Is hedging an effective tool to manage revenue risk for Dutch potato and wheat producers on sandy and clayey soil?

The effect of correlated price and yield on the use of futures contracts of Dutch potato and wheat producers

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Specialisation:	Spatial & Regional Economics
Thesis code:	AEP-80433

Preface

This thesis was written as a part of my Master Management and Economics at the University of Wageningen and is the main thesis regarding my specialisation Spatial and regional Economics. Conducting this thesis gave me the opportunity to learn about conducting research in practice and acquire more knowledge about futures markets and options in an agricultural setting.

There are several people who I would like to thank for their help while writing this thesis. First of all I want to thank my supervisors, Dr. Ir. Frans Verhees and Dr. Andres Trujillo-Barrera for their guidance, support and patience during my thesis period. I would like to thank Dr. Ir. Jack Peerlings who made it possible to conduct this thesis in cooperation between the Marketing and Consumer Behaviour group and the Agricultural Economics and Rural Policy group. Also I would like to thank Ir. Ruud van der Meer from LEI for providing yield data which made conducting this thesis possible.
Special thanks to my girlfriend and parents for their support and patience during my thesis period.

Bas Scheepers
Wageningen, June 2014

Summary

Crop prices fluctuate substantially due to inelastic demand and static production. Accordingly agricultural crop producers face revenue risk. The use of futures market contracts might be an appropriate risk management tool. The correlation between price and yield (production) influences the effectiveness of hedging as a risk management tool. Because the correlation between price and yield differs (due to soil differences) per region, it is expected that the effectiveness of hedging also differs per region. The objective of this study was to investigate whether the price yield correlation among Dutch potato and wheat producers differs between regions and to identify the effect this has on the use of futures market contracts as revenue risk management tool.

Soil texture was identified as the potentially biggest plant growth influencing regional factor in the Netherlands. Sand and clay textures were found most different in terms of plant growth characteristics. In order to calculate price yield correlations, average yield data of wheat and potato producers on both sandy and clayey soil was collected from the LEI (Landbouw Economisch Instituut). Market price data was collected by using futures market quotes as proxies for market price.

Pearson correlations were calculated for potato and wheat growers on both sandy and clayey soils. Although correlations found were as expected, none of the correlation coefficients were significant. Testing for significant differences between correlation strengths, using Fishers z-difference test, showed no significant differences between correlations. This might be due to the small sample size. A regression analysis was conducted to measure the impact of yield, soil and crop on market price. The regression model as a whole and the individual predictors were found not significant. Analysis of the variable correlations revealed multicollinearity. Consequently, due to the low sample size, the dataset contains insufficient information to identify the effect of yield, soil and crop on price.

Although no scientific conclusions can be drawn from the empirical part of the study, literature suggests that for farmers it is important to take the price yield correlation into account when using the futures market. If both price and yield risk are present, the combination of yield insurance and hedging is most effective in reducing revenue risk compared to hedging alone. The reduction in risk depends on the level of yield variability and the price yield correlation. Increasing the sample size, by for example using farm data, might result in significant correlations between price and yield. This could provide answers to whether price yield correlation differs between regions of Dutch potato and wheat producers.

Keywords: yield insurance, hedging, potato, wheat, futures market, soil

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Chapter one: Introduction

Supply of agricultural goods fluctuates considerably due to various uncontrolled factors often related to weather, creating yield (output per ha) variability. Demand for food only changes moderately, which results in larger price fluctuations (i.e. price variability: price risk) for agricultural producers compared to other producers that are not subjected to inelastic demand. Moreover, individual production is inelastic (i.e. a farmer's production is fixed during growing season) resulting in increasing revenue risk. In order to ensure financial success it is important for agricultural producers to manage revenue risk. Price variability, yield variability, and relationships between price and yield cause revenue variability (i.e. revenue risk) (Dismuskes and Coble, 2006; Sherrick, 2012). The relationship between price and yield varies per region due to differences in growing conditions (Harwood et al., 1999; Coble et al., 2000). Growing conditions in the Netherlands are affected by the region's soil texture, the most import physical property of soil that cannot be changed (McCauley et al., 2005). Since the Netherlands consist of different soil textures throughout the country, growing conditions and thereby revenue risk differs per region.

Hedging, using the futures market as a risk management tool to compensate or offset the probability of loss from crop price fluctuations, has a potentially large role in farmers level of profit (Dorfman and Karali, 2010). Yet, literature shows that agricultural producers often do not hedge (Collins, 1997; Pannel, 2008). Moreover, farmers do not regard hedging as an important risk management tool (Patrick et al., 1985; Greiner, 2009; Meuwissen et al., 2009). However they do consider price and yield risk as the most important types of risk (Patrick et al., 1985; Blank et al., 1997; Harwood et al., 1999; Meuwissen et al., 2001).

The fact that hedge ratios tend to be lower in areas with negative correlated price and yield (as shown by for example: Harwood et al. (1999) and Coble et al. (2000), might be due to the effect of a natural hedge. Coble et al. (2000) states "When price and yield move inversely, a producer can expect higher prices in a low yield year and vice versa. By hedging, price is locked into a particular level (ignoring basis risk). Thus, the natural hedge is eliminated." Conversely, in the case of weaker (or even positive) correlated price and yield, high yields and high prices or low yield and low prices are more likely to occur. In this case, the use of futures contracts decreases price risk (locking price into a particular level: fixed price) and in doing so reduce revenue variability.

Since hedging effectiveness (risk reducing role of the futures contract) is dependent on the correlation between price and yield, which varies per location (e.g. major production areas are likely to have more negative correlated price and yield) (Harwood et al., 1999; Coble et al., 2000), it is expected that hedging is not equal effective for all Dutch farmers regarding their location.

The inverse relationship between market price and farm yield exists when a farmer is situated in a major production area of a certain crop. Individual farm yields move together (same growing conditions) and are therefore positively correlated with aggregated supply. Since the aggregated supply of this major production area influences market price, the farmer has negative correlated price and yield (i.e. natural hedge). Harwood et al. (1999) found that the strength of the relationship between farm yield and market prices tends to be stronger in the major production areas. The natural hedge outside major production areas is much weaker.

This indicates that low yield and low prices (or high yields and high prices) are more likely to occur simultaneously. If production is less geographically concentrated, it is also more likely to find lower price yield correlations and weaker natural hedges (Harwood et al., 1999).
Since the correlation between price and yield varies per region and soil texture is the most influential soil property which affects growing conditions, it is expected that this correlation effect between price and yield is dependent on soil texture.

The study investigates whether the price yield correlation among Dutch potato and wheat producers differs between regions and the effect this has on the use of futures market contracts as revenue risk management tool.

Chapter two: Background information

This chapter provides existing research on the use of futures market contracts as a risk management tool and the influence of price yield correlation and yield variability on hedging. Furthermore the impact of soil on the price yield correlation, the market influence of Dutch potato and wheat producers, and the use of futures market quotes as proxy for market prices are explained. Finally, existing research on farmers' low hedging is provided.

2.1 The effect of correlated price and yield for agricultural producers

Food demand changes only moderately, which makes food demand inelastic. Food supply however fluctuates considerably since supply is dependent on several uncontrolled factors often related to weather. This results in high prices when aggregated production is low since consumers bid up the price, and low prices when production is high since the market is only cleared at low prices because of abundance of supply.

Farm yield differs each year, and tends to move in the same direction as the aggregated yield of a production area (i.e. positively correlated farm and aggregate yield) since all farmers in the region are affected by the same factors. Whether this aggregated area's yield influences price depends on the productions area. Changes in yield that affect aggregated (total market) supply (i.e. major production areas) can impact market prices. Farmers outside major production area are less likely to impact world prices.

The correlation between price and yield can be calculated by using the Pearson correlation coefficient (r) expressed in equation (1).

$$r(P,Y) = \frac{cov\ (P,Y)}{s_p\ s_y} \tag{1}$$

A distinction can be made between three different correlation outcomes between market price (P) and yield per hectare at the farm level (Y). The existence of a negative correlation ($-1 \leq r < 0$) between P and Y (r=Pearson correlation coefficient) meaning price and yield move in opposite direction, non-correlated P and Y (r=0) and positive correlated P and Y ($0 < r \leq 1$) where price and yield move in the same direction.

Negative correlated price and yield ($-1 \leq r < 0$)

Farms located in major production areas of a certain crop (e.g. corn producers located in the corn belt) find their yield positively correlated with yields of that specific production region (due to similar growing conditions). Regional yield is positively correlated with national yield (in major production area of that particular crop) and therefore farmers in major production areas find their yield negatively correlated with price (Harwood et al., 1999, Cooper, 2009).

This negative correlation between price and yield is also referred to as a natural hedge. A natural hedge decreases the variability of farmers' revenue resulting in decreasing revenue risk. The more negative this correlation, the higher the probability of low market prices and high yield at the farm level occurring simultaneously. A negative correlation exists if growing conditions are similar to growing conditions of a major production area.

If a farmer is not located in a major production area, hence the area's limited yield: the area does not influence market price, the magnitude of the negative correlation between price and yield is substantial lower.

Positive correlated price and yield ($0<r\leq1$)

A positive correlation could exist if growing conditions deviate from growing conditions in the major production area of a crop. Cooper (2009) found positive correlations between county yield and national price of corn for counties far removed from the corn belt in the US.

Kimura et al. (2010), for example, found positive correlations between yield and price for wheat at the individual farm level and the aggregate level in Estonia and Italy, negative correlations were found for Australia, Germany and the United Kingdom.

Consider for example a major producing area of a certain crop, which has rich soils that could potentially hold large amounts of water. Agricultural crop producers that are situated outside the major production area in an area which consists of a different kind of soil, for example a soil that does not possess the ability to hold large amounts of water (dry land), could find their yield positively correlated with market price.
If there would be excessive rainfall during growing season, the major production area's aggregated yield would be less than in a year without excessive rainfall. Producers outside the major production area, on soils that do not hold water, may have high yield due to the soils ability to drain excess water.
Due to the lower aggregated yield of the major production area, price would rise. Producers in the major production area would find their yield negatively correlated with market price. On the other hand, producers on dry land outside the major production area would have their yield positively correlated with price due to their relatively high yield and low market price.

Non correlated price and yield ($r=0$)

Market prices are non-correlated with farm yields if crop market prices are fully integrated. That is, a specific region has no influence on aggregated supply. For example the production is geographically spread (different growing conditions; no major production area). Individual farm yield is therefore not correlated with aggregated yield and as a result not correlated with market price.

2.2 Impact of price-yield correlation on farmers' revenue

The correlation affects agricultural producers' revenue. In general, revenue (R) per hectare can be calculated by multiplying price (P) (market price of the produced commodity) with quantity per hectare (Y). However the existence of a correlation effect between price and yield can influence farmers' revenue.

Since price and yield are expected to be correlated, expected revenue cannot be calculated by simply multiplying price with quantity because of the correlation effect. In order to define the influence of price-yield correlations the impact on revenue is examined. Cooper (2009) uses a formula for the expected value product of two correlated random variables given (Mood and Graybill, 1963). The expected revenue or mean revenue (R) per hectare is defined as:

$$E[R] = E\ [P] \cdot E[Y] + COV\ (P,Y) \tag{2}$$

E[P] is the expected value of P, E[Y] is the expected value of Y. The statistical relationship between P and Y is expressed in COV (P,Y) which is equal to the correlation (P,Y) times the standard deviation of P times the standard deviation of Y as expressed in equation (3).

$$COV\ (P,Y) = \boldsymbol{r}_{p,y}\ \boldsymbol{s}_p\ \boldsymbol{s}_y \tag{3}$$

Equation (2) shows the effect of correlation between yield per hectare (Y) and prices (P) on revenue. A negative correlation (P,Y) results in lower expected mean revenue. The expected revenue decreases the more negative the value of the COV (P,Y), ceteris paribus. However, the correlation effect not only affects the mean value but also the variability of revenue; negative correlated price and yield also reduce revenue variability (i.e. revenue risk) (Sherrick, 2012). Goodman (1960) shows that the more negative the correlation (P,Y) the more variability of revenue decreases (Cooper, 2009).

Due to the correlation effect, expected revenue will be lower (higher) in case of a negative (positive) correlation (Mood and Graybill, 1963). In the case of a negative correlation between price and yield a natural hedge exists. As a result revenue is locked into a particular level; in case of a bad harvest prices rise while yield drops (and vice versa in case of a bumper harvest) which stabilizes revenues (Harwood et al. 1999). Consequently, revenue risk will be lower the more negative the price yield correlation (Sherrick, 2012). In the existence of a natural hedge price-risks are managed through this decreasing variability of revenue. In case of a positive correlation between price and yield, high (low) prices corresponding to high (low) yields, revenue variability (i.e. revenue risk) is larger since there is no natural hedge effect.

2.3 Hedging under the existence of correlated price and yield

Futures market contracts can play a crucial role by compensating or offsetting price risk and by doing so stabilizing revenue. Xing and Pietola (2005) suggest that the correlation coefficient between yield and price plays a crucial role in the optimal hedge ratio (i.e. ratio comparing the value of the purchased futures market contract to the expected value of the cash crop). Coble et al. (2000) state that hedging under the existence of a negative correlation between price and yield eliminates the natural hedge. Also Xing and Pietola (2005) show that the risk reducing role of futures contracts is weakened due to the negative correlation between prices and yield.

In the case of strong negatively correlated price and yield, hedging will reduce price risk and maximize revenue under decreasing prices (i.e. prices are fixed: price risk is offset, if yield increases; revenue increases). However if yield is low, due to the negative correlation, price is relatively high. Since price is locked onto a particular level by the futures contract, price is fixed, the effect of the natural hedge is compromised. Since yield is lower and price is locked, revenue will be even lower as a consequence of the hedge. In production areas where price and yield are highly negatively correlated the use of futures market contracts as risk management tool is not effective in reducing revenue risk.

In the case of non-correlated or positively correlated price and yield, using futures contracts is useful to decrease risk. Hedging can minimize price risk by locking price. Farmers with positive correlated price and yield will experience low prices when yield will be low. When futures market contracts are used, price is locked onto a particular level, revenue will be higher due to the hedge. In the case of high prices and high yields, hedging will decrease revenue however also decrease variability of revenue and thereby revenue risk.

Thus the risk reducing role of the futures contract (i.e. hedging effectiveness) is influenced by the price-yield correlation (Xing and Pietola, 2005; Lapan and Moschini, 1994; Harwood et al., 1999; Coble et al., 2000).

2.4 The impact of yield variability on hedging

An agricultural crop producer, with a growing crop in the field, is also subjected to yield risk. Coble et al. (2000) find that optimal hedge ratios are relatively low in areas of high yield variability. The optimal hedge ratio decreases as yield variability increases (Xing and Pietola, 2005; Lapan and Moschini, 1994). This can be explained by the uncertainty about crop output (i.e. yield variability) a farmer has during production. If the hedged quantity is not produced, the producer cannot cover the hedge (i.e. the producer cannot deliver the specified amount (quantity) as committed to in the futures contract). When yield variability is present the optimal hedge ratio is less than the expected output.

Yield variability tends to be low in irrigated areas and in areas where soil is deep and rainfall is dependable. In corn belt states, for example, yield variability is low because climate and soil provide almost perfect conditions for corn production. Production areas which use irrigation facilities, for example Nebraska, also have low yield variability. Corn production areas far removed from the central corn belt generally have higher yield variability as do production areas with low corn acreage. The variability of yield for a certain crop is dependent on soil, climate, weather and the use of irrigation. Since these variables differ per region, the variability of yield and thereby yield risk differs geographically (Harwood et al., 1999).

2.5 Hedging under the existence of correlated price and yield, and yield variability

If both price and yield risk is present, a farmer's choice for risk management instruments is more complicated. Harwood et al. (1999) show that, by comparing four regions in the US with different yield variabilities and different yield-price correlations, hedging modestly reduced revenue variability compared to not using a risk management strategy. The impact, however, varies greatly between the different areas. In general crop-yield insurance (i.e. paying a fee to mitigate yield risk) is more effective in reducing risk among the four tested regions. However, in areas that have low yield variability (e.g. due to the use of irrigation facilities) crop insurance hardly reduces any risk and hedging is more effective in reducing revenue risk. "In the other locations, crop insurance has an advantage over forward pricing because farm-level yields are generally more variable then crop prices." (Harwood et al., 1999).

For areas that have low yield variability and weak yield-price correlation hedging greatly reduces revenue risk. In this case of low yield variability, yield is stable and only price risk has to be managed in order to manage revenue risk. Because there is in addition to the low yield variability also a weak yield-price correlation present, the futures market can be used to decrease price risk (locking price on a certain level: fixed price). The low yield variability makes it possible to hedge an optimal amount (optimal hedge ratio). As a result the combination of the low yield variability and the use of futures market contracts under low price-yield correlation stabilizes revenue (i.e. reduced revenue risk).

If on the other hand a strong negative correlation between price and yield or yield variability that exceeds price variability is present, hedging is prevented to greatly reduce risk (Harwood et al. 2009). Yield risk prevents a farmer from optimally using futures contracts: since output is uncertain hedge ratio's will be lower. When crop insurance is combined with an optimal hedge, the reduction in risk is much more effective than the use of insurance or hedging alone. "By protecting both yield and price, the combined use of both tools is very effective, particularly in areas with a weak price yield correlation and high yield variability." (Harwood et al., 1999)

The effectiveness of hedging and crop insurance on farms that have different price yield correlations and yield variabilities is shown in table 1. On the horizontal axis, the yield variability increases from the left to the right side of the table. The vertical axis shows the price yield correlation increasing downwards. The probabilities of revenue falling below 75 per cent of expectations are expressed in the table. One can see that the higher the yield variability (left to right) the more the crop insurance (crop insurance at the 75 per cent yield coverage level; MPCI in table) reduces the chance of revenue falling below the 75 per cent of expectations in comparison with no risk management strategy.
In contrast the added risk reducing effect of hedging combined with crop insurance is, however reducing risk in all categories compared to crop insurance alone, diminishing as the yield variation increases. Harwood et al. (1999) conclude, "Thus, the effects of changes in yield variability or price yield correlation on the total risk reduction obtained from insurance and hedging can differ substantially for farmers in different situations."

Table 1. Effect of futures hedges and crop insurance on the probability on returns of less than 75 per cent of expectations

		Yield correlation of variation (standard deviation/mean)				
Price-yield correlation	Risk strategy	0.1	0.2	0.3	0.4	0.5
0	None	0.14	0.19	0.21	0.24	0.25
	MPCI	.12	.15	.18	.18	.20
	MPCI +hedge	.06	.08	.12	.14	.18
-0.1	None	.14	.17	.20	.22	.25
	MPCI	.12	.14	.15	.17	.18
	MPCI +hedge	.06	.06	.11	.15	.17
-0.2	None	.13	.17	.20	.21	.24
	MPCI	.11	.13	.14	.16	.17
	MPCI +hedge	.06	.06	.10	.14	.16
-0.3	None	.13	.15	.19	.20	.23
	MPCI	.11	.12	.13	.14	.16
	MPCI +hedge	.06	.06	.10	.13	.14
-0.4	None	.12	.15	.18	.19	.22
	MPCI	.10	.11	.10	.13	.14
	MPCI +hedge	.06	.07	.10	.11	.13
-0.5	None	.11	.14	.17	.19	.20
	MPCI	.10	.10	.09	.12	.13
	MPCI +hedge	.06	.07	.08	.10	.11

Source: Harwood et al. (1999)

Thus in addition to the correlation effect between price and yield also yield variability plays a crucial role in the risk reducing role of the futures market contract. The reduction in risk by using futures market contracts depends on the price-yield correlation and the yield variability a farmer is subjected to.

2.6 Why hedging is not always effective in stabilizing revenue: a numerical example

If we consider the following hypothetical example; a farmer that has an excepted yield of 40.000 kg and the futures price for this crop is 0.15 per kg. The correlation (P,Y) is one (perfect positive correlation) meaning an increase in price corresponds to the same percentage increase in yield. There are two possible situations shown; an increase in price corresponding to an increase in yield, and a price decrease corresponding to a decrease in yield. For simplicity reasons, there are no fees attached to the use of the futures market. The agricultural producer uses a direct hedge against price risks, the farmer uses the futures market by going short (i.e. selling a futures contract to deliver a pre-specified amount for a pre-specified price at harvest) and offsetting at maturity, resulting in a win or loss in the futures market compensating a win or loss in the spot market.

Table 2a shows that a farmer with positive correlated price and yield, the un-hedged standard deviation of revenue is larger than the hedged standard deviation of revenue. This because the hedge causes the reduction in revenue variability. Even though in situation two (price decrease) the hedged amount is not reached due to the yield variability of 15 per cent, the farmer has to go long (buy) 6,000 kg to fulfil the pre-specified output of the futures market contract of 40,000 kg, the variance of revenue (or standard deviation) is still lower in the hedged position compared to the un-hedged position. More specifically: by using the futures market under the existence of positive correlated price and yield the revenue risk (variance) is smaller than without using futures market contracts. If a farmer is risk-averse, the hedged position is preferred because of a decrease in the standard deviation of revenue.

Table 2a. The effects of hedging with perfect positive correlated prices and yield, yield variability (15 per cent)

	Situation one: Price increase	Situation two: Price decrease
Expected Yield (kg)	40,000	40,000
Hedge price	0.15	0.15
Actual price	0.1725 (up 15%)	0.1275 (down 15%)
Yield	46,000 (up 15%)	34,000 (down 15%)
Total Revenue Un-hedged	46,000*0.1725=7935	34,000*0.1275=4335
Revenue Hedging	40,000*(0.15-0.1725)=-900	40,000*(0.15-0.1275)- (40,000-34,000)*0.1275=135
Total Revenue Hedged	7935-900=7035	4335+135=4470
Mean Revenue Un-hedged	(7935+4335)/2=6135	
Mean Revenue Hedged	(7035+4470)/2=5752.5	
SD Revenue Un-hedged	$\sqrt{((((7935-6135)^2+(4335-6135)^2)/2))}=1800$	
SD Revenue Hedged	$\sqrt{((((7035-5752.5)^2+(4470-5752.5)^2)/2))}=1282.5$	
Spread Total Revenue Un-hedged	7935-4335=3600	
Spread Total Revenue Hedged	7035-4470=2565	

In table 2b, the farmer is facing the same decision however now with a perfect negative correlation (P,Y) of minus one, meaning that a decrease in price corresponds to the same percentage increase in yield (perfect natural hedge).

The example, illustrated in table 2b, shows that in the case of a negative correlation between prices and yield (natural hedge), the hedged standard deviation of revenue is larger than the un-hedged standard deviation of revenue. By using the futures market the effect of the natural hedge is eliminated. The farmer hedges 40,000 kg while in situation one (price increase) the yield drops 15 per cent, the farmer is left with 6,000 kg output shortage. The farmer has to go long, (buy) 6,000 kg, in order to fulfil the futures contract. Since price is also higher, the revenue of the hedge decreases further. In situation two the hedge increases revenue by compensating the price decrease. However, overall the hedge eliminates the effect the natural hedge has on revenue. The un-hedged position has higher mean revenue and lower revenue variability, which makes hedging very adverse in this specific example.

Table 2b. The effects of hedging with perfect negative correlated prices and yield, yield variability (15 per cent)

	Situation one: Price increase	Situation two: Price decrease
Expected Yield	40,000	40,000
Hedge price	0.15	0.15
Actual price	0.1725 (up 15%)	0.1275 (down 15%)
Yield	34,000 (down 15%)	46,000 (up 15%)
Total Revenue Un-hedged	34,000*0.1725=5865	46,000*0.1275=5865
Revenue Hedging	40,000*(0.15-0.1725)-(40,000-34,000)*0.1725=-1935	40,000*(0.15-0.1275)=900
Total Revenue Hedged	5865-1935=3930	5865+900=6765
Mean Revenue Un-hedged	(5865+5865)/2=5865	
Mean Revenue Hedged	(6765+3930)/2=5347.5	
SD Revenue Un-hedged	$\sqrt{((((5865-5865)^2+(5865-5865)^2)/2))}=0$	
SD Revenue Hedged	$\sqrt{((((3930-5347.5)^2+(6765-5347.5)^2)/2))}=1417.5$	
Spread Total Revenue Un-hedged	5865-5865=0	
Spread Total Revenue Hedged	6765-3930=2835	

In table 3a, the same farmer now uses crop insurance, which means that the farmer is compensated if the yield drops below the ensured level (for simplicity assume 100 per cent yield coverage level, no cost attached). In this situation, revenue risk is reduced even further than in the situation without yield insurance. Because the farmer now uses the yield insurance to compensate yield variability, mean revenue is higher and also revenue variability is lower.

Table 3a. The effects of hedging with perfect positive correlated prices and yield, yield variability (15 per cent) and yield insurance

	Situation one: Price increase	Situation two: Price decrease
Expected Yield (kg)	40,000	40,000
Hedge price	0.15	0.15
Actual price	0.1725 (up 15%)	0.1275 (down 15%)
Yield	46,000 (up 15%)	34,000 (down 15%)
Total Revenue Un-hedged	46,000*0.1725=7935	34,000*0.1275 + 6,000*0.1275 = 5100
Revenue Hedging	40,000*(0.15-0.1725)=-900	40,000*(0.15-0.1275)=900
Total Revenue Hedged	7935-900=7035	5100+900=6000
Mean Revenue Un-hedged	(7935+5100)/2=6517.5	
Mean Revenue Hedged	(7035+6000)/2=6517.5	
SD Revenue Un-hedged	$\sqrt{(((7935-6517.5)^2+((5100-6517.5)^2))/2)}=1417.5$	
SD Revenue Hedged	$\sqrt{(((7035-6517.5)^2+((6000-6517.5)^2))/2)}=517.5$	
Spread Total Revenue Un-hedged	7935-5100=2835	
Spread Total Revenue Hedged	7035-6000=1035	

Table 3b. The effects of hedging with perfect negative correlated prices and yield, yield variability (15 per cent), and yield insurance

	Situation one: Price increase	Situation two: Price decrease
Expected Yield (kg)	40,000	40,000
Hedge price	0.15	0.15
Actual price	0.1725 (up 15%)	0.1275 (down 15%)
Yield	34,000 (down 15%)	46,000 (up 15%)
Total Revenue Un-hedged	34,000*0.1725 + 6,000*0.1725 = 6900	46,000*0.1275=5865
Revenue Hedging	40,000*(0.15-0.1725)=-900	40,000*(0.15-0.1275)=900
Total Revenue Hedged	6900-900=6000	5865+900=6765
Mean Revenue Un-hedged	(6900+5865)/2=6382.5	
Mean Revenue Hedged	(6000+6765)/2=6382.5	
SD Revenue Un-hedged	$\sqrt{((((6900-6382.5)^2+(5865-6382.5)^2)/2))}=517.5$	
SD Revenue Hedged	$\sqrt{((((6000-6382.5)^2+(6765-6382.5)^2)/2))}=382.5$	
Spread Total Revenue Un-hedged	6900-5865=1035	
Spread Total Revenue Hedged	6765-6000=165	

In table 3b, the same farmer again uses yield insurance however now subjected to perfect negative price yield correlation. In this situation, the revenue risk (variance or standard deviation) is higher than in table 2b without hedging. However mean revenue is higher when using yield insurance and a futures market contract combined, the revenue variability increases; while mean revenue rises from 5865 in un-hedged and un-insured position to 6385.5 under yield insurance and futures market contract, the standard deviation increases from 0 (perfect natural hedge) to 382.5.

Farmers preferences for increasing mean revenue over decreasing the variability of revenues depends on the extent to which they are willing to take risk (increasing the variability of revenues) for a reward (higher mean revenue) which defines their risk attitude.

2.7 The influence of Dutch potato and wheat growers on market price

According to macroeconomic theory, market prices are determined through excess supply and demand. If a country has excess supply, that is national production is higher than demand, the country influences market supply. If the proportion of this excess supply is large in comparison to total market supply, the country's aggregated yield could influence prices.

Despite the relative small size of the Netherlands (33,803 km²)[1], the Netherlands is one of the largest exporting countries of agricultural commodities. In terms of production (see figure 1), the Netherlands is the tenth largest (7,333,472 tons) producer of potatoes. Countries as China (88,350,220 tons), India (42,339,200 tons), USA (19,488,460 tons) have much larger production.

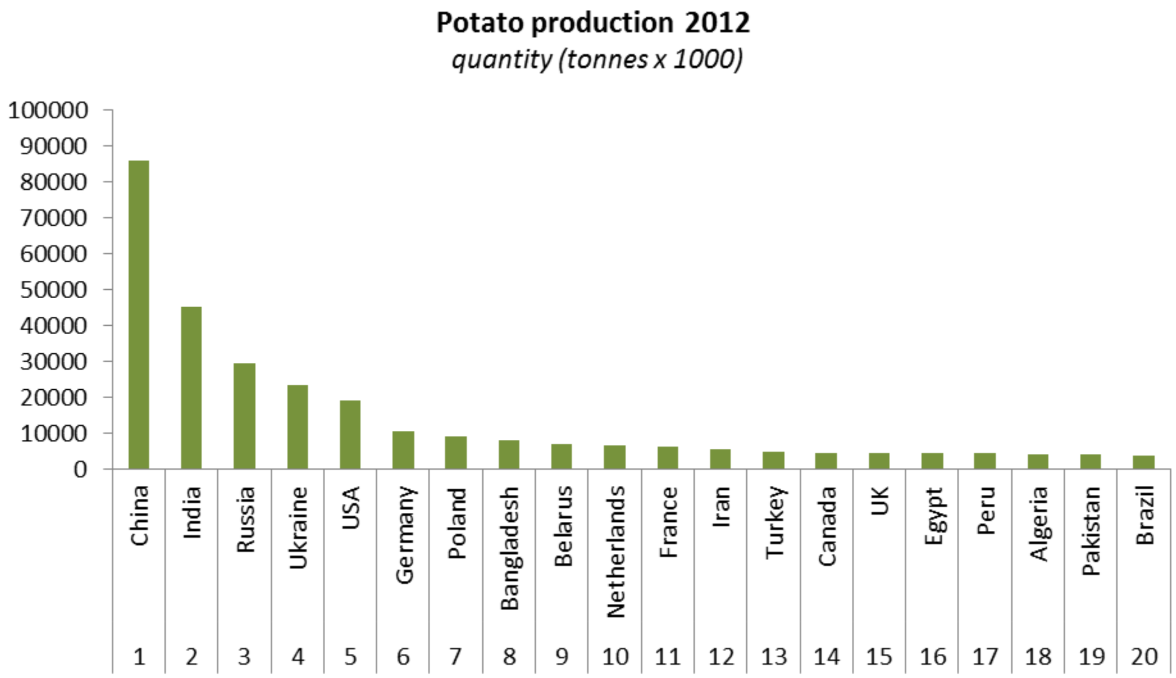

Figure 1. Potato production 2012
Source: FAO

However, the Netherlands is after France the biggest exporter (see figure 2). The much higher population in countries as China, India, USA might explain why these countries export much less of their production.

[1] Source: CBS 2013 data

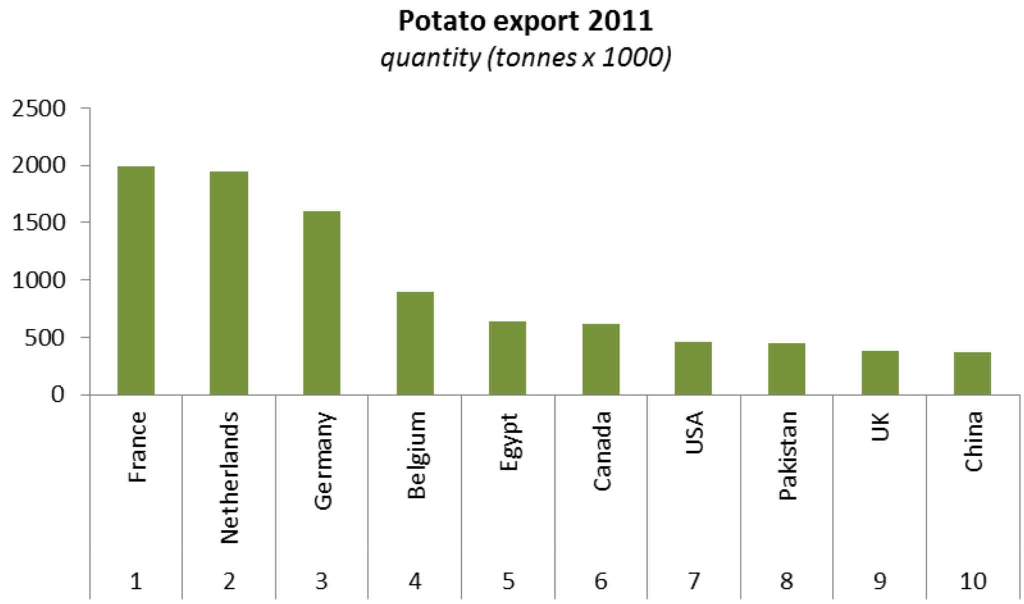

Figure 2. Potato export 2011
Source: FAO

In terms of wheat production, the Netherlands is ranked 46th worldwide. Furthermore the Netherlands is only 27th on the worlds rank of biggest wheat exporting countries.

Due to the introduction of barrier free trade within the European Union for agricultural products (introduced by the Comman Agricultural Policy), national agricultural markets are fully integrated into a single European market. The European market is however not fully integrated with the World market. Although the European Union is engaged in a series of WTO (World Trade Organisation) negotiations wich led to massive reductions of tariffs for trade, agricultural (and primary factured goods) tariffs and subsidies were maintained to protect products from the EU from competition (Gubb, 2007).

Considering the influence of Dutch potato and wheat growers on the European potato and wheat market, the production and export of the Netherlands compared to other EU member states is important.

Within the EU, Dutch wheat export only ranks 13th while production ranks 16th [2]. Accordingly, Dutch wheat producers are expected to have no influence on the European market due to the low production and export of the Netherlands compared to other countries. Within Europe the major producers are France, Germany and the United Kingdom. These countries are also the highest exporters within the EU[2].

In terms of EU potato production, the Netherlands is after Germany and Poland the biggest producer. After France the Netherlands has the highest potato exports. Because the Netherlands also import potato, the net export of the Netherlands is important to outline the influence of Dutch potato growers on market price. That is, exports adjusted for the influence of imports. In terms of import the Netherlands ranks second on the world's list of biggest potato importing country (see figure 3). The Netherlands mainly import from Germany and

[2] Source: Fao 2012

Belgium[1]. The largest part (approximately 65-70% of all fresh potato imports) however is destined for processing (table 4).

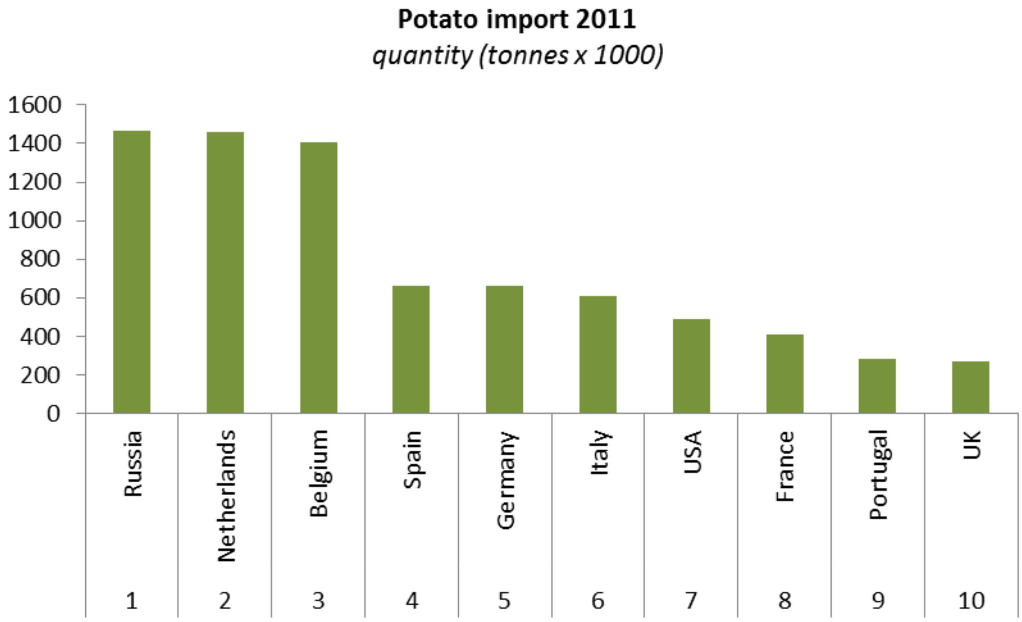

Figure 3: Potato import 2011
Source: FAO

Table 4. Process Potato (in 1000 ton)

	2009	2010	2011	2012
January	267.6	275.5	290.8	283.6
February	273.2	271.2	281.7	286.0
March	286.8	289.2	300.7	312.8
April	301.5	281.3	300.6	301.0
May	280.2	273.1	286.3	302.5
June	295.3	292.9	273.2	293.5
July	262.5	254.1	236.8	260.8
August	280.2	278.0	338.8	335.1
September	291.8	286.5	295.6	299.6
October	294.4	305.4	297.8	320.0
November	262.6	294.0	288.7	305.5
December	267.6	287.8	284.6	263.6
Total	**3363.7**	**3389.0**	**3475.6**	**3564.0**
Of which import	1027.60	1085.20	1074.1	1226.0
share import	30.6 %	32.0 %	30.9 %	34.4 %
Of which Dutch production	69.4 %	68.0 %	69.1 %	63.6 %

Source: Aardappelinfo.nl

Since the Netherlands is the second largest exporter of potatoes within the EU, and the large import of the Netherlands is mostly destined for production, it is expected that the yield of Dutch potato growers influences market price.

2.8 Influence of soil on production

Soil consists of minerals, soil organic matter, water and air (see figure 4). The physical properties (structure, texture and porosity), which affect air and water movement in the soil, are mostly influenced by the size of the soil components relative to each other (McCauley et al., 2005).

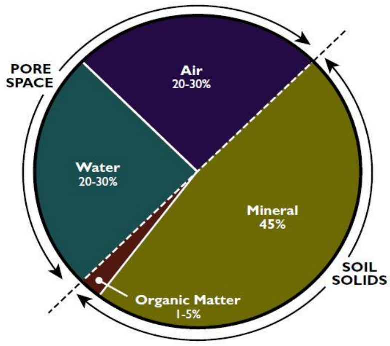

Figure 4. Soil components
Source: McCauley et al., 2005

Texture, which is considered one of the most important physical properties due to the effect it can have on other properties, is defined as the proportion of the particles sand, silt and clay (see figure 5). These particles can be distinguished by their size. While sand-particles are between 0,05-2 mm, silt-particles are smaller (0,002-0,05 mm) and clay-particles are the smallest (<0,002) (Locher and Bakker (1990), McCauley et al., 2005). Note that in figure 5 loam is pointed out as a solid consisting of 25% clay and 40% silt.

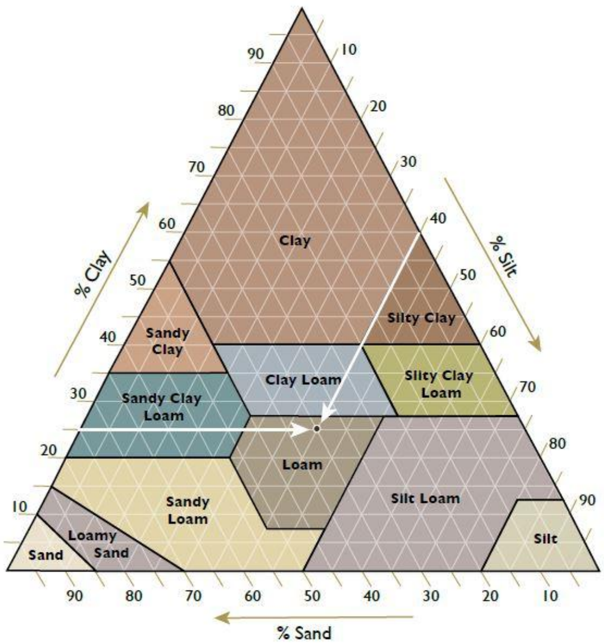

Figure 5. Textural triangle
Source: McCauley et al., 2005

Texture originates from weathering of rocks and minerals. The texture of a soil cannot be altered due to the slow process of weathering which makes the texture of a soil fairly constant.

The structure of the soil exists of so-called aggregates or peds which are the arrangement and binding together of soil particles into large clusters. Soil aggregation is important for improving the soil's fertility for numerous reasons for example by holding valuable nutrients, preserving level of porosity and stability against erosion.
The air or water filled spaces between particles are called pores. The structure and texture of soil influence the porosity of the soil. The structure and texture of a soil determine the size, number and interconnection of the pores. There can be a distinction made between macro and micro pores. Macro pores exists between aggregates while micro pores exist within peds. In contrast to fine-textured soils (more smaller particles), which are more tightly arranged and consist of more small micro pores within arrogates and macro pores between aggregates, coarse-textured soils (more larger particles) have many large macro pores due to the loose arrangement of the particles. Contrary to texture, porosity and structure are not constant and can be changed by cultivation. Water and air movement in the soil are directly affected by texture, and the properties it influences such as porosity. Plant water use and growth are primarily based on texture. If a soil contains high amount of macro pores (coarse-textured soil e.g. sand) a lot of water is lost due to gravitation which can lead to drought stress for the plant during dry periods. If a soil mainly consist of micro pores (fine-textured soil e.g. clay) water is retained within these pores (i.e. not affected by gravity). In figure 6 the difference in pores between a sandy and clayey soil can be seen. Due to the fact that fine-textured soils hold more water, they can be subjected to poor aeration and subsequently anaerobic environment which negatively affects plant growth. (McCauley et al., 2005)

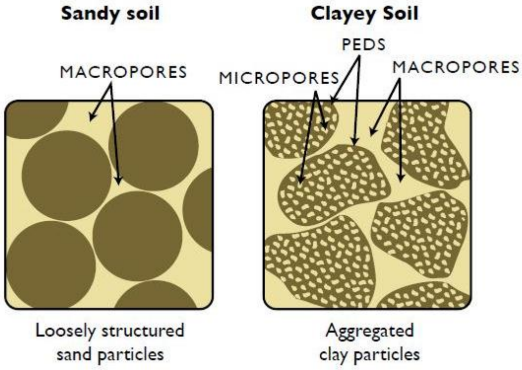

Figure 6. Generalized porosity in sandy and clayey soils
Source: McCauley et al., 2005

Chemical properties of a soil can be altered by using pesticides or adding nutrients, which are available for all Dutch farmers. By doing so the optimal nutritional balance can be achieved to maximize plant growth. The non-changeability of the texture of a soil makes it the only yield influencing factor between regions in the Netherlands.

2.9 Effect of soil and market influence on price yield correlations

Agricultural production is spread throughout the Netherlands. Since Dutch soils are very heterogeneous and vary throughout the country, as can be seen in figure 7, farmers are subjected to different growing conditions depending on their region's soil texture (Rottink, 2007; Remmelink et al. 2012).

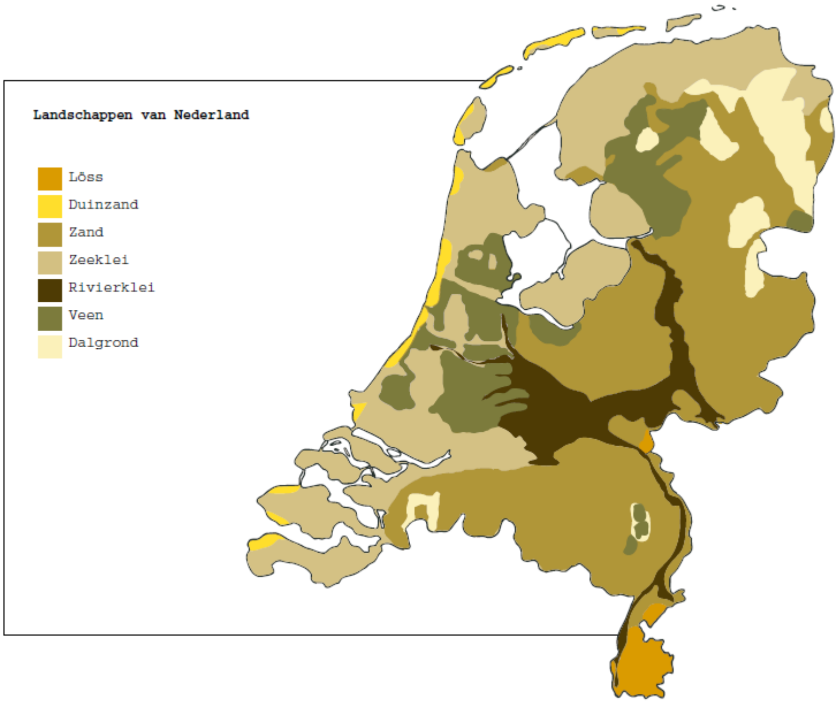

Figure 7. Soil textures of the Netherlands
Source: BLGG

If production is geographically spread without a major concentration, price and yield are expected to be uncorrelated. If there exists a major production area and a farmer is located outside this area, growing conditions might deviate from major production area, farm yield might be positively correlated with market price.

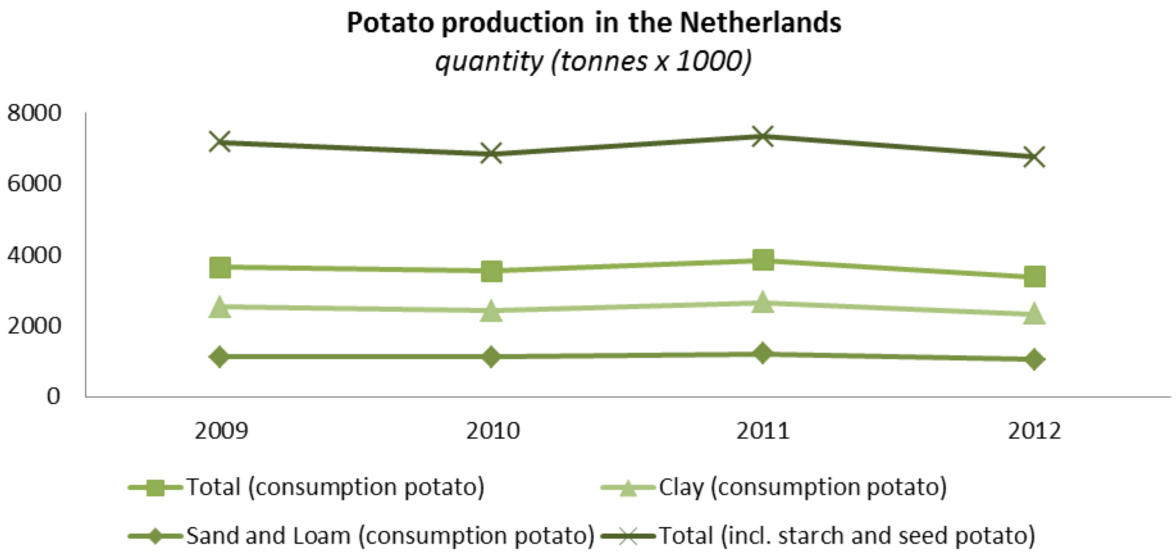

Figure 8. Potato production in the Netherlands on clay soil or sandy and loam soil
Source: CBS

Major potato production in the Netherlands is located in clay soil areas (see figure 8). Since the Netherlands is a major exporter of potato, it is expected that the Netherlands might influence world market price. Since the majority of Dutch potato growers are situated on clayey soils, it is expected that the properties of this type of soil determine the negative price yield correlation. If for example there would be a lot of rainfall during growing season, the potato yield in the clay areas would be low (clay holds a lot of water: unfavourable wet conditions). This would decrease yields in this area and potentially influence (decrease) market price. Potato growers on sandy soils within the Netherlands would also experience the excessive rainfall during growing season. In contrast to the low production in production areas on clayey soils, potato growers on sandy soils would experience good yields due to the properties of sandy soils (sand does not hold water). Potato growers on sandy soils might experience low negative or even positive price yield correlations.

For producers in countries with low production, which are expected to have no influence on the market (i.e. aggregated yield is low and excess supply is low or non-existent), a negative correlation between farm yield and market price can only exist if growing conditions are similar to major producing country's production area. This is the case for Dutch wheat producers. Due to low aggregated yield, it is expected that Dutch wheat growers do not influence market price.

2.10 Futures market contracts as market price proxy for potato and wheat

Since the existence of a single market for agriculture in the European Union, free trade between EU countries is possible. National markets are integrated with the European market. Price differences between areas are held constant by transportation and transaction cost (Harwood et al., 1999). The law of one price suggests that identical commodities that are traded in efficient multiple markets can only have one price regardless of where they are traded (Ejrnæs et al., 2008). The explanation for this is the impact of market arbitrage. If the price differential between markets would exceed transportation and transaction cost, traders would take the opportunity to make a profit by shipping the crop from the low price market to the high price market. This arbitrage would increase price in the low price market due to the increased demand and decrease price in the high price market due to the increased supply. Since traders adjust their inventory (storage release) as they anticipate shipments from the low price market, prices are depressed immediately. If the price differential does not exceed transportation and transaction cost, hence the price ratio is less than one, traders would decrease the release from their inventory and thereby decrease supply which will increase price domestically while simultaneously decrease price in the foreign market by decreasing demand.

Shocks, which violate the law of one price, will take time to get diffused to other markets depending on the state of information technology, whether markets operate with inventories and how competitive markets are. Eventually the price ratio will be one again (Ejrnæs et al., 2008). Protopapadakis and Stoll (1983) show, by using weekly data for commodities traded in futures markets in different countries in the period 1973-1980, that the law of one price approximately adjusted for transaction cost holds.

Futures market contracts are good proxies for market prices since the futures prices equal spot prices in the delivery month of the futures price contract, if the spot price would deviate from the futures price there would be arbitrage possibilities which would decrease the gap in prices (Leuthold, Junkus and Cordier, 1989).

2.11 Existing research on farmers' low hedging

Agricultural producers consider price and yield risk as the most important types of risk (Patrick et al., 1985; Blank et al., 1997; Harwood et al., 1999; Meuwissen et al., 2001). However they consider hedging not to be an important risk management tool (Patrick et al., 1985; Greiner, 2009; Meuwissen et al., 2009). Hedging literature suggests various contributing factors explaining agricultural producers low hedging ratio's. Collins' (1997) hypothesis that "hedging is motivated by a desire to avoid financial failure rather than by a desire to reduce income variability" suggests that the financial structure, cost structure and profitability of a farm affect the likelihood of financial failure, influencing the motivation of the decision to hedge. Pannel (2008) also concludes that biased price expectations might have a major impact on the optimal hedge ratio. Dorfman et al. (2010) found that also habit and risk perception influence hedging ratios. The use of other risk management tools might also decrease the demand for hedging.

Yield variability, price variability, and the correlation between price and yield all influence farmers' hedging decision. Yield variability and correlation between price and yield is influenced by the farmer's location regarding their soil type. Farmers in major production areas, which impact market prices, tend to have strong negatively correlated price and yield. Producers outside major production areas, subjected to other growing conditions, tend to have weaker price yield correlations (high prices and high yields or low prices and low yields are more likely to occur at the same time). As a result, it is expected that farmers have different optimal hedge ratios due to the difference in price yield correlation regarding their location's soil.

Chapter three: Data and Methodology

For this study, yield data was initially collected by using a survey (see appendix 1). Due to a low response rate, aggregated averages were collected from the LEI (Landbouw Economisch Instituut). Yields were collected for potato and wheat producers on both sandy and clayey soil. Potato yield was collected for the years 2009 to 2012 while wheat yield was collected for the years 2008 to 2012. The collected yield data was combined with historical futures quotations to form the database that was used to examine the correlation between price and yield. The database is included in appendix 2.

3.1 Data collection

In order to estimate the price yield correlation per farm, multiple entries are required to accurately estimate correlation coefficients. Yield data that was collected from the LEI (Landbouw Economisch Instituut) (see appendix 3 for LEI data sheet). In order to find different price yield correlations for individual farmers, there should be significant different growing conditions. In terms of growing conditions there are multiple variables influencing yield. However in the Netherlands, soil (more specifically soil texture) is the only non-changeable variable (weather differences between different regions are neglected). Plant water use and growth is primarily based on soil texture. Although the Netherlands consist of different types of soil, only sandy and clayey textured soils were selected. These soil textures differ the most regarding their characteristics.

Yield data was collected for potato and wheat growers on both sandy and clayey soils. The yield data in the LEI datasheet consisted of average yield, of farmers in their sample, for each growing season. The farm level data could not be provided due to privacy issues. Potato yield averages were collected for the years 2009-2012 with exception of 2009 sandy soil yield. An average could not be included because the sample size of potato growers on sandy soils for 2009 was not large enough to provide the datasheet with a yield average. Wheat yield was collected for the period 2008-2012. There was no distinction between milling and feed wheat in the LEI datasheet.

Price data was collected from European exchanges, the Liff exchange in London (Euronext), the Matif exchange in Paris (Euronext) and the Eurex exchange in Frankfurt (see appendix 4 for contract specifications). The choice for these specific stock exchanges was based on the fact that these contracts reflect the European market price (wheat and potato futures are only traded in these futures markets in the European Union). Accordingly these are the contracts Dutch farmers use to hedge their revenue risk.

Table 5. Processing potato (Eurex) contract trading volume

	2009	**2010**	**2011**	**2012**	**2013**
April	0	13789	61390	34143	53868
November	6	136	179	272	272

Source: barchart.com

Historical futures price data is collected for milling wheat and feed wheat for the period 2008-2012 while for processing potato price data was collected for 2010-2013. Price data for potato was collected from 2010 onwards since the processing potato futures contract was first introduced in 2009. Because of significant more trading volume in April (see table 5), the April contract price was used for the production of previous year (April 2010 contract for 2009 yield etc.). For milling wheat and feed wheat the November contract was used since there was the most trading activity in November, as can be seen in table 6 and 7. Futures prices have been collected from exchange database barchart.com.

Table 6. Feed Wheat (Euronext) trading volume

	2009	2010	2011	2012	2013
January	13848	7266	11354	7477	4330
March	8371	5037	3970	4996	1056
May	41099	34407	51566	52138	43001
July	5330	3883	4207	4832	4530
November	57796	67856	104839	76940	68146

Source: barchart.com

Table 7. Milling Wheat (Euronext) trading volume

	2009	2010	2011	2012	2013
January	212943	311869	833901	683558	1442312
March	288418	377474	753590	1015073	1617190
May	346379	488149	945983	982354	1300709
November	905100	2039093	3311373	3286200	2666745

Source: barchart.com

The prices that are used for the construction of the database are calculated as 30 day averages of the closing price before maturity. The 30 day average is used because within the month before delivery the futures price equals the spot price however short fluctuation within this month are smoothened out. For the calculation of the London feed wheat price in Euro, average exchange rates have been calculated for the corresponding 30 day average of the contract. The average exchange rate calculation is added in appendix 5. Collected prices were converted to prices per ton to match the price per ton yield averages.

3.2 Statistical analysis

To examine the relationship between price and yield, Pearson correlation coefficients were calculated. Correlations have been calculated between price and yield for potato and wheat growers on both sandy and clayey soils.

Correlation expectation for potato growers on clayey soil
Because potato production in the Netherlands is mostly on clayey soils and the potato production of the Netherlands is expected to influence market price, it is expected that Dutch potato growers on clayey soils have their yield negatively correlated with market price.

Correlation expectation for potato growers on sandy soil
Because sandy soils differ significantly from clayey soils in terms of growing conditions, and potato growers on sandy soils are minor producers of potato (major production is on clayey soils) and accordingly are not expected to influence market price to a large extend, it is expected that potato growers on sandy soils experience weaker negative correlated price and yield or even positive correlated price and yield.

Correlation expectation for wheat growers on clayey soil

Since the wheat production of the Netherlands does not influence the market price, the correlation between price and yield is dependent on the growing conditions of major wheat producing countries that influence wheat prices. Since France is Europe's biggest producer and exporter of wheat, growing conditions in France influence the correlation between price and yield for Dutch wheat growers. The greatest extend of wheat production of France is located in the Northern regions. Since these Northern regions have both clayey and sandy types of soil, and are subjected to approximately the same weather and climate as the Netherlands, it is expected that Dutch wheat producers on clayey soil are also subjected to negative correlated price and yield.

Correlation expectation for wheat growers on sandy soil

Although growing conditions of sandy soils differ from growing conditions of clayey soils it is expected that wheat producers on sandy soils in the Netherlands also experience negative price yield correlations. Because the growing conditions of major wheat producing regions in France (the biggest producer and exporter of wheat) are on both sandy and clayey soils, soil type has no influence on aggregated yield.

To compare price yield correlations between soil types, Z-difference tests was used. This test can be used to test for statistically differences between correlation coefficients (Field, 2009). After converting the calculated Pearson correlation coefficients by z_r-scores, Fisher's Z-difference test was used to calculate z-scores. Calculated z-scores can be transformed to two-tailed probabilities, using the table for normal distribution of z-scores, which makes statistically testing for difference in correlation between groups possible (difference between soils for both potato and wheat producers). The formula for conversion of the Pearson correlation to Z_r-scores is expressed in equation (4). The formula for Fisher's Z-difference test is given by equation (5).

$$z_r = \frac{1}{2}\ln\left(\frac{1+r}{1-r}\right) \tag{4}$$

$$Z_{\text{Difference}} = \frac{z_{r1} - z_{r2}}{\sqrt{\frac{1}{N_1 - 3} + \frac{1}{N_2 + 3}}} \tag{5}$$

To examine the statistical relationship between the set of independent variables (Soil, Crop and Yield) and the dependent variable (Futures price) the (OLS; Ordinary Least Squares) multiple linear regression model, expressed in equation (6), has been created. Because the slope and intercept of the yield curve depends on soil and crop, interaction effects (Soil*Yield, Crop*Yield and Crop*Soil*Yield) have been added in the model. The added interaction effects allow for different slope and intercept for Yield and makes testing for a different coefficient of Yield across Crop and Soil possible (Lattin et al., 2003).

$$Futures\ Price = b_0 + b_1\, Soil + b_2\, Crop + b_3\, Yield + b_4(Soil * Yield) + b_5(Crop * Yield) + b_6(Crop * Soil * Yield) + \varepsilon \tag{6}$$

The dependent variable Futures price is the futures price per ton. Soil, Crop and Yield are the predictors. Yield is the production per hectare in ton. Where Crop and Soil are dummy variables which either have value zero or one. The dummy variable Crop has value zero for potato or value one for wheat. The dummy variable Soil is either zero for sand or one for clay. With the interaction effect Soil*Yield it is possible to test whether Yield has a different coefficient across soil type. Which makes it possible to test whether Soil influences the impact Yield has on the Futures price. The same effect is measured with the interaction effect Crop*Yield for Crop. The interaction term Crop*Soil*Yield measures the same effect as the two-way interaction term Soil*Yield, however now the two-way interaction differs for levels of the third variable Crop. This three-way interaction made testing for a different coefficient of Yield across Soil and Crop possible.

Since there could no distinction be made between milling wheat yield and feed wheat yield due to lacking information of the type of wheat in the LEI database, both milling wheat and feed wheat futures prices were used to calculate price yield correlations. In the regression analysis of equation (6) are, for simplicity reasons, only Paris milling wheat futures prices and Frankfurt potato futures prices used. Performing an independent samples T-test revealed that there was no significant difference, $t(8)=-0.437$, $p>.05$, between the Paris Milling wheat price and (to Euro converted) London feed wheat price (see appendix 4 for calculation of 30 day average exchange rates).

Assumptions for the use of regression analyses, normal distribution of residuals, constant variance of residuals and linearity of the model were also met. P-values lower than 0.05α were considered significant. The statistical analysis was conducted in SPSS 19.0 (IBM SPSS Inc., Chicago, IL, USA).

Chapter four: Results

In order to estimate the effectiveness of hedging for potato and wheat growers in the Netherlands, Pearson correlation coefficients between price and yield are calculated for potato and wheat growers on both sandy and clayey soil (see table 8). For wheat there has been a distinction made between three types of prices: Paris milling wheat, the London feed wheat and the (to euro) converted London feed wheat price. The reason for this is that the collected average wheat yield data consisted of aggregated milling wheat and feed wheat yields. No distinction between yields could be made.

Table 8. Correlation between yield and price per contract per crop

	Clay	**Sand**
	r	*r*
Potato	-.707	.269
Wheat (milling)	-.526	-.200
Wheat (feed) GBP	-.545	-.172
Wheat (feed) Euro	-.545	-.133

Note: All correlation were statistically not significant (p>.05).

Although the correlation coefficients for potato growers (positive correlation between price and yield for farmers located on sandy soil and negative correlation between price and yield for farmers located on clayey soil) resemble expectations, the correlations are both not significant. The correlation coefficient between price and yield for wheat growers is negative for both producers on sandy as clayey soils. This result again is as expected, however again not significant.

Fisher's Z-difference test, to test for statistically different correlation strengths, was conducted. The formula for the test is expressed in equation (5). Calculated z_r-scores, by using equation (4), are together with group sample size (n) presented in table 9. The reason for the low (group) sample size is the fact that average year data (2008-2012 for wheat and 2009-2012 for potato with exemption of 2009 for sand) was used to calculate the Pearson correlation coefficient. Accordingly the correlation was calculated per soil type per crop, which explains the low group sample sizes. Fisher's Z-difference test was used to statistically test for different correlation strengths between the price yield correlation of potato and wheat growers on both sandy and clayey soils. Z-difference scores are presented in table 10. Two-tailed probabilities were calculated using the table of normal distribution for z-scores. None of the Z-difference test (between soil types) were found significant.

Table 9. Z_r-scores

	Clay	**Sand**
	Z_{r1} (n)	Z_{r2} (n)
Potato	-.881 (4)	.276 (3)
Wheat (milling)	-.585 (5)	-.203 (5)
Wheat (feed) GBP	-.611 (5)	-.174 (5)
Wheat (feed) Euro	-.611 (5)	-.134 (5)

Table 10. Z-difference score

	Z-difference	Two-tailed probability (P-value)
Potato	-1.082	.280
Wheat (milling)	-.483	.632
Wheat (feed) GBP	-.553	.582
Wheat (feed) Euro	-.604	.549

Note: Z-difference score were all not significant (p>.05).

Yield, crop, soil, and the interaction terms Soil*Yield, Crop*Yield and Crop*Soil*Yield were used to predict Price. By performing a regression analysis the effect of a single independent variable on the dependent variable are measured. The regression model, as defined in equation (4), was found not statistically significant F(6,10)=0.536, p>.05. The results of the regression model, as expressed in equation 6, can be seen in table 11. None of the regression coefficients were significant. The correlation of the variables are shown in table 12. As can be seen, none of the predictor variables are statistically correlated with the dependent variable. The independent variable Yield is highly correlated with Crop, there exists an almost linear relationship between crop and yield. This correlation is found statistically significant p<.001. This relationship indicates multicollinearity. Multicollinearity is a problem of independent variables that are highly correlated.

Table 11. Standard regression results

	b	SE b	β	SR^2
Constant	435.657	805.183		
Yield	-5.022	14.653	-1.362	.008
Crop	-231.425	781.125	-1.676	.006
Soil	511.272	595.182	3.755	.056
Soil*Yield	-10.683	11.141	-3.253	.070
Crop*Yield	2.710	50.531	.163	.023
Crop*Soil*Yield	-46.079	61.260	-2.765	.043

Note: The dependent variable was price. R^2=.243, Adjusted R^2=-.212. All coefficients were statistically not significant (p>.05).

Table 12. Correlation of the variables in the analysis (n=17)

	1	2	3	4	5	6	7
1 Price	-						
2 Yield	-.294	-					
3 Crop	.279	-.996***	-				
4 Soil	-.068	.056	-.070	-			
5 Soil*Yield	-.250	.555*	-.591**	.670**	-		
6 Crop*Yield	.251	-.973***	.983***	.038	-.557*	-	
7 Soil*Crop*Yield	.133	-.513*	.538*	.607**	-.178	-.653**	-

Note: *p=<.05, **p=<.01, ***p=<.001

Removing soil from the model by splitting the data set in two parts, creating sub-datasets for soil deletes the collinearity between the independent variables Crop and Yield. This procedure also reduces the sample size. Testing the assumptions for regression analysis on the split dataset showed that the assumptions were violated.

Chapter five: Conclusions & Discussion

The objective of this study was to investigate whether the price yield correlation among Dutch potato and wheat producers differs between regions and to identify the effect this has on the use of futures market contracts as revenue risk management tool. In this study, potato and wheat farmers on both sandy and clayey soils were compared based on their correlation between price and yield.

Although the sign of the correlation coefficients confirmed expectations, they were found not significant. Comparing the strength of the correlations between market price and yield of producers on sandy soils and producers on clayey soils revealed no statistical difference. There has to be pointed out that the small (group) sample size (below 30) do not give accurate Z-scores which affect significance levels.

To measure the unique impact of yield, soil and crop on market price, a regression analysis was conducted. The regression model as a whole and the individual predictors were found not significant. Analysis of the variable correlations revealed that the predictor variables yield and crop were highly correlated. This indicates multicollinearity. Consequences of multicollinearity are unstable estimates and inflated standard errors of unexpected sign or magnitude (Verbeek, 2008). As a result, it is hard for the model to identify the individual impact of the independent variables (Verbeek, 2008; Vocht, 2004). Consequently, due to the low sample size, the dataset contains insufficient information to identify the effect of yield, soil and crop on price. A remedy for multicollinearity is collecting more data with sufficient variation of the independent variables (Verbeek, 2008; Lattin et al., 2003). Green (1993) uses a rule of thumb for the minimal acceptable sample size for regression analysis. When testing individual predictors he suggests a minimal sample size of 104+k, were k is the number of predictor variables. If testing the overall fit, he suggests a minimal sample size of 50+8k. If testing both overall fit and contribution of individual variables, he suggests to calculate both rules of thumb and use the minimal sample sizes that is highest. The model used in the regression analysis had 6 predictors which would, according to Green, need a minimum sample size of 110 to get valid results.

Although no significant conclusions can be drawn from the empirical part of this study, literature (Lapan and Moschini, 1994; Harwood et al., 1999; Coble et al., 2000; Xing and Pietola, 2005) showed that, for farmers it seems prudent to take the price yield correlation in account when making the decision to use the futures market to decrease revenue risk. In the case of positively correlated price and yield, hedging is effective in reducing revenue risk. If a negative correlation is present hedging is less effective in reducing revenue risk.

Furthermore, Harwoord et al. (1999), Kimura et al. (2000) and Cooper (2009) found that the price yield correlation differs between regions and depends on growing conditions. The Netherlands is relative small in size and therefore subjected to the same climate throughout the country. Soil texture, which differs per region in the Netherlands (Locher and Bakker, 1990; Rottink et al., 2007; Remmelink et al. 2012), is an import plant growth influencing factor (McCauley et al., 2005). These findings might suggest that the price yield correlation differs between soil types within the Netherlands and should be accounted for when using the futures market. Unfortunately, there are no empirical results that can be presented to support this thesis.

If both price and yield risk are present the effect of hedging becomes more complex. Yield risk can be deleted by using yield insurance. The combination of yield insurance and hedging is most effective in reducing revenue risk compared to hedging alone. Due to crop insurance, yield risk is eliminated, and the optimal hedge ratio can be used. The realized risk reduction of this combined approach depends on the level of yield variability and the price yield correlation.

Increasing the sample size by using farm level yield data would increase the variance in yield. Also, there could be a distinction made between multiple soil types, increasing the variance in soil. This might result in finding significant correlations between price and yield, which could provide answers to whether the price yield correlation differs between regions of Dutch potato and wheat producers. If yield data is collected at the farm level, also information on the farmer's use of futures market contracts could be collected. Also other regional variables influencing yield, for example information on irrigation differences, could be taken into account. By doing so one could test whether the price yield correlation impacts the farmer's use of futures market contracts.

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Appendices

Appendix 1. Qualtrics questionnaire

Algemeen

De volgende vragenlijst is een onderdeel van een onderzoek naar de relatie tussen de prijs en oogstopbrengst, en de consequenties hiervan voor het gebruik van termijnmarkten onder akkerbouwers in Nederland.

Het onderzoek betreft akkerbouwers die één of meerdere van de volgende gewassen verbouwen:
Consumptie Aardappel
Tarwe (voeder- en baktarwe)

Om mee te werken aan deze vragenlijst heeft u de volgende gegevens (2009-2013) nodig:

Beteelde oppervlakte gewas (hectare)
Oogstopbrengst per gewas (ton)
Grondsoort waarop het gewas verbouwd werd (leem, zand, zeeklei, rivierklei, veen)

Antwoorden zijn anoniem en zullen als strikt vertrouwelijk behandeld worden. Het onderzoek is uitsluitend bedoeld voor academische doeleinden. Gegevens worden niet aan derden verstrekt.

De vragenlijst zal ongeveer 5 minuten in beslag nemen. Alvast bedankt voor uw medewerking!
Let op: Na het beantwoorden van de onderstaande vragen kan niet meer worden teruggekeerd naar deze vragen. Controleer a.u.b. uw antwoord alvorens op volgende te klikken.

Als u de resultaten van dit onderzoek wilt ontvangen kunt u hieronder uw e-mail adres invullen.

Vul onderstaand de postcode van het bedrijf in kwestie in. (1234 AB)

Kies uw grondsoort

- ○ Leem
- ○ Zand
- ○ Zeeklei
- ○ Rivierklei
- ○ Veen

Geef onderstaand uw bedrijfstype aan

- ◉ Biologische akkerbouw
- ○ Reguliere akkerbouw (gebruik van bemesting en bestrijdingsmiddelen)

Heeft u de mogelijk tot beregenen

- Ja
- Nee

Geef aan welk(e) gewas(sen) u verbouwd heeft in de periode 2009-2013. (meerdere keuzes mogelijk)

- ☐ Consumptie aardappel
- ☐ Voedertarwe en/of baktarwe
- ☐ Geen van bovenstaand

Processing Aardappel

De volgende vragen gaan over (let op!) consumptie aardappelen.
Vul onderstaand de totale opbrengst van de consumptie aardappelen (ton) en de beteelde oppervlakte voor consumptie aardappelen (hectare) voor de jaren 2009-2013 in.
Indien er in het betreffende jaar geen consumptieaardappel verbouwd is vul nul (0) in.

Futures processing aardappel	Opbrengst in ton	Beteelde oppervlakte in hectare
2009	Opbrengst in ton	Beteelde oppervlakte in hectare
2010	Opbrengst in ton	Beteelde oppervlakte in hectare
2011	Opbrengst in ton	Beteelde oppervlakte in hectare
2012	Opbrengst in ton	Beteelde oppervlakte in hectare
2013	Opbrengst in ton	Beteelde oppervlakte in hectare

Geef aan of voor de productie van consumptie aardappelen, gebruik is gemaakt van termijncontracten (Futures Market Contracts).

- ○ Ja, ik heb gebruik gemaakt van termijn contracten
- ○ Nee, ik heb geen gebruik gemaakt van termijn contracten maar ik ben wel van plan in de toekomst termijncontracten te gebruiken
- ○ Nee, ik heb geen gebruik gemaakt van termijn contracten en ben dit ook niet van plan in de toekomst

Tarwe

De volgende vragen gaan over tarwe. Geef aan welk soort tarwe er verbouwd is:

- ☐ Voedertarwe
- ☐ Baktarwe
- ☐ Er is geen voedertarwe of baktarwe verbouwd

Vul onderstaand de totale opbrengst van voedertarwe (ton) en de beteelde oppervlakte voor tarwe (hectare) voor de jaren 2009-2013 in.
Indien er in het betreffende jaar geen tarwe verbouwd is vul nul (0) in.

	Opbrengst in ton	Beteelde oppervlakte in hectare
2009	Opbrengst in ton	Beteelde oppervlakte in hectare
2010	Opbrengst in ton	Beteelde oppervlakte in hectare
2011	Opbrengst in ton	Beteelde oppervlakte in hectare
2012	Opbrengst in ton	Beteelde oppervlakte in hectare
2013	Opbrengst in ton	Beteelde oppervlakte in hectare

Vul onderstaand de totale opbrengst van baktarwe (ton) en de beteelde oppervlakte voor tarwe (hectare) voor de jaren 2009-2013 in.
Indien er in het betreffende jaar geen tarwe verbouwd is vul nul (0) in.

	Opbrengst in ton	Beteelde oppervlakte in hectare
2009	Opbrengst in ton	Beteelde oppervlakte in hectare
2010	Opbrengst in ton	Beteelde oppervlakte in hectare
2011	Opbrengst in ton	Beteelde oppervlakte in hectare
2012	Opbrengst in ton	Beteelde oppervlakte in hectare
2013	Opbrengst in ton	Beteelde oppervlakte in hectare

Geef aan of voor de productie van tarwe, gebruik is gemaakt van termijncontracten (Futures Market Contracts).

- ○ Ja, ik heb gebruik gemaakt van termijn contracten
- ○ Nee, ik heb geen gebruik gemaakt van termijn contracten maar ik ben wel van plan in de toekomst termijncontracten te gebruiken
- ○ Nee, ik heb geen gebruik gemaakt van termijn contracten en ben dit ook niet van plan in de toekomst

Appendix 2. Database SPSS

Crop	Soil	Price year	Contractprice	Exchangerate	Currency	Priceperton	Yieldyear	Yieldtonperhectare	N	Futurescontract
0	0	2011	€ 19,20		1	€ 192,00	2010	52,59991809	10	1
0	0	2012	€ 4,00		1	€ 40,00	2011	54,89143974	9	1
0	0	2013	€ 24,33		1	€ 243,30	2012	57,40598969	13	1
0	1	2010	€ 9,40		1	€ 94,00	2009	50,967	78	1
0	1	2011	€ 19,20		1	€ 192,00	2010	48,25455296	76	1
0	1	2012	€ 4,00		1	€ 40,00	2011	54,93150446	78	1
0	1	2013	€ 24,33		1	€ 243,30	2012	50,99606398	80	1
1	0	2008	GBP 91,53	1,205146667	2	€ 110,31	2008	7,584	18	2
1	0	2009	GBP 103,14	1,114513333	2	€ 114,95	2009	8,236	18	2
1	0	2010	GBP 164,00	1,169903333	2	€ 191,86	2010	6,899	25	2
1	0	2011	GBP 149,67	1,166157143	2	€ 174,54	2011	6,536	21	2
1	0	2012	GBP 213,00	1,244457692	2	€ 265,07	2012	7,908	25	2
1	1	2008	GBP 91,53	1,205146667	2	€ 110,31	2008	9,244	110	2
1	1	2009	GBP 103,14	1,114513333	2	€ 114,95	2009	9,63	113	2
1	1	2010	GBP 164,00	1,169903333	2	€ 191,86	2010	9,288941724	121	2
1	1	2011	GBP 149,67	1,166157143	2	€ 174,54	2011	7,944445871	117	2
1	1	2012	GBP 213,00	1,244457692	2	€ 265,07	2012	8,501151542	118	2
1	0	2008	€ 145.50		1	€ 145.50	2008	7.584	18	3
1	0	2009	€ 127.57		1	€ 127.57	2009	8.236	19	3
1	0	2010	€ 213.13		1	€ 213.13	2010	6.899	25	3
1	0	2011	€ 187.20		1	€ 187.20	2011	6.536	21	3
1	0	2012	€ 265.38		1	€ 265.38	2012	7.908	25	3
1	1	2008	€ 145.50		1	€ 145.50	2008	9.244	110	3
1	1	2009	€ 127.57		1	€ 127.57	2009	9.63	113	3
1	1	2010	€ 213.13		1	€ 213.13	2010	9.288941724	121	3
1	1	2011	€ 187.20		1	€ 187.20	2011	7.944445871	117	3
1	1	2012	€ 265.38		1	€ 265.38	2012	8.501151542	118	3

Appendix 3. LEI datasheet

Sample consumption potato producers

	2008	2009	2010	2011	2012
Clay	79	78	76	78	80
Sand	4	5	10	9	13

Production consumption potato (kg / ha)

	2008	2009	2010	2011	2012
Clay	54.360	50.967	48.255	54.932	50.996
Sand			52.600	54.891	57.406

Sample consumption wheat producers

	2008	2009	2010	2011	2012
Clay	110	113	121	117	118
Sand	18	18	25	21	25

Production wheat (kg / ha)

	2008	2009	2010	2011	2012
Clay	9.244	9.630	9.289	7.944	8.501
Sand	7.584	8.236	6.899	6.536	7.908

Source: LEI Wageningen UR

Appendix 4. Contract specifications

Contract Specifications for potato (FEPP)

Symbol	GO
Name	European Processing Potato Futures / EPP Index (FEPP)
Exchange	EUREX
Trading Months	January, February, March, April, May, June, July, August, September, October, November, December (F, G, H, J, K, M, N, Q, U, V, X, Z)
Trading Unit	250 quintals (25 tons) potatoes
Tick Size	0.1 points (EUR 25.00 per contract)
Daily Limit	consult exchange
Trading Hours	9:50a.m. - 4:00p.m. (CET)
Last Trading Day	Tuesday following third Friday of the maturity month
Value of one futures unit	EUR 250
Value of one options unit	EUR 250

Contract Specifications for Milling Wheat (ML)

Symbol	ML
Name	Milling Wheat (EBM)
Exchange	MATIF
Trading Months	January, March, May, July, September, November (F, H, K, N, U, X)
Trading Unit	50 metric tonnes
Tick Size	EUR 25 cents per metric tonne (EUR 12.50 per contract)
Daily Limit	+/- 3.5 EUR per metric ton
Trading Hours	10.45a.m. - 6:30p.m. (Paris)
Last Trading Day	The 10th of the delivery month. If it is a non working day, the first trading day after this day
Value of one futures unit	EUR 50
Value of one options unit	EUR 50

Contract Specifications for Feed Wheat (LW)

Symbol	LW
Name	Feed Wheat (T)
Exchange	LIFFE
Trading Months	January, March, May, July, September, November (F, H, K, N, U, X)
Trading Unit	100 metric tonnes
Tick Size	5 pence per metric tonne (GBP 5.00 per contract)
Daily Limit	consult exchange
Trading Hours	9:25a.m. - 5:28p.m. GMT
Last Trading Day	23rd day of the delivery month (in the case of July, the 7th day). If not a business day then the first business day immediately preceding
Value of one futures unit	GBP 100
Value of one options unit	GBP 100

Appendix 5. Exchange rate calculation

2008	Exchange rate	2009	Exchange rate	2010	Exchange rate	2011	Exchange rate	2012	Exchange rate
01-11-08	1.2652	01-11-09	1.1166	01-11-10	1.1544	01-11-11	1.1646	01-11-12	1.2447
02-11-08	1.2652	02-11-09	1.1104	02-11-10	1.1427	02-11-11	1.1605	02-11-12	1.2462
03-11-08	1.2530	03-11-09	1.1156	03-11-10	1.1393	03-11-11	1.1606	03-11-12	1.2479
04-11-08	1.2301	04-11-09	1.1139	04-11-10	1.1449	04-11-11	1.1626	04-11-12	
05-11-08	1.2284	05-11-09	1.1156	05-11-10	1.1531	05-11-11	1.1626	05-11-12	1.2483
06-11-08	1.2369	06-11-09	1.1192	06-11-10	1.1531	06-11-11	1.1626	06-11-12	1.2487
07-11-08	1.2319	07-11-09	1.1192	07-11-10	1.1531	07-11-11		07-11-12	1.2481
08-11-08	1.2319	08-11-09	1.1192	08-11-10	1.1599	08-11-11	1.1706	08-11-12	1.2523
09-11-08	1.2319	09-11-09	1.1169	09-11-10	1.1617	09-11-11	1.1758	09-11-12	1.2533
10-11-08	1.2225	10-11-09	1.1173	10-11-10	1.1698	10-11-11	1.1709	10-11-12	
11-11-08	1.2290	11-11-09	1.1053	11-11-10	1.1801	11-11-11	1.1683	11-11-12	1.2509
12-11-08	1.1960	12-11-09	1.1147	12-11-10	1.1775	12-11-11	1.1683	12-11-12	1.2499
13-11-08	1.1557	13-11-09	1.1195	13-11-10	1.1775	13-11-11	1.1683	13-11-12	1.2491
14-11-08	1.1682	14-11-09	1.1195	14-11-10	1.1775	14-11-11	1.1673	14-11-12	1.2494
15-11-08	1.1682	15-11-09	1.1195	15-11-10	1.1814	15-11-11	1.1724	15-11-12	1.2438
16-11-08	1.1682	16-11-09	1.1236	16-11-10	1.1778	16-11-11		16-11-12	1.2410
17-11-08	1.1852	17-11-09	1.1236	17-11-10	1.1758	17-11-11	1.1695	17-11-12	
18-11-08	1.1859	18-11-09	1.1236	18-11-10	1.1762	18-11-11	1.1700	18-11-12	1.2480
19-11-08	1.1922	19-11-09	1.1236	19-11-10	1.1688	19-11-11	1.1687	19-11-12	1.2463
20-11-08	1.1844	20-11-09	1.1236	20-11-10	1.1688	20-11-11	1.1687	20-11-12	1.2418
21-11-08	1.1821	21-11-09	1.1236	21-11-10	1.1688	21-11-11	1.1670	21-11-12	1.2433
22-11-08	1.1821	22-11-09	1.1236	22-11-10	1.1708	22-11-11	1.1595	22-11-12	1.2437
23-11-08	1.1821	23-11-09	1.1100	23-11-10	1.1799	23-11-11	1.1574	23-11-12	1.2374
24-11-08	1.1738	24-11-09	1.1082	24-11-10	1.1835	24-11-11	1.1636	24-11-12	
25-11-08	1.1858	25-11-09	1.1041	25-11-10	1.1835	25-11-11	1.1608	25-11-12	1.2360
26-11-08	1.1902	26-11-09	1.1041	26-11-10	1.1775	26-11-11	1.1660	26-11-12	1.2367
27-11-08	1.1902	27-11-09	1.1020	27-11-10	1.1775	27-11-11	1.1660	27-11-12	1.2356
28-11-08	1.2127	28-11-09	1.1020	28-11-10	1.1775	28-11-11	1.1644	28-11-12	1.2387
29-11-08	1.2127	29-11-09	1.1020	29-11-10	1.1859	29-11-11	1.1644	29-11-12	1.2383
30-11-08	1.2127	30-11-09	1.0954	30-11-10	1.1988	30-11-11	1.1710	30-11-12	1.2365
Average	**1.205147**		**1.1145133**		**1.16990333**		**1,166157**		**1.24445769**

Source: Yahoo Finance