Supply risk assessment of major agricultural commodities

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Management summary

Background and objectives

The prices of agricultural commodities increased in 2008 to levels that were higher than ever before. Most of the commodity prices stayed above their previous levels. In addition, markets are becoming more volatile. Companies face increasing supply risk from the agricultural markets. Multiple factors contributed to the increased risks in commodity supply. The aim of this thesis is to assess the supply risk of major agricultural commodities and rank them. In order to do this, several risk sources and their underlying drivers at the agricultural markets will be identified. To assess the supply risk several risk indicators are identified and quantified. In order to evaluate the supply risk a profit impact evaluation is carried out. In this study, five relevant risk sources from the agricultural supply market have been identified: (1) global sourcing, (2) number of qualified suppliers, (3) market constraint, (4) price increase and (5) geopolitical climate. Depending on supply risk of the commodity, food and agribusiness companies are able to decide whether it is necessary to take actions for securing their supply. More insight into the risks of key input commodities helps companies in their decision-making and risk management.

Material and method

In the supply risk assessment 40 commodities have been included. The commodities have been selected from the FAO agricultural database and in consultation with Rabobank market analysts based on importance, production quantity and production value. Per source of risk has been selected based on the literature, and included in the supply risk assessment. Global sourcing risk is measured by the global geographic concentration of production. This is calculated by applying the Herfindahl index. The number of qualified suppliers is measured by the market power of companies. To measure market power, market analysts have scored the market share of the top five companies in the specific market. The availability of commodities in a constrained market is measured by calculating the difference between domestic supply growth rate and production growth rate. Fluctuations in production, due to weather circumstances, can be an important factor that results in unstable prices. In order to measure the fluctuation in production, the variability in yield is calculated. The geopolitical climate as a risk source is covered by assessing the country risk. The country risk score is a country's share in production for the top 5 producing countries multiplied by their country risk index. The input data for this risk assessment is extracted mainly from the FAO agricultural database. The supply risk score is the average score of the normalized indicator values. The commodity with the highest indicator value receives a score of 1.00 and the country with the lowest indicator value receives a score of 0.00. In addition to the supply risk assessment, a profit impact evaluation is conducted. Market analysts are asked to score the commodity profit impact for companies on a scale of low (0.00), medium (0.50), or high (1.00). The analysts made their decision on the following points: (1) ability to store commodity, (2) value added to commodity, (3) availability of future market, (4) importance of sustainability and (5) substitution possibility. Finally, the risk value is determined by multiplying the supply risk score with the profit impact score.

Results

Palm oil has the highest concentration of production and cow milk the lowest. Market power is highest in the market of concentrated orange juice. In several commodity markets, (egg, olives, potatoes and onions) market power is low. In the cocoa bean market, demand has been growing faster than production over the last decennium. The maize, barley and tea markets show a higher growth rate of production relative to domestic supply. The highest fluctuations in yield are shown for olives. Pig meat shows a low fluctuation in yield per animal. Cocoa beans also receives a high score for the country risk index. Butter of cow milk has the lowest score for this indicator. The end result of both the supply risk assessment and the profit impact evaluation are presented in table 1.

Table 1. Ranking of commodities based on risk value with an equal distribution of weights per indicator

Rank	Commodity	Supply risk	Profit impact	Risk value
1	Cocoa beans	0.71	0.60	0.43
2	Olives	0.46	0.80	0.37
3/4	Bananas	0.33	0.90	0.30
3/4	Apples	0.42	0.70	0.30
5	Oranges	0.35	0.80	0.28
6	Orange juice, s. strength	0.54	0.50	0.27
7	Olive oil	0.66	0.40	0.26
8/9	Coffee	0.49	0.50	0.24
8/9	Tea	0.40	0.60	0.24
10/11/12/13	Tomatoes	0.33	0.70	0.23
10/11/12/13	Apple juice, s. strength	0.46	0.50	0.23
10/11/12/13	Sunflower Cake/meal	0.46	0.50	0.23
10/11/12/13	Pig meat	0.33	0.70	0.23
14	Hen eggs, in shell	0.22	1.00	0.22
15/16	Sunflower seed	0.42	0.50	0.21
15/16	Apple juice, concentrated	0.52	0.40	0.21
17	Orange juice, concentrated	0.65	0.30	0.20
18/19/20/21	Rice	0.37	0.50	0.18
18/19/20/21	Soybeans Cake/meal	0.46	0.40	0.18
18/19/20/21	Grapes	0.23	0.80	0.18
18/19/20/21	Cow milk, Whole/ fresh	0.20	0.90	0.18
22	Cow Milk, Cheese	0.20	0.80	0.16
23/24	Cow milk, Butter	0.18	0.80	0.14
23/24	Palm oil	0.68	0.20	0.14
25/26/27/28	Pulses	0.27	0.50	0.13
25/26/27/28	Rapeseed Cake/Meal	0.33	0.40	0.13
25/26/27/28	Soybeans	0.44	0.30	0.13
25/26/27/28	Sunflower oil	0.43	0.30	0.13
29/30	Soybean oil	0.39	0.30	0.12
29/30	Potatoes	0.23	0.50	0.12
31/32/33	Bovine Meat	0.19	0.60	0.11
31/32/33	Rapeseed oil	0.38	0.30	0.11
31/32/33	Rapeseed	0.37	0.30	0.11
34	Onions	0.21	0.50	0.10
35	Poultry Meat	0.19	0.50	0.09
36	Cotton lint	0.43	0.20	0.09
37	Barley	0.33	0.20	0.07
38	Wheat	0.26	0.20	0.05
39	Sugar	0.39	0.10	0.04
40	Maize	0.34	0.10	0.03

Conclusions

The result is a supply risk ranking where cocoa beans received the highest supply risk. This is due to the high concentration of production, which takes place in countries with a high risk profile. Cocoa beans are traded intensively and market power is high. In addition, production has been growing slower than demand. The profit impact of cocoa beans is high, resulting in a first place ranking for risk value. Palm oil, olive oil and concentrated orange juice score high in supply risk. Olive oil scores high for production shocks and market balance. In the market of orange juice, market power is high. The risk indicators score for palm oil is more evenly distributed. Orange juice single strength, coffee, apple juice single strength, concentrated orange juice and olives are listed in the top 10 in the supply risk ranking. Commodities that have a low supply risk are mainly animal-based products from cows (bovine meat, milk, butter and cheese) and poultry (hen eggs, poultry meat). For the commodities milk and eggs, the risk value is much higher because of high profit impact, they are listed in the top 10 of the risk value ranking. Vegetables and fruits are commodities with a low supply risk. However, because of their high profit impact the risk value of these commodities is high. Bananas, apples and oranges are listed in the top 10 of the risk value ranking.

Recommendations

This study is conducted in cooperation with the Rabobank Food & Agribusiness Research department. This study will give Rabobank more knowledge about the risk that food and agribusiness companies face. Companies that source commodities with a high risk profile should provide a strategy to reduce these risks. In the agricultural market uncertainty affects supply risk. It would be helpful to understand more thoroughly how markets interact to each other. Where prices affect decisions for farmers and companies in the food supply chain. It is clear that geopolitical climate creates uncertainty in a volatile agricultural supply market. Therefore governments and policy makers should work closer together to reduces negative effects that create this uncertainty.

Preface

This report is a final product of my Master thesis. I learned a lot during my research period. Both the study and the assignment gave me a lot to think about. The assignment was challenging but I believe that I have managed to answer some of the major questions. With the result of the study, Rabobank International can support companies by answering their questions about sourcing and securing commodity supply. I hope this report will have a contribution to the sourcing issues that organisations are currently dealing with.

I would like to thank everyone who had a contribution to my master thesis. With special attention, I thank Miranda Meuwissen who has guided me during these months. With critical questions, advice and support, she made it possible for me to do this project. I also want to thank Sebastian Schreijen for his guidance from Rabobank International. I appreciate that he has given me the opportunity to do this master thesis in collaboration with Rabobank. I also thank all the people working at Rabobank International Food & Agribusiness Research and in particular the analysts who contributed to the outcome of this report.

Asten, December 2012

Peter Kanters

Table of Contents

1 Introduction

1.1 Background

The world population is growing towards 9 billion people in 2050 (OECD and FAO, 2011). The result of this population growth is an increasing demand for food. Changes in diets in emerging countries also contribute to this increase in food demand (European Commission, 2011). There has been an estimated increase in food demand of 70% and at the same time the demand for industrial products and biofuel is growing rapidly (Godfray et al., 2010). The prices of agricultural commodities increased in 2008 to levels that were higher than ever before. Most of the commodity prices stayed above their previous levels (Carter et al., 2011). In addition, prices are becoming more volatile (OECD and FAO, 2010). Due to increasing food demand together with changing markets, calamities caused by weather, climate change and trade or infrastructure breakdowns markets are becoming more volatile and risks are increasing (Heyder et al., 2010). As a consequence, food companies are dealing with new challenges to secure their supply of raw material.

The Rabobank Food & Agribusiness Research and Advisory department also observe this. According to the Rabobank (2011), there is an increasing risk in the supply of agricultural commodities. Companies face increasing supply risk due to price volatility, scarcity of resources and increasing trade. How companies deal with more volatile markets has been studied by Heyder et al. (2010). Companies prefer long-term contracts with supply partners, price hedging and vertical integration. Vertical backward integration helps in reducing risks (Ziggers & Trienekens, 1999). Little research has been done in backward integration other than contracts for securing supply. To secure the supply of affordable and sufficient agricultural commodities investments are needed and extra efforts have to be made. It also leads to reduced flexibility, high investments and more management time for coordination (Donk et al., 2010; Rabobank, 2011).

Supply risk can come from three sources; risk from individual suppliers, item characteristics and risk from supply markets (Zsidisin, 2003b). For food and agribusiness companies this raises a question: for what agricultural commodities can the market become imbalanced and create a potential risk in supply. The supply risk that companies face can result in an inability of the company to satisfy customer demand (Heyder et al., 2010; Roth et al., 2008, Jaffee et al., 2008). Risk from the supply market can come from multiple sources. Zsidisin (2003b) also accounts unstable prices and market constraint as source of supply risk. All actors in the agricultural supply chain are closely interlinked and affected by these prices. Uncertainty about the volatility (price and quantity) of the market creates concern about the financial success of the firm (Heyder et al., 2010). Companies can, based on the risks, apply a suitable risk mitigation strategy. In a global market, it is difficult to measure these risks. Piesse & Thirtle (2009) and Trostle (2008) studied the causes for high price volatility for some basic commodities and found that supply shocks are the main cause of price volatility. Gilbert & Morgan (2010) also concluded that supply shocks are a main cause for changes in price and availability of commodities. They also give several reasons for why price volatility will maintain high. Carter et al. (2011) goes in to more detail why supply and demand shocks result in price volatility and supply disruption. Supply shocks emerge in most cases from climate conditions, adverse weather like floods, droughts or hurricanes. Additionally shocks can be a result of labour strikes, pest and plant diseases and geological events as wars and trade disputes” (Carter et al, 2011). Headey (2009) gives attention to the role of trade shocks that affect price and availability. These studies mainly pay attention on finding reasons for higher price volatility. Jaffee et al. (2008) assessed the risk in the agricultural supply chain. He identified some risk factors that affect price, availability, quality and cost. Some other researchers looked at the risk impact of calamities to supply (Meuwissen et al., 2010).

Multiple factors contributed to the increased risk in commodity supply. However, little or no research is done in assessing supply risk of multiple commodities. This knowledge gap could therefore lead to unsatisfactory risk mitigation strategies. According to Heyder et al. (2010), companies will select the easiest solution to cope with the problem of volatile markets. Companies are limited in knowledge and therefore select the solution that is closest to the problem instead of the optimal solution. Companies recognize the problem of volatile markets and show that they are willing to adapt. The right strategy of the food supply chain to adapt depends on the adaption that is required (Heyder et al., 2010). Depending on supply risk of the commodity, food and agribusiness companies are able to decide whether it is necessary to take actions for mitigating their supply risk. More insight into the risks of key input commodities helps companies in their decision-making and risk management.

1.2 Research objectives

In the context described above, the aim of this thesis is to assess the supply risk of major agricultural commodities and rank them. More specifically, the objectives are to:

1. Identify important supply risks from agricultural commodity markets.
2. Identify underlying sources and drivers per supply risk factor.
3. Select and quantify relevant indicators to assess the supply risk.
4. Analyse and rank commodities based on supply risk indicators.

The supply risk assessment is carried out for major agricultural commodities.

1.3 Outline of report

Chapter 3 is dedicated to supply risk from agricultural markets. Explained is why risks have increased and how risk can affect food and agribusiness companies. Risks are identified and sources and drivers of supply risk are described. At the end of chapter 2, attention is given to supply risk assessment techniques in literature. Chapter 3 of this report is focussing on the materials and methods used. In chapter 4, the results of the supply risk assessment are presented and the outcomes are described. The final chapter 5 provides the discussion and conclusion with some additional recommendations for further research.

2 Supply risks on agricultural markets

As described earlier, supply risk is one of the risks that companies face. To reduce risk, companies have to apply a good risk mitigation strategy. In order to select a good strategy, risks have to be analysed. Risk management has become an important part of today's corporate management. Loman (2009) observed comparable steps in risk management. The following steps are part of risk management:

1. Risk identification
2. Measuring risk
3. Analyzing the risk
4. Risk mitigation
5. Planning & control

This research concentrates on the first three steps of risk management.

Risk identification is the process in which risks are identified and listed. Risks are events or circumstances that have a negative impact on achieving an objective (Loman, 2009). It is almost impossible to identify all the risks that are present today (Loman, 2009). Not only do risks have to be identified but it is also important to identify the sources and drivers of these risks (Christopher et al., 2002). Identifying sources and drivers helps one to better understand the risk (Loman, 2009).

2.1 Risk value

The appropriate sourcing strategy decision to apply is based on two factors (Padhi et al, 2011). Kraljic (1983) explains this best and he is often cited regarding the application or implementation of a suitable sourcing strategy within the company. Sourcing decisions, performance indicators and supply management should be applied based on the value of the item for the company (Zsidisin, 2003; Padhi et al., 2011). The Kraljic Portfolio Matrix is an instrument used to evaluate the risk value of a raw material for a company. Depending on the supply risk and profit impact on the company, companies can decide on the best strategy for purchase of a single commodity. The risk value is two-dimensional as shown in the figure below.

Risk value Matrix- Kraljic model

High	Leverage items	Strategic items
Profit impact		
Low	Non- Critical items	Bottleneck items
	Low **Supply risk**	High

Figure 1 Risk value matrix based on Kraljic Model.
Source: Padhi et al. 2011

2.1.1 Supply risk

Dr. Zsidisin, associate professor at Bowling Green State University, has purchasing and supply management as his area of expertise. Zsidisin published and contributed to multiple studies that deal with supply risk. These studies are characterized by a broad view on current literature. Zsidisin (2003a) defines the supply risk as the probability of an event that will result in problems with the inbound supply of raw materials. Supply risk assessment techniques have been concentrating on the supply risk from suppliers. According to Zsidisin (2003b; 2005), there are three sources of supply risk: risk from suppliers, risk from the supply market and risk item characteristics. Risk assessments of suppliers focuses on decision-making and selecting the best supplier(s) based on several indicators. Item characteristics, as supply risk, is the impact of the item on profitability and the knowledge of the companies about the item.

In the field of supply risk management, studies focusing on assessing the risk from supply markets are getting less attention (Zsidisin, 2010). The risk from supply markets is the risk that a market is unable to meet the demand of the customer. The supply risk for companies from markets is that the price is too high or the product is not available at the supply market (Zsidisin, 2003a). If prices are too high or if products are not available, companies are unable to satisfy customer demand in price, quantity and quality. According to Zsidisin (2003b; 2005), the risks from supply markets are:

- Global sourcing
- Number of qualified suppliers
- Market capacity constraint
- Market price increase
- Geopolitical climate

The risks mentioned by Zsidisin are based on a broad overview from multiple supply risk studies. However, these studies are more focused on supply risk for the metal industry rather than on risks for food and agribusiness companies. Moreover, other supply risk assessment studies that are not mentioned by Zsidisin are only concentrating on the supply risk of mineral raw materials, such as metals and oil.

A study of Jaffee et al. (2008) about the risks in agricultural supply chains on behalf of the World Bank's agriculture department provides a comparable definition of supply risk for agricultural products. The supply risk of agricultural commodities involves a problem with the product flow between farmer, processors and other supply chain partners. According to Jaffee et al. (2008) the flow of agricultural products starts with input suppliers and ends with the final product for the consumer. At farmer level, product flow is the raw product produced and sold to the next actor in the supply chain. This can be marketers or processors. Marketers sometimes transform products so that storage is possible and the products are easier to trade. These products are traded as commodities at local and global markets (Jaffee et al., 2008; Roth et al., 2008). In these local and global markets, processors source their products. Processors transform the commodity into one or more finessed goods. The supply risk for processors is that the product is not available for the right price at a certain quality.

2.1.2 Profit impact for food and agribusiness companies

Increased supply risk has large consequences for food and agribusiness companies. They are unable to meet customers demand in quantity, quality and price. Shortage of a commodity will not occur instantly. Price and availability are closely linked (Carter et al., 2011). Often a commodity is available but the price is too high, leading to high financial losses for the company sourcing the commodity. Processors and other actors in the food supply chain are confronted with volatile markets. Volatile markets create uncertainty, which companies have to adapt to (Heyder et al., 2010). Volatile markets are part of the overall business risk that companies face (OECD, 2009). According Heyder et al. (2010), this management challenge is getting much attention in agricultural research.

For food and agribusiness companies it depends on how they can manage this volatility of price and quantity. Volatility differs between agricultural commodities. Gilbert and Morgan (2010) concluded a lower volatility for grains and high volatility for fresh fruits. Grains are easier to store than fresh fruits. Storage of commodities can help as buffer in markets. These buffers mitigate the impact of supply shocks and reduce the volatility of the market.

In rich countries, most food is processed and a single commodity often has a small part in the total end-product value (Gilbert & Morgan, 2010; Carter et al., 2011). In some markets, producers and processors are able to pass on the costs to the consumer. One of the major reasons why stocks have been lowered is that there has been a shift from stockholding to 'just in time' delivery of raw materials in all industries. For food and agribusiness companies, this has led to minimal stocks at companies' sites (Zsidisin, 2005). However, stocks are seen as an important tool to cope with uncertainty in the market, for they provide a buffer in supply and demand peaks (Heyder et al., 2010). Food processors are also affected by the possibility of substitution of ingredients in their products. When one commodity price goes up, they are often able to substitute that particular commodity with another commodity (Carter et al., 2011; Trostle, 2008).

Many food and agribusiness companies can also choose to mitigate the price risk. It depends on the market if there are tools available (Gilbert & Morgan, 2010; Carter et al., 2011). Some markets operate only with spot market prices, while other markets allow companies to set future prices, negotiate contracts for delivery or even develop fully vertical integration to assure supply. Hedging the demand for a single commodity in a competing market can help to secure the supply in today's volatile and competitive markets (Buhl, 2011). According to Buhl (2011), only a few companies choose vertical backward integration to reduce the risk of volatile commodity prices; the majority prefer to use financial tools to mitigate the risk. Commodity future markets help to transfer the risk from hedgers to speculators (Gilbert & Morgan, 2010). Some researchers believe these speculators contribute to the increasing volatility in commodity prices. For the producers and consumers it should lead to more stable prices (Buhl, 2011; Carter et al. 2011). Heyder et al. (2010) concluded that choosing to use hedging as a tool to reduce the price risk of companies is strongly correlated with the turnover of the company. Larger companies are also more active in a larger number of countries, which increases their risk of foreign exchange currency. Those companies are also using hedging of foreign exchange. A commonly used instrument to reduce price risk is a long-term forward contract with suppliers and customers (Heyder et al., 2010).

2.2 Sources and drivers of supply risk

As we stated earlier, it is not only important to identify risks from the supply market but also to find the underlying sources and drivers of those direct risks. According to Loman (2009), sources are the potential or actual causes that create the risk. Drivers are the characteristics of the supply chain that lead to those risks. Risk drivers will increase the probability of occurrence. The definition of a risk drivers is best defined by International Risk Governance Council (2010): "Background characteristics, or trends, in the environment, science and society that act to either amplify or attenuate the scale, frequency or probability of risks arising from various sources." Five risk sources that affect the supply risk from supply markets have been identified in paragraph 2.1.1. In this paragraph the underlying sources and drivers of those direct risks for the agricultural supply market are discussed.

2.2.1 Global sourcing

A major force that affects the food supply chain is globalisation (Roth et al., 2008). Globalisation is one of the reasons that companies' sourcing strategy has become more important (Ahtonen & Virolainen, 2009; Heyder et al., 2010). In previous decades, the food market was much more localized with small and medium-sized companies that sourced their product from local small to medium-sized farms. According to Saltmarch and Wakeman (2004), this has led to relatively inefficient logistics. This is driven by growing competition in retail and the need for cost reduction, companies are increasingly importing goods at lower prices and exporting products to earn higher profits. The food supply chain moved from a regional to a global supply chain with large multinational companies that participate in all stages of the food supply chain. As local supply was no longer sufficient and prices were too high, companies have chosen to source globally (Christopher et al., 2011; Roth et al., 2008). According to Roth et al., (2008) "Extensive global sourcing of ingredients is certainly today's reality for food products" Importing and exporting have become natural steps in the product flow throughout the food supply chain, as shown in figure 2. Statistics also show that total export value of food products tripled between 1980 and 2007 (WTO, 2007).

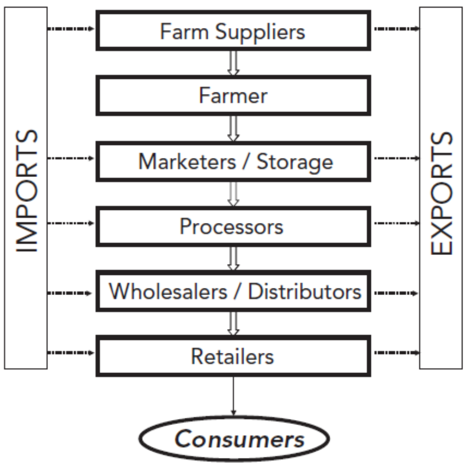

Figure 2 Generic model of food supply chain (one ingredient).
Source: Roth et al., 2008

The need to reduce costs by producing more efficiently has led to regional specialisation. With regional specialisation, producers can exploit economies of scale. Better circumstances for production and good infrastructure shift the supply chain to a competitive market with increased concentration (Jaffee et al., 2008; Carter et al., 2011). The difference in regional specialisation between two commodities is illustrated in Figure 3. The figure shows the concentration of palm oil production versus the concentration of beef production.

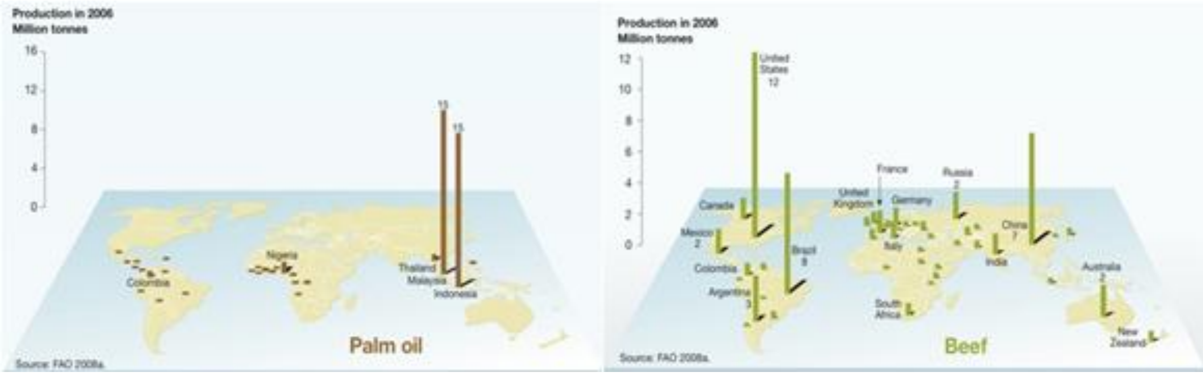

Figure 3 Major producers of palm oil and beef. Source: Rekacewicz et al. (2009)

With increased concentration of production and supply chain becoming longer, transportation methods have to be developed in order to supply the produced goods to the region where consumption takes place. Trade and therefore logistics are incorporated into all stages of the supply chain. Poor logistics and communication have become a major source of risk for the agricultural supply chain (Jaffee et al., 2008). Additional risk in trade is the risk occurring with logistics and infrastructure (Jaffee et al., 2008; Christopher et al., 2011). Harbours, airports and roads support easy transport at low costs. Transporting products over long distances makes inbound supply highly vulnerable to disruptions in the system.

As Headey (2008) and Gilbert & Morgan (2010) mention, the risk in trade includes the currency rate and the power of importers. Zsidisin (2003b) also denotes dynamic currency rates is an underlying source of risk in global sourcing. When a trade flow is concentrated, the trade is more vulnerable to currency rate fluctuation. In addition, if export is concentrated, it comes from only a few countries. When a commodity export and import is concentrated, it is more vulnerable to an event in that specific flow area. This can be trade barriers, fluctuating currency rates, terrorism, natural disasters, strikes, etc. (Carter et al., 2011; Zsidisin 2003b). Production and consumption that is local for local have a lower exposure to risk in global markets (Jaffee et al., 2008; FAO, 2009).

2.2.2 Number of qualified suppliers

To reduce the need of communication and knowledge of item characteristics, supply managers want highly standardized volumes of consistent quality for a low price (Roth et al., 2008). According to Jaffee et al. (2008), this has become the underlying objective in the supply chain. Because products are standardized, undifferentiated and in large quantities, they can be traded easily. This creates a spot market based only on price (Roth et al., 2008). These forces drive companies to global sourcing with organisations crossing political and geographic borders.

With growing trade, logistics has become important. Logistic services transport the product from producer to consumer. Transport over long distances is the reality in global sourcing (Roth et al., 2008; Jaffee et al., 2008; FAO, 2009). This causes the supply chain to get longer and more complex (Roth et al., 2008; Christopher & Peck, 2004). Many stakeholders are involved in trade: traders, transporters, financial services, etc. (Jaffee et al., 2008). In the agricultural commodity market, economies of scale affect the market. Shrinking profit margins and the pressure to reduce costs, Roth et al. (2008) argues, have led to a few large companies dominating the field. With fewer options in traders a company has less bargaining power and companies depend on only a few suppliers.

2.2.3 Market constraint

As mentioned earlier, agricultural products (commodities) are traded in large (standardized) quantities in a global market (Roth et al., 2008). With as result that companies and traders are competing in this market for the availability of commodities. The availability of commodities can be an important source of supply risk from the supply market (Zsidisin, 2003b). Many factors determine the price and availability of a commodity on the global and local market. These factors and risk are beyond the control of companies active in this market (Zisdisin & Wagner, 2010). As illustrated by Figure 4, domestic markets affect global markets and the other way around (FAO, 2009).

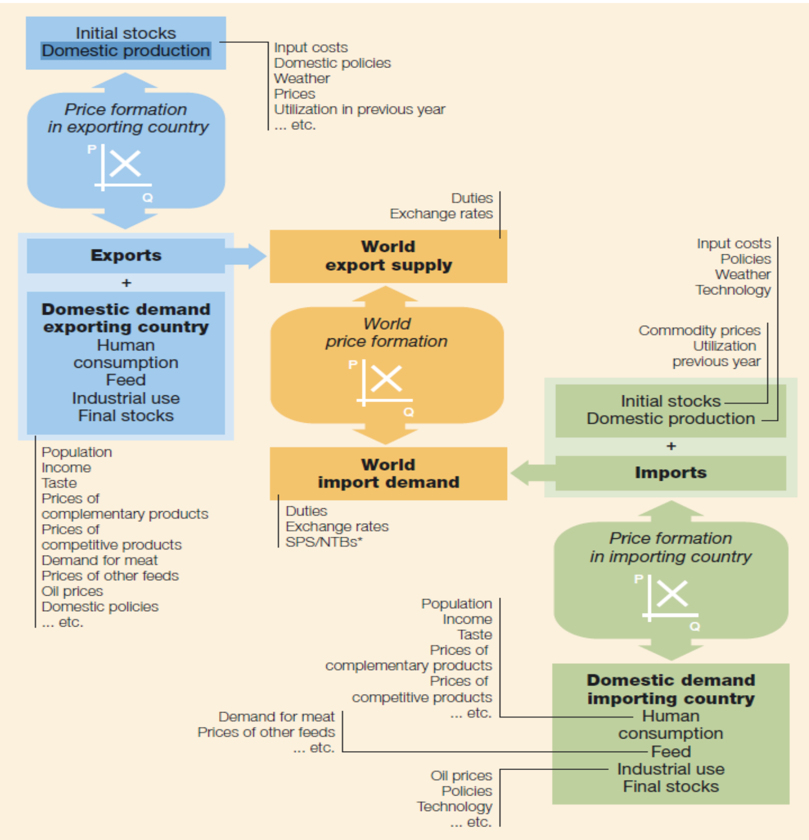

Figure 4 Factors affecting the commodity market.
Source: FAO (2009)

These domestic and global markets are becoming more dynamic and prices more volatile (FAO & OECD 2011). Volatility is the extent in which the price or quantity is variable (Gilbert & Morgan, 2010). The factors that affect the price and availability of agricultural supply market are divided into two categories, long-term factors and short term factors (Trostle, 2008). Gilbert and Morgan (2010) also make a distinction between predictable variability and unpredictable variability, whereas predictable variability is the trend and the unpredictable variability is characterized by shocks. Long-term factors cause significant structural change (trend) in supply and demand and therefore determine long-term price levels. For example, growing populations, higher welfare and biofuel from crops have increased demand. On the supply side, factors include the decreasing production growth, increasing costs for agriculture inputs and global climate change (Abbott et al., 2008; Trostle, 2008; OECD, 2008). Short-term factors create shocks in the market (Headey, 2011; Trostle, 2008). Carter et al. (2011) has analysed the sudden increase in food prices in 1973-1974 and in 2007- 2008 and states that at the core of a commodity boom lies a set of supply and demand shocks. How these shocks result in price volatility is best explained by Gilbert and Morgan (2010); "Shocks to production and consumption transmit in price variability" and "The extent in to which given production and consumption shocks translate into price volatility depends on the supply and demand elasticities" Gilbert and Morgan (2010) give four categories of factors that explain why prices are becoming more volatile and why this volatility will increase in future. The four categories are: an increase in the variance of demand shocks, an increase in the variance of supply shocks, a decline in the elasticity of demand and a decline in the elasticity of supply. Several factors have led to these changes in elasticity and variance.

For food and agribusiness companies this does not lead directly to a shortage in supply. The uncertainty of the market is one of the risks that affect the supply of commodities (Jaffee et al., 2008). The market is an important factor that influences producers and consumers. The supply and demand balance determines prices. Both high and low prices influence agricultural commodity supply. The availability of commodities depends on the responsiveness of producers and consumers to these prices (Gilbert & Morgan, 2010). Prices and the responsiveness of farmers adjusting to markets determine the level of production (Gilbert & Morgan, 2010; Jaffee et al., 2008; Mamingi, 1996). Changes in market demand for quantity and quality can also result in lower or higher prices. Facing low prices, farmers will have less incentive to produce and they will change their production. They adjust production to optimal profit levels. Farmer can choose what to produce in a limited geographic area. Currently, the total area of agricultural land is growing only very slightly compared to agricultural product demand (Trostle, 2008). Therefore, within this limited area, crops are substitutes in production. When a crop is easier to substitute is it also easier to adjust to the market conditions. When prices of one commodity go up, leading to more production, in the season after this there will be lower production of the crop substituted (Menezes & Piketty, 2011; Carter et al., 2011; Mamingi, 1996). For supply and demand, elasticities are low for most commodities, creating large price responses (Carter et al., 2011). Generally, in the area where farmers produce one crop, no other crop can be produced. When the price of commodities fluctuates and stocks are low, there is often even bigger price volatility (Abbott et al., 2011). However, when investments in production assets are high, there are lower incentives to increase production. Setting up a plantation or farm requires large investments before production is possible. This reduces the ability to adapt to the market conditions. With stable and more constant supply, prices will be less volatile. However, availability is lower when demand increases suddenly. A reduced ability to adjust to market condition can result in structural shortage (Jaffee et al., 2008).

The supply and demand at the supply market is affected by other markets. The supply of agricultural commodities also depends on the costs of inputs, such as the prices of energy and minerals (Trostle, 2008). According to Jaffee et al. (2008), market prices of inputs are also a critical factor. If costs go up and prices of output drop, they may decide to shift to the production of other commodities. There are some slowly evolving trends like decreasing production growth of agricultural products and a strengthening demand (Trostle, 2008). In the literature, the main reason for the decreasing production growth is the lower investments in agriculture. Because prices were low in the 1980s and 1990s less money was invested in R&D and assets (Abbott et al., 2009; Trostle, 2008). Moreover, costs for inputs, especially oil prices, have gone up while prices of output did not increase (Piesse & Thirtle , 2009; Abbott et al., 2008; Trostle, 2008; Carter et al., 2011). Where supply could no longer meet demand, stocks declined (Trostle, 2008).

The demand for commodities is growing for several reasons. Higher levels of welfare in developing countries lead to a diet that includes more animal protein. For meat production, commodities such as grains and soybeans are needed for feeding livestock. This is a less efficient use of the grain than directly processing it for human food; therefore, this leads to even higher demand for grains and soybeans (Trostle, 2008). This change in diet is mainly occurring in Asian countries, and in these countries grains and soybeans make up only a small amount of total food production. This ultimately leads to higher imports for those products.

The use of biofuel is one of the most important factors that increased demand. Oil prices have risen and, together with policies stimulating the production of biofuel, the demand for crops as a biofuel source have increased over the last decade (Trostle, 2008). Biofuel production will continue to increase the demand for commodities. Production of biofuel is driven by policies in the United States and the European Union. With prices of crude oil rising, the high demand for biofuel will continue and government policies will have a smaller influence on this high demand. Because of decreasing growth of production and increasing demand, the market balance is becoming precarious. As shown in Figure 5, stocks have been decreasing over the last decade (Carter et al., 2011; Abbott et al., 2008).

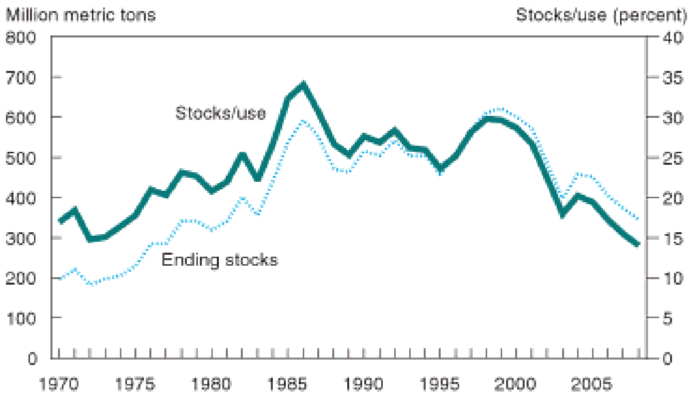

Figure 5 Total world grain & oilseeds stock to use ratio.
Source: Trostle, 2008

Many experts see stocks as an important tool that can be used to eliminate price shocks for suppliers and demanders (Gilbert & Morgan, 2010; Carter et al., 2011). A stable price leads to a very stable market. With stocks depleting in the first decennia of this millennium, the shocks became heavier. In the past, producers could easily bring those stocks back up to previous levels by increasing production. This increase in production came primarily by increasing agricultural area. However, agricultural area is growing very slowly nowadays. The world's agricultural area is limited while demand is growing. Because of lower supply and increasing demand, stocks will remain at low levels (Trostle, 2008; Piesse & Thirtle , 2009).

2.2.4 Market price increase

The prices of agricultural commodities rised in 2007-2008 to higher levels than ever before. Many researchers have tried to explain the sudden increase in commodity prices (Heyder et al., 2010). They give several reasons for the sudden market fluctuations: weather influencing agricultural production, political interference with trade, and the financial crisis leading to distortion in the already thin market balance (Headey, 2011; Carter et al., 2011; Gilbert & Morgan, 2010). The literature often mentions speculation on the futures market as a possible cause of the food crisis in 2007-2008 (Gilbert & Morgan, 2010; Abbot et al., 2008; Mitchell, 2008). Unfortunately, researchers have not come to a consensus about how this has affected the commodity market or will affect it in the future (Headey, 2011).

Major cause of the food crises of 2007- 2008 was the low harvest in some specific regions due to bad weather. This led to production shocks and sudden increase in prices. As reaction on the higher prices export bans and higher import tariffs were set. All of these unexpected events had a big impact on the commodity market. The trend towards more regional production and specialization, because this leads to efficient production, has also negative impacts to the supply market. Although concentration of production leads to efficient production, it will also increase volatility due to the increasing impact of local weather on the commodity markets (Carter et al., 2011; Jaffee et al., 2008). According to Jaffee et al. (2008), weather fluctuations can result in changing crop yields over the years. Weather is an important factor that affects the supply of a commodity, it can result in large production shocks (Gilbert & Morgan, 2010; Trostle, 2008). Many researchers see global warming as a factor that affects future production variability.

The effects of weather and natural disasters can be very diverse. It can also affect the quality of crops and their harvest. The type of crop and the circumstances in which it is produced determine how big the impact of weather is on yield. In some regions, crops are produced using irrigation and some crops are produced in greenhouses. If production takes place in a concentrated area, weather in that specific area has a larger impact to global production. Fluctuations in production will affect the market balance (Gilbert & Morgan, 2010; Carter et al., 2011). Depending on the concentration of production and share in total world production, weather can result in large price fluctuations in both the domestic and the global market price (FAO, 2009). In a market where supply and demand is well balanced, with low stocks, a production shock due to bad weather will result low product availability. With low availability price will increase (Jaffee et al., 2008).

The same holds for natural disasters. When hurricanes, cyclones and other types of extreme weather occur in a specific region, they can have a large impact on supply. A disaster can result in large supply losses or destroy a complete harvest. If a disaster destroys assets like farm housings, crop plantations and related infrastructures, this results in supply losses for multiple years. Longer term supply losses can change market relations. If a producer is unable to deliver, partners and customers will have to search for other sources of supply and this creates additional costs for alternative sourcing (Jaffee et al., 2008). Pest, diseases, contamination, food safety and degradation of natural resources and production are risks that affect supply chain product flows (Jaffee et al., 2008). According to Jaffee et al. (2008), this can result in production losses, loss of quality and decrease future productivity. The impact for food companies can be lower availability of products, bad quality of product, high prices, low product safety and brand reputation damage.

The increase in prices in 2007-2008 was seen by many as a food crisis, but this was not the first crisis to occur. Carter et al. (2011) has analyzed the most recent food crisis and the food crisis that arose in 1973-1974 and he has found some key factors that caused both food crises. There is little doubt that the last food crisis is very different from the crisis of 1973-1974. In the past, periods of high food price volatility were very short (Gilbert & Morgan, 2010). Nevertheless, all the factors and conditions (strong demand growth, low stocks, financial crisis and instable political climate) that led to the crisis in 2007 are still present nowadays (Carter et al. 2011). This would suggest that a new food crisis could easily happen again and that the current markets are changing. Company managers perceive increased market volatility and think that this will be normal in the future (Heyder et al., 2010).

2.2.5 Geopolitical climate

The political and institutional environment influences the total food supply chain (Jaffee et al., 2008). Political involvement can be found everywhere. Political and institutional risks occur at every step in the food supply chain. It influences production, market and trade (Trostle, 2008; Yu. Hsiang et al., 2011; Carter et al., 2008; Headey, 2011). The macroeconomic environment is one major source of uncertainty in the current agricultural markets. Policies create the landscape for decision-making and incentives (Jaffee et al., 2008).

At the production (farmer) level, institutional policies can influence agricultural production (Trostle, 2008; Yu et al., 2011; Abbott et al., 2008). Credit services and subsidies affect farmer's income and production. Uncertainty and low subsidies, high taxes, etc. result in lower incentives for farmers to scale up production (Mamingi, 1996). With high subsidies or unequal distribution of subsidies, farmers are more likely to change to the production with the highest profitability (Jaffee et al., 2008). Supply of a commodity is affected by other markets. This is today's reality with respect to biofuel policies which increased the demand on other markets (Trostle, 2008; Abbott et al., 2011). Moreover, diets consist of more animal protein. The economic development and GDP growth result in more demand for food and input for animal production (Trostle, 2008). This is what is happening in China (Abbott et al., 2011). China has become a large player on the commodity market and it is affecting prices (Headey, 2011). In the macroeconomic environment the responses of policies to shocks, such as setting export restrictions, creates even bigger shocks (Carter et al., 2011; Trostle, 2008). Headey (2011) explores this further and hypothesises that policies like export restrictions and import surges have a larger impact in food crises than other factors like speculation, futures markets, currency rates and especially the dollar currency rate.

The currency exchange rate, and specifically the dollar devaluation, had a role in the most recent food crisis. The currency exchange rates can affect the purchasing power and price incentives globally without affecting the total supply and demand balance (Gilbert & Morgan, 2010; Mamingi, 1996). Most trade is done in terms of dollars. The exchange rate of the dollar will therefore determine prices. With fluctuating exchange rates, commodity prices will also fluctuate (Gilbert & Morgan, 2010; Carter et al., 2011; FAO, 2009). It depends on the concentration production area concentration of consumption. If export or import flows are concentrated, the exchange rate of a few currencies can result in higher price volatility than when trade export and import streams are diffused.

Headey (2011), analyses the role of trade shocks in the global food crisis. Therefore, the rice market, grain market and soybean market were the cases. He observed that the concentration of imports could affect the market, for example, many of the larger rice importing countries or companies can affect prices. At the stage of trade, political and institutional risks occur when commodities are exported or imported. Trade policies are one large factor affecting the global commodity market (FAO, 2008; Carter et al., 2011). Trade tariffs affect prices and changes in trade (Yu. Hsiang et al., 2011). This was the case with the food crises in 2007 - 2008 . Politics became involved in the trade of commodities to support local markets (Headey, 2011; FAO, 2008). With trade barriers, companies have to look for other sources of supply and this can result in changes in market relations and structures (Jaffee et al., 2008). In the macroeconomic environment, product flows are affected by monetary policies. With different currency rates, trade and different costs affect prices globally (Mamingi, 1996; Abbott et al., 2011; Menezes & Piketty, 2011). With trade at the import side, political involvement has also been a risk to the commodity market. As discussed earlier in this chapter, other researchers conclude that this involvement can be an important risk factor in the market dynamics. Headey (2011) provided evidence that the macroeconomic environment in terms of policies regarding trade barriers and export restriction did play a significant role in market dynamics.

2.3 Overview of identified risks

The literature review provides a better understanding of the dynamics in the current commodity market. It is obvious that many factors play a role and determine the conditions of the market. Unfortunately, we cannot determine exactly how those factors are connected and how large the effect is in terms of price and availability. Based on the literature, it is clear that several factors affect the commodity market. Table 2 summarizes the identified sources and drivers. These are categorized in the five risks sources as described by Zsidisin.

Table 2 Overview of risk sources and underlying drivers for agricultural supply market.

Author (source)	Risk driver	Impact on the agricultural commodity market
Global sourcing (dynamic currency rates and natural disasters region)		
Roth et al, 2008	Global sourcing in order to reduce cost and increase efficiency.	Higher vulnerability to disruptions
Caret et al., 2011	Regional specialisation and concentration of production increases trade. Increased trade makes inbound supply highly vulnerable for supply disruption.	Supply disruptions and currency rates affect prices
Jaffee et al., 2008	Growing distance between production and demand results in increase trade.	Market power, currency risks and supply disruptions.
Number of qualified suppliers (Few supplier/ high market power)		
Roth et al. 2008	Decreasing margins pressure to increase profits and commoditization of markets resulted in large companies that compete on price.	Increased market power.
Market capacity constraint (constrained market)		
Headey, 2011	Population growth, change in diets and biofuel use increases demand. At the same time declining yield growth, due to lower R&D investments and political instability.	Declining stocks and imbalance market growth.
Jaffee et al., 2008	Biofuel policies and cost of input changes production incentives. Lower ability to adjust to market condition and substitution of production.	Market balance becomes tighter.
Carter et al. 2011	Negative production shocks result in lower stocks. Decrease of elasticities, ability to adjust to prices.	Lower market availability.
Market price increase (unstable price)		
Headey, 2011	Concentrated production area's makes production vulnerable to extreme weather. Extreme drought leading to yield losses.	Production shocks and shortage
Carter et al., 2011;	Increased impact of local weather due to regional specialisation in production results in production shocks.	Increase of price volatility
Jaffee et al., 2008	Regional specialisation and climate changes result in yield fluctuation and losses due to weather or natural disasters.	Losses in production and losses in production assets
Gilbert & Morgan 2010	Lower supply elasticities due to lower ability of farmer to respond to prices. Weather causes variation in yield. Policies and demand shocks.	Price volatility
Geopolitical climate		
Jaffee et al., 2008)	Institutional environment changes production incentives and trade at markets.	Trade barriers, shifting trade patterns and supply disruptions
Headey, 2011	Extensive stockholding by countries, export restrictions and import tariffs as reaction to domestic food price inflation.	Higher prices, trade shocks and supply disruptions.

2.4 Supply risk assessment techniques

After the sources of risks are identified along with their drivers, these risks have to be measured. Measuring the risk part of the overall process of risk management. According to Loman (2009), there are two different ways to do this: quantitative analysis and qualitative analysis. Qualitative data is applied when statistical data is not available or when risk measurement is more describing the nature of risk. Quantitative risk measurement enables one to compare and rank the risks (Loman, 2009). In order to measure the risk a selection of criteria/ indicators is necessary. There is unfortunately little literature available that deals with supply risk from markets. Studies on supply risk of suppliers are broadly available however only a few deal with supply risk that is comparable to this research. A study of Rosenau-Tornow (2009) does give some inside in a quantitative supply risk model. The research has been concentrating on the supply risk of mineral raw materials. However, comparable sources and drives of risk are incorporated in the model.

2.4.1 Concentration index

In the studies of Rosenau-Tornow (2009) and Sivaramkrishnan (2011) the concentration of production is measured. Regionalisation/ concentration of production has been identified as an important driver of risk in the agricultural supply market. To measure the concentration of supply the Herfindahl-Hirschmann Index (HHI) method is applied. According to Stepanek et al., 2012 the Herfindahl-Hirschmann Index is a broadly accepted indicator for assessing supply risk. The HHI was originally used to measure the concentration of firms in order to define their market power (Gardebroek & Peerlings, 2011). When suppliers have a high market power, there is less bargaining power for the company sourcing their ingredient. In addition, high dependency can result in a supply risk if an event reduces a supplier's ability to deliver the product (Zsidisin, 2003; Jaffee et al., 2008).

As the data is often not available for small players, the concentration index is adjusted and only includes the top 5 or top 10 shares. The concentration index is the sum of all countries/ companies squared percentage share of size dimension (production, turnover, profits). The result is a score ranging between 0 and 10,000. The score of 10.000 is the highest possible concentration with one country having a 100% share in production (100^2= 10.000). Rosenau-Tornow (2009) and Sivaramkrishnan (2011) defined a score from 0-1000 as low risk, 1000-2000 medium risk and above 2000 as high risk in concentration and market power.

2.4.2 Market balance

As Zsidisin (2003) has argued, market capacity is an important source of risk. With a low capacity of the market, availability of resources will be limited when demand suddenly increases. In the study of Rosenau-Tornow (2009), the market balance and expected market developments are incorporated into the supply risk model. The market balance is the difference between demand and production. Current stocks are also included in the market balance. In agricultural research, stocks are mainly indicated by the stocks to usage ratio in percentage (Rabobank, 2011; Trostle, 2008; FAO, 2009). For future market development, Rosenau-Tornow (2009) uses investment and market capacity as an indicator. Argued is that with high investment, mining companies are less likely to explore new mines. In addition, the market of raw material is different from that of minerals. Companies that explore mines and produce the specific raw material cannot shift easily to other products. Capacity is constrained by the available materials. The agricultural supply market in constrained by the available global agriculture area. As discussed earlier, the response of companies, or in this case farmers, determines the market balance.

To measure the supply response of farmers on prices the indicator supply elasticity is mainly used. Supply elasticity is the response of farmers' production when prices increase or decrease. According to Gilbert & Morgan (2010) and Magingi (1996), supply elasticity in agriculture can be short or long. It depends on the ability of farmers to adjust to prices. A farmer cannot harvest more than he has planted. Therefore, supply elasticity is low in the short term. Dairy and meat producers, however, can slaughter animals earlier or increase milk production, which means their short-term supply response can be higher. Otherwise, the long-term supply elasticities of animal products are low. They have to build new farm housing and breed animals. This is also true for tree farming; planting trees and production takes a long time. Long-term supply elasticity for grains and soy are high because additional investments are low. Farmer can easily decide to plant the crop with the highest profit margin (Mamingi, 1996; Rabobank, 2011; Gilbert & Morgan, 2010). Rosenau-Tornow (2009) also recognizes supply elasticity as an indicator. However his attempt to include this in the assessment failed due a lack of data. Also, in agricultural research supply elasticities are not available for most agricultural products. Research in this field concentrates mostly on supply or demand elasticity of a specific commodity for a specific country or area, not for global production responses.

2.4.3 Geopolitical climate

Rosenau-Tornow (2009) and Sivaramkrishnan (2011) used country risk in the quantitative supply risk model. The researchers multiplied the country risk score of each specific country with the share in total production and summed up the outcomes. They did this for the top 10 countries. According to these studies, country risk is an indicator of the likelihood and probability of occurrence in which political instability leads to disruption in supply. Political instability could also lead to fewer incentives for producers to invest in additional production capacity.

How do politics react to markets developments? It has been shown, for example, that biofuel policies affect markets. However, it is difficult to say whether politics would affect the supply risk. According to the literature, food price inflation is the biggest driver for politics to interfere in the market. However, it is shown that in those cases the interference of politics was a reaction on the already instable market.

3 Materials and methods

In the previous chapter, the risks that affect the agricultural supply markets were identified. Measuring the risk is the second step. By measuring the supply risk of different commodities, we are able to say whether a commodity will have a higher or lower supply risk. This chapter describes how risks in the global supply market are measured. First, there is an explanation of what commodities are included in the analysis. Secondly, indicators are selected, and how these are quantified and which data sources are used is discussed. The last step of the supply risk assessment is ranking the commodities. In addition, a profit impact evaluation is conducted with market analysts in order to calculate the risk value of a commodity.

3.1 Selection of commodities

3.1.1 Selection process

For the supply risk assessment, 40 commodities have been selected. These commodities are selected from the list of commodities extracted from the FAO agriculture statistics database. The list is extracted from the commodity balance sheet under the heading food balance sheets. This list from the FAO includes 110 crop primary commodities and 40 livestock and fish primary commodities. Those 150 commodities are presented in standardized forms. There are actually over 600 commodities that are traded globally. These 600 commodities are categorized in one of these 150 standardized commodity groups. The aim of this standardization is to show the data in a less detailed form. According to the FAO, "The selected commodities include the equivalents of their derived products falling in the same commodity group, but exclude the equivalents of by-products and derived commodities, which through processing, change their nature and become part of different commodity groups" (FAO, 2012). To clarify, when cocoa powder is produced from cocoa beans it belongs to the standardized commodity group of cocoa beans. However, when soybeans are processed and oil and meal is produced, the product has changed in its nature and therefore belongs to a different commodity group. From this extracted list of 150 commodities, 40 commodities have been selected that are included in the supply risk assessment. This selection is done in consultation with market analysts. These market analysts selected the most important commodities based on production quantity, export quantity and production value. Commodities that are produced in large quantities have been selected along with commodities that are extensively traded. In addition, important commodities (value) in the food supply chain are included this assessment. This selection found place in February 2012. The list of 150 commodities is divided in multiple categories accordance the commodity domains of the market analyst as shown in appendix B.

3.1.2 Commodity list

The list of 40 commodities is presented in table 3.

Table 3 List of commodities and global production and global export quantity in 2007. Source: FAO statistical database production and trade sheets.

item	Production (tonnes x1000)	Export Quantity (tonnes x 1000)
Apples	66,159	15,157
1 Apples		
2 Apple juice, single strength		
3 Apple juice, concentrated		
4 Bananas	87,616	18,951
5 Barley	132,328	33,292
6 Cocoa Beans	4,098	7,020
7 Coffee	7,747	8,613
8 Cotton Lint	24,970	8,665
9 Grapes	65,539	8,706
10 Maize	787,341	113,464
11 Olive Oil	2,982	1,529
12 Olives	16,750	767
13 Onions	69,740	6,141
Oranges, Mandarins	93,288	31,372
14 Oranges		
15 Orange juice, single strength		
16 Orange juice, concentrated		
17 Palm Oil	38,386	32,023
18 Potatoes	322,602	23,707
19 Rape and Mustard Cake	26,014	7,004
20 Rape and Mustard Oil	18,013	5,210
21 Rape and Mustard seed	51,754	12,210
22 Rice (Milled Equivalent)	437,498	34,368
23 Soybean Cake	157,969	61,357
24 Soybean Oil	37,038	13,001
25 Soybeans	219,578	75,350
26 Sunflower seed	26,115	3,068
27 Sunflower seed Cake	12,552	4,067
28 Sunflower seed Oil	11,424	5,216
29 Tea	4,711	2,094
30 Tomatoes	133,501	17,472
31 Wheat	604,464	167,091
32 Pulses	59,343	10,644
33 Sugar	196,596	65,410
34 Bovine Meat	64,736	10,438
35 Butter, ghee *(butter of cow milk)*	8,819	1,509
36 Cheese *(cheese of cow milk)*	19,252	4,774
37 Eggs	63,991	1,918
38 Milk, Whole *(cow milk fresh)*	675,564	29,258
39 Pig meat	99,878	12,028
40 Poultry Meat	85,326	12,119

The definition or composition of the specific commodity group can be found in appendix A. As stated earlier, the commodity group includes derived products. In the selection, some derived products are also included. This is because these products are of importance and value for the food supply chain. The commodity group 'apples' is split up into (1) apples, (2) apple juice single strength and (3) apple juice concentrated. The same holds for the commodity group 'oranges' (14, 15 and 16). The USDA statistical database does also make this split up. The reason for this split up is that juices, concentrated and single strength, are important commodities for companies, according to market analysts. In addition, FAO notes that the largest volume of apples and oranges is processed into juice. Moreover, for these commodities, export share of production is much larger than for apples or oranges and markets differ. For example, the export share of production for oranges is 10.68%, orange juice single strength 99.07% and concentrated orange juice 73.07% (calculated from FAO statistics).

Maize, milk and wheat are the largest commodities in production quantity. Olive oil, cocoa beans and tea are small commodities based on production quantity. However, for example, the value of production is for cocoa beans is more than seven times the value of wheat per tonnes ($1038 for cocoa beans and $140 for wheat in 2010) (FAO, 2012). In addition, the export share of production differs between commodities. Although maize, milk and wheat are large in production, the export quantity in percentage of production is low. Cocoa beans and coffee are heavily traded with relative high export quantity. Mainly because these products are shipped and imported by a country and then again exported with truckloads.

3.2 Selection of relevant risk sources and indicators

The selection of risk sources is done by identifying relevant sources in the literature. The overview of relevant risk sources that affect supply risk is described in paragraph 2.2, sources and drivers of supply risk. The risk sources are selected because they affect product flow and therefore could lead to supply risk from the supply market. Supply risk is defined as the inability of the supply market to meet customers’ demand in price and quantity. In this research, the risks at the agricultural market are defined as follows:

Risks:	***Definition:***
1. Global sourcing:	The risk that occurs with the trade of agricultural products from production to consumer. As trade markets become larger, they are more vulnerable to currency rate fluctuation, logistical breakdown and supply disruptions.
2. Number of qualified suppliers:	With increased globalisation, companies and traders have become large multinational companies. When commodities are traded in large standardized quantities competition is based on price. With less option to purchase and less bargaining power, companies face increased supply risk.
3. Market constraint:	The constraint is the limited world agricultural area. With limited agricultural area, the total production quantity is limited. Risks that occur in other markets and affect

	production and demand. These are the risks from farming input markets, oil price markets and other markets that affect farmers' production decisions.
4. Market price increase:	Risks that affect global production due to weather, natural disasters and biological risks. These risks lead to shocks in yield, which results in a lower or higher availability and price at the supply market.
5. Geopolitical climate:	Risk that occurs due to the institutional environment. This involves political instability in a country's rules and policy that affect production, markets and trade. Governments, politics and institutions create uncertainty in the supply market.

In order to measure these risks, indicators have to be selected. The next section explains what sources and drivers of risk are incorporated into the supply risk assessment. Indicators are selected that measure these risks. These indicators are selected based on relevance (the indicators measures a source of risk) and measurability (it is possible to measure the source or driver of risk with available data).

Risk factor 1. Global Sourcing

The identified factor that drives this risk is regional specialization. Regional specialization makes production vulnerable for risk occurring in that specific area. Thus, it is assumed that when production takes place in a concentrated area it will be more vulnerable to any weather circumstances, biological risks and natural disasters that may occur. Concentrated production also increases trade and makes inbound supply vulnerable for supply disruptions. In order to measure concentration, the second indicator belonging to this risk factor is selected. This indicator is *concentration of global production areas*. It measures the global concentration of production.

Risk factor 2. Number of qualified suppliers

The second indicator selected is *market power*. Trade involves companies shipping their products from the one actor to the next actor in the supply chain. Companies that source their product from the supply market depend on these traders or do it themselves. When companies depend on these traders, they have to bargain for a good price. If the traders' market power is high, the companies have few alternative options to purchase. This results in less bargaining power for the companies, who depend only on a few traders. This increases the risk in supply.

Risk factor 2. Market constraint

As been discussed in chapter 2 the market as constraint to supply is in the agriculture market different from other markets. The price and availability of a commodity is closely linked and depends on the ability of farmers to respond to prices. Production and demand cannot be determined within one year. Only trends in production and demand can be observed. The third indicator selected is *market balance*. The FAO publishes data of domestic supply in the commodity balance sheet. Domestic supply is the quantity of a commodity available for domestic use. Domestic supply is used for consumption, processing, animal feed and other purposes. It is assumed that domestic supply derives from domestic demand. With growing or declining demand, domestic supply will also grow or decline over time, due to increasing production or imports. In order to measure how balanced the future market is, the difference between global growth rate of domestic supply and global growth rate of production is calculated. The growth rate of production and domestic supply is calculated between time period 1997 and 2007. If domestic supply grows faster than production, this will result in higher supply risk.

Risk factor 4. Market price increase

The risk identified at the supply market is price volatility. However all prices for all commodities over the years are not available. Fluctuation of production in the supply market can result in price volatility (due to changing market balance) and, in the worst-case scenario, shortage of products (loss of harvest and infrastructure for a longer time). It also depends on many other factors within the supply chain how prices are determined, for example stocks can buffer fluctuation in production. The sources identified at the farmer's level that create this fluctuation in production are weather risks, biological risks and natural disasters. As described in the literature, the main source for fluctuating production is weather. This leads to fluctuation in production. Due to variation in yield over the years. The indicator selected from this source of risk is *yield variability.* This indicator measures the variance in yield over the years. The extent to which yield fluctuates is an indication of the extent to which the commodity is vulnerable to the identified risks and result in price volatility.

Risk factor 5. Geopolitical climate

The literature describes how the geopolitical climate affects production, markets and trade. The geopolitical climate has an impact on productivity, affects decision-making and creates incentives for actors in the supply chain. These impacts affect the supply market. Biofuel policies and subsidies created additional demand. Productivity is influenced by subsidies for farmers, investments in research, infrastructure and financial services for farmers. Trade is affected by policies in export and changing or uncertain monetary situations. It would be rather difficult to estimate how these risks affect a single commodity market. In other studies, country risk is included in the assessment. In this study, attention is given to the country risk of the producing countries, the *country risk of producing countries* is selected as an indicator.

Thus, the indicators selected measure the sources and drivers of risk at the supply market for the selected commodities. This explains why these indicators are selected and what assumptions were made. An overview of the risk factors and indicators is presented in table 4.

Table 4 Overview of indicators and perceived risk.

Indicator	Perceived value of risk	Explanation
1. Concentration of production	Low is better	Low concentration of production area makes global production less vulnerable to disasters and other risk events in the production area that result in supply disruptions
2. Market power	Low is better	With more options to purchase, companies have more bargaining power.
3. Market balance	low is better	The difference between production and domestic supply is an indication of the market balance and underlying factors that influence production and domestic supply.
4. Yield variability	Low is better	If variability in yield is low, this will result in lower production shocks and in more stable prices.
5. Country risk	Low is better	If production takes places in countries with high political risk, this could lead to distortion in production, market and trade due to changing policies and institutional environment.

3.3 Quantification of indicators

3.3.1 Indicator 1. Concentration of production

The concentration of production is calculated by applying the general formula for the Herfindahl index. The FAO statistical database defines 21 geographic areas. These areas are: Eastern Africa, Middle Africa, Northern Africa, Southern Africa, Western Africa, Northern America, Central America, Caribbean, South America, Central Asia, Eastern Asia, Southern Asia, South-Eastern Asia, Western Asia, Eastern Europe, Northern Europe, Southern Europe, Western Europe, Australia and New Zealand, Melanesia, Micronesia and Polynesia. For all these areas, the production quantity of all selected commodities is extracted from the FAO database. The function is as follows:

$$H= \sum_{n=1}^{N} \left(\frac{Qn}{\sum_{n=1}^{N} Qn}\right)^2 \quad 1/n < H =< 1$$

(Source: Gardebroek & Peerlings, 2011)

H: Herfindahl index (concentration), Q_n: size dimension (production quantity), N: total number of areas (1,2,...,22) areas.

3.3.2 Indicator 2. Market power

In order to measure market power, qualitative data is transformed into quantitative data for these indicators. Market analysts are asked (in a personal interview with the researcher) to score the summed market share of the top 5 companies in each commodity market. These interviews took place at the Rabobank International research department in May 2012. The market analysts and their domain/ sector are presented in appendix B. The market analysts had to judge to which category the market share of top 5 companies is closest to. Categories included: (0%), (20%), (40%), (60%), (80%), and (100%).

3.3.3 Indicator 3. Market balance

For both global production and global domestic supply, the values are gathered from the FAO database for the time period 1997-2007. FAO gives totals for both global production and global domestic supply. Both production and domestic supply are aggregated numbers from all countries. Based on these numbers, a linear trend line is calculated using Excel. A linear trend line eliminates the possibility of extreme numbers between years.

Trend: Production trend line $P_t = b_0 + b_1*t$; for all commodities

Domestic supply trend line $S_t = b_0 + b_1*t$; for all commodities

P_t and S_t are expected global production and global domestic supply in year *t* and

b_0 and b_1 are the regression coefficient;

t0 is the year 1995 and t14 is 2009.

The growth percentages of these linear trend lines are calculated using the following formula:

$((P_{10}- P_0) / P_0)*100\% = G_{Pt}$ and $((S_{10}- S_0) / S_0)*100\% = G_{St}$

$G_{Pt} =$ percentage of production growth between 1995 and 2009, and $G_{St} =$ percentage of domestic supply growth in same time period. The growth percentage could be positive or negative growth.

The indicators' value is the difference between the percentage growth per year between global production and global domestic supply. Formula: $G_{St} – G_{Pt}$

3.3.4 Indicator 4. Yield variability

The fluctuation of production is the variance of yield over the years. As explained earlier, this indicator measures the extent to which the production of a commodity vulnerable to risks (natural climatic conditions, extreme weather and biological risk) that result in both positive or negative production shocks at the market that increase price volatility. Yield variability per commodity is measured by calculating the standard deviation of the residual from the linear trend relative to the average yield over the time period 2000 to 2010.

Trend: $Y_t = b_0 + b_1*t$; for all commodities

Y_t is the expected global average yield in year *t,* and b_0 and b_1 are the regression coefficient;

b_0 and b_1 are the regression coefficient.

t0 is the year 2000 and t10 is 2010.

Relative standard deviation: $$\frac{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(\mathrm{Yt}-\mathrm{Yact})^2}}{\bar{y}}$$

Y_{act} is the actual production in year *t,* Y_t is the expected global yield in year *t,* and $\bar{y}$ the average yield between 2000 and 2010

3.3.5 Indicator 5. Country risk

Political risk is assessed by using the country risk scores. For the top 5 producers in the world the country risk score is multiplied with country percentages share in global production. The sum of these 5 numbers is the outcome score for political risk. The country risk is based on the following indicators: voice and accountability, political stability and absence of violence, government effectiveness, regulatory quality, rule of law and control of corruption (PRS group, 2010). The countries' risk were defined by scores ranging from 0.00 (high risk country) to 1.00 (low risk country). These scores are transformed to a scale ranging from 1.00 (high risk) to 0.00 (low risk) in order to represent low risks with low values.

Thus, country risk value for this indicator is: $S_1xR_1 + S_2 \text{ x } R_2 + S_3xR_3 + S_4xR_4 + S_5xR_5$.

S_1-S_5 are the percentage shares of the countries' production in global production.

R_1-R_5 are the country risk scores from the PRS group for the specific country.

3.4 Data

The main data source is the FAO statistics database. Some additional data are extracted from the USDA statistical database. Both organisations have developed a large agricultural statistic database with respect to the agricultural commodity market. The country risk data is from the PRS group. PRS group is an institute that focuses on country risk analysis. Table 5 shows which indicators and data sources are used. For the FAO database, the exact pathway is mentioned.

Table 5 Selected indicators with source of input.

Indicator	Unit	Source/ database
1. Concentration of production	Production data per area	FAO production statistics ➢ Crops → production quantity stat (2010) per area ➢ Crops processed → production quantity stat (2010) per area ➢ Livestock primary → production quantity stat (2010) per area ➢ Livestock processed → production quantity stat (2010) per area
2. Market power	Market share of top 5 companies	Market analyst (2012), eight people working on Rabobank Food and Agribusiness research department (see appendix B)

3. Market balance	Global production data Global domestic supply	FAO food balance sheet stat → commodity balance ➢ Crops primary equivalent → world global production & domestic supply (1997-2007) ➢ Livestock and fish primary equivalent → world global production & domestic supply (1997-2007)
4.Yield variability	Yield per hectare	FAO production statistics → Crops, yield stat. (2000-2010) FAO production statistics → Livestock primary, yield stat. (2000-2010)
5. Country risk index	Country risk index per country Production per country	Political risk service (PRS) (2010) FAO production stat → production quantity for crops, processed crops, livestock primary and livestock processed (2010)

3.5 Ranking the commodities on supply risk

In order to aggregate different values in one value normalisation is necessary. This is also applied when making multi-criteria decision. This normalization process is based on the study of Diaz-Balteiro and Romero (2004), which ranked forest management systems on sustainability. In this current study, multiple indicators with different values are also included in the assessment. By applying the MCDM method, indicators can be aggregated by normalizing the calculated values of the indicators.

3.5.1 Normalizing indicators

After collecting all the data for the selected indicators, all the values are normalized. Different indicators' values are transformed to the same scale. This scale ranges from 0.00 to 1.00. The normalized values for each indicator are the inputs for measuring the risk factors' scores. Before normalizing the values, the ideal (value where perceived risk is lowest) and anti-ideal values (value where perceived risk is high) have been determined for every indicator. In the list of commodity values, the minimum and maximum value is set for every indicator. The ideal value is the value for which the perceived risk is low (see table 3). In this study, the minimum value is the ideal value. The anti-ideal value is the value where risk is perceived to be highest possible, the maximum value.

After setting the ideal and anti-ideal, the values are normalized. The normalized values range from 0.00 (low risk) to 1.00 (high risk) and this is relative to other commodities with the minimum (normalized value 0.00) and maximum value (normalized value 1.00). Introduced is following model scenario. There are n agricultural commodities (C_i where i = 1,2,....,n) with m indicators of supply risk (I_j where j = 1,2,...,m). The normalized values have the outcome R_{ij} (where R = normalized value for i^{th} commodity and j^{th} indicator). The outcome table is the matrix n x m. R^*_j is the ideal value for the indicator of risk and the R_{*j} is the anti-ideal value. The function for normalization is as follows:

$$R_{ij} = \frac{R_{ij} - R^*_j}{R^*_j - R_{*j}} \quad \text{for all i, j (Diaz-Balteiro and Romero, 2004)}$$

3.5.2 Supply risk

After all the values are normalized, the supply risk can be calculated. In consultation with market research analysts conducting food and agribusiness research, weights are given to the individual risk factors. However, according to the experts, it is difficult to say which risk factors/ indicators contribute more or less to the final supply risk. Thus, the five risk factors that are taken into account are given equal weights. The average of all indicators is the supply risk. When all supply risk scores are measured, the commodities are ranked based on supply risk. The top ranked commodity is the one with the highest supply risk.

3.6 Food and agribusiness companies' risk value analysis

In addition to the supply risk assessment, the commodities are evaluated on their risk value for food and agribusiness companies. As mentioned earlier in chapter three, the risk value of supply risk from a commodity to a company is dependent on the profit impact. In order to evaluate the profit impact, a survey is carried out. Appendix B shows with which market analyst the evaluation is carried out for what commodity. This evaluation is based on five different points.

These points are:

a. Ability to stock the commodity.
b. Prime usage/ value added in end product.
c. Sustainability preference for consumers.
d. Availability of substitutes.
e. Availability of market-hedging tools.

These points of evaluation have been determined together with the analysts from the Rabobank Food & Agribusiness Research department. These five points of profit impact have been described in the report of Rabobank (2011) as "sourcing in new reality". The next section explains how the evaluation is carried out. The assessment of the profit impact on food and agribusiness companies is from a European market perspective.

3.6.1 Profit impact evaluation

For every point mentioned above, the market analysts are asked to rate the profit impact as low, medium, or high (see appendix B for details about market analysts). In this case, low means a low-profit impact for a company. In this study, the evaluation of the commodities' profit impact is carried out for the end products in which the commodity is mainly used (barley for beer, milk for fresh drinking milk, sugar for drinks and coffee for coffee drinks, etc.). To provide more information about these points of evaluation, they are described below in detail.

a. Ability to stock the commodity

When it is possible for companies to store a product they may be less influenced by markets. If prices are high or if there is a supply disruption, companies can fall back on their stocks. Low profit impact is when a commodity is easy to store for long period without significant loss of quality. Medium profit impact means the commodity can be stored but over time there is loss of quality or the costs of storage are high. High profit impact is when the products cannot be stored (fresh products) or when storage is only possible for a very short time or at high costs.

b. Prime usage in end product (Indication of value added to end product)

When a product has a significant value contribution to the end product, securing supply will be of great importance to the company. An indication of this added value is the percentage that the commodity represents of the total cost of the end product. For example, barley accounts only for 5% of the total cost of beer. In order to quantify the scale, it is considered low-profit impact when the commodity cost is less than 1/3 of total cost price. Medium profit impact is when the commodity cost is between 1/3 and 2/3 of total cost price and high profit impact is when this is above 2/3 of cost price.

c. Importance of sustainability to the consumer

Depending on the commodity market and the importance of sustainable production, companies not only have to secure the supply of a commodity but also have to secure a sustainable commodity source. This could increase the profit impact. The market analysts are asked to rate the importance of sustainability as an issue in the specific commodity market for the European consumer. Low profit impact means that there is no attention to sustainability, medium profit impact means sustainability is getting more attention and high profit impact means that sustainable production is important to the consumer.

d. Availability of substitutes

When a company can only use one specific commodity for production, it makes the company highly dependent on the supply of that commodity. High prices or low availability can result in major losses for the company. Having only one possible commodity source increases the profit impact of a commodity. The market analysts are asked to rate the availability of substitutes. Low profit impact is defined as having many substitution possibilities. Medium profit impact means there are a few substitution possibilities and high profit impact is defined as having no substitution possibilities.

e. Availability of market-based hedging tools

Companies can mitigate the profit impact of a commodity by using a proper hedging tool. By using a hedging tool, they are more or less able to set the future cost price for their commodity source. This can help the company to mitigate the risk of price fluctuations but it does not secure commodity availability. Market analysts are asked to rate the availability of market-based hedging tools for the European market. Low profit impact means there is a well-developed futures market; medium profit impact means there is a small or young futures market and high profit impact means there is no futures market.

After evaluation, the impact scale (low, medium and high) is transformed into scores: low= 0.00, medium = 0.50 and high =1.00. For every commodity, the average profit impact is calculated.

These can range from the lowest profit impact of 0.00 (average of five times 0.00) to the highest profit impact of 1.00 (average of five times 1.00).

3.6.2 Measuring risk value

Risk value is a two dimensional matrix that was developed by Kraljic (1963). On the horizontal axis the supply risk and on the vertical axis profit impact. The risk value is the aggregated score of both the supply risk and the profit impact. The final risk value of a commodity is the normalized supply risk x the profit impact. Based on this final risk value, the commodities can be ranked.

4 Results

In this chapter all results are presented. First all the indicator values and their normalized values for each commodity are presented. The calculated risk indicator values are shown and the final supply risk ranking is presented. A sensitivity analysis is carried out and at the end of this chapter the results of the profit impact evaluation are presented.

4.1 Supply risk from market

4.1.1 Indicator values

All indicator values are calculated. Table 6 presents the retained values for each indicator and for each commodity. In this table, the ideal values are in bold face and the anti-ideal values in underlined italics. For the commodities orange juice single strength, orange juice concentrated, apple juice single strength and apple juice concentrated the data for indicator market balance (3) is extracted from the group they belong to according to the FAO database. Thus, for oranges juices, this is the commodity group oranges & mandarins and for apple juices, it is the commodity group apples. For the market balance data for the commodities cow milk fresh, butter and cheese of cow milk market data is extracted for the commodity group milk, butter and cheese. These groups include buffalo milk data. However, buffalo milk products are only a very small part of that commodity group.

Production concentration
Palm oil has the highest concentration of production (0.79). In 2010, 80% of palm oil global production took place in Indonesia (48%) and Malaysia (38%). Second and third largest concentration is the production of olive oil and olives. The production of whole cow milk has the lowest concentration (0.10). Largest producer of cow milk is the United States, which produces 15% of global milk production.

Market power
Market power in the market of juices is strongest. The top 5 companies have a share of total trade above 80%. Also for the tea, sugar, maize and the banana market, the power of companies is strong. This is low for egg, olives, potatoes and onions. In these markets, the top 5 companies have close to 0% of market share.

Market balance
For the indicator market balance, cocoa beans receives the highest value. With a production growth of 3.6% and domestic supply growth of 4.6% the difference is 1.1% points. The market for apples and oranges shows also an imbalanced growth rate. For these products production growth did not meet domestic supply growth and therefore stocks have declined. For all animal products the market was well balanced. The difference between production growth rate and domestic supply growth is close to 0.0%

Yield variability
For the indicator Yield variability, the highest value is for olives and olive oil (7.6%) and the lowest is for pig meat (0.2%). Olive yield is affected by weather conditions and shoot growth. High yield results in bad shoot growth in the year after and low yield results in good shoot growth. This

causes large fluctuations in yield (University of California, 2006). Other animal product show low fluctuations in yield. This could be caused by the fact that animal product are much less exposed and affected by weather circumstances. Both yield per animal as production in total show a constant line.

Country risk
For the country risk indicator, cocoa beans received the highest value. Côte d'Ivoire and Nigeria are countries with high risk profiles and they produce together 39% of global production. This results in a total indicator value of 0.44. The commodity butter of cow milk achieves the lowest value for the country risk.

Table 6 Outcome values for the 5 supply risk indicators.[1]

Commodity	1. Production concentration	2. Market power	3. Market Balance	4. Yield variability	5. Country risk
Apple juice, concentrated	0.20	80%	0.9%	2.4%	0.21
Apple juice, s. strength	0.14	60%	0.9%	2.4%	0.23
Apples	0.28	**0%**	0.9%	2.4%	0.28
Bananas	0.18	80%	-0.2%	3.2%	0.10
Barley	0.12	40%	-0.3%	4.2%	0.26
Bovine Meat	0.11	40%	-0.1%	0.7%	0.15
Cocoa beans	0.38	60%	*1.1%*	3.5%	*0.44*
Coffee	0.29	60%	0.0%	4.2%	0.29
Cotton lint	0.21	40%	0.0%	4.1%	0.32
Cow milk, Butter	0.13	40%	0.0%	1.0%	**0.07**
Cow Milk, Cheese	0.18	40%	-0.1%	1.0%	0.09
Cow milk, Whole/ fresh	**0.10**	40%	0.0%	1.0%	0.13
Grapes	0.13	20%	0.0%	2.6%	0.15
Hen eggs, in shell	0.21	**0%**	0.0%	0.8%	0.24
Maize	0.22	80%	**-0.5%**	2.1%	0.21
Olive oil	0.59	20%	0.9%	*7.6%*	0.23
Olives	0.48	**0%**	-0.1%	*7.6%*	0.22
Onions	0.18	**0%**	-0.1%	1.5%	0.23
Orange juice, concentrated	0.42	*100%*	0.7%	2.1%	0.32
Orange juice, s. strength	0.28	80%	0.7%	2.1%	0.27
Oranges	0.16	20%	0.7%	2.1%	0.22
Palm oil	*0.79*	60%	0.3%	3.7%	0.37
Pig meat	0.28	40%	0.0%	**0.2%**	0.27
Potatoes	0.14	**0%**	0.1%	2.3%	0.22
Poultry Meat	0.13	20%	0.0%	0.4%	0.18
Pulses	0.13	20%	0.1%	2.9%	0.19
Rapeseed	0.17	20%	-0.1%	4.5%	0.31
Rapeseed Cake/Meal	0.19	40%	-0.3%	4.5%	0.19
Rapeseed oil	0.19	40%	0.1%	4.5%	0.19
Rice	0.27	40%	0.0%	3.9%	0.31
Soybean oil	0.25	40%	-0.2%	3.2%	0.31
Soybeans	0.40	20%	0.2%	3.2%	0.29
Soybeans Cake/meal	0.25	40%	0.3%	3.2%	0.31
Sugar	0.15	80%	0.1%	3.6%	0.22
Sunflower Cake/meal	0.29	40%	0.1%	4.6%	0.27
Sunflower oil	0.29	40%	-0.1%	4.6%	0.27
Sunflower seed	0.31	20%	0.1%	4.6%	0.25
Tea	0.26	80%	-0.4%	0.8%	0.33
Tomatoes	0.14	20%	0.0%	4.3%	0.25
Wheat	0.12	40%	-0.1%	2.4%	0.17

[1] The ideal values are in bold face and the anti-ideal values in underlined italics

4.1.2 Normalized values

After obtaining all values of the indicators, the values are normalized in order to aggregate them in one score for supply risk. It could be difficult to see or understand how the normalized values are obtained. In order to better clarify these normalized values, an example is shown for the indicator production shocks (1a.) for the commodity maize. For the indicator production shocks, maize received a value of 7%, as can be seen in Table 7. In the list of commodities, the minimum value for production shocks is 0.8%, which is achieved by pig meat. The maximum value is 25.3% (olives). So the normalized value for maize can be calculated as:

$$\frac{7\% - 0.8\%}{25.3\% - 0.8\%} = 0.25$$

The values of normalisation are presented in table 5. This table also shows the ideal values in bold face and the anti-ideal values in italics. The ideal value is set at 0.00 and the anti-ideal value at 1.00.

Table 7 Normalized values of indicator outcome values.[2]

Commodity	1. Production concentration	2. Market power	3. Market Balance	4. Yield variability	5. Country risk
Apple juice, concentrated	0.15	0.80	0.88	0.29	0.38
Apple juice, s strength	0.06	0.60	0.88	0.29	0.43
Apples	0.27	**0.00**	0.88	0.29	0.57
Bananas	0.13	0.80	0.19	0.40	0.08
Barley	0.04	0.40	0.13	0.54	0.51
Bovine Meat	0.02	0.40	0.25	0.06	0.22
Cocoa beans	0.41	0.60	*1.00*	0.44	*1.00*
Coffee	0.28	0.60	0.31	0.54	0.59
Cotton lint	0.17	0.40	0.31	0.52	0.68
Cow milk, Butter	0.05	0.40	0.31	0.11	**0.00**
Cow Milk, Cheese	0.13	0.40	0.25	0.11	0.05
Cow milk, Whole/ fresh	**0.00**	0.40	0.31	0.11	0.16
Grapes	0.05	0.20	0.31	0.31	0.22
Hen eggs, in shell	0.17	**0.00**	0.31	0.07	0.46
Maize	0.18	0.80	**0.00**	0.25	0.38
Olive oil	0.71	0.20	0.88	*1.00*	0.43
Olives	0.55	**0.00**	0.25	*1.00*	0.41
Onions	0.12	**0.00**	0.25	0.17	0.43
Orange juice, concentrated	0.47	*1.00*	0.75	0.25	0.68
Orange juice, s. strength	0.27	0.80	0.75	0.25	0.54
Oranges	0.09	0.20	0.75	0.25	0.41
Palm oil	*1.00*	0.60	0.50	0.47	0.81
Pig meat	0.27	0.40	0.31	**0.00**	0.54
Potatoes	0.07	0.00	0.38	0.27	0.41
Poultry Meat	0.05	0.20	0.31	0.03	0.30
Pulses	0.05	0.20	0.38	0.36	0.32
Rapeseed	0.10	0.20	0.25	0.57	0.65
Rapeseed Cake/Meal	0.14	0.40	0.13	0.57	0.32
Rapeseed oil	0.14	0.40	0.38	0.57	0.32

[2] The ideal values are in bold face and the anti-ideal values in underlined italics

Rice	0.25	0.40	0.31	0.13	0.65
Soybean oil	0.22	0.40	0.19	0.40	0.65
Soybeans	0.43	0.20	0.44	0.40	0.59
Soybeans Cake/meal	0.22	0.40	0.50	0.40	0.65
Sugar	0.08	0.80	0.38	0.24	0.41
Sunflower Cake/meal	0.28	0.40	0.38	0.59	0.54
Sunflower oil	0.28	0.40	0.25	0.59	0.54
Sunflower seed	0.31	0.20	0.38	0.59	0.49
Tea	0.24	0.80	0.06	0.08	0.70
Tomatoes	0.07	0.20	0.31	0.56	0.49
Wheat	0.04	0.40	0.25	0.29	0.27

4.1.3 Supply risk

The calculated score for supply risk is presented in figure 6. The supply risk is the average normalized values of indicators. The commodities are ranked in descending order from highest to lowest supply risk. As can be seen in the ranking, cocoa bean is the commodity with the highest supply risk. This is followed by palm oil, olive oil and concentrated orange juice. Products from cows and poultry are listed at the bottom of the ranking.

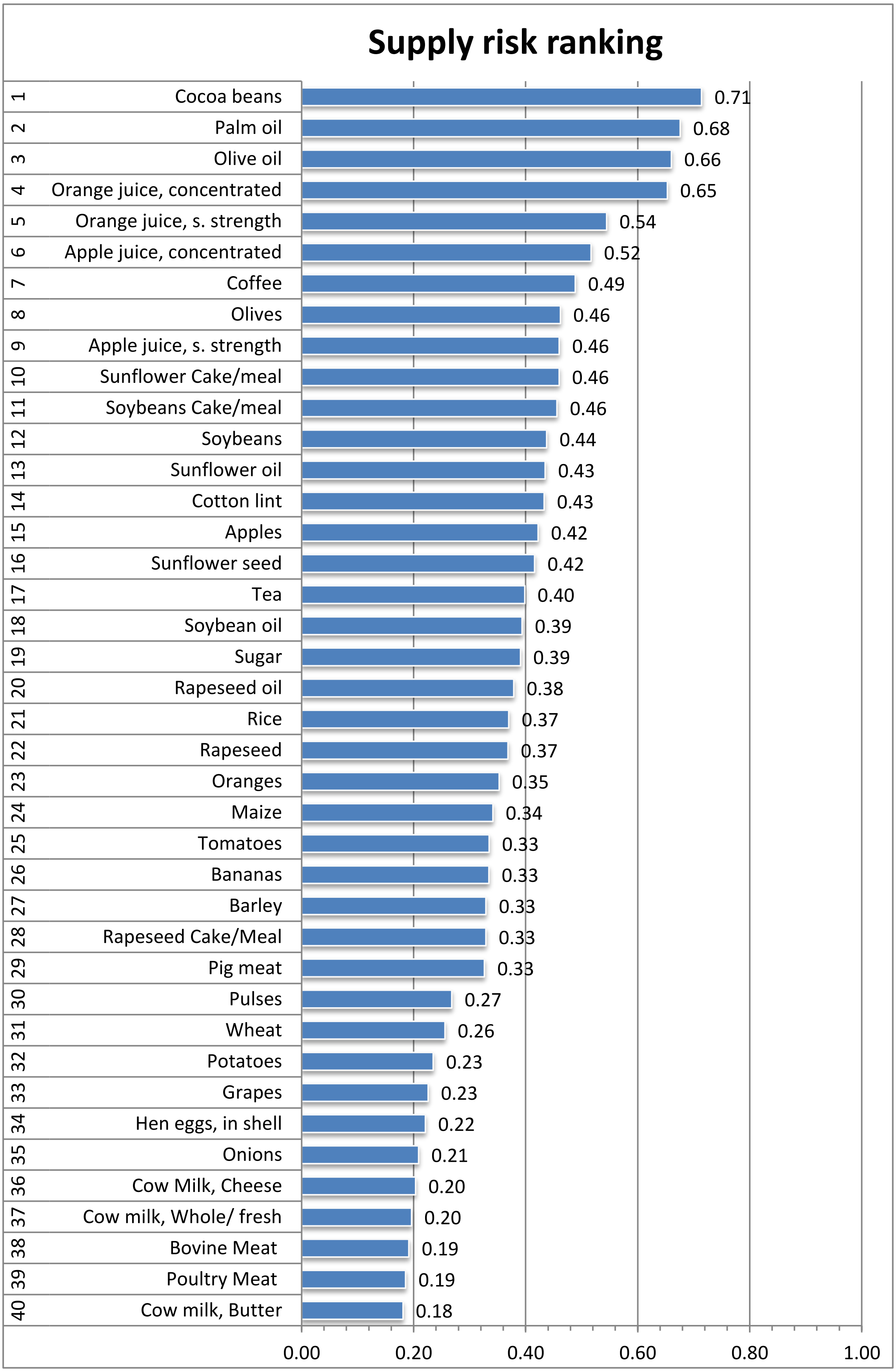

Figure 6 Ranking of 40 major agricultural commodities based on supply risk.

4.1.4 Sensitivity analysis

Based on the advice received from the market experts, all the risk indicators were weighted equally. It is not possible to say whether an indicator has a higher or lower contribution to supply risk. In order to see whether the ranking is robust, a sensitivity analysis is carried out. In the sensitivity analysis the minimum supply risk and the maximum supply risk are calculated. Additionally, the standard deviation of the normalised values is calculated. In the ranking in figure 6 all five risk indicators contributed equally to the supply risk (20% per indicator). In this sensitivity analysis one specific risk indicator is weighted 60%, while the other risk indicators are given the weight of at least 10%. The minimum supply risk value is the value where the minimum normalized value is weighted with a maximum of 60% (the point where the four other indicator are weighted at least 10%). The maximum supply risk is the point where the maximum normalized value is weighted with a maximum of 60%. These minimum and maximum supply risk values per commodity are presented in the following table and visualized in figure 7.

Table 8 Minimum and maximum supply risk based on max. 60% weight and min. 10% weight per indicator.

	Min. normalized value	Max normalized value	Std. deviation nor. values	Minimum supply risk	Supply risk	Maximum supply risk
Cocoa beans	0.41	1.00	0.26	0.55	0.69	0.85
Palm oil	0.47	1.00	0.20	0.57	0.68	0.84
Olive oil	0.20	1.00	0.29	0.42	0.64	0.82
Orange juice, concentrated	0.25	1.00	0.25	0.44	0.63	0.81
Orange juice, s. strength	0.25	0.80	0.23	0.39	0.52	0.66
Apple juice, concentrated	0.15	0.88	0.29	0.33	0.50	0.69
Coffee	0.28	0.60	0.14	0.37	0.47	0.53
Apple juice, s. strength	0.06	0.88	0.28	0.25	0.45	0.66
Olives	0.00	1.00	0.33	0.22	0.44	0.72
Sunflower Cake/meal	0.28	0.59	0.11	0.36	0.44	0.51
Soybeans Cake/meal	0.22	0.65	0.14	0.33	0.43	0.54
Cotton lint	0.17	0.68	0.17	0.29	0.41	0.55
Soybeans	0.20	0.59	0.13	0.31	0.41	0.50
Sunflower oil	0.25	0.59	0.13	0.33	0.41	0.50
Apples	0.00	0.88	0.30	0.20	0.40	0.64
Sunflower seed	0.20	0.59	0.13	0.30	0.39	0.49
Sugar	0.08	0.80	0.24	0.23	0.38	0.59
Tea	0.06	0.80	0.31	0.22	0.38	0.59
Soybean oil	0.19	0.65	0.16	0.28	0.37	0.51
Rapeseed oil	0.14	0.57	0.14	0.25	0.36	0.47
Rapeseed	0.10	0.65	0.22	0.23	0.35	0.50
Rice	0.13	0.65	0.17	0.24	0.35	0.50
Oranges	0.09	0.75	0.23	0.22	0.34	0.55
Tomatoes	0.07	0.56	0.18	0.20	0.32	0.44
Barley	0.04	0.54	0.20	0.18	0.32	0.43
Maize	0.00	0.80	0.27	0.16	0.32	0.56
Bananas	0.08	0.80	0.26	0.20	0.32	0.56
Rapeseed Cake/Meal	0.13	0.57	0.17	0.22	0.31	0.44
Pig meat	0.00	0.54	0.18	0.15	0.30	0.42
Pulses	0.05	0.38	0.12	0.15	0.26	0.32
Wheat	0.04	0.40	0.12	0.14	0.25	0.32
Potatoes	0.00	0.41	0.16	0.11	0.22	0.32
Grapes	0.05	0.31	0.10	0.13	0.22	0.27
Hen eggs, in shell	0.00	0.46	0.17	0.10	0.20	0.33
Cow milk, Whole/ fresh	0.00	0.40	0.14	0.10	0.20	0.30
Onions	0.00	0.43	0.14	0.10	0.19	0.31
Bovine Meat	0.02	0.40	0.14	0.10	0.19	0.29
Cow Milk, Cheese	0.05	0.40	0.12	0.12	0.19	0.29
Poultry Meat	0.03	0.31	0.12	0.11	0.18	0.25
Cow milk, Butter	0.00	0.40	0.16	0.09	0.17	0.29

In figure 7 the minimum and maximum supply risk per commodity is visualized. The triangles are the original supply risk and the lines present the minimum and maximum supply risk.

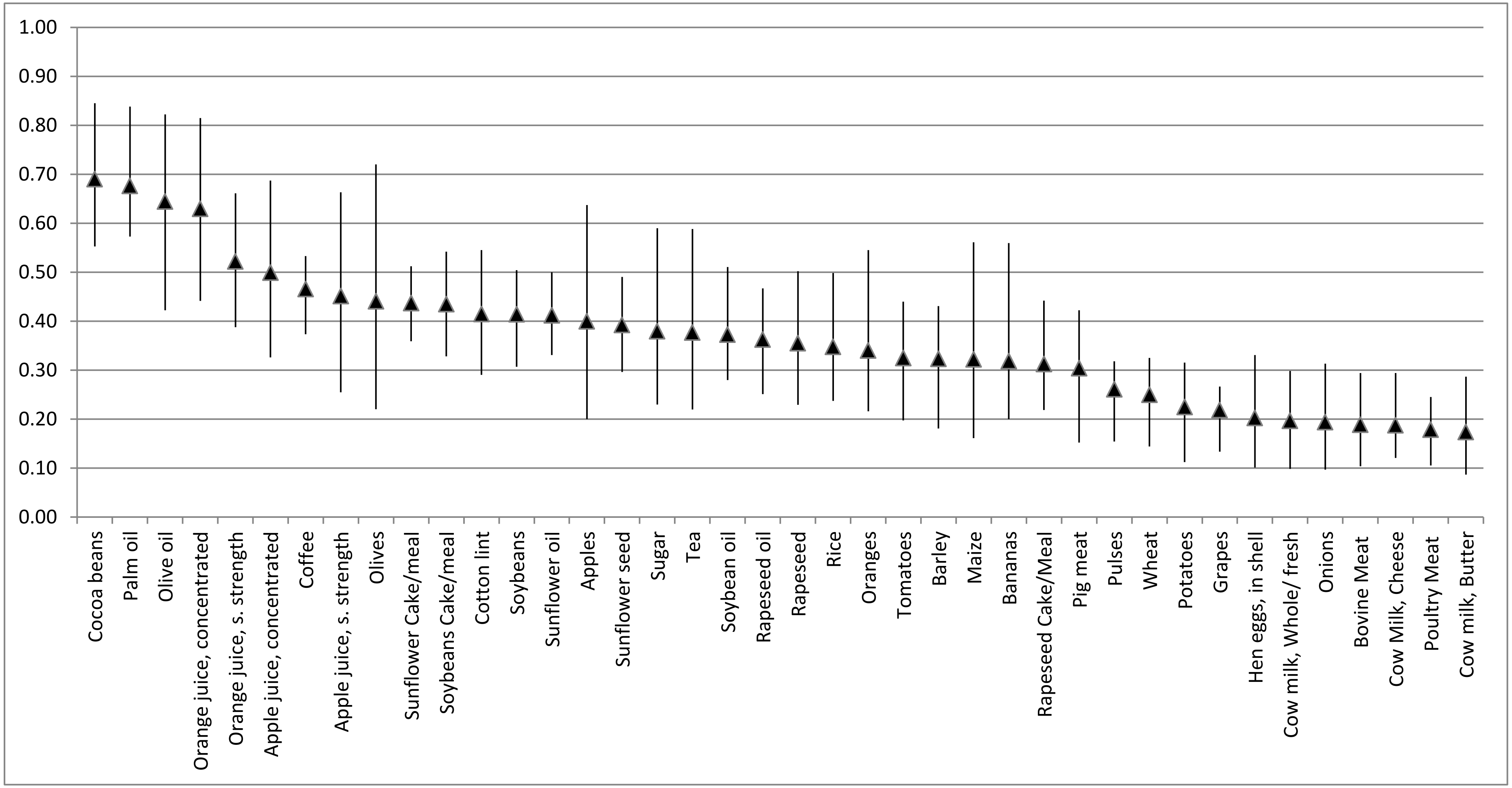

Figure 7 Minimum and maximum supply risk with unequal distribution of weights per indicators.

As shown in the ranking, cocoa beans received the highest supply risk. Therefore, cocoa beans stands at the top of the supply risk ranking. When different weights are given to the specific risk indicators, the position of cocoa beans and other commodities could change in the ranking.

- In the top 4 of high supply risk commodities, olive oil shows a broader range of possible supply risk scores than cocoa beans, palm oil and concentrated orange juice.
- In the middle region of the ranking, commodities such as sunflower products and soybean products show a smaller range of possible supply risk scores.
- In the middle region of the ranking olives, apple juice single strength, apples, tea, sugar, maize and bananas show a broader range of possible supply risk scores.
- Olives has the highest standard deviation of normalized values (0.33), followed by the commodity tea (0.31) and apples (0.30).
- Grapes has the lowest standard deviation of normalized values (0.10) Followed by the commodities sunflower cake (0.11) and pulses, wheat, poultry meat and cow milk (0.12).

4.2 Impact of supply risk

In order to see what the value of impact of the commodity is, a profit impact evaluation is conducted. The results of this evaluation are presented in table 9. Every commodity received a score for its profit impact on the supply chain companies. The five points of evaluation have been described in chapter 4. The categories for scores are: (0.00) low profit impact, (0.50) medium profit impact and (1.00) high profit impact. In the final column, the average value of the profit impact evaluation is shown.

Table 9 Profit impact per indicator and average outcome.[3]

Commodity	Prime usage in end product	Ability to store	Substitution Possibility	Sustainability preference	Availability market hedging tools	Average profit impact
Apple juice, concentrated	0.50	0.00	0.50	0.50	0.50	0.40
Apple juice, single strength	0.50	0.00	0.50	0.50	1.00	0.50
Apples	1.00	1.00	0.50	0.00	1.00	0.70
Bananas	1.00	1.00	0.50	1.00	1.00	0.90
Barley	0.00	0.00	1.00	0.00	0.00	0.20
Bovine Meat	0.00	1.00	0.50	0.50	1.00	0.60
Cocoa beans	0.50	0.00	1.00	1.00	0.50	0.60
Coffee	0.50	0.00	1.00	1.00	0.00	0.50
Cotton lint	0.00	0.00	0.50	0.50	0.00	0.20
Cow milk, Butter	1.00	0.50	1.00	1.00	0.50	0.80
Cow Milk, Cheese	1.00	0.50	1.00	1.00	0.50	0.80
Cow milk, Whole/ fresh	1.00	1.00	0.50	1.00	1.00	0.90
Grapes	1.00	1.00	1.00	0.00	1.00	0.80
Hen eggs, in shell	1.00	1.00	1.00	1.00	1.00	1.00
Maize	0.00	0.00	0.00	0.50	0.00	0.10
Olive oil	0.00	0.50	0.50	0.00	1.00	0.40
Olives	1.00	1.00	1.00	0.00	1.00	0.80
Onions	1.00	0.00	0.50	0.00	1.00	0.50
Orange juice, concentrated	0.50	0.00	0.50	0.50	0.00	0.30
Orange juice, single strength	0.50	0.00	0.50	0.50	1.00	0.50
Oranges	1.00	1.00	1.00	0.00	1.00	0.80
Palm oil	0.00	0.00	0.00	1.00	0.00	0.20
Pig meat	1.00	0.50	0.50	1.00	0.50	0.70
Potatoes	1.00	0.50	0.50	0.00	0.50	0.50
Poultry Meat	0.50	0.50	0.50	0.50	0.50	0.50
Pulses	1.00	0.00	0.50	0.00	1.00	0.50
Rapeseed	0.50	0.00	0.50	0.00	0.50	0.30
Rapeseed Cake/Meal	1.00	0.00	0.50	0.00	0.50	0.40
Rapeseed oil	0.00	0.50	0.50	0.00	0.50	0.30
Rice	1.00	0.00	1.00	0.00	0.50	0.50
Soybean oil	0.00	0.50	0.50	0.50	0.00	0.30
Soybeans	0.50	0.00	0.50	0.50	0.00	0.30
Soybeans Cake/meal	1.00	0.00	0.50	0.50	0.00	0.40
Sugar	0.00	0.00	0.50	0.00	0.00	0.10
Sunflower Cake/meal	1.00	0.00	0.50	0.00	1.00	0.50
Sunflower oil	0.00	0.00	0.50	0.00	1.00	0.30
Sunflower seed	0.50	0.50	0.50	0.00	1.00	0.50
Tea	0.50	0.00	1.00	1.00	0.50	0.60
Tomatoes	1.00	0.00	1.00	0.50	1.00	0.70
Wheat	0.50	0.00	0.50	0.00	0.00	0.20

Hen eggs scores the highest in the profit impact evaluation (1.00). It receives at all points a high profit impact. It is followed by bananas and fresh/whole cow milk (0.90). Grapes, olives and oranges are also rated high in the profit impact evaluation (0.80). Low profit impact (0.20) is given for barley, cotton lint, palm oil and wheat. The lowest profit impact is achieved by sugar and maize (0.10).

[3] 0.00 = low impact, 0.50 = medium impact and 1.00 = high impact

4.3 The supply risk value

For measuring the risk value, the score for supply risk and the score for profit impact are multiplied. Both scores contribute equally to the risk value as shown in table 10 in the last column. The table is ranked based on risk value.

Table 10 Ranking of agricultural commodities based on risk value.

Rank	Commodity	Supply risk	Profit impact	Risk value
1	Cocoa beans	0.71	0.60	0.43
2	Olives	0.46	0.80	0.37
3/4	Bananas	0.33	0.90	0.30
3/4	Apples	0.42	0.70	0.30
5	Oranges	0.35	0.80	0.28
6	Orange juice, s. strength	0.54	0.50	0.27
7	Olive oil	0.66	0.40	0.26
8/9	Coffee	0.49	0.50	0.24
8/9	Tea	0.40	0.60	0.24
10/11/12/13	Tomatoes	0.33	0.70	0.23
10/11/12/13	Apple juice, s. strength	0.46	0.50	0.23
10/11/12/13	Sunflower Cake/meal	0.46	0.50	0.23
10/11/12/13	Pig meat	0.33	0.70	0.23
14	Hen eggs, in shell	0.22	1.00	0.22
15/16	Sunflower seed	0.42	0.50	0.21
15/16	Apple juice, concentrated	0.52	0.40	0.21
17	Orange juice, concentrated	0.65	0.30	0.20
18/19/20/21	Rice	0.37	0.50	0.18
18/19/20/21	Soybeans Cake/meal	0.46	0.40	0.18
18/19/20/21	Grapes	0.23	0.80	0.18
18/19/20/21	Cow milk, Whole/ fresh	0.20	0.90	0.18
22	Cow Milk, Cheese	0.20	0.80	0.16
23/24	Cow milk, Butter	0.18	0.80	0.14
23/24	Palm oil	0.68	0.20	0.14
25/26/27/28	Pulses	0.27	0.50	0.13
25/26/27/28	Rapeseed Cake/Meal	0.33	0.40	0.13
25/26/27/28	Soybeans	0.44	0.30	0.13
25/26/27/28	Sunflower oil	0.43	0.30	0.13
29/30	Soybean oil	0.39	0.30	0.12
29/30	Potatoes	0.23	0.50	0.12
31/32/33	Bovine Meat	0.19	0.60	0.11
31/32/33	Rapeseed oil	0.38	0.30	0.11
31/32/33	Rapeseed	0.37	0.30	0.11
34	Onions	0.21	0.50	0.10
35	Poultry Meat	0.19	0.50	0.09
36	Cotton lint	0.43	0.20	0.09
37	Barley	0.33	0.20	0.07
38	Wheat	0.26	0.20	0.05
39	Sugar	0.39	0.10	0.04
40	Maize	0.34	0.10	0.03

The highest risk value of 0.43 is achieved by cocoa beans. In addition, olives, bananas, apples have a high risk value above 0.30. Palm oil, which was ranked high in the supply risk ranking, has a final risk value of 0.14 and therefore it has a place in the middle region of the risk value ranking. Hen eggs was ranked low in the supply risk ranking but it is placed much higher in the risk value ranking. Even if a specific commodity has a low supply risk, it still can have a high risk value for companies.

5 Discussion and conclusion

5.1 Discussion

Life span of research

The supply risk assessment was conducted in 2012. The analysis is based on historical data. The different indicator values are sensitive to change over the years. The geopolitical climate is also continuously changing. However, changes in production and assets take time. Therefore, it is unlikely that the results of this assessment would be significantly different in two to five years. The factors that led to the food crisis in 2008 are still present today (Heyder et al., 2010). However, for many the food crisis 2007- 2008 came out of nowhere. It is likely that new and unexpected events will occur with uncertain outcomes for the agricultural supply market.

Data availability

Several studies have explained the causes of the increase in price volatility and supply disruptions. However, there seems to be so many factors that play a role that it was not only impossible for this study to include them all in the assessment, but also the availability of data would be a limitation. Covering all the factors and circumstances is rather difficult with a quantitative analysis (Loman, 2007). The optimal supply risk assessment would include all of the factors discussed in chapter two. Unfortunately, this was not possible because of limited data and academic knowledge.

A second limitation to this research is the unavailability of elasticity as indicator for the market constraint. Explained earlier, substitution can cause price volatility in the supply market. Supply elasticity is a good indicator of the ability of farmers to respond to prices. Unfortunately, due to lack of data, it was not possible to include this in the analysis. There is some data available but only for a small number of commodities for a specific area. Supply elasticity is the relative change in supply with the increase or decrease in price. Farmers change their supply by adjusting their production level for a specific commodity. For crops, this leads to substitution because production area is limited. Supply elasticity determines how long prices stay high or low and how fast farmers can adjust to prices in order to balance the market.

Market balance as indicator

However, the market constraint as source of supply risk is important and should not be ignored. Selecting indicators that measure these risks, though, is difficult. As is explained in literature, the identified long-term factors, namely oil prices, input prices, biofuel policies and welfare growth, contributed to the crisis in 2008. These long-term factors, together with other short term factors (shocks), were the cause of the sudden increase in prices and availability of commodities. As explained, supply and demand determine price and availability at the supply market. In the study of Rosenau-Tornow (2009) current production, demand and stocks determine the market balance. Future market balance is determined by production and demand growth. Thus, in order to determine how balanced this global commodity market is, production and demand data could be analysed. However, current data is also not available and an analysis of this data would show fluctuations that are caused by short term production risks. In addition, demand in global markets is difficult to measure. In order to measure the market as constraint, production and demand trends are incorporated in the analysis. These will contribute to a better estimation of market developments of price and availability in the near future.

Ranking method

In the study of Rosenau-Tornow (2009), the supply risk of a single commodity is relative to the historical minimum and maximum reference point. Available data was limited and no historical reference point could be set. The ranking is relative to the commodities that have been included in the assessment. If other commodities were included in the list, this could lead to a different interpretation of results. To clarify, cocoa beans received in this study the highest supply risk. If other commodities were included, such as those with a higher supply risk, this would change the rank of cocoa beans. However, these commodities have been selected with market analysts of the Rabobank Food & Agribusiness Research department. The list of commodities selected should cover both the most important commodities as well as the commodities with the expected highest supply risk. Therefore, it would be unlikely that within the current agricultural market important commodities exist that would score higher on the risk ranking. However, this would not change the order of the selected commodities within the ranking. It could be possible that in the future new commodities become an important ingredient for many food or agribusiness companies.

Results

The results have been discussed with the market analysts of Rabobank. The results were not surprising; the analysts indicated that they expected this order of rank. The sunflower commodities were the most surprising, and olives were not expected to score so high in the supply risk assessment. Both sunflower and olives received their highest indicator value for the indictor yield variability. This could raise the question whether yield variability as indicator contributes to a better estimation of price volatility as source of supply risk.

Profit impact evaluation

The profit impact evaluation conducted in order to measure the risk value (supply risk x profit impact) for companies cannot be generalized to all companies. It depends on the companies' profile how this could be interpreted. The market analysts and the researcher are aware about the difficulty of evaluating the commodities on their profit impact for companies, because commodities can be used in a wide range of products. However, in this research it is not the main goal to study the profit impact but it can give a better understanding of the impact of supply risk in a company. Although palm oil received a low score for profit impact, for a company where palm oil is the most important ingredient, the risk value would be much higher for that specific company. The supply risk assessment shows what commodities companies should be concentrating on.

5.2 Conclusion

The first objective of this study was to identify important supply risks from agricultural commodity markets. Five relevant risk sources from the agricultural supply market have been identified: (1) global sourcing, (2) number of qualified suppliers, (3) market capacity constraint, (4) market price increase and the (5) geopolitical climate. The second objective of this study was to identify underlying sources and drivers per supply risk. Based on the literature review, different sources and drivers have been identified. Global sourcing has increased for companies due to the fact that local supplies were no longer sufficient and prices were too high. This makes companies more vulnerable to dynamic currency rates and disaster in the sourcing region. Longer supply chains and the need to reduce risks have led to commoditisation of agricultural products. In a commodity market suppliers compete on price. By exploiting economics of scale this have led to few large multinational companies, with high market power, dominating the field. Do you mean This increases the dependency and reduces the bargaining power of sourcing companies. These companies source in a commodity market that is constrained by the availability of agricultural land. In this agricultural market, price and availability are closely linked. The availability of commodities depends on the responsiveness of producers and consumers to these prices. Prices and the responsiveness of farmers adjusting to markets determine the level of production. With the cost of production increasing, the ability of famers to respond to prices has declined. Agricultural markets have become more volatile mainly due to increasing production shocks and low stocks. Production shocks can result in large price fluctuations. The political and institutional environment influences the total food supply chain. Political and institutional risks occur at every step in the food supply chain. It influences production, market and trade. The macroeconomic environment is one major source of uncertainty in the current agricultural markets. Policies create the landscape for decision-making and incentives

The final objective of this study was to analyse and rank commodities based on supply risk. Therefore, five relevant indicators have been selected to assess the supply risk from the agricultural market: geographic concentration of production, market power, market balance, yield variability and country risk. Using these indicators the supply risk is assessed. The result is a supply risk ranking where cocoa beans received the highest supply risk. This is due to the high concentration of production, which takes place in countries with a high risk profile. Cocoa beans are traded intensively and market power is high. In addition, production has been growing slower than demand. The profit impact of cocoa beans is high, resulting in a first place ranking for risk value. Palm oil, olive oil and concentrated orange juice score high in supply risk. Olive oil scores high for production shocks and market balance. In the market of orange juice, market power is high. The risk indicators score for palm oil is more evenly distributed. Orange juice single strength, coffee, apple juice single strength, concentrated orange juice and olives are listed in the top 10 in the supply risk ranking. Commodities that have a low supply risk are mainly animal-based products from cows (bovine meat, milk, butter and cheese) and poultry (hen eggs, poultry meat). For the commodities milk and eggs the risk value is much higher. Because of high profit impact they are listed in the top 10 of the risk value ranking. Vegetables and fruits are commodities with a low supply risk. However, because of their high profit impact the risk value of these commodities is high. Bananas, apples and oranges are listed in the top 10 of the risk value ranking.

5.3 Recommendations

This research is conducted because there is growing concern about the risks in global sourcing. There are some studies that underpin that (Heyder et al., 2010). Researchers are paying close attention to the increased prices and volatility (Gilbert & Morgan, 2010). These researchers concentrated their studies mainly on the effect on the poor people in developing countries. Further research should also investigate the effect of different markets on the supply of commodities. Substitution and the ability of farmers to farmers determine the availability of commodities. It would be helpful to understand more thoroughly how markets interact to each other. Price and availability at agricultural markets interact and create(d) price volatility. Extreme price volatility and policies has been proven as an uncertain factor that affect the market. In the agricultural market uncertainty affects supply risk. Where prices affect decisions for farmers and companies in the food supply chain. As Heyder et al. (2010) stated, is uncertainty one of the most important risks for companies. Therefore governments and policy makers should work closer together to reduces negative effects that create this uncertainty. It would be more helpful to study the possible ways to reduce those uncertain and undesired effects.

This study is conducted in cooperation with the Rabobank Food & Agribusiness Research department. This study will give Rabobank more knowledge about the risk that food and agribusiness companies face. Companies that source commodities with a high risk profile should provide a strategy to reduce these risks when finances for their investments are needed.

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Appendix A - commodity list, item name and definition

This commodity list is extracted from the FAO statistical database. The numbers in the second column present the code that FAO uses for its database. The item name is the primary commodity used in this research. The last column (definition) presents the composition of the primary commodity.

Group Name	Item FAO Code	Item Name	Definition
Crops Primary Equivalent	2617	Apples	Default composition: 515 Apples, 518 Apple juice, single strength, 519 Apple juice, concentrated
Crops Primary Equivalent	2615	Bananas	Default composition: 486 Bananas
Crops Primary Equivalent	2513	Barley	Default composition: 44 Barley, 45 Pot Barley, 46 Barley Pearled, 49 Malt, 50 Malt Extract; nutrient data only: 47 Bran of Barley, 48 Barley Flour and Grits
Crops Primary Equivalent	2633	Cocoa Beans	Default composition: 661 Cocoa beans, 662 Cocoa Paste, 665 Cocoa powder and Cake, 666 Chocolate Prsnes
Crops Primary Equivalent	2630	Coffee	Default composition: 656 Coffee, green, 657 Coffee Roasted, 659 Coffee Extracts
Crops Primary Equivalent	2620	Grapes	Default composition: 560 Grapes, 561 Raisins, 562 Grape Juice, 563 Must of Grapes
Crops Primary Equivalent	2514	Maize	Default composition: 56 Maize, 58 Flour of Maize, 64 Starch of Maize, 846 Gluten Feed and Meal; nutrient data only: 57 Germ of Maize, 59 Bran of Maize, 63 Maize gluten
Crops Primary Equivalent	2580	Olive Oil	Default composition: 261 Olive oil, virgin, 274 Oil of Olive Residues
Crops Primary Equivalent	2563	Olives	Default composition: 260 Olives, 262 Olives Preserved
Crops Primary Equivalent	2602	Onions	Default composition: 403 Onions, dry
Crops Primary Equivalent	2611	Oranges, Mandarines	Default composition: 490 Oranges, 491 Orange juice, single strength, 492 Orange juice, concentrated, 495 Tangerines, mandarins, clem., 496 Tangerine Juice
Crops Primary Equivalent	2577	Palm Oil	Default composition: 257 Palm oil, 1276 Fatty Acids, 1277 Res.Fatty Subs

Crops Primary Equivalent	2531	Potatoes	Default composition: 116 Potatoes, 117 Potatoes Flour, 118 Frozen Potatoes, 119 Starch of Potatoes, 121 Tapioca of Potatoes
Crops Primary Equivalent	2549	Pulses, Other	Default composition: 181 Broad beans, horse beans, dry, 191 Chick peas, 195 Cow peas, dry, 197 Pigeon peas, 201 Lentils, 203 Bambara beans, 205 Vetches, 210 Lupins, 211 Pulses, nes, 212 Flour of Pulses; nutrient data only: 213 Bran of Pulses
Crops Primary Equivalent	2574	Rape and Mustard Oil	Default composition: 271 Rapeseed oil, 293 Mustard oil
Crops Primary Equivalent	2805	Rice (Milled Equivalent)	Default composition: 27 Rice, paddy, 28 Rice Husked, 29 Milled/Husked Rice, 31 Rice Milled, 32 Rice Broken, 34 Starch of Rice, 38 Rice Flour; nutrient data only: 33 Rice gluten, 35 Bran of Rice
Crops Primary Equivalent	2804	Rice (Paddy Equivalent)	
Crops Primary Equivalent	2571	Soybean Oil	Default composition: 237 Soybean oil
Crops Primary Equivalent	2555	Soybeans	Default composition: 236 Soybeans, 239 Soya Sauce, 240 Soya Paste, 241 Soya Curd
Crops Primary Equivalent	2542	Sugar (Raw Equivalent)	Default composition: 158 Cane sugar, raw, centrifugal, 159 Beet sugar, raw, centrifugal, 162 Sugar Raw Centrifugal, 164 Sugar Refined, 168 Sugar Confectionery, 171 Sugar flavoured
Crops Primary Equivalent	2557	Sunflower seed	Default composition: 267 Sunflower seed
Crops Primary Equivalent	2573	Sunflower seed Oil	Default composition: 268 Sunflower oil
Crops Primary Equivalent	2635	Tea	Default composition: 667 Tea, 671 Maté, 672 Extracts Tea, Mate, Prep
Crops Primary Equivalent	2601	Tomatoes	Default composition: 388 Tomatoes, 389 Tomatojuice Concentrated, 390 Juice of Tomatoes, 391 Paste of Tomatoes, 392 Tomato Peeled
Crops Primary Equivalent	2511	Wheat	Default composition: 15 Wheat, 16 Flour of Wheat, 18 Macaroni, 20 Bread, 21 Bulgur, 22 Pastry, 23 Starch of Wheat, 41 Breakfast Cereals, 110 Wafers; nutrient data only: 17 Bran of Wheat, 19 Germ of Wheat, 24 Gluten of Wheat, 114 Mixes and Doughs, 115 Food Prep,Flour,Malt Extract
Livestock and Fish Primary	2731	Bovine Meat	Default composition: 867 Cattle meat, 870 Meat-CattleBoneless(Beef and Veal), 872 Meat of Beef,Drd, Sltd,Smkd, 873 Meat Extracts, 874 Sausage Beef and Veal, 875 Preparations of Beef Meat, 876 Beef canned, 877

Equivalent			Homogen.Meat Prp., 947 Buffalo meat
Livestock and Fish Primary Equivalent	2740	Butter, Ghee	Default composition: 886 Butter Cow Milk, 887 Ghee,Butteroil of Cow Milk, 952 Butter of Bufmilk, 953 Ghee Oil of Buf, 983 Butter,Ghee of Sheep Milk, 1022 Butter of Goat Mlk
Livestock and Fish Primary Equivalent	2741	Cheese	
Livestock and Fish Primary Equivalent	2744	Eggs	Default composition: 1062 Hen eggs, in shell, 1063 Eggs Liquid, 1064 Eggs Dried, 1091 Other bird eggs,in shell; nutrient data only: 916 Egg Albumine
Livestock and Fish Primary Equivalent	2738	Milk, Whole	
Livestock and Fish Primary Equivalent	2733	Pig meat	Default composition: 1035 Pig meat, 1038 Pork, 1039 Bacon and Ham, 1041 Sausages of Pig Meat, 1042 Prep of Pig Meat
Livestock and Fish Primary Equivalent	2734	Poultry Meat	Default composition: 1058 Chicken meat, 1060 Fat Liver Prep (Foie Gras), 1061 Meat of Chicken Canned, 1069 Duck meat, 1073 Goose and guinea fowl meat, 1080 Turkey meat

Source: FAO database, metadata, classifications, food balance.

Appendix B - Market analysts and commodity coverage

This is an overview of the market analysts consulted as experts in the study. The market analysts have been consulted to measure the indicator market power and to evaluate the profit impact for the commodities. The market analysts were working in the food and agribusiness research department at the time of the study. These analysts were consulted in personal interviews in May 2012. Name and commodity domain coverage are presented in following table.

Name	**Food & Agribusiness sector**	**Commodity coverage**
Albert Vernooij	Animal Protein	Bovine meat and pig meat
Nan Dirk Mulder	Animal Protein	Poultry meat and Eggs
Vito Matelli	Grains & Grain-based products Oilseeds Complex and Sugar	Olive oil, palm oil, barley, wheat, sunflower (seed, oil, meal), soybean (meal and oil), rapeseed (meal and oil), maize
Francois Sonneville	Food Retail & Consumer behaviour	Apple juice (single strength and concentrated), Orange juices (single strength and concentrated)
Cindy van Rijswick	Fruits & Vegetables	Apples, oranges, tomatoes, olives, bananas, pulses, potatoes, onions
Marina Rebello	Dairy	Milk products (cow milk fresh, butter and cheese)
Maya Conceva	Oilseeds Complex and Sugar	Sugar
Additional and final interview with Harry Smit and Sebastiaan Schreijen	Farm Inputs Food Retail & Consumer behaviour	Rice, cocoa beans, cotton, coffee, tea, pulses

Appendix C - Production quantity per geographic area in 2010

Commodity	Eastern Africa	Middle Africa	Northern Africa	Southern Africa	Western Africa	Northern America	Central America	Caribbean	South America	Central Asia	Eastern Asia	Southern Asia	South-Eastern Asia	Western Asia	Eastern Europe	Northern Europe	Southern Europe	Western Europe	Australia and New Zealand	Melanesia	Micronesia	Polynesia	Total world production
Apple juice, concentrated						0		0	131560	7530		34412	1527	99540	157540	9908	15568	98285	2100				557970
Apple juice, single strength			3899	30550		13300	25835		146050	4550	182000	45991	2149	38061	124600	22953	94013	9372	75000				818323
Apples	11845		1457860	740459		4559007	607845	2290	3449476	1185750	35275971	4330484		3648750	5713345	382276	3922809	3697244	584201				69569612
Bananas	5582191	1999572	1394570	399021	936200	8440	7801902	1888534	17905738		9849065	33084096	18497770	645988			414740		302173	1350609	11690	42520	102114819
Barley	1605719	800	4524463	200685	1300	11530170	673817		3844214	1903699	2846436	5348705	20000	9883734	27598725	13581400	10224006	22087021	7602298				123477192
Cocoa beans	32020	274488			2428537		41909	67107	475645			14030	834282							62131	40	601	4230790
Coffee, green	639621	108224			159900	3580	1026928	86256	3786240		28800	295147	2138338	19029			0			67253		60	8359376
Cotton lint	297257	100500	197120	10574	629810	3941700	159621	344	1267670	1715152	5984600	7748526	87709	739000	300		221230		386800				23487913
Grapes	34770		2434720	1734230		6290340	325307	16700	7165198	1414849	9142155	5032970	93037	5926439	2545940	1000	16996531	7275630	1881650				68311466
Maize	24290440	4316050	7358660	13083313	15207895	327879500	27277478	602788	92160951	1302561	179298287	22397691	37732701	5388800	38422172	47300	25800842	21306152	516812	14678	110		844405181
Olives			3707010			172370	27300		304536	120	2900	47200		2849878			13362712	32960	71200				20578186
Onions, dry	670145	191020	4858700	538452	1314500	3519949	1487641	167620	3989375	1879200	23054537	17989761	2955607	2856733	3759454	516393	2151206	2090559	259947		10		74250809
Orange juice, concentrated			11120	33517		385000	124460	560	987400		5000	12675	2380	4925	0	5513	82700	917					1656167
Orange juice, single strength	3640		107479	28300		291629	177566	1900	1095840		48903	102944	33922	37370	24148	7300	182645	5379	95000				2243965
Oranges	210623	207810	4176217	1459310	695800	7478830	5170850	490542	21758430	1100	5056289	9427950	3270536	3112997	130		6494299	600	401843	570	70	1540	69416336
Potatoes	9627486	1143535	9522840	2189830	984160	22438970	2146159	269514	14321328	6529039	79361547	54660020	2314069	9388474	61488187	10665073	7124196	28195773	1809220	1838		630	324181888
Pulses,Total + (Total)	5841429	1065425	1129079	102085	5354635	7825212	1958427	249350	4406042	294029	4788506	19026660	5386096	1728868	2781890	940556	801391	2019652	1944994	8616			67652942
Rapeseed	40000		45900	32500		12979820	4000		230969	111382	13084410	7174172		106450	8011948	4074222	171135	10820689	2183600				59071197
Rice, paddy	6726891	682478	4403590	3005	11039354	11027000	1262106	1498624	23382492	822904	216042010	188556290	200887445	1019759	1334448		2990200	118500	206000	12334	158		672015588
Soybeans	374757	29232	44542	566000	437115	94955100	216070		132309102	113910	15761049	10072362	1757167	91090	3290687	0	1262136	238579	59600				261578498
Sunflower seed	474656	23500	304464	493750		1308430	3797		2780431	404734	1710000	1027978	662831	1430556	16560246		1574812	1757450	41000				30558635
Tea	620941	6891		1375	130		760		113920		1553767	1515804	457727	239045	370		130			7200			4518060
Tomatoes	1077958	644730	12235440	557707	2720193	13394796	3620093	817429	6533340	3795420	42959190	17978900	1355606	15722895	5930844	200067	13817553	1811683	570483	4010	250	2920	145751507
Wheat	3941997	22941	16484640	1498039	69101	83269400	3689410		25731739	21039645	116296177	126044130	183000	28878494	89291100	26814300	17386312	67657676	22582891	10			650881002
Sugar Raw Centrifugal	3795799	378655	2806000	2719380	418091	7309000	9120409	1875742	48368690	65600	12060000	25452800	12063510	2566234	7297371	1937700	1970000	9897462	4519000	175000			650881002
Cotton lint	297257	100500	197120	10574	629810	3941700	159621	344	1267670	1715152	5984600	7748526	87709	739000	300		221230		386800				154796443
Sunflower oil	161568	7864	87920	256355		344300	4600		1299042	165336	349487	482549	222657	706477	6346294	14873	800154	1347141	19201				23487913

Soybean oil	41840	587	303900	39500	4833	9012800	417068	17976	14580714	8476	9750907	1553837	770009	359268	350130	215400	1145085	1180144	9377				12615818
Palm oil	23868	389800			1725309		764605	41000	1458930		245400		39906510					0		542000			39761851
Rapeseed oil	22200		15936	15400		2984500	532000		73468	22344	6313940	2945624	35	114104	1676010	1341029	240436	5943350	286800				45097422
Olive oil, virgin			380600			4000	2175		21210			1632		383235			2464189	5800	6408				22527176
Cow milk, whole, fresh	11752130	640787	13279730	3538120	2374474	95718800	14246812	1641876	63569806	15541290	46167715	71648927	3376452	20750444	72810863	34480110	24660781	75306472	26033500	66591		3204	3269249
Hen eggs, in shell	330469	39311	923930	483720	867126	5844944	2815176	252849	3945101	461590	27100398	4976377	3334814	1688510	4824577	1117294	2024865	2475532	226300	14859	1453	3830	597608884
Pig meat	407947	152643	1403	322480	354207	12111602	1335673	328635	4888578	246198	54194287	351898	7163577	98499	6639101	3399091	6004442	10896679	382878	80440	1992	8249	63753025
Poultry Meat	503470	118142	2058673	1506985	581696	20799661	3510371	626327	17173643	154597	19446957	4951011	6760480	3545139	6221734	2304747	2963823	4731428	1065342	23513	1004	1738	109370499
Butter	77819	985	181552	14020	28086	789446	37358	3500	212968	26733	233445	4300813	26408	221185	623728	419942	197137	1134180	513000	2042			99050481
Cheese	23349	1237	843735	47916	72871	5510700	245738	20500	1046000	56351	403757	277622	79943	638203	2097875	1271672	1764960	5159584	660200				9044347

Source: FAO production statistics, production quantity stat per area

Appendix D - World total production quantity 1995- 2009

Commodity	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Apples	50082359	56074435	57376196	56541819	57790486	58956191	57493495	55815999	58250987	62674071	62393675	64089664	65462133	69023608	70955209
Bananas	55081371	54320425	60046656	59948992	64754765	63702882	65437754	65808373	68451624	73206041	77140381	83025900	88238512	92292871	95624265
Barley	139850773	153787667	153567189	136563520	127652432	132632706	143345840	135329329	141442285	152786216	137559076	138196304	132983005	154013499	147412740
Cocoa Beans	2950412	3198150	2963001	3270487	2926053	3315395	3169494	3270749	3652067	4021736	4104381	4210278	3960642	4255844	4091673
Coffee	5370465	6056606	5841150	6478406	6647295	7421287	7293256	7761442	7068676	7603158	7249994	7939576	8096940	8308879	8230130
Cotton Lint	19586998	19241806	18990247	18165734	18156453	18455494	20998987	18824197	19444132	24497423	24447150	24478467	25066034	22489067	20946504
Grapes	55340281	58447137	57795204	56400639	60339288	64239226	60765173	61331237	63147024	67547325	66824007	66902574	64924396	66637049	67817843
Maize	515429967	587439124	583686637	613884903	605366407	590788330	613602520	602810176	643234698	726682572	711418731	704701914	787410720	825322057	816684810
Olive Oil	1796919	2805523	2832002	2611240	2557358	2790271	2869782	2636012	3347701	3166169	2769033	3156014	2995555	2901324	3112482
Olives	10193934	15363396	15093806	14455389	14195557	15614585	15470669	15619915	18382820	18001255	15960059	18581732	16983248	18061766	19735617
Onions	39433121	40346266	40223933	44798414	47944009	49742417	51291369	52411604	56179152	61812103	64757980	67545118	72260377	73485630	72650213
Oranges, Mandarines	73965238	75957285	84112097	78662797	81589418	81562865	80320643	82749438	81257895	87984396	86701012	91783906	85775513	90963896	89819320
Palm Oil	15512322	16546995	17857121	17759888	20264823	21665583	24179772	25603717	27997413	29451337	31677904	38557204	39191656	41407274	43207350
Potatoes	285330632	311100852	302694103	300148101	298765534	326683621	310241943	315169153	313483884	335105266	323837088	304448170	321499397	326625241	331448790
Rape and Mustard Cake	17018695	17336278	18580170	18122784	20152738	21001933	19555548	19140374	18060520	21726874	24552335	25727258	26176691	27995903	30523939
Rape and Mustard Oil	10752126	11017661	11734800	11587068	12935693	13510803	12565922	13171304	12537251	15084004	16821734	17963538	17944503	19253839	21309624
Rape and Mustardseed	34666310	30882028	35577017	36321502	43802037	40014315	36316814	34908055	37478506	47344453	50543700	48438932	51790048	58302136	62705238
Rice (Paddy Equivalent)	546281600	567865075	575936985	577996998	610056092	598630704	599055764	570362104	586148434	606863283	633229063	639879106	655609444	687737036	683218256
Soyabean Cake	87492745	89268268	91685993	104507316	106287108	110321001	118688533	122984800	130945528	133631240	143600823	148629291	157443016	153911501	153253892
Soyabean Oil	20013409	20389173	20946876	24188644	24844876	25568485	27588369	28869529	30596055	30460957	33967818	34738898	37143209	36208349	35847828
Soyabeans	126928968	130190388	144341370	160123943	157766241	161277825	178230652	181662285	190635767	205497147	214467105	221899788	219659251	231313424	223133509
Sugar (Raw Equivalent)	118584311	125880398	127423241	129841624	133829389	132126975	133545150	146483448	149276220	145504739	141406838	151595635	164929949	161015409	156548333
Sunflowerseed	26225585	24781108	23333716	25036374	29166520	26476921	20489957	24570167	27485521	26121954	30685382	31756529	26414698	36127419	32533422
Sunflowerseed Cake	10364548	10841248	10523976	10451730	11299134	11162791	9323999	8976060	10355425	11135875	11825233	12582573	12494858	12156056	14020056
Sunflowerseed Oil	8808284	9366041	9183734	8891124	9590221	9811480	8261986	7921764	9337574	9928955	10734863	11659590	11244944	11118164	13023062
Tea	3197791	3246662	3423675	3778535	3929868	3844370	4116460	4122933	4125624	4169856	4410709	4494926	4786106	4945739	4985023
Tomatoes	86437697	92515324	88819154	94859883	107870269	108903108	106478246	114687337	118658341	126419391	126782038	128936121	136072811	140000349	152694893
Wheat	539341776	581566986	609561199	589530956	584287217	583821401	587316330	569456119	554302688	628464843	620348129	597423788	605895304	679228733	680102371
Pulses + (Total)	55806418	53769235	54901771	56080061	57341470	55235388	55563538	57544159	58920757	59496491	60713896	60170428	60722627	61836942	63120843
Bovine Meat	56139210	56526585	57407562	57266905	58414201	58800922	57727766	59282697	59661375	60661329	61919406	63802000	65444901	65680941	66065133
Butter, Ghee	6684388	6676152	6754411	6893592	7128526	7355078	7684281	7994845	8065453	8231157	8478161	8556176	8781722	8840403	8919421
Cheese	14530256	14888244	15174024	15526295	15908579	16482019	16866119	17247502	17489580	18228204	18815491	19368211	19804906	19762879	19974348
Eggs	46615941	49625127	49831419	51470135	53460802	54962399	56161746	57464708	58536987	59748556	61043143	62356107	64237905	66784196	67982683
Milk, Whole	535619074	542125763	545659121	554298057	565120761	573844668	584518153	599365796	610892189	624406801	643254912	661502082	677149316	690774871	697838747
Pigmeat	79210118	79038834	82948841	88561069	89487462	89866581	90922195	93177180	95676999	96682138	99101803	100954810	99863637	103881712	106269147
Poultry Meat	54373850	55915816	59349590	61842493	64896420	68240376	70654262	73459629	74879657	77857697	80396789	82611392	87660683	91901271	93817563

Source: FAO food balance sheet stat, commodity balance.

Appendix E - World total domestic supply quantity 1995 - 2009

Commodity	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Apples	51792025	56263238	57176036	58412673	60397038	60298722	59786034	59271947	60857285	65929904	67904395	68817886	73674109	75552594	76287361
Bananas	54618202	53276629	58193223	59150839	63928601	62980587	63120100	64053323	66438652	71633854	75674649	80891855	85941630	89966013	92081756
Barley	154908993	148245418	143110438	137486516	131864399	133509269	136634792	132956303	141551925	141237460	137670834	142871298	136316838	146410030	140314116
Cocoa Beans	2877412	3208461	3198646	3409446	3193255	3597258	3532799	3591479	3889579	3956195	4407911	4477463	4588967	4642037	4715089
Coffee	5598145	5929956	6179637	6324997	6597563	6708544	7110179	7216681	7224871	7683022	7634174	7783965	8180863	8241661	8024386
Cotton Lint	19366172	19501758	19365300	18114200	18433429	18798880	20591099	18414614	18929716	24432446	23981196	24573774	25121379	23854296	20572116
Grapes	54913352	58573100	57774355	56328869	60366585	64103874	60409670	61059848	62738566	67757255	66742024	67034045	64898862	66744339	67275717
Maize	545143828	572101763	578591612	582459096	596954205	606640140	625602387	635362002	659776565	693537786	705201521	711995647	773117658	753501718	799766797
Olive Oil	2138686	2386619	2516108	2528010	2687432	2816321	2840582	2903180	2984211	3250645	2958972	3146756	3149423	3132778	3301750
Olives	10188380	15317995	15130708	14438661	14216836	15776372	15474606	15718861	18110936	17994567	15792941	18839868	17044872	18178394	19233812
Onions	38814503	40019735	40083429	44343592	47585581	49352300	50943933	51730407	55639654	60819203	63665213	66217255	71660645	72570883	71613614
Oranges, Mandarines	67464465	70312267	77664745	72911783	75180837	75086538	71835902	78640592	77179263	83147558	82776030	88952294	82191164	88985250	88414616
Palm Oil	14336893	14923112	14839455	16551242	17533484	19033614	21150223	23559745	26156557	26000821	28017888	34478746	37229017	36438363	38263844
Potatoes	284472748	300548082	307579643	306194264	303663763	323704926	318474151	318033680	317299511	335312034	326041613	310629900	321731921	329054884	332307102
Rape and Mustard Cake	16943267	16763236	18389333	18519314	20331604	20804998	19100385	18871558	17777647	21418058	23563264	25039247	25719057	27841254	29513121
Rape and Mustard Oil	9927217	10648068	11371914	11297307	12686611	13408165	12427481	12638565	12395108	15009909	15892799	17003906	17282448	19060773	20742686
Rape and Mustardseed	32460115	32808773	34567244	34274237	38614611	40934789	38222572	37322737	36233285	43682074	47972002	50297224	51047753	53908870	61750573
Rice (Paddy Equivalent)	545614707	554810507	560651665	570539359	589389359	589022419	593706455	599461193	600532926	609291906	618146032	631468615	639900038	668233113	674109700
Soyabean Cake	84487564	87838979	90416588	102357262	105150495	110196435	118545015	123665447	128565301	133502809	140038716	147866833	157576333	153937472	152683279
Soyabean Oil	18387471	19618488	20512294	22096424	23661594	24556359	26628404	27743318	29804911	29932981	30359402	31732347	34181235	34266069	34631372
Soyabeans	133207366	135732850	140892397	155950894	159322246	164662112	176432990	182625173	193369036	200074027	212337899	218371250	227590602	237153227	234518506
Sugar (Raw Equivalent)	112575788	117573026	121546817	122723647	121523327	125841173	132185629	136031247	137493839	140628373	141068897	144125439	149099665	154299911	151525290
Sunflowerseed	24376788	25606041	24866023	24694310	26550683	26849991	22865487	22648389	26044345	27198057	29037972	30649611	30181131	31281486	35203995
Sunflowerseed Cake	10137569	10785836	10413786	10363717	11229148	11262541	9673863	9167110	10279406	11115248	11669341	12416366	12362180	12330439	13230244
Sunflowerseed Oil	8340954	8566776	8457526	8917868	8942951	9064713	8710622	8517856	9301153	9534070	10113396	10715919	11098869	10384798	12038858
Tea	3250500	3240727	3298146	3627289	3817717	3638278	3886498	3832402	3851857	3779989	4167319	4295927	4623662	4782290	4713377
Tomatoes	85316187	91119730	88116307	93366441	106470232	107489112	104360074	112809331	116858589	124931708	125156648	126324477	133817877	137859194	151080472
Wheat	555244724	554148624	560195363	570304348	572247386	576247890	586111325	599171367	590641814	605984138	610669637	611343395	605432491	636343498	634601579
Pulses + (Total)	54045191	54329583	54889113	55148007	55450737	54642405	56628520	57455253	58133912	58871334	59674906	59899209	62066397	60395724	62710555
Bovine Meat	55592855	56073538	56871786	57037151	57846983	58017728	57011813	58609055	58964881	59809981	60904151	62503289	64448401	64339401	64722637
Butter, Ghee	6734838	6622714	6659661	6799513	7077274	7306406	7570170	7871811	8091843	8296468	8437462	8706733	8778377	8683598	8862702
Cheese	14281868	14684248	15062577	15279789	15722578	16129582	16636461	17011565	17254437	17858983	18348824	18879863	19514772	19382267	19605580
Eggs	46510175	49604944	49746235	51476148	53357530	54851138	56038216	57321550	58415399	59627613	60917330	62224641	64139199	66462791	67533686
Milk, Whole	534643852	538074693	542508525	552624567	567607107	574734207	580916409	598177880	610939510	623028838	643689307	660947176	675697896	687833545	699175012
Pigmeat	78931049	78850279	82347331	88223054	89665217	90248842	90956986	93173036	95639244	96321764	98494276	100582300	99634932	103839650	106151642
Poultry Meat	53621568	54801760	58463823	60744160	63860824	67171027	69411324	72378564	74232135	76926780	79237189	81992512	86679531	90607493	92029911

Source: FAO food balance sheet stat, commodity balance.

Appendix F - Yield data 2000 - 2010

Commodity	**element**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	***Average***
Apples	Yield (Hg/Ha)	109555	112129	114498	121940	131739	130240	135910	135876	148218	149961	147133	*130654*
Bananas	Yield (Hg/Ha)	148589	154379	154196	153673	161962	170816	172661	181834	196183	197841	213990	*173284*
Barley	Yield (Hg/Ha)	24418	25633	24738	24693	26732	25049	24744	24066	27490	27986	25782	*25576*
Cocoa beans	Yield (Hg/Ha)	4433	4348	4694	4632	4709	4549	5060	4502	4648	4659	4743	*4634*
Coffee, green	Yield (Hg/Ha)	7053	6963	7684	6958	7158	6751	7730	7897	8032	8014	8212	*7496*
Grapes	Yield (Hg/Ha)	88465	83043	83499	85389	91511	91512	91157	89878	93774	91130	94904	*89478*
Maize	Yield (Hg/Ha)	43245	44771	44054	44580	49311	48395	47627	49888	51332	51605	52153	*47906*
Oil palm fruit	Yield (Hg/Ha)	120118	121377	119664	128587	133160	141302	147460	139024	141741	141452	140638	*134048*
Olives	Yield (Hg/Ha)	18711	18388	18537	20912	19676	16535	18578	17737	17924	20915	21895	*19073*
Onions, dry	Yield (Hg/Ha)	175331	176262	179608	179970	189061	185886	183203	192333	197600	200701	199894	*187259*
Oranges	Yield (Hg/Ha)	174288	166920	168362	162597	170320	164742	171525	163415	171160	167354	170943	*168330*
Potatoes	Yield (Hg/Ha)	163171	158135	165123	164635	174918	168053	166009	172753	180357	178934	174327	*169674*
Rapeseed	Yield (Hg/Ha)	15296	15921	15010	15669	18382	18060	17501	17220	18870	19617	18646	*17290*
Rice, paddy	Yield (Hg/Ha)	38904	39477	38705	39531	40384	40943	41304	42401	43706	43240	43736	*41121*
Seed cotton	Yield (Hg/Ha)	16687	17334	17460	17836	20104	20021	20629	22019	21392	20394	21240	*19556*
Soybeans	Yield (Hg/Ha)	21688	23208	23008	22795	22438	23182	23292	24373	23975	22440	25548	*23268*
Sugar beet	Yield (Hg/Ha)	415997	382289	430636	408771	459589	469506	466896	477976	517532	535740	488600	*459412*
Sugar cane	Yield (Hg/Ha)	648335	646448	655445	668037	661627	665328	685955	710112	717316	702742	707719	*679006*
Sugar crops, nes	Yield (Hg/Ha)	67270	67628	66928	74839	73865	76360	79299	74455	73781	75082	78775	*73480*
Sunflower seed	Yield (Hg/Ha)	12526	11486	12582	11708	12093	13275	13113	12338	14326	13479	13226	*12741*
Tea	Yield (Hg/Ha)	12612	12928	13039	13035	13380	13624	13524	13678	14190	14152	14464	*13511*
Tomatoes	Yield (Hg/Ha)	273079	270601	279954	284117	284938	279614	280376	327636	332457	346800	335923	*299590*
Watermelons	Yield (Hg/Ha)	245075	253509	267995	251999	270327	277053	277740	279144	286932	287334	281568	*270789*
Wheat	Yield (Hg/Ha)	27186	27484	26880	26968	29167	28527	28460	28269	30667	30553	29998	*28560*
Pulses,Total + (Total)	Yield (Hg/Ha)	8550	8391	8100	8286	8547	8638	8356	8205	8630	9193	8904	*8527*
Hen eggs, in shell	Yield (100Mg/An)	101815	102191	101105	101116	100218	99337	97777	98372	99277	99771	97789	*99888*
Cow milk, whole, fresh	Yield (Hg/An)	22183	22259	22554	22168	22262	22458	22797	22961	23299	23068	22666	*22607*
Poultry Meat + (Total)	Yield/Carcass Weight (0.1Gr/An)	15783	15792	15892	15911	16154	15960	16182	16169	16398	16433	16522	*16109*
Pig meat	Yield/Carcass Weight (Hg/An)	783	784	786	789	784	786	790	794	793	795	794	*789*
Beef and Buffalo Meat + (Total)	Yield/Carcass Weight (Hg/An)	2004	1996	2014	1988	1999	2017	2040	2061	2050	2045	2053	*2024*

Source: FAO production statistics, crops, yield statistics and livestock primary, yield statistics.

Appendix G – Top 5 countries production 2010 and country risk

	Worldtotal	Poland	Turkey	Argentina	Austria	Brazil	
Apple juice, concentrated	557969	109500	97919	57860	55500	39600	
Share in World production		20%	18%	10%	10%	7%	Weighted average
Country risk		0.22	0.47	0.42	0.07	0.43	**0.21**

	Worldtotal	China	Brazil	Australia	Italy	Ukraine	
Apple juice, single strength	818324	182000	145000	75000	43400	39900	
Share in World production		22%	18%	9%	5%	5%	Weighted average
Country risk		0.49	0.43	0.11	0.29	0.46	**0.23**

	Worldtotal	China	United States of America	Turkey	Italy	India	
Apples	69569612	33265186	4212330	2600000	2204970	2163400	
Share in World production		48%	6%	4%	3%	3%	Weighted average
Country risk		0.49	0.15	0.47	0.29	0.35	**0.28**

	Worldtotal	India	China	Philippines	Ecuador	Brazil	
Bananas	102114819	31897900	9848895	9101340	7931060	6978310	
Share in World production		31%	10%	9%	8%	7%	Weighted average
Country risk		0.35	0.49	0.40	0.57	0.43	**0.27**

	Worldtotal	Germany	France	Ukraine	Russian Federation	Spain	
Barley	123477192	10412100	10102000	8484900	8350020	8156500	
Share in World production		8%	8%	7%	7%	7%	Weighted average
Country risk		0.11	0.19	0.46	0.46	0.23	**0.10**

	Worldtotal	China	Canada	India	Germany	France	
Rapeseed	59071197	13082010	11866200	6410000	5697600	4815520	
Share in World production		22%	20%	11%	10%	8%	Weighted average
Country risk		0.49	0.10	0.35	0.11	0.19	**0.19**

	Worldtotal	China	United States of America	India	Turkey	Egypt	
Tomatoes	145751507	41879684	12902000	11979700	10052000	8544990	
Share in World production		29%	9%	8%	7%	6%	Weighted average
Country risk		0.49	0.15	0.35	0.47	0.51	**0.25**

	Worldtotal	Côte d'Ivoire	Indonesia	Ghana	Nigeria	Cameroon	
Cocoa beans	4230790	1242300	810100	632037	427800	264077	
Share		29%	19%	15%	10%	6%	Weighted average
Country risk		0.66	0.44	0.44	0.61	0.48	**0.44**

	Worldtotal	Brazil	Viet Nam	Indonesia	Colombia	India	
Coffee, green	8359376	2874310	1105700	801000	514128	289600	
Share in World production		34%	13%	10%	6%	3%	Weighted average
Country risk		0.43	0.43	0.44	0.45	0.35	**0.29**

	Worldtotal	China	India	United States of America	Pakistan	Uzbekistan	
Cotton lint	23487913	5970000	5695000	3941700	1948200	1136000	
Share in World production		25%	24%	17%	8%	5%	Weighted average
Country risk		0.49	0.35	0.15	0.53		**0.28**

	World +	United	France	Germany	Italy	Netherlan	

	(Total)	States of America				ds	
Cheese of Whole Cow Milk	16880682	4733660	1755940	1300600	1068900	740000	
Share in World production		28%	10%	8%	6%	4%	Weighted average
Country risk		0.15	0.19	0.11	0.29	0.08	**0.09**

	Worldtotal	China	India	Indonesia	Bangladesh	Viet Nam	
Rice, paddy	672015588	197212010	120620000	66411500	49355000	39988900	
Share in World production		29%	18%	10%	7%	6%	Weighted average
Country risk		0.49	0.35	0.44	0.51	0.43	**0.31**

	Worldtotal	China	Italy	United States of America	Spain	France	
Grapes	68311466	8651831	7787800	6220360	6107200	5848960	
Share in World production		13%	11%	9%	9%	9%	Weighted average
Country risk		0.49	0.29	0.15	0.23	0.19	**0.15**

	Worldtotal	United States of America	China	Brazil	Mexico	Argentina	
Maize	844405181	316165000	177540788	56060400	23301900	22676900	
Share in World production		37%	21%	7%	3%	3%	Weighted average
Country risk		0.15	0.49	0.43	0.37	0.42	**0.21**

	Worldtotal	Spain	Italy	Greece	Morocco	Turkey	
Olives	20578186	8014000	3170700	1809800	1483510	1415000	
Share		39%	15%	9%	7%	7%	Weighted average
Country risk		0.23	0.29	0.33	0.34	0.47	**0.22**

	Worldtotal	China	India	United States of America	Egypt	Iran (Islamic Republic of)	
Onions, dry	74250809	20507759	13372100	3320870	2208080	1922970	
Share in World production		28%	18%	4%	3%	3%	Weighted average
Country risk		0.49	0.35	0.15	0.51	0.50	**0.23**

	Worldtotal	Brazil	United States of America	Spain	Mexico	South Africa	
Orange juice, concentrated	1656168	977000	385000	72250	57600	33517	
Share in World production		59%	23%	4%	3%	2%	Weighted average
Country risk		0.43	0.15	0.23	0.37	0.38	**0.32**

	Worldtotal	Brazil	United States of America	Mexico	Spain	Australia	
Orange juice, single strength	2243965	1090490	291629	160000	112750	95000	
Share in World production		49%	13%	7%	5%	4%	Weighted average
Country risk		0.43	0.15	0.37	0.23	0.11	**0.27**

	Worldtotal	Brazil	United States of America	India	China	Mexico	
Oranges	69416336	19112300	7478830	6268100	5003289	4051630	
Share in World production		28%	11%	9%	7%	6%	Weighted average
Country risk		0.43	0.15	0.35	0.49	0.37	**0.22**

	Worldtotal	Indonesia	Malaysia	Thailand	Nigeria	Colombia

Palm oil	45097422	21534000	16993000	1287510	1086600	800000	
Share in World production		48%	38%	3%	2%	2%	Weighted average
Country risk		0.44	0.32	0.5	0.61	0.45	**0.37**
	Worldtotal	China	India	United States of America	Russian Federation	France	
Wheat	650881002	115180303	80710000	60102600	41507600	38207000	
Share in World production		18%	12%	9%	6%	6%	Weighted average
Country risk		0.49	0.35	0.15	0.46		**0.17**
	Worldtotal	India	Canada	China	Myanmar	Brazil	
Pulses	67652942	17110000	5191500	4470693	4389700	3228150	
Share in World production		25%	8%	7%	6%	5%	Weighted average
Country risk		0.35	0.1	0.49	0.69	0.43	**0.19**
	World + (Total)	China	United States of America	Germany	Spain	Brazil	
Pig meat	109215302	51677264	10185600	5488370	3368920	3078410	
Share in World production		47%	9%	5%	3%	3%	Weighted average
Country risk		0.49	0.15	0.11	0.23	0.43	**0.27**
	World + (Total)	United States of America	Brazil	China	Argentina	India	
Beef and Buffalo Meat + (Total)	65736987	12047200	6977480	6546443	2630160	2549160	
Share in World production		18%	11%	10%	4%	4%	Weighted average
Country risk		0.15	0.43	0.49	0.42	0.35	**0.15**
	World + (Total)	Spain	Italy	Greece	Syrian Arab Republic	Morocco	
Olive oil, virgin	3269249	1487000	548500	352800	177400	169900	
Share in World production		45%	17%	11%	5%	5%	Weighted average
Country risk		0.23	0.29	0.33	0.52	0.34	**0.23**
	World + (Total)	China	Germany	Canada	India	France	
Rapeseed oil	22527177	5320500	2889050	2496400	2284000	1808900	
Share		24%	13%	11%	10%	8%	Weighted average
Country risk		0.49	0.11	0.1	0.35	0.19	**0.19**
	World + (Total)	China	United States of America	Argentina	Brazil	India	
Soybean oil	39761852	9069800	8771500	7000080	6928000	1349300	
Share in World production		23%	22%	18%	17%	3%	Weighted average
Country risk		0.49	0.15	0.42	0.43	0.35	**0.31**
	World + (Total)	Brazil	India	China	United States of America	Thailand	
Sugar Raw Centrifugal	154796443	39872000	20637000	11430000	7215000	6928710	
Share in World production		26%	13%	7%	5%	4%	Weighted average
Country risk		0.43	0.35	0.49	0.15	0.5	**0.22**
	World + (Total)	Ukraine	Russian Federation	Argentina	Turkey	France	
Sunflower oil	12615820	2945510	2619610	1127700	645707	592000	
Share in World production		23%	21%	9%	5%	5%	Weighted average
Country risk		0.46	0.46	0.42	0.47	0.19	**0.27**
		United					

	World + (Total)	States of America	Germany	France	New Zealand	Russian Federation	
Butter Cow Milk	4812675	709425	449479	426500	385000	206830	
Share in World production		15%	9%	9%	8%	4%	Weighted average
Country risk		0.15	0.11	0.19	0.07	0.46	**0.07**

	World + (Total)	United States of America	China	Brazil	Mexico	Russian Federation	
Poultry Meat + (Total)	98089871	19583788	16987035	11142198	2722472	2580400	
Share in World production		20%	17%	11%	3%	3%	Weighted average
Country risk		0.15	0.49	0.43	0.37	0.46	**0.19**

	Worldtotal	United States of America	Brazil	Argentina	China	India	
Soybeans	261578498	90609800	68518700	52677400	15083204	9810000	
Share in World production		35%	26%	20%	6%	4%	Weighted average
Country risk		0.15	0.43	0.42	0.49	0.35	**0.29**

	World + (Total)	United States of America	India	China	Russian Federation	Brazil	
Cow milk, whole, fresh	599438003	87461300	50300000	36036086	31895100	31667600	
Share in World production		15%	8%	6%	5%	5%	Weighted average
Country risk		0.15	0.35	0.49	0.46	0.43	**0.13**

	World + (Total)	China	United States of America	India	Japan	Mexico	
Hen eggs, in shell	63571536	23827390	5411600	3414000	2515000	2381380	
Share in World production		37%	9%	5%	4%	4%	Weighted average
Country risk		0.49	0.15	0.35	0.15	0.37	**0.24**

	Worldtotal	Ukraine	Russian Federation	Argentina	China	France	
Sunflower seed	30558635	6771500	5344820	2220710	1710000	1633110	
Share in World production		22%	17%	7%	6%	5%	Weighted average
Country risk		0.46	0.46	0.42	0.49	0.19	**0.25**

	Worldtotal	China	India	Kenya	Sri Lanka	Turkey	
Tea	4518060	1467467	991180	399000	282300	235000	
Share in World production		32%	22%	9%	6%	5%	Weighted average
Country risk		0.49	0.35	0.45	0.48	0.47	**0.33**

	Worldtotal	China	India	Russian Federation	Ukraine	United States of America	
Potatoes	324181888	74799084	36577300	21140500	18705000	18016200	
Share in World production		23%	11%	7%	6%	6%	Weighted average
Country risk		0.49	0.35	0.46	0.46	0.15	**0.22**

Source: Countries risk index from the Political risk service (PRS), (2010)

Production per country, FAO production stat, production quantity for crops, processed crops, livestock primary and livestock processed (2010)