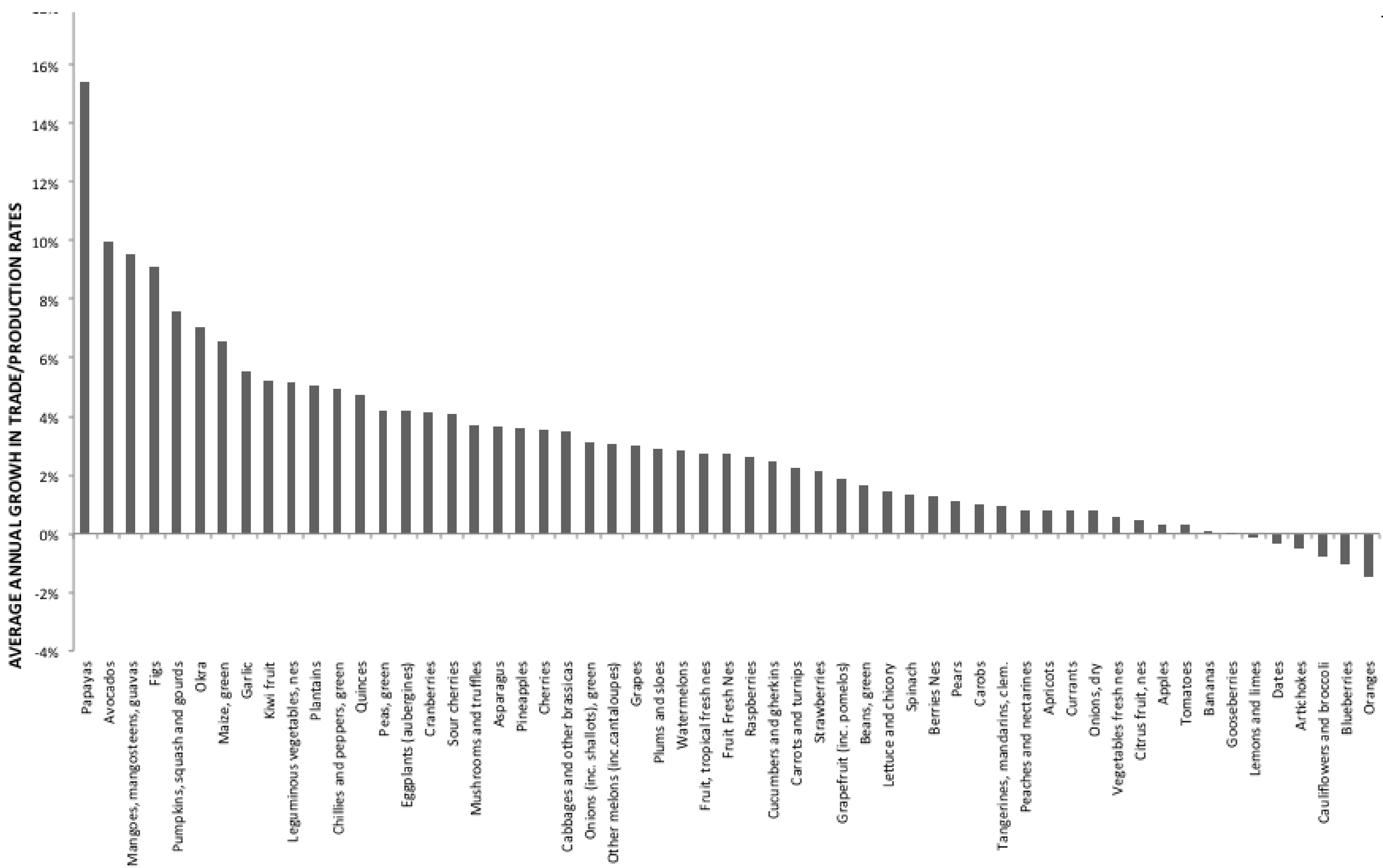
Figure 12- 1991-2008 Annual Average Growth Rate of Trade/Production Ratio



[7]

[7] Note that gooseberries, parsimons and other stone fruit not classified were excluded from the chart above due to exceptionaly low growth rates of -12.1%, -12.8 and -20.4% respectively. However, the starting base for these products were already too low and should not be taken very seriously.

Figure 13 1961-2008 Annual Average Growth Rates of Trade/Production Ratio



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[8] Persimmons and other stone fruit had annual growth rates of -3.7 & -10.3% and were left out from the chart due to readability issues

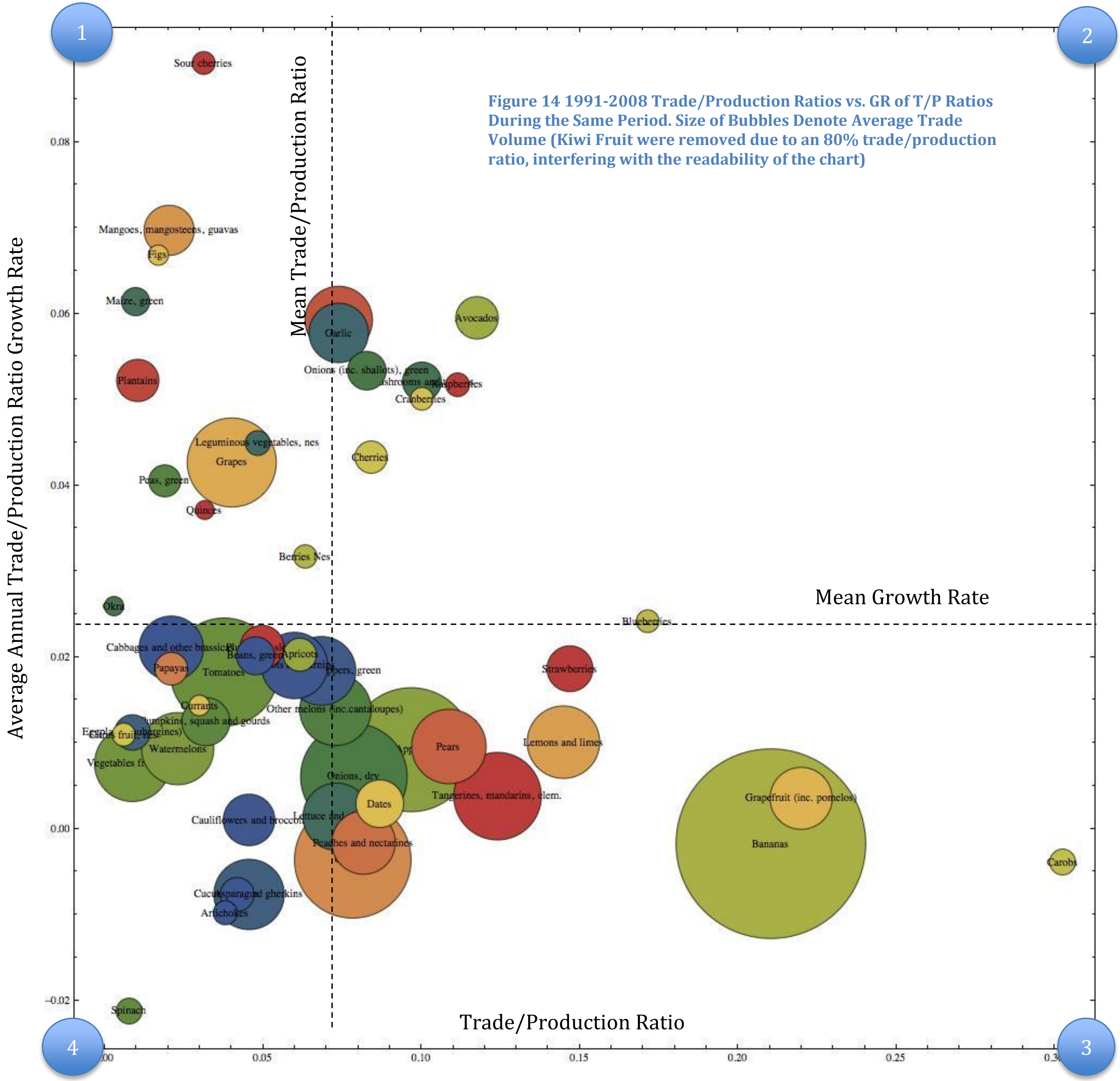

Figure 14 1991-2008 Trade/Production Ratios vs. GR of T/P Ratios During the Same Period. Size of Bubbles Denote Average Trade Volume (Kiwi Fruit were removed due to an 80% trade/production ratio, interfering with the readability of the chart)

3.2 Trade Network Analysis

For 1993,1997,2000, 2004 & 2008 individually, the data below were calculated:

- Total number of out degrees
- Total number of nodes
- Graph density
- Degree centrality

Due to the large amount of data analyzed, we will not report on each individual metric in great detail. We will also present only data that we could map onto the FAO Stat data (37 products out of the total of 90 commodities for which data was pulled) to simplify the discussion of the analysis. Since the ultimate goal is to correlate trade volumes with network structures, it made sense to only look at the classes that could be compared. We will also report only on 2004 data since it is recent enough to be representative but also offers a relatively complete set of reporting counties compared to earlier time periods.

Table 2- Output of the Network Analysis by Product

	VertexCount					Edge Count					Density					Centrality				
	2008	2004	2000	1997	1993	2008	2004	2000	1997	1993	2008	2004	2000	1997	1993	2008	2004	2000	1997	1993
Tomatoes, fresh or chilled	139	140	140	114	87	685	602	545	435	238	3.57	3.09	2.80	3.38	3.18	0.20	0.16	0.17	0.29	0.26
Onions and shallots, fresh or chilled	161	173	168	146	103	972	944	829	726	385	3.77	3.17	2.95	3.43	3.66	0.16	0.15	0.11	0.15	0.20
Garlic, fresh or chilled	150	158	145	122	78	498	533	480	416	272	2.23	2.15	2.30	2.82	4.53	0.09	0.09	0.10	0.15	0.20
Leeks & other alliaceous vegetables, fresh or chilled	96	91	84	73	43	271	253	220	192	99	2.97	3.09	3.16	3.65	5.48	0.13	0.14	0.16	0.15	0.16
Cauliflowers and headed broccoli, fresh or chilled	114	103	103	84	49	376	300	269	238	134	2.92	2.86	2.56	3.41	5.70	0.11	0.09	0.07	0.14	0.18
Cabbage lettuce (head lettuce) fresh or chilled	101	96	84	60	54	348	271	227	189	132	3.45	2.97	3.26	5.34	4.61	0.11	0.10	0.09	0.15	0.22
Lettuce, fresh or chilled except cabbage lettuce	101	88	88	66	47	297	218	209	152	92	2.94	2.85	2.73	3.54	4.26	0.17	0.15	0.12	0.14	0.27
Carrots and turnips, fresh or chilled	135	137	135	107	65	581	494	437	354	197	3.21	2.65	2.42	3.12	4.74	0.17	0.10	0.12	0.19	0.16
Cucumbers and gherkins, fresh or chilled	104	105	102	83	63	424	371	325	286	165	3.96	3.40	3.15	4.20	4.22	0.18	0.14	0.15	0.22	0.32
Globe artichokes, fresh or chilled	4	42	40	34	26	2	75	79	61	34		4.36	5.06	5.44	5.23	0.22	0.13	0.13	0.10	0.11
Asparagus, fresh or chilled	62	58	55	48	44	229	197	179	167	103	6.05	5.96	6.03	7.40	5.44	0.19	0.22	0.22	0.27	0.35
Aubergines(egg-plants), fresh or chilled	95	91	91	72	44	266	219	195	142	74	2.98	2.67	2.38	2.78	3.91	0.10	0.09	0.12	0.16	0.20
Peppers (Capsicum, Pimenta) fresh or chilled	130	133	123	111	77	608	522	429	372	197	3.63	2.97	2.86	3.05	3.37	0.22	0.18	0.19	0.24	0.26
Spinach fresh or chilled	61	50	48	34	25	120	90	82	64	34	3.28	3.67	3.63	5.70	5.67	0.10	0.17	0.16	0.19	0.24
Onions, dried, not further prepared	100	103	95	81	56	374	326	269	246	139	3.78	3.10	3.01	3.80	4.51	0.13	0.15	0.13	0.18	0.31
Peas dried, shelled	143	138	133	115	83	762	659	585	561	352	3.75	3.49	3.33	4.28	5.17	0.14	0.13	0.12	0.14	0.26
Bananas, including plantains, fresh or dried	144	151	149	137	109	771	716	730	710	444	3.74	3.16	3.31	3.81	3.77	0.19	0.16	0.20	0.21	0.29
Dates, fresh or dried	118	116	110	84	52	461	431	338	269	190	3.34	3.23	2.82	3.86	7.16	0.13	0.13	0.12	0.13	0.33
Figs, fresh or dried	85	82	71	72	48	261	244	204	179	81	3.66	3.67	4.10	3.50	3.59	0.13	0.11	0.13	0.14	0.14
Pineapples, fresh or dried	129	118	104	93	70	601	456	361	318	222	3.64	3.30	3.37	3.72	4.60	0.22	0.16	0.16	0.28	0.22
Avocados, fresh or dried	89	82	79	64	46	326	263	215	176	111	4.16	3.96	3.49	4.37	5.36	0.18	0.17	0.20	0.21	0.22
Guavas, mangoes and mangosteens, fresh or dried	132	125	116	90	79	568	527	476	354	250	3.28	3.40	3.57	4.42	4.06	0.24	0.22	0.26	0.31	0.35
Oranges, fresh or dried	156	160	149	127	93	1061	984	863	720	430	4.39	3.87	3.91	4.50	5.03	0.18	0.16	0.17	0.18	0.28
Lemons and limes, fresh or dried	133	123	125	99	77	849	656	583	473	257	4.84	4.37	3.76	4.88	4.39	0.20	0.20	0.16	0.25	0.24
Grapefruit, fresh or dried	108	110	101	88	71	598	540	441	384	237	5.17	4.50	4.37	5.02	4.77	0.20	0.20	0.21	0.23	0.30
Citrus fruits, fresh or dried, nes	85	79	69	76	44	157	147	116	114	61	2.20	2.39	2.47	2.00	3.22	0.11	0.14	0.20	0.14	0.23
Grapes, fresh	147	150	138	118	80	992	863	702	551	316	4.62	3.86	3.71	3.99	5.00	0.21	0.18	0.15	0.21	0.26
Grapes, dried	132	133	120	112	74	663	622	516	479	278	3.83	3.54	3.61	3.85	5.15	0.13	0.12	0.13	0.13	0.24
Melons (including watermelons), fresh	137	129	133	124	92	801	685	600	562	320	4.30	4.15	3.42	3.68	3.82	0.19	0.20	0.19	0.24	0.28
Papaws (papayas), fresh	87	81	62	56	48	177	165	113	104	77	2.37	2.55	2.99	3.38	3.41	0.27	0.23	0.15	0.15	0.25
Apples, fresh	160	169	161	145	92	1197	1132	953	816	422	4.71	3.99	3.70	3.91	5.04	0.22	0.16	0.15	0.23	0.26
Pears and quinces, fresh	141	142	130	108	74	782	716	605	514	306	3.96	3.58	3.61	4.45	5.66	0.15	0.14	0.14	0.28	0.23
Apricots, fresh	89	83	83	65	46	305	267	221	169	86	3.89	3.92	3.25	4.06	4.15	0.24	0.24	0.13	0.23	0.21
Cherries, fresh	94	81	83	69	48	349	286	248	226	102	3.99	4.41	3.64	4.82	4.52	0.27	0.18	0.22	0.25	0.34
Peaches, nectarines, fresh	114	111	104	87	61	506	424	364	296	160	3.93	3.47	3.40	3.96	4.37	0.21	0.15	0.14	0.20	0.21
Plums, sloes, fresh	115	117	105	89	62	508	445	376	339	187	3.87	3.28	3.44	4.33	4.94	0.22	0.18	0.13	0.17	0.30
Strawberries, fresh	94	89	76	58	51	347	292	237	203	139	3.97	3.73	4.16	6.14	5.45	0.13	0.15	0.16	0.22	0.29
Maize except seed corn	156	168	158	133	96	937	818	654	582	287	3.88	2.92	2.64	3.32	3.15	0.13	0.10	0.09	0.11	0.16

Figure 15 Density & Edge Number by Product for 2004

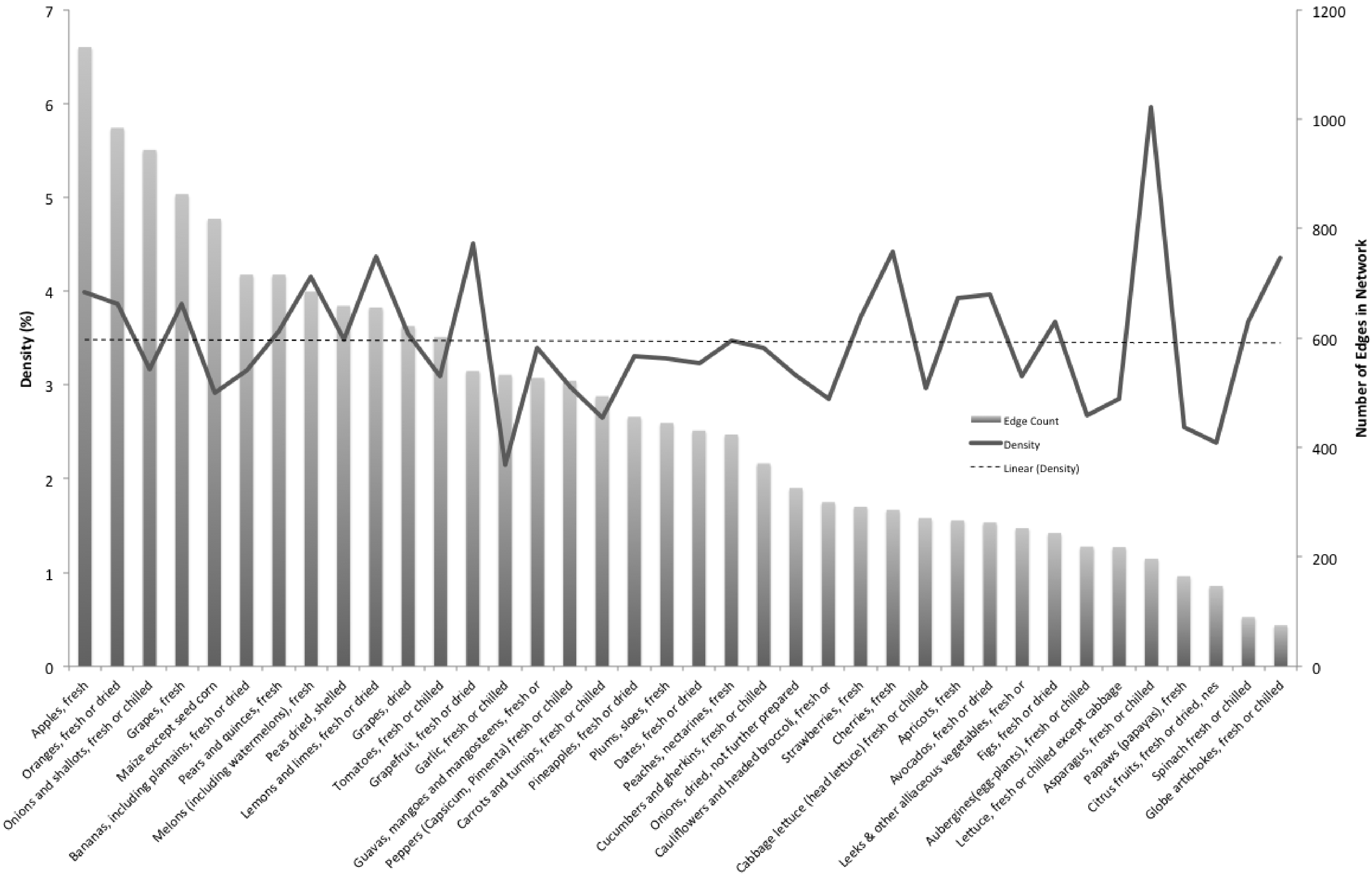

Table 4- Correlation Matrix for the Output of the Network Analysis

	VC2008	VC2004	VC2000	VC1997	VC1993	EC2008	EC2004	EC2000	EC1997	EC1993	D2008	D2004	D2000	D1997	D1993	C2008	C2004	C2000	C1997	C1993
VC2008	1.000	0.983	0.969	0.949	0.914	0.904	0.902	0.913	0.891	0.914	0.395	0.153	0.110	-0.030	0.036	0.177	0.016	0.058	0.209	0.122
VC2004		1.000	0.981	0.965	0.921	0.898	0.912	0.923	0.906	0.918	0.392	0.118	0.097	-0.049	0.006	0.111	-0.044	-0.002	0.141	0.080
VC2000			1.000	0.972	0.917	0.886	0.894	0.915	0.899	0.903	0.408	0.136	0.041	-0.081	-0.010	0.122	-0.050	-0.013	0.159	0.081
VC1997				1.000	0.933	0.893	0.906	0.925	0.924	0.920	0.417	0.161	0.096	-0.140	-0.066	0.130	-0.016	0.052	0.129	0.071
VC1993					1.000	0.875	0.871	0.899	0.895	0.940	0.477	0.215	0.205	0.013	-0.184	0.270	0.138	0.195	0.294	0.218
EC2008						1.000	0.989	0.984	0.971	0.947	0.688	0.458	0.398	0.201	0.117	0.234	0.083	0.094	0.208	0.188
EC2004							1.000	0.993	0.985	0.952	0.640	0.446	0.395	0.193	0.123	0.169	0.075	0.089	0.182	0.194
EC2000								1.000	0.992	0.963	0.622	0.412	0.372	0.170	0.082	0.163	0.058	0.095	0.170	0.176
EC1997									1.000	0.966	0.621	0.417	0.375	0.175	0.088	0.134	0.024	0.068	0.137	0.167
EC1993										1.000	0.594	0.373	0.355	0.170	0.106	0.189	0.089	0.138	0.224	0.257
D2008											1.000	0.834	0.733	0.604	0.306	0.351	0.160	0.120	0.261	0.273
D2004												1.000	0.870	0.738	0.393	0.301	0.409	0.360	0.414	0.432
D2000													1.000	0.798	0.327	0.202	0.359	0.395	0.308	0.352
D1997														1.000	0.494	0.090	0.190	0.155	0.287	0.390
D1993														0.494	1.000	-0.198	-0.153	-0.178	-0.097	0.169
C2008																1.000	0.663	0.485	0.523	0.453
C2004																	1.000	0.782	0.637	0.631
C2000																		1.000	0.657	0.634
C1997																			1.000	0.523
C1993																				

VC- Vertex Count   EC- Edge Count   D- Density   C- Centrality (Degree)   >0.5 Correlation

Table 3- Final Correlation Matrix for the Output of Trade Volume and Trade Network Analysis

	T/P 2001-2008	GR 1961-2008	Storage Life	2004 Producer Count (>10K MT)	2004 Producer Count (>50K MT)	2006-2008 Trade	2006-2008 Production	2004 VC	2004 EC	2004 D	2004 C	2004 Prod/ Producer (MT)	2004 Trade/ Producer (MT)
T/P 2001-2008	1.00	-0.20	0.17	0.01	-0.03	0.42	-0.07	0.22	0.27	0.24	0.16	-0.21	0.68
GR 1961-2008		1.00	-0.26	-0.28	-0.25	-0.32	-0.26	-0.10	-0.19	-0.16	0.18	-0.23	-0.35
Storage Life			1.00	0.19	0.19	0.10	0.07	0.23	0.17	-0.13	-0.32	-0.02	0.19
2004 Producer Count (>10K MT)				1.00	0.97	0.62	0.89	0.46	0.39	-0.24	-0.09	0.64	0.44
2004 Producer Count (>50K MT)					1.00	0.67	0.94	0.44	0.40	-0.19	-0.03	0.70	0.45
2006-2008 Trade						1.00	0.69	0.45	0.46	-0.06	0.01	0.56	0.91
2006-2008 Production							1.00	0.40	0.40	-0.11	0.00	0.82	0.47
2004 VC								1.00	0.93	-0.27	-0.17	0.30	0.48
2004 EC									1.00	0.05	0.02	0.31	0.51
2004 D										1.00	0.55	-0.04	0.05
2004 C											1.00	-0.02	0.05
2004 Prod/ Producer (MT)												1.00	0.42
2004 Trade/ Producer													1.00

D- Density   C- Centrality   GR-Growth Rate   T/P- Trade/Production

5. DISCUSSION

5.1 – Trade Volume Analysis:

On a high level, fruits and vegetables have indeed been gaining ground as % of total agricultural trade (Figure 7), both in quantity and value. Especially since the 1970s, there is a clear upward trend starting from around 11% of total agricultural trade, drastically increasing around the 1980s and slowly flatting out around the 1990s at around 15%. This is not to say that this is a perfect trend- there are significant annual variations in the overall trend. Trade value is especially more variable, but this could easily be due to geopolitical situations that impact the prices on short term basis. Trend in quantity is more stable and follows the same path.

Trade quantity/ production quantity could be used as a simple but powerful indicator of the internationalization of a certain product. If more of the production is in circulation around the world, this would imply higher demand, higher supply, less resistance to the trade of the product or possibly a combination of both. This ratio has consistently increased Figure 8since the 1960s for a basket of horticultural products. Not only the trade/production ratio has been increasing for the whole basket, but also the ratio for the average product in the basket has been increasing. This is consistent with the previous note that since the 80s, consumers have been seeing a wider variety of FFVs at their local retailer, especially in the West.

However, even though the trade has been increasing overall, the product level situation is significantly different. World production wise, top 20 produced fruits and vegetables make up almost 70% of all production (Figure 9). Likewise, traded fruits and vegetables are even more concentrated with the top 20 traded products making up about 82% of all trading. This is significant concentration but should not come as a surprise, especially when common supermarket fruits and vegetables are considered; rarely would we see a consumer with a larger FFV consumption basket than 20 products (REF). In both cases, production and trade, the top 20 products are indeed quite similar. 16 products are in the top 20 for both production quantity and trading quantity. The top of the list are taken by bananas, apples, tomatoes, onions, citrus fruit, grapes, water melons, pineapples, salads and cabbages etc. None of these should come as a big surprise as these horticultural products are the common denominator in many cultures including the west. Just this metric in itself could be used to measure the internationalization of these products: the more a product is traded, more there should be demand for it, and possibly across many borders and the more the requirement for sourcing from various regions. All of these product have a storage life of >2.5 weeks, which is about the right time for a long haul shipping container to arrive in most major ports of the world from a nearby producing region. However, this kind of categorization puts too much emphasis on the commoditized, largely traded products. By calculating the trade/production ratio for each product, we were able to gain a better understanding of the level of internationalization (or trade demand) Figure 11. There are many new entrants to the top 20 in this list compared to the original ranking by trade: kiwi fruit are at the top of the list with 80% of the world's production in trade circulation, followed by carobs, grapefruit, berries, avocados, strawberries, cherries etc. All of these fruit are either very specialized and exotic or perishable, which is counter intuitive since this should hinder their exporting ability. However, it should be noted that most fruit, when shipped and handled under correct conditions, can reach any country in the world via airplanes and/or trucks. Naturally, this would be reflected in the price but personal experience suggests that most of these highly internationalized produce are more of less the expensive ones: berries, cherries, exotics etc. However, most of these produce are traded in low volumes and the other major items in the top 20, such as apples, pears, bananas, oranges would make up the bulk of the top 20 if volumes traded are considered.

However, none of the analysis gave us information about the development of trade/production ratios over time. These ratios were calculated for all years and within certain brackets (CROSS REF-APPENDIX) but here we only focus on the more recent period of 1991-2008 (Figure 12). Once again, a comparison to the 2001-2008 trade/production top 20 show that only 9 of the 20 in the growth rate list are also present in the trade/production chart. In other words, 9 of 20 have a large trade volume as compared to product and also have had large growth rates in these ratios over the past 20 years. However, the interesting point is that the 11 of the 20 are fast growers but still have relatively low rates of trade/volume ratio. These products could potentially have significant upside in the world markets and the high growth rates could be an indication of latent demand (or of opening up of supply, possibly in the case of sour cherries, largely grown in ex-soviet bloc). However, some of these products could also be very low volume products and the growth rates could simply be a matter of starting from a low base.

To put all the information mentioned above in a framework to better understand and visualize the structure of internationalization and identify potential opportunities in the market, we created a bubble chart (Figure 14) by plotting the trade/production against the last 20 year growth rate of the trade volume ratio. The size of the bubbles were correlated to the overall trade volume to visualize the potential opportunity. In addition, mean values for the both axes were calculated the chart was divided in 4 quadrants:

1- High growth, low trade/production volume
2- High growth, high trade/production volume
3- Low growth, high trade/production volume
4- Low growth, low trade/production volume

According to the classification above, quadrants 1 & 2 are the attractive choices characterized by high growth rates. However, Q2 would have proven its position in markets with high trade/production ratios. In other words, these would be more lucrative export oriented products probably dominated by some mid sized specialized exporters/growers. Q1 would also be very interesting, potentially with less competition due to the relatively small size of the export supply chain existing at this point. Alternatively, Q1 could be viewed as an interesting entry point to the FFV trade business, with probably a high supply of the produce in domestic markets and with the possibility of making the shit towards Q2 in the future. Q3 is certainly to be avoided for entrepreneurs, possibly dominated by slow growth, commoditized products where large scale distributors would be the main competition. Only with large amounts of capital could there be a chance to start a new supply chain for these products. Q4, on the other hand, is probably a market waiting for a new wave of commercialization and rejuvenation due to the fact of having low levels of trade and growth in trade. However, all the above hypothesis would be dependent also on the relative size of the trades (among other factors such as tariffs, quotas, product dynamics, supply, demand etc. which are not directly deducible from the data used in this analysis.

An detailed analysis of figure 12 actually supports the above mentioned hypothesis. Most of the high growth products in Q1 &2 are relatively small in trade volumes and relatively expensive, niche products. The outlier is grapes, with a large base trade base but still a relatively high growth rate. On the other hand, the below average growth rates are dominated with the commoditized products commonly found in all the FFV sections of supermarkets such as bananas, citrus, tomatoes, salads/cabbages, apples, pears, peppers, watermelons, cauliflowers etc. As an small traders, these would best be avoided, unless a significant price advantage is available. On the other hand, there could be opportunities for capital intensive investors in production or value added processing since the products have well proven markets.

In addition to the above analysis, we performed a correlation matrix (both for Pearson & Spearman coefficients) but the results were not impressive. There were no clear correlations between various growth rates, perishability figures and various ratios (APPENDIX 6).

Ultimately, based on the data above, it would be logical, in general terms, to say that certain horticultural products are different than others in terms of their trading patterns, that some have become commodities even though they have limited storage life (bananas, tomatoes) and that the these metrics can be used to hypothesize about potentially different market dynamics of the respective products.

However, none of the above analysis gives us any information about the actual relationship between the actors involved in the trade of these horticultural products. How centralized are they? Are these volumes shifting between a few producers or many? How concentrated are these markets. To answer these questions, we performed the network analysis.

5.1 – Trade Network Analysis:

The trade network part of the analysis ultimately was envisioned to serve two purposes:

1- Uncover correlations between trade volume data and network structure (correlation to growth rates which ultimately could be used to model future growth rates)
2- Make simple deductions about the competitive structure of the market

To achieve the above, we first calculated 4 basic network characteristics at the product level for 5 specific years. The initial suggested and extremely low density, often around 4% and a relatively low centralization index, suggesting a de-centralized trade network. These numbers were quite similar for almost all the products and fell within a narrow range. A quick plot of 2004 values (Figure 15) showed that connection for each product differed significantly but the density of the networks were more or less similar. Base on this lack of trend, we adopted a brute analysis approach where network related data were cross correlated (Table 4). Unfortunately, the analysis did not yield any correlations between density & centrality and/or vertex & edge numbers. The major finding in this analysis that the results of the analysis for various metrics were consistent across the time frame of the analysis. This was especially try for edge & vertex numbers, less so for density and centrality numbers, but never the less significant. In other words, when looking at basic characteristics of the network, a reasonable timeframe of 5 years does not effect the outcome of the analysis (i.e. could pick 2005 instead of 2000 etc.).

The next step was to correlate the network metrics with the trade volume data from the first part of the analysis (Table 3). Also in this correlation matrix we did not uncover any significant trends. However, there are certain points that should be mentioned:

- Even though in most cases there was not a strong correlation, there almost always was a correlation. Especially vertex/producer ratio showed promising results related to growth rates. However, the

Table 5- Vertex/Producer Ratios for 2004- Only for producers with >50K Tons/year/item

Product	Vertex/Producer
Onions (inc. shallots), green	17.3
Figs	16.4
Maize, green	10.5
Asparagus	9.7
Cherries	9.0
Dates	8.9
Grapefruit (inc. pomelos)	8.5
Garlic	7.5
Peas, green	6.9
Strawberries	6.4
Artichokes	5.3
Lemons and limes	5.1
Pears	5.1
Citrus fruit, nes	4.9
Plums and sloes	4.7
Apricots	4.6
Avocados	4.6
Cauliflowers and broccoli	4.5
Papayas	4.3
Peaches and nectarines	4.0
Chillies and peppers, green	3.9
Spinach	3.8
Pineapples	3.8
Other melons (inc.cantaloupes)	3.8
Eggplants (aubergines)	3.8
Mangoes, mangosteens, guavas	3.6
Lettuce and chicory	3.4
Oranges	3.3
Apples	3.0
Grapes	2.6
Carrots and turnips	2.6
Bananas	2.4
Cucumbers and gherkins	2.2
Watermelons	2.0
Tomatoes	1.6
Cabbages and other brassicas	1.5
Onions, dry	1.4

analysis is not reported due to various choices made while analyzing that specific metric.

- In most cases, the correlations were observed to improve when statistically insignificant samples were removed from the data set (a product with a very low base or trade volume etc.). However, because there was not a robust scientific methodology around this, the data was not reported.

Ultimately, the conclusion of the network analysis was that density and centrality are not useful at this level of the analysis: the networks are loosely connected and these metrics do not resolve the sub-structures of the network in a satisfactory way. Alternatively, the explanation could be that the sub-structures are the same. This would agree with the work of some other researchers suggesting that core-periphery tendencies are more or less dominating factors in world trade with multiple cores and peripheries around these cores. This would explain the low centrality indices as well. However, with the layering of producer data some additional resolution was gained. Especially the vertex/producer ratios showed significant variation by product and could signify producer country control of supply of certain produce. The correlation between vertex/producer rates and growth rates could also be indicative of a significant correlation.

6. CONCLUSION

This analysis reached most of its initial goals such that:

1- Product level differences were shown at the trade volume level data
2- Product level differences were shown to a limited extent for trade network data
3- Differences at the product level were gathered in a loose framework to illustrate potential ways to identify opportunities in horticultural trade
4- Illustrated the short comings and strengths of the methods applied and points at future improvement opportunities

The analysis also had certain shortcomings, due to method and framework:

1- The framwork was kept too wide for the given timeframe. It should either have focused on a limited data set or a single framework
2- The definition of internationalization/gloabalization is relatively open ended and there is not a consensus on its definition. Therefore, this study would have to define internationalization of products in a relatively vague way
3- Too much time was spent analyzing the network data, writing the code, streamlining it, checking the code and the data etc. However, this process also resulted in a better understanding of the intracacies of the data such that several improvements to the analysis were made this way.

However, the way to improve the analysis is clear and we would like to emphasize that:

1- The cut-offs for the data should be well managed. The FAO STAT and UN COMTRADE data should be treated as raw data and the filtered based on reasonable criteri. For example, at what level should a country be eliminated from the producer list, or as a trading partner for a class of product? How should these leves be different by product? How should products be treated by year?
2- The issue of the number of reporters changing seems more problematic than anticipated and is probably reflected in lower correlations going back in time. Therefore, the analysis should try to stick with a more limited timeframe.
3- The network analysis has significant room for improvement through distinguishing between importers and exporters (instead of only nodes) and the various ratios based on these.
4- The strength of connection is critical in this network analysis, however, the methods to analyze weighted connections is complex and out of scope of this assignment. However, better equipped researchers should look into it as a siginificant improvement opportunity.
5- Finally, the results of the analysis should be backed up by product level real world analysis to for certain key products through interviews with industry expert/players to understand if the key assumptions/predictions made match with reality.

Ultimately, this student would like to note that the following learning outcomes were achieved:

1- Gained a better understanding of world FFV trade
2- Gained insight into potential data sources and lack there of to make strategic planing decisions in a commercial setting
3- Gained insight into application of social network theory to the study of comlex networks and its shortcoming.

As an aspiring plant scientist and horticultural entrepreneur, this student will continue following up on the the above mentioned research topics for his own personal coomercial goals, as he believes that there is significant insight to be gained from the data mentioned in this research.

APPENDIX 1: RECENT WORLD TRADE OF HORTICULTURAL PRODUCTS

Product	Rank	2006-2008 Trade Average (MT)	% of Total	Cumulative % of Total
Bananas	1	1.69E+07	19.0%	19.0%
Apples	2	7.30E+06	8.2%	27.3%
Tomatoes	3	5.89E+06	6.7%	33.9%
Onions, dry	4	5.60E+06	6.3%	40.3%
Oranges	5	5.50E+06	6.2%	46.5%
Grapes	6	3.61E+06	4.1%	50.6%
Tangerines, mandarins, clem.	7	3.49E+06	3.9%	54.5%
Pineapples	8	2.60E+06	2.9%	57.4%
Pears	9	2.34E+06	2.6%	60.1%
Watermelons	10	2.26E+06	2.6%	62.6%
Lemons and limes	11	2.19E+06	2.5%	65.1%
Cucumbers and gherkins	12	2.13E+06	2.4%	67.5%
Chillies and peppers, green	13	2.13E+06	2.4%	69.9%
Other melons (inc.cantaloupes)	14	2.03E+06	2.3%	72.2%
Carrots and turnips	15	1.88E+06	2.1%	74.3%
Garlic	16	1.69E+06	1.9%	76.2%
Lettuce and chicory	17	1.66E+06	1.9%	78.1%
Cabbages and other brassicas	18	1.62E+06	1.8%	80.0%
Peaches and nectarines	19	1.49E+06	1.7%	81.6%
Grapefruit (inc. pomelos)	20	1.13E+06	1.3%	82.9%
Kiwi fruit	21	1.11E+06	1.3%	84.2%
Mangoes, mangosteens, guavas	22	1.03E+06	1.2%	85.3%
Cauliflowers and broccoli	23	8.51E+05	1.0%	86.3%
Dates	24	7.73E+05	0.9%	87.2%
Avocados	25	6.99E+05	0.8%	88.0%
Pumpkins, squash and gourds	26	6.58E+05	0.7%	88.7%
Strawberries	27	6.35E+05	0.7%	89.4%
Plantains	28	5.47E+05	0.6%	90.0%
Plums and sloes	29	5.38E+05	0.6%	90.6%
Fruit, tropical fresh nes	30	4.65E+05	0.5%	91.2%
Mushrooms and truffles	31	4.62E+05	0.5%	91.7%
Beans, green	32	4.10E+05	0.5%	92.2%
Onions (inc. shallots), green	33	3.96E+05	0.4%	92.6%
Eggplants (aubergines)	34	3.52E+05	0.4%	93.0%
Asparagus	35	2.65E+05	0.3%	93.3%
Leeks, other alliaceous veg	36	2.63E+05	0.3%	93.6%
Papayas	37	2.60E+05	0.3%	93.9%
Cherries	38	2.58E+05	0.3%	94.2%
Apricots	39	2.24E+05	0.3%	94.4%
Peas, green	40	1.87E+05	0.2%	94.6%
Maize, green	41	1.51E+05	0.2%	94.8%
Spinach	42	9.89E+04	0.1%	94.9%
Cranberries	43	7.71E+04	0.1%	95.0%
Berries Nes	44	7.69E+04	0.1%	95.1%
Raspberries	45	7.47E+04	0.1%	95.2%
Leguminous vegetables, nes	46	6.80E+04	0.1%	95.3%
Blueberries	47	6.63E+04	0.1%	95.3%
Carobs	48	5.58E+04	0.1%	95.4%
Citrus fruit, nes	49	5.09E+04	0.1%	95.5%
String beans	50	4.89E+04	0.1%	95.5%
Sour cherries	51	4.55E+04	0.1%	95.6%
Artichokes	52	4.35E+04	0.0%	95.6%
Figs	53	2.63E+04	0.0%	95.6%
Okra	54	2.00E+04	0.0%	95.7%
Quinces	55	1.52E+04	0.0%	95.7%
Currants	56	1.39E+04	0.0%	95.7%
Persimmons	57	7.19E+03	0.0%	95.7%
Stone fruit, nes	58	5.13E+02	0.0%	95.7%
Gooseberries	59	4.61E+02	0.0%	95.7%
Cassava leaves	60		0.0%	95.7%
Cashewapple	61		0.0%	95.7%
Pome fruit, nes	62		0.0%	95.7%
Vegetables fresh nes		2.46E+06	2.8%	98.5%
Fruit Fresh Nes		1.34E+06	1.5%	100.0%
Total		**8.85E+07**	**100%**	

APPENDIX 2: RECENT WORLD PRODUCTION OF HORTICULTURAL PRODUCTS

Product	Rank	2006-2008 Production (MT)	% of Total	Cumulative % of Total
Tomatoes	1	1.34E+08	9.0%	9.0%
Watermelons	2	9.52E+07	6.4%	15.5%
Bananas	3	8.90E+07	6.0%	21.5%
Onions, dry	4	7.00E+07	4.7%	26.2%
Cabbages and other brassicas	5	6.86E+07	4.6%	30.9%
Apples	6	6.68E+07	4.5%	35.4%
Oranges	7	6.65E+07	4.5%	39.9%
Grapes	8	6.63E+07	4.5%	44.3%
Cucumbers and gherkins	9	4.42E+07	3.0%	47.3%
Plantains	10	3.42E+07	2.3%	49.6%
Mangoes, mangosteens, guavas	11	3.41E+07	2.3%	51.9%
Eggplants (aubergines)	12	3.34E+07	2.3%	54.2%
Tangerines, mandarins, clem.	13	2.79E+07	1.9%	56.1%
Other melons (inc.cantaloupes)	14	2.76E+07	1.9%	58.0%
Chillies and peppers, green	15	2.73E+07	1.8%	59.8%
Carrots and turnips	16	2.65E+07	1.8%	61.6%
Lettuce and chicory	17	2.31E+07	1.6%	63.2%
Pumpkins, squash and gourds	18	2.08E+07	1.4%	64.6%
Pears	19	2.04E+07	1.4%	65.9%
Pineapples	20	1.99E+07	1.3%	67.3%
Cauliflowers and broccoli	21	1.83E+07	1.2%	68.5%
Peaches and nectarines	22	1.81E+07	1.2%	69.7%
Fruit, tropical fresh nes	23	1.67E+07	1.1%	70.9%
Garlic	24	1.58E+07	1.1%	71.9%
Spinach	25	1.41E+07	1.0%	72.9%
Lemons and limes	26	1.32E+07	0.9%	73.8%
Plums and sloes	27	1.01E+07	0.7%	74.5%
Papayas	28	9.53E+06	0.6%	75.1%
Maize, green	29	9.42E+06	0.6%	75.8%
Peas, green	30	8.43E+06	0.6%	76.3%
Citrus fruit, nes	31	7.44E+06	0.5%	76.8%
Asparagus	32	7.01E+06	0.5%	77.3%
Dates	33	6.89E+06	0.5%	77.8%
Beans, green	34	6.74E+06	0.5%	78.2%
Okra	35	6.37E+06	0.4%	78.7%
Grapefruit (inc. pomelos)	36	4.55E+06	0.3%	79.0%
Strawberries	37	4.01E+06	0.3%	79.2%
Onions (inc. shallots), green	38	3.62E+06	0.2%	79.5%
Avocados	39	3.62E+06	0.2%	79.7%
Persimmons	40	3.47E+06	0.2%	80.0%
Apricots	41	3.44E+06	0.2%	80.2%
Mushrooms and truffles	42	3.44E+06	0.2%	80.4%
String beans	43	2.06E+06	0.1%	80.6%
Leeks, other alliaceous veg	44	2.05E+06	0.1%	80.7%
Cherries	45	1.88E+06	0.1%	80.8%
Cashewapple	46	1.85E+06	0.1%	81.0%
Artichokes	47	1.46E+06	0.1%	81.1%
Leguminous vegetables, nes	48	1.35E+06	0.1%	81.1%
Kiwi fruit	49	1.26E+06	0.1%	81.2%
Sour cherries	50	1.17E+06	0.1%	81.3%
Figs	51	1.11E+06	0.1%	81.4%
Berries Nes	52	8.68E+05	0.1%	81.4%
Currants	53	6.98E+05	0.0%	81.5%
Raspberries	54	4.93E+05	0.0%	81.5%
Stone fruit, nes	55	4.83E+05	0.0%	81.6%
Quinces	56	4.72E+05	0.0%	81.6%
Cranberries	57	4.05E+05	0.0%	81.6%
Blueberries	58	2.83E+05	0.0%	81.6%
Carobs	59	1.74E+05	0.0%	81.6%
Gooseberries	60	1.30E+05	0.0%	81.7%
Pome fruit, nes	61	7.18E+04	0.0%	81.7%
Cassava leaves	62	5.20E+04	0.0%	81.7%
Vegetables fresh nes		2.45E+08	16.6%	98.2%
Fruit Fresh Nes		2.62E+07	1.8%	100.0%
Total		**1.48E+09**	**100.0%**	

APPENDIX 3: TRADE/PRODUCTION RATIO GROWTH RATES

	Geometric Means of Growth Rates						
PRODUCTS	1961-1970	1971-1980	1981-1990	1991-2000	2001-2008	1991-2008	1961-2008
Artichokes	-0.3%	3.6%	-3.9%	3.4%	-6.2%	-1.0%	-0.5%
Asparagus	10.6%	0.7%	8.9%	-1.2%	-0.3%	-0.8%	3.6%
Beans, green	-0.5%	-0.7%	5.2%	0.0%	4.5%	2.0%	1.6%
Cabbages and other brassicas	4.8%	3.4%	4.9%	1.4%	3.0%	2.1%	3.5%
Carrots and turnips	2.2%	1.2%	4.0%	0.7%	3.4%	1.9%	2.2%
Cauliflowers and broccoli	0.5%	-3.5%	-0.7%	-0.4%	0.7%	0.1%	-0.8%
Chillies and peppers, green	12.4%	5.7%	3.4%	0.7%	3.3%	1.8%	4.9%
Cucumbers and gherkins	9.9%	4.5%	-0.2%	-3.5%	2.8%	-0.8%	2.4%
Eggplants (aubergines)	16.4%	5.5%	-1.7%	-1.1%	4.0%	1.1%	4.2%
Garlic	12.0%	2.3%	2.9%	5.4%	6.3%	5.8%	5.6%
Leguminous vegetables, nes	1.5%	11.0%	4.2%	11.0%	-3.2%	4.5%	5.2%
Lettuce and chicory	5.7%	-0.8%	2.2%	0.1%	0.1%	0.1%	1.4%
Maize, green	1.7%	5.8%	12.8%	6.5%	5.7%	6.1%	6.6%
Mushrooms and truffles	-0.9%	-1.8%	11.2%	7.0%	3.0%	5.2%	3.7%
Okra	17.5%	21.0%	-6.0%	2.6%	2.6%	2.6%	7.1%
Onions (inc. shallots), green	0.2%	4.1%	0.9%	7.1%	3.2%	5.3%	3.1%
Onions, dry	1.8%	0.2%	0.7%	-0.8%	2.4%	0.6%	0.8%
Other melons (inc.cantaloupes)	10.2%	1.0%	2.1%	3.3%	-1.0%	1.4%	3.1%
Peas, green	-0.2%	3.0%	10.0%	5.7%	2.0%	4.0%	4.2%
Pumpkins, squash and gourds	18.0%	13.9%	4.5%	3.0%	-0.9%	1.2%	7.6%
Spinach	1.5%	0.7%	8.2%	-4.0%	0.2%	-2.1%	1.3%
Tomatoes	1.0%	-1.9%	-0.8%	0.7%	3.2%	1.8%	0.3%
Vegetables fresh nes	4.8%	1.8%	-4.5%	-1.7%	3.9%	0.8%	0.6%
Watermelons	2.8%	5.5%	3.6%	-0.5%	2.7%	0.9%	2.8%
Apples	-1.7%	1.7%	-0.3%	-0.5%	2.7%	0.9%	0.3%
Apricots	0.8%	-0.7%	0.1%	3.2%	0.6%	2.0%	0.8%
Avocados	13.4%	16.1%	8.3%	6.1%	5.7%	6.0%	10.0%
Bananas	-0.1%	0.3%	0.4%	1.4%	-2.2%	-0.2%	0.1%
Berries Nes	-1.3%	0.6%	1.0%	-3.8%	12.6%	3.2%	1.3%
Blueberries	-11.5%	-3.7%	5.6%	0.9%	4.3%	2.4%	-1.1%
Carobs	2.7%	1.7%	1.3%	0.3%	-1.2%	-0.4%	1.0%
Cherries	2.7%	3.3%	3.1%	0.9%	8.8%	4.3%	3.6%
Citrus fruit, nes	1.3%	5.4%	-6.0%	-0.7%	3.4%	1.1%	0.5%
Cranberries	-4.8%	1.3%	14.4%	4.0%	6.3%	5.0%	4.1%
Currants	7.6%	-4.5%	-0.8%	9.0%	-7.3%	1.4%	0.8%
Dates	4.6%	-7.2%	1.3%	-3.9%	5.8%	0.3%	-0.3%
Figs	1.9%	18.5%	11.4%	8.3%	4.6%	6.7%	9.1%
Fruit Fresh Nes	5.7%	2.4%	0.5%	0.6%	5.6%	2.8%	2.7%
Fruit, tropical fresh nes	2.0%	-6.5%	5.2%	4.1%	11.4%	7.3%	2.8%
Gooseberries	7.8%	10.7%	6.7%	-5.7%	-19.5%	-12.1%	0.0%
Grapefruit (inc. pomelos)	3.4%	2.8%	2.4%	-1.6%	2.9%	0.4%	1.9%
Grapes	0.8%	-0.1%	6.0%	4.4%	4.1%	4.3%	3.0%
Kiwi fruit		9.0%	5.8%	3.4%	2.4%	2.9%	5.2%
Lemons and limes	1.3%	-0.5%	-3.1%	-0.3%	2.7%	1.0%	-0.2%
Mangoes, mangosteens, guavas	11.2%	13.1%	9.2%	10.5%	2.7%	7.0%	9.6%
Oranges	-0.7%	-3.8%	-1.8%	-1.9%	1.5%	-0.4%	-1.5%
Papayas	61.8%	12.3%	9.6%	3.3%	0.1%	1.9%	15.4%
Peaches and nectarines	1.9%	-0.3%	2.7%	-0.1%	-0.3%	-0.2%	0.8%
Pears	0.2%	0.5%	2.9%	-0.1%	2.3%	1.0%	1.1%
Persimmons	9.0%	7.4%	-7.9%	-1.8%	-24.8%	-12.8%	-3.7%
Pineapples	0.5%	1.6%	4.2%	3.1%	9.6%	5.9%	3.6%
Plantains	5.0%	1.0%	9.0%	8.3%	1.5%	5.2%	5.1%
Plums and sloes	1.4%	4.2%	4.4%	1.6%	2.8%	2.1%	2.9%
Quinces	-0.6%	8.3%	8.2%	4.0%	3.3%	3.7%	4.7%
Raspberries	-2.4%	2.8%	2.6%	1.6%	9.8%	5.2%	2.6%
Sour cherries	6.2%	-6.9%	5.5%	16.1%	0.5%	8.9%	4.1%
Stone fruit, nes	0.7%	8.1%	-16.8%	-17.2%	-24.2%	-20.4%	-10.3%
Strawberries	4.1%	0.9%	2.0%	2.7%	0.9%	1.9%	2.1%
Tangerines, mandarins, clem.	1.2%	2.6%	0.2%	1.7%	-1.3%	0.4%	1.0%

APPENDIX 4: TRADE/PRODUCTION RATIOS

PRODUCTS	Harmonic Mean of Trade/Production Ratios 1961-1970	1971-1980	1981-1990	1991-2000	2001-2008	1991-2008	1961-2008
Artichokes	3.9%	3.9%	3.8%	4.2%	3.4%	3.8%	3.8%
Asparagus	1.1%	1.7%	3.1%	4.7%	3.7%	4.2%	2.1%
Beans, green	3.2%	2.8%	3.3%	4.3%	5.5%	4.7%	3.5%
Cabbages and other brassicas	0.6%	0.9%	1.2%	2.1%	2.1%	2.1%	1.1%
Carrots and turnips	3.0%	3.5%	4.3%	5.7%	6.4%	6.0%	4.2%
Cauliflowers and broccoli	6.2%	5.2%	4.5%	4.6%	4.5%	4.5%	4.9%
Chillies and peppers, green	1.4%	3.1%	4.8%	6.6%	7.3%	6.9%	3.2%
Cucumbers and gherkins	2.3%	4.6%	5.3%	4.9%	4.1%	4.5%	3.9%
Eggplants (aubergines)	0.3%	0.9%	0.9%	0.8%	1.0%	0.9%	0.6%
Garlic	1.3%	2.6%	3.4%	6.2%	9.8%	7.4%	2.8%
Leguminous vegetables, nes	0.5%	1.1%	1.6%	4.5%	5.2%	4.8%	1.2%
Lettuce and chicory	5.1%	5.9%	6.1%	7.4%	7.2%	7.3%	6.2%
Maize, green	0.1%	0.2%	0.3%	0.8%	1.4%	1.0%	0.2%
Mushrooms and truffles	2.8%	2.2%	3.4%	8.6%	12.6%	10.0%	3.7%
Okra	0.0%	0.1%	0.5%	0.3%	0.3%	0.3%	0.0%
Onions (inc. shallots), green	2.8%	4.0%	4.6%	7.6%	9.4%	8.3%	4.6%
Onions, dry	6.2%	6.2%	7.0%	7.8%	7.9%	7.9%	6.9%
Other melons (inc.cantaloupes)	2.7%	4.2%	4.4%	7.4%	7.2%	7.3%	4.4%
Peas, green	0.3%	0.4%	0.7%	1.6%	2.5%	1.9%	0.6%
Pumpkins, squash and gourds	0.2%	0.7%	2.1%	3.3%	3.0%	3.2%	0.6%
Spinach	0.4%	0.4%	0.7%	0.8%	0.7%	0.8%	0.6%
Tomatoes	4.0%	3.5%	3.4%	3.6%	4.0%	3.8%	3.7%
Vegetables fresh nes	1.0%	1.3%	1.2%	0.8%	0.9%	0.9%	1.0%
Watermelons	0.7%	1.2%	1.7%	2.5%	2.1%	2.3%	1.3%
Apples	8.2%	9.2%	8.8%	9.2%	10.3%	9.7%	9.1%
Apricots	4.5%	4.1%	4.6%	6.1%	6.2%	6.2%	4.9%
Avocados	0.4%	1.7%	5.5%	9.8%	15.6%	11.7%	1.4%
Bananas	17.7%	19.3%	17.3%	21.9%	20.0%	21.0%	19.1%
Berries Nes	4.6%	5.9%	6.0%	6.3%	6.3%	6.3%	5.7%
Blueberries	30.9%	11.6%	13.9%	14.5%	22.1%	17.1%	16.2%
Carobs	20.2%	20.0%	30.7%	26.1%	37.8%	30.2%	25.1%
Cherries	3.1%	4.5%	5.4%	7.0%	11.1%	8.4%	5.1%
Citrus fruit, nes	0.6%	0.9%	0.7%	0.5%	0.7%	0.6%	0.7%
Cranberries	2.7%	1.7%	2.4%	7.5%	16.9%	10.0%	3.1%
Currants	2.0%	2.8%	2.1%	3.9%	2.3%	3.0%	2.5%
Dates	18.3%	13.7%	9.0%	8.2%	9.4%	8.7%	10.7%
Figs	0.1%	0.1%	0.5%	1.3%	2.5%	1.7%	0.2%
Fruit Fresh Nes	2.0%	2.8%	3.1%	3.0%	4.1%	3.4%	2.8%
Fruit, tropical fresh nes	0.8%	0.7%	0.8%	0.9%	2.3%	1.3%	0.9%
Gooseberries	0.2%	0.7%	1.5%	1.3%	0.4%	0.7%	0.5%
Grapefruit (inc. pomelos)	12.5%	17.7%	21.5%	21.5%	22.7%	22.0%	18.1%
Grapes	1.5%	1.6%	2.1%	3.5%	4.8%	4.0%	2.2%
Kiwi fruit		20.1%	34.3%	68.7%	82.5%	74.2%	35.1%
Lemons and limes	19.5%	18.8%	15.5%	13.7%	15.6%	14.5%	16.4%
Mangoes, mangosteens, guavas	0.1%	0.2%	0.6%	1.7%	2.8%	2.0%	0.2%
Oranges	16.2%	12.8%	9.5%	7.6%	8.2%	7.8%	10.1%
Papayas	0.0%	0.4%	0.8%	1.8%	2.8%	2.1%	0.0%
Peaches and nectarines	6.0%	7.1%	7.9%	8.2%	8.2%	8.2%	7.3%
Pears	7.2%	7.4%	7.6%	10.8%	11.0%	10.8%	8.4%
Persimmons	0.2%	0.7%	0.6%	0.3%	0.1%	0.1%	0.2%
Pineapples	2.6%	3.4%	4.5%	6.0%	10.4%	7.4%	4.2%
Plantains	0.2%	0.2%	0.4%	0.8%	1.5%	1.0%	0.4%
Plums and sloes	1.9%	2.5%	2.8%	4.7%	5.3%	4.9%	2.9%
Quinces	0.4%	0.8%	1.3%	3.1%	3.2%	3.1%	1.0%
Raspberries	5.1%	4.9%	6.8%	10.2%	12.6%	11.1%	6.8%
Sour cherries	0.7%	0.7%	0.7%	2.8%	3.6%	3.1%	1.0%
Stone fruit, nes	15.6%	15.3%	10.6%	1.3%	0.1%	0.3%	0.7%
Strawberries	5.9%	9.8%	9.1%	14.1%	15.5%	14.7%	9.5%
Tangerines, mandarins, clem.	8.0%	10.0%	11.5%	12.6%	12.2%	12.4%	10.5%

APPENDIX 5: OWN CODE WRITTEN FOR THE ANALYSIS OF NETWORK DATA

```
(*Import external data*)
comlookup = Import[
   "/Users/bakikantasi/Documents/Wageningen/Thesis-MGMT/Data/commoditylookup.csv"];
countrylookup = Import[
   "/Users/bakikantasi/Documents/Wageningen/Thesis-MGMT/Data/countrycodes.csv"];
data = Import["/Users/bakikantasi/Documents/Wageningen/Thesis-MGMT/Data/ComTrade
      Data/All Years.csv"];

(*transform the country and commodity lookup tables into replacement rules*)
comlookup2 = Table[{comlookup[[i, 1]] → comlookup[[i, 2]]}, {i, 1, Length[comlookup]}];
countrylookup2 =
  Table[{countrylookup[[i, 1]] → countrylookup[[i, 2]]}, {i, 1, Length[countrylookup]}];

(*create a new data table to be analyzed*)


(*eliminate record with a weight of less than the cutoff value AND ALSO NOTE
 THE ELIMINATION OF TOTAL WORLD RECORDS FROM THE LIST AS DENOTED BY ENTRY 0*)
cutoff := 20 000;

middata =
  Select[Transpose[Flatten[Table[Take[Transpose[data], {i}], {i, {1, 2, 4, 6, 9}}], 1]],
   #[[2]] ≠ 0 && #[[3]] ≠ 0 && #[[5]] ≥ cutoff &&
     #[[4]] ≠ 70 952 && #[[4]] ≠ 71 210 && #[[4]] ≠ 81 030 &];

newdata = Flatten[Map[Sort[#, #2[[4]] > #1[[4]] &] &, GatherBy[middata, #[[1]] &], {1}], 1];

(*comparison of densities by year by commodity*)

(*prepare the data for analysis*)
densitydata = GatherBy[newdata, {#[[1]] &, #[[4]] &}];
graphfunction[a_] := Apply[Flatten, Map[{#[[2]] → #[[3]]} &, a, {2}], {2}];
graphs = Map[Graph, Map[graphfunction, densitydata], {2}];
gr := graphs;

(*prepare headings to be used in table creation*)
columnheadings = densitydata[[All, 1, 1]][[All, 1]];
rowheadings = densitydata[[1, All, 1]][[All, 4]] /. Flatten[comlookup2];

(*descriptive graph metrics calculations*)
vcount[gr_] := Map[VertexCount, gr, {2}];
ecount[gr_] := Map[EdgeCount, gr, {2}];
indegrees[gr_] := Map[VertexInDegree, gr, {2}];
outdegrees[gr_] := Map[VertexOutDegree, gr, {2}];
indegreesMean[gr_] := Map[Mean, indegrees, {2}] // N;
outdegreesMean[gr_] := Map[Mean, outdegrees, {2}] // N;
degreecent[gr_] := DegreeCentrality /@ gr // N;
density[edges_, vertexes_, gr_] :=
  edges[gr] / (vertexes[gr] * (vertexes[gr] - 1)) * 100 // N;

graphcentrality[gr_] := Map[Sum[Max[VertexOutDegree[#]] - VertexOutDegree[#][[i]],
      {i, 1, Length[VertexOutDegree[#]]}] / (VertexCount[#] - 1)^2 &, gr, {2}] // N


(*to print data in table format*)
densitytable = TableForm[Transpose /@ density[ecount[gr], vcount[gr]],
   TableHeadings → {rowheadings, columnheadings}];
tablecreator[g_] := TableForm[Transpose[g], TableHeadings → {rowheadings, columnheadings}]
tablecreator /@ {density[ecount, vcount, gr], graphcentrality[gr], ecount[gr], vcount[gr]};
```

APPENDIX 6: PEARSON AND SPEARMAN COEFFICIENT MATRICES FOR TRADE VOLUME ANALYSIS OUTPUT

Pearson Correlation

	T/P1961-1970	T/P1971-1980	T/P1981-1990	T/P1991-2000	T/P2001-2008	T/P1991-2008	T/P1961-2008	GR1961-1970	GR1971-1980	GR1981-1990	GR1991-2000	GR2001-2008	GR1991-2008	GR1961-2008	Storage Life	2006-2008 Trade	2006-2008 Production
T/P1961-1970	1.00	0.87	0.82	0.72	0.69	0.72	0.89	-0.38	-0.47	-0.27	-0.31	0.13	-0.09	-0.50	0.22	0.37	0.08
T/P1971-1980		1.00	0.96	0.87	0.74	0.84	0.98	-0.31	-0.43	-0.39	-0.36	0.10	-0.14	-0.49	0.22	0.54	0.15
T/P1981-1990			1.00	0.94	0.84	0.92	0.98	-0.31	-0.34	-0.30	-0.33	0.14	-0.09	-0.42	0.13	0.48	0.09
T/P1991-2000				1.00	0.93	0.99	0.92	-0.32	-0.33	-0.15	-0.17	0.21	0.05	-0.31	0.08	0.48	0.03
T/P2001-2008					1.00	0.97	0.82	-0.34	-0.29	0.03	-0.07	0.35	0.21	-0.19	0.09	0.32	-0.08
T/P1991-2008						1.00	0.90	-0.33	-0.32	-0.09	-0.14	0.28	0.12	-0.27	0.09	0.43	-0.01
T/P1961-2008							1.00	-0.38	-0.45	-0.32	-0.32	0.14	-0.08	-0.50	0.17	0.51	0.12
GR1961-1970								1.00	0.47	0.06	0.07	-0.14	-0.06	0.68	-0.10	-0.16	-0.09
GR1971-1980									1.00	0.14	0.10	-0.10	-0.01	0.66	-0.21	-0.20	-0.15
GR1981-1990										1.00	0.35	0.31	0.43	0.55	-0.15	-0.25	-0.21
GR1991-2000											1.00	0.19	0.72	0.50	-0.21	-0.18	-0.20
GR2001-2008												1.00	0.82	0.35	0.07	0.03	0.10
GR1991-2008													1.00	0.54	-0.08	-0.08	-0.05
GR1961-2008														1.00	-0.20	-0.26	-0.17
Storage Life															1.00	0.11	0.10
2006-2008 Trade																1.00	0.72
2006-2008 Production																	1.00

Sperman Correlation

	T/P1961-1970	T/P1971-1980	T/P1981-1990	T/P1991-2000	T/P2001-2008	T/P1991-2008	T/P1961-2008	GR1961-1970	GR1971-1980	GR1981-1990	GR1991-2000	GR2001-2008	GR1991-2008	GR1961-2008	Storage Life	2006-2008 Trade	2006-2008 Production
T/P1961-1970	1.00	0.96	0.90	0.84	0.76	0.81	0.98	-0.57	-0.67	-0.46	-0.35	0.06	-0.32	-0.71	0.26	0.47	0.11
T/P1971-1980		1.00	0.96	0.88	0.77	0.84	0.98	-0.40	-0.54	-0.54	-0.39	0.02	-0.38	-0.66	0.26	0.52	0.15
T/P1981-1990			1.00	0.94	0.85	0.90	0.96	-0.35	-0.42	-0.42	-0.35	0.09	-0.30	-0.53	0.24	0.53	0.11
T/P1991-2000				1.00	0.95	0.99	0.90	-0.40	-0.40	-0.21	-0.12	0.17	-0.07	-0.36	0.19	0.45	-0.01
T/P2001-2008					1.00	0.98	0.82	-0.44	-0.35	-0.07	0.00	0.36	0.13	-0.20	0.17	0.40	-0.08
T/P1991-2008						1.00	0.87	-0.43	-0.38	-0.15	-0.07	0.27	0.02	-0.29	0.19	0.43	-0.04
T/P1961-2008							1.00	-0.49	-0.57	-0.45	-0.33	0.08	-0.28	-0.62	0.23	0.51	0.12
GR1961-1970								1.00	0.42	0.00	-0.01	-0.23	-0.06	0.44	-0.08	-0.08	0.14
GR1971-1980									1.00	0.20	0.14	0.08	0.17	0.57	-0.06	-0.25	-0.07
GR1981-1990										1.00	0.39	0.27	0.50	0.60	-0.18	-0.25	-0.24
GR1991-2000											1.00	0.12	0.79	0.59	-0.21	-0.25	-0.27
GR2001-2008												1.00	0.61	0.34	0.05	0.09	-0.10
GR1991-2008													1.00	0.68	-0.24	-0.18	-0.25
GR1961-2008														1.00	-0.29	-0.18	-0.05
Storage Life															1.00	0.39	0.26
2006-2008 Trade																1.00	0.85
2006-2008 Production																	1.00