Customised commodity derivatives

The case of natural gas in the Dutch horticulture sector

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Financial banks in the Netherlands are developing customised derivatives for the agriculture industry to decrease the volatility of input or output prices. These derivatives can also be attractive for Dutch agriculture producers because a big part of the business risk in agriculture is caused by fluctuating commodity input and output prices. This report provides insight on how customised derivatives can be constructed and what the advantage is for a farmer. This insight is given by a simulation of the natural gas market for horticulture producers in the Netherlands.

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Contents

		Page
Preface		7
Summary		9
1.	**Purpose**	11
2.	**Overview**	12
3.	**Horticulture industry in the Netherlands**	13
4.	**Overview of derivatives**	16
5.	**Explanation of contracts considered in this analysis**	18
6.	**A case study analysis**	20
7.	**A simulation analysis**	27
8.	**Conclusions**	32
9.	**Considerations for offering customised derivatives**	34
10.	**Suggestions for further research**	35
References		37
Appendices		
1.	Black's option pricing model for futures and forwards ('BOPM')	39
2.	Volatility calculations, quarterly and annual	40
3.	Case study data	41
4.	Strategy data for simulation analysis	43

Preface

Volatility of prices is becoming more and more important in the agriculture production. The size of farms and firms are increasing, they get more specialised and the policy of market support by the EU is coming to an end. On the other hand financial institutions are offering new products to the market to help manage these price risks. One of these products is customised derivatives. This research was financially supported by the chain and network production programme.

We want to thank Kent Horsager for doing the research and writing this report during his sabbatical leave in the Netherlands. Kent stayed at LEI from January 2006 till July 2006. He shared his knowledge about future markets and combined this with figures from Dutch horticulture firms.

We hope that this report will increase the knowledge of customised derivatives in practice in a way that agriculture producers can make a balanced decision about how to decrease the volatility of prices and at the end the volatility in farm income.

Dr J.C. Blom
Director General LEI B.V.

Summary

The aim of this report is to provide information on customised derivatives, their background and contemporary applications for natural gas procurement in the Netherlands' horticulture sector. The price of natural gas in the Netherlands has doubled in the past five years, making natural gas the number two input for green house producers and accounting for between 20% and 25% of all input costs. The combination of global pressure on the energy markets and the liberalisation of the gas market in the Netherlands have also increased the volatility of natural gas prices causing increasing input cost risk and income instability.

Recently several financial institutions have begun to offer risk management tools in the form of customised derivatives to help producers manage their natural gas input price risk. In this study we look at the case of a typical horticulture producer who has several choices of how to purchase natural gas. The producer may continue to buy on the spot market where natural gas is priced quarterly or he may choose to use a fixed price contract to purchase natural gas. In addition the producer may choose to purchase his natural gas needs by using a customised derivative. In this study the producer may choose either a maximum price contract or a collar price contract derivative. Here we looked at the outcome of each contract type over the past five years. We also conducted a simulation analysis to consider the expected volatility under each contracting method in future years.

Our findings show that the use of natural gas customised derivatives for the horticulture sector in the Netherlands could help producers decrease input costs and lower the variability of natural gas prices. The use of a maximum price derivative contract would have lead to an annual savings in natural gas costs of €0.66/m^2 of production or about €12,500 in annual savings for a 1.9 hectare operation. In addition, the use of customised derivatives reduced the volatility of the cost of natural gas for the operation by 75% to 90%. This information can be helpful for producers in determining the types of procurement contracts they will choose to use in their horticulture operations.

In this report we offer considerations for identifying other sectors or application where customised derivatives may be useful in improving risk adjusted returns. Since customised derivative applications are relatively new in the Netherlands it is likely that there a number of other areas where agricultural producers and industry could benefit with new and innovative tools in financial risk management.

1. Purpose

Customised natural gas commodity price derivatives are relatively new for horticulture in the Netherlands. Two banks recently started to offer customised derivatives for natural gas. The purpose of this report is to provide information about customised commodity derivative pricing tools. In this report we provide a background on the sector and derivatives. The cornerstone of our analysis is to consider the value of using customised commodity derivatives by looking at the expected returns (in this setting returns are measured as the procurement costs) and the riskiness of the outcome (volatility of the procurement costs). We offer a case study analysis and a simulation analysis for assessing the value of using customised commodity derivatives in one's horticulture operation. We have included some considerations for offering customised derivatives and suggest areas where further research might advance the use of customised derivatives in managing price risk in agriculture. It is our hope that this report will serve as a catalyst to prompt additional research in the area of customised commodity derivatives.

2. Overview

Global shifts to more market based policies and a movement toward more fluid trade combined with local and global competition are producing farm and agribusiness income volatility stemming from underling commodity price volatility. An entrepreneur's ability to manage price risk will likely play an increasing role in distinguishing successful production and agri-business operations from their less profitable counterparts. These successful entities will demand more innovation and customisation in the menu of marketing and price risk management tools offered to them.

In this report we analyse several price risk management strategies for natural gas used in the horticulture sector of agriculture in the Netherlands. In the Netherlands, this sector of agriculture represents about one third of all primary agriculture production and the sector continues to be a growth area. Natural gas is typically the second largest production cost for the sector ranking just under labor. Energy costs represent about 20% of total production costs for a typical greenhouse operator (Van der Knijff et al., 2004). The high price and volatility of natural gas has a profound impact on greenhouse profitability (Van der Velden, Van der Meer, 2005).

The availability of new derivative contract structures adds to the timeliness and value of an analysis of customised derivatives in this sector. The authors recognise that numerous applications for customised derivatives will likely emerge and extend the usage of such derivatives across industries, geographies and commodities in the future.

3. Horticulture industry in the Netherlands

The horticulture sector is one of the leading sectors in agriculture production in the Netherlands (Minister LNV, 2002). Figure 3.1 shows the value of primary production of each of the major agriculture sectors for 2004. The garden crop sector can be divided into the open ground production and greenhouse production. The greenhouse sector generates approximately €5 billion of the €17 billion of annual total primary agriculture production in the Netherlands (Berhout, Van Bruchem, 2005).

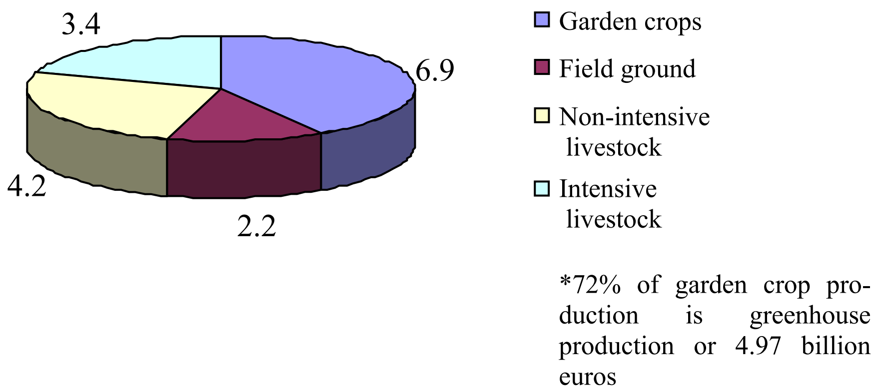

Figure 3.1 Dutch Agriculture Production 2004 (billion euros)
Source: Original data published by CBS and LEI, e.g. in *Agricultural Economic Report*.

Figure 3.2 shows the value of the production of garden crops relative to the total value of primary agriculture production in the Netherlands (Productschap Tuinbouw 2006). Approximately 72% of the total garden crop production is conducted in greenhouses with the balance of production taking place on open ground. The value of greenhouse production has enjoyed steady growth over the last 15 years and this sector is expected to see continued growth.

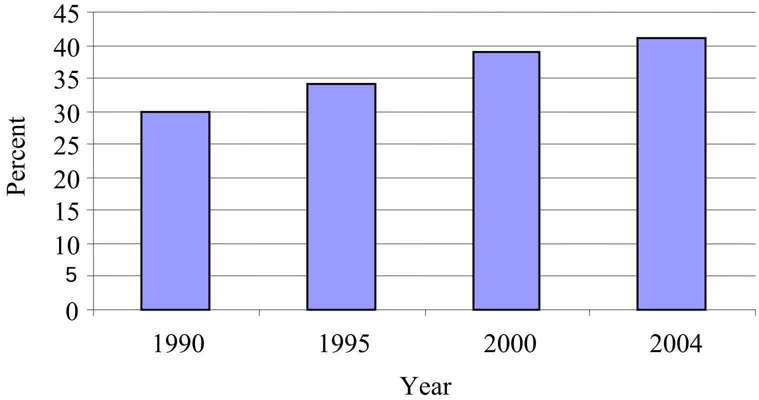

Figure 3.2 Dutch Garden Crop Production (Percent of total Dutch agricultural production)
Source: Original data published by CBS and LEI, e.g. in *Agricultural Economic Report*.

Table 3.3 shows the income and expenses per square meter for a typical greenhouse operation (De Bont and Van der Knijff, 2005). The largest expense is typically labor which is approximately one third of the total cost of production. The second largest expense for a greenhouse is generally energy. About 85% of all energy costs are natural gas with the balance being electricity, diesel and petrol. Each square meter of greenhouse production utilises between 35 and 45 m^2 of natural gas per year. Natural gas usage depends primarily upon the type of products grown in the greenhouse. Natural gas costs represent about 20% of the total cost of production for a greenhouse.

Table 3.3 Estimated income and expenses for a greenhouse, 2005 (in eurocent per square meter and percent)

	Vegetable greenhouse		Flower greenhouse	
	eurocent/m^2	in % of expense	eurocent/m^2	in % of expense
Income	36.40		52.90	
Expenses	39.00		55.40	
Land/Interest	7.20	18	10.00	18
Energy	9.90	25	11.70	21
Labor	13.00	33	16.70	29
Other	11.20	29	20.10	36

Natural gas prices have risen dramatically in the last five years as can be seen in Figure 3.3 (Agricultural Prices, 2006). The impact of rising energy prices on greenhouse operators has been to significantly increase the cost of production over the past several years. Rising energy costs and volatility have influenced the financial performance of the sector in 2005 (Van der Velden and Van der Meer, 2005).

The natural gas market in the Netherlands has been undergoing a liberalisation process for the last several years (Van der Velden et al., 1999). Greenhouse operators now have a choice of energy suppliers and also a choice of purchase contract structures. The contract choices typically include variable price and fixed price contracts, but suppliers and third parties are beginning to add other contract choices for energy users. The new contract structures seek to offer greenhouse operators more choices in how entrepreneurs may manage their energy price and volatility risk.

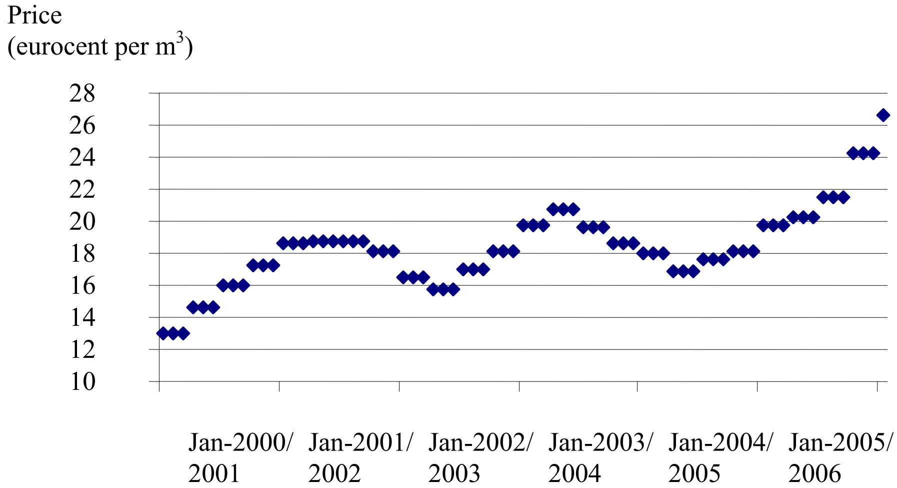

Figure 3.3 Natural gas price. Quarterly prices from 2000 to 2006

4. Overview of derivatives

A derivative is an instrument whose characteristics and value depends upon the characteristics and value of an underlying instrument. Derivatives are generally designed to manage or hedge price risk, or to swap cash flows (Hull, 2002).

Some derivatives are standardised and traded on regulated exchanges while others are customised bilateral agreements. An exchange traded derivative is a derivative that is traded on an organised and regulated exchange. These derivatives are most commonly standardised by quantity, grade, delivery location and expiration date. Exchange traded derivatives are typically cleared and settled through the multilateral clearing process used by regulated exchanges.

An example of an exchange traded derivative is a futures contract on natural gas. Exchange traded natural gas contracts are actively traded on organised exchanges such as the New York Mercantile Exchange in New York or the Intercontinental Exchange which is electronic and offered for trading globally. Options traded on such exchanges which settle directly to cash or to a futures contract are also considered exchange traded derivatives.

A customised derivate is one that is designed specifically for a user or a group of users or for a specific application. Customised derivatives are also known as over the counter ('OTC') derivatives. These instruments generally contain some unique characteristics such as the size, grade, delivery location or settlement benchmark, expiration date, pay-off matrix or counter party characteristics. Customised derivatives are generally bilateral and can not be directly offset against other customised or exchange traded derivatives.

An example of a customised derivative would be a contract offered by a gas company to purchase natural gas at a fixed price for the next year designed to meet a customer's requirements. There are numerous other examples of customised derivatives where the supplier customises some aspect of a standardised contract to meet his customer's needs.

Customised Derivatives Background

The Netherlands has a notable history of using derivatives in agriculture by offering trade in forward contracts on tulip bulbs in the seventeenth century. The tulip bulb forward contract trade came to an abrupt halt with the market mania and crash of the tulip market in 1637. It took another 200 years for organised exchanges to be formed in the USA (The Chicago Board of Trade was founded in 1848). In the ensuing years, organised exchanges offered a limited set of standardised derivatives.

The last two decades have brought rapid innovation in customised derivatives. This activity has dramatically expanded the menu of customised derivative choices available to producers and agriculture firms in the US and other countries. In the Netherlands Rabobank and ABN-AMRO have developed customised derivatives for the agricultural market. Besides the natural gas market also the interest market and the 'valuta' market have customised derivatives. Escalating firm level commodity price risk has been a healthy encourager for the adoption of new pricing and risk management tools. Changing business models and financial engineering innovations have further stimulated the development and usage of customised derivatives in agriculture. In some areas commodity purchase and sales contracts are now frequently offered with a menu of choices which contain imbedded optionality or customised derivatives. Primary producers and agriculture related companies are finding it advantageous to utilise these tools in their ordinary purchasing and marketing plans. In US agriculture customised derivatives are currently available for managing a number of commodity input and output prices. For example, one can utilise customised derivatives to purchase fuel or other energy products or to sell arable or livestock production.

Customised Derivative Pricing

The practice of determining the price of a customised derivative is closely linked to option pricing practices. This is because customised derivatives generally offer some form of optionality imbedded into a purchase or sales contract. Thus, a customised derivative is generally constructed with some combination of forward or futures contracts and option contracts.

The price of an option is dependent upon the price of the underlying instrument, the strike price of the option, the distribution of returns for the underlying instrument, the time remaining prior to expiration and the prevailing risk free rate of interest. In Appendix 1 we show Black's Option Pricing Model for Futures and Forwards (Black, 1976). In this study we will use this model to price the option components of the derivatives we are analysing.

5. Explanation of contracts considered in this analysis

5.1 Variable price contract

A variable price contract is a contract where two parties have a relationship to supply and receive a good, but the price floats until the customer takes delivery of the physical commodity. At the time the physical product is exchanged, the price is fixed based upon prevailing market conditions. An example of a variable price contract is a case where a greenhouse operator is receives gas each day from a certain supplier. However, the price floats according to the prevailing market price and can be established each day, week, month or quarter depending on the agreed upon period and method for establishing the price.

5.2 Fixed price contract

A fixed price contract is a contract where the buyer and seller fix the price of a good for a certain period. An example of a fixed price contract could be where a greenhouse operator agrees to purchase a certain amount of natural gas at a certain price for a certain period, such as a calendar year.

5.3 Maximum price contract

A maximum price contract is a contract where the supplier (or a third party) agrees to charge no more than a predetermined price for a commodity. In this case the buyer will pay a premium up front for the maximum price contract. The maximum price is known as the strike price. If the market price is below the strike price, the greenhouse operator is charged the prevailing market price. However, if the market price is above the strike price, the supplier will only charge the contract maximum price.

5.4 Collar contract

A collar (sometimes also called a fence) contract establishes both a maximum price and a minimum price between the supplier and the buyer. If the market price is between the minimum and the maximum prices the user pays the prevailing market price. If the market price is above the maximum price, the user pays only the contract maximum price. If the market price is below the minimum price, the user pays the agreed upon contract minimum price.

Figure 5.1 shows a graphical representation of the natural gas price payable by the user under each type of contract. The x axis represents the current market price while the y axis represents the price paid by a greenhouse operator. The blue line shows the price a greenhouse operator would pay if he utilises a variable price contract. As the market price rises, the price the greenhouse operator pays rises in a one to one relationship with the market price. The yellow line shows the price paid by the greenhouse operator if he uses a fixed price contract. Here it can be seen that the price is fixed and any change in market price is irrelevant since the contract has a fixed price. This is true whether the market price rises or falls. The red line illustrates the price to be paid under a maximum price contract. In this case the operator pays a premium for the option which is similar to an insurance premium. After paying that premium the operator receives any benefit from falling prices and shall pay no more than the maximum established price regardless of the prevailing market price at the time of delivery of the commodity. A collar contract is represented by the green line. This type of contract establishes both a contract maximum price and a contract minimum price to be paid regardless of how high or low the market price may be. In between the maximum and minimum prices the buyer pays the prevailing market price.

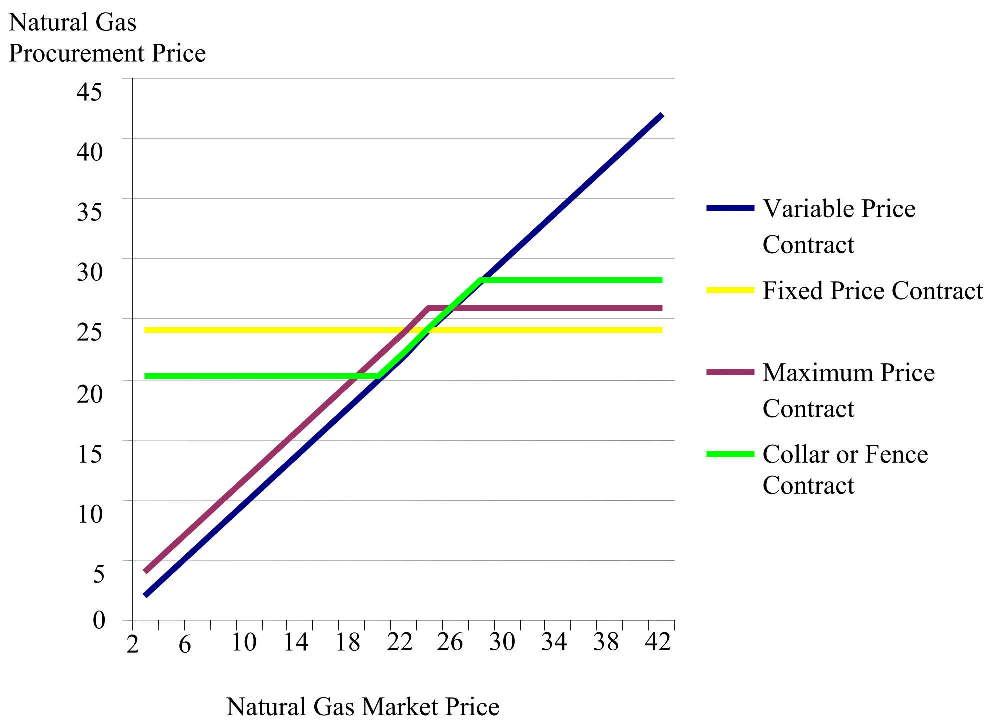

Figure 5.1 Natural gas contract comparison (prices in eurocents per m^3)

6. A case study analysis

The purpose of this portion of the report is to compare the performance of several natural gas procurement strategies in a typical green house business by using historical data in the natural gas market. We will use natural gas price data available at LEI (Agricultural Prices, 2006) and compare the cost and volatility of the four procurement strategies outlined in section 5.

Customised derivatives are relatively new to the greenhouse sector in the Netherlands so by using historical data we will consider the case of a fictitious Mr. Wagen. Our interest is to gain some insight into whether there are strategies for procuring natural gas that tend to dominate other strategies when considered in a risk and reward framework.

Meet our typical but fictitious Mr. Wagen

Mr. Wagen[1] operates a fairly typical flower greenhouse in the Netherlands. He has 1.9 ha of production under glass production. In 2005 his business income was €1,005,100. Mr. Wagen showed expenses of €1,052,600 yielding a negative net profit of (€47,500). His total energy costs were €222,300 and natural gas constituted about 85% of the total energy costs at €188,955. Natural gas usage was 44 m^3 per square meter for a total usage of 836,000 m^3.

Table 6.1 Assumptions for our fictitious Mr. Wagen

Income (€)	1,005,100
Expenses (€)	1,052,600
Profit (€)	(47,500)
Total Energy Costs (€)	222,300
Natural Gas Costs (€)	188,955
Natural Gas Usage (m^3)	836,000

We will assume that Mr. Wagen makes his natural gas procurement decision each year on October 1. The decision he will make is which natural gas procurement strategy he will use for the upcoming calendar year. Mr. Wagen is presented with four contract choices each year on October 1.

[1] In Dutch, 'wagen' is the word for wagon, but it can also have a double meaning 'to risk or to dare'. Therefore considering the setting, we have named our pleasant and typical greenhouse entrepreneur Mr. Wagen.
The production and cost numbers for Mr. Wagen are based on the average green house operator in statistics collected by LEI. See references for further information on where to obtain information about the horticulture sector in the Netherlands.

Variable price contract
Mr. Wagen may buy his natural gas needs on a variable price. In that case he would simply pay the prevailing market rate for natural gas which is established each quarter.

Fixed price contract
Mr. Wagen may purchase natural gas using a fixed price contract whereby the price he pays is fixed for the upcoming calendar year. In the case of the fixed price we will assume that the price offered is the average of the previous 4 quarters. The method makes the assumption that the market structure is flat. In other words the market is neither in contango (deferred prices are higher than the spot price) nor in backwardisation (spot prices are higher than deferred prices). This is a conservative assumption. Often the market is in backwardisation where the deferred prices are lower than the spot. The current market verifies the conservative nature of this assumption by showing that the market for calendar 2009 is lower the calendar 2008 which is lower than calendar 2007 which is also lower than the spot price.[1] This is a reasonable assumption, however, it is more likely that sometimes the market is in contango and some of the time it is in backwardisation.

Maximum price contract
Mr. Wagen may purchase his natural gas needs with the use of a maximum price contract where the maximum price is fixed. If market prices at the time of natural gas usage are lower than the maximum price Mr. Wagen will pay the prevailing market price. If the market price at the time of usage is greater than the maximum price established, Mr. Wagen will pay only the maximum price.

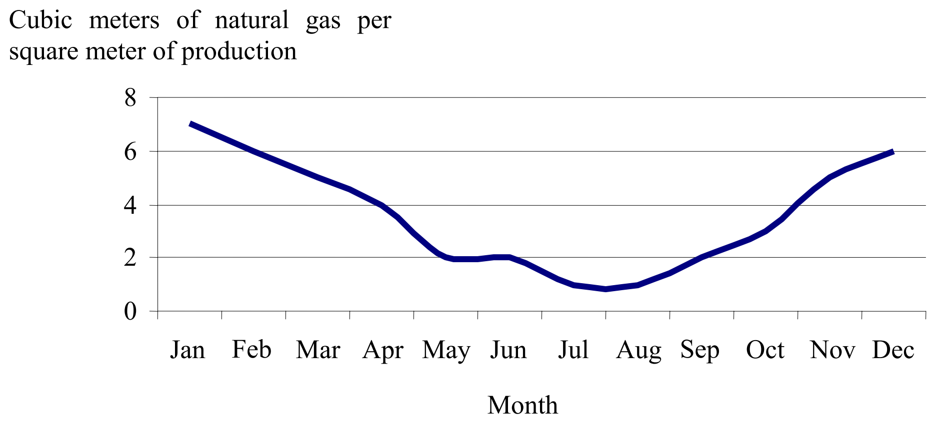

Figure 6.1 Mr. Wagen's natural gas use by month

[1] Market quotes as shown on Endex, (www.endex.nl), which shows prices for the title transfer facility in the Netherlands, May, 2006.

Collar price contract
Mr. Wagen may use a collar or fence contract whereby both a minimum and a maximum price are fixed. However, if the prevailing market price at the time of usage is between the minimum and maximum established prices then Mr. Wagen will pay the prevailing market price. If the market price at the time of usage is above the maximum established price, Mr. Wagen need only to pay the maximum established price. If the market price is below the minimum price, Mr. Wagen will pay the minimum established price.

Mr. Wagen's natural gas annual usage by month is shown in figure 6.1. The annual cost of natural gas per square meter of production is obtained by using the quarterly natural gas price weighted according to the usage each quarter.

Further Case Study Assumptions

For this case study we will use Black's Option Pricing Model for Futures and Forwards ('BOPM') to price the derivatives we use in the study (Black, 1976) (See Appendix I for model, See Appendix III for Case Study Data).

One of the requirements of the model is to estimate the future volatility. There are several common methods for estimating future volatility. One method is to look at current market conditions of the same or a similar instrument which is based on the same or a similar underlying instrument. One can calculate the implicit volatility by setting the known parameters in BOPM to the market-based values and then solve BOPM iteratively for the volatility. The solution is known as implied volatility. Traders generally consider this market-based method of calculating the implied volatility to be a good estimate of future volatility. In our case, implied volatility is not available due to the lack of traded derivatives in the Netherlands.

Another method of forecasting future volatility is to use past or historical volatility. Historical volatility can be calculated as:

$$\sigma_h = (P_t - P_{(t-1)}) / P_{(t-1)} * \sqrt{t}$$

where: σ_h is the historical volatility
P_t is the current price,
$P_{(t-1)}$ is the previous quarter's price and,
t is the number of periods in a year
(See Appendix II for the volatility calculations).

After calculating the historical volatility, we adjust the historical volatility in the following manner to obtain the estimated future volatility:

$$\sigma_e = 1.25\ \sigma_h$$

where: σ_e is the estimated volatility and,
1.25 is a constant based upon the observation that there is generally a premium for future volatility relative to calculated historically volatility.

Options based strategies in this study utilise quarterly options with exercises at the beginning of each quarter which is the time the natural gas price for the upcoming quarter is published and fixed. A contract year utilises four quarterly options which are weighted by expected volumes consumed and price to calculate a single annual option price.

We do not consider a value for the *interest* on the premium paid in the case of the maximum price contract. We also do not consider administration costs and profits for intermediaries (for instance banks).

The maximum price contract utilises an at the money call option. This means that on October 1 of each year, which is the time the derivative is agreed upon by both parties, the average price of the previous four quarters (a proxy for the forward price) and the contract maximum price are the same.

The collar contract uses the current market price plus 2 eurocents for the maximum price of the contract and the current price minus 1.70 eurocents for the contract minimum price. The purpose of this method of structuring a collar is to create a realistic collar price contract where the derivative premiums are approximately the same so that initial capital outlay is approximately zero (premium for the collar is zero).

Results of the Case of Mr. Wagen

Table 6.2 shows the results of the historical case study analysis. If Mr. Wagen used only variable price contracts for procuring natural gas his average procurement price would have been €8.38 per square meter of production from 2002 through 2005. By enlisting the use of fixed price purchase contracts Mr. Wagen would have paid €7.91 per square meter. The maximum price strategy would have resulted in Mr. Wagen spending on average €7.72 per square meter and by using collar price contracts he would spend €8.02 in gas procurement per square meter. The standard deviation of the returns is an important measure of the riskiness of a strategy. Here we can see that the standard deviation of the procurement strategies using variable price, fixed price, maximum price and collar price are €1.17, €0.61, €0.13, €0.32 respectively.

Table 6.2 Natural gas cost (€/m²)

Year	Contract type			
	variable price	fixed price	maximum price	collar price
2002	7.45	8.17	7.62	7.61
2003	8.60	7.42	7.78	8.26
2004	7.50	8.65	7.87	7.92
2005	9.95	7.41	7.60	8.24
Average Cost	8.38	7.91	7.72	8.02
Standard Deviation	1.17	0.61	0.13	0.32

Figure 6.2 shows the plot of points where the x axis is the standard deviation of returns and the y axis is the cost of natural gas per square meter. This plot can provide some insight into the risk and reward of each procurement strategy. One would likely seek strategies with outcomes that are the furthest down and left on the chart. This area represents the lowest cost and least risk. In our example the maximum price contract has the lowest costs per square meter and the lowest volatility.

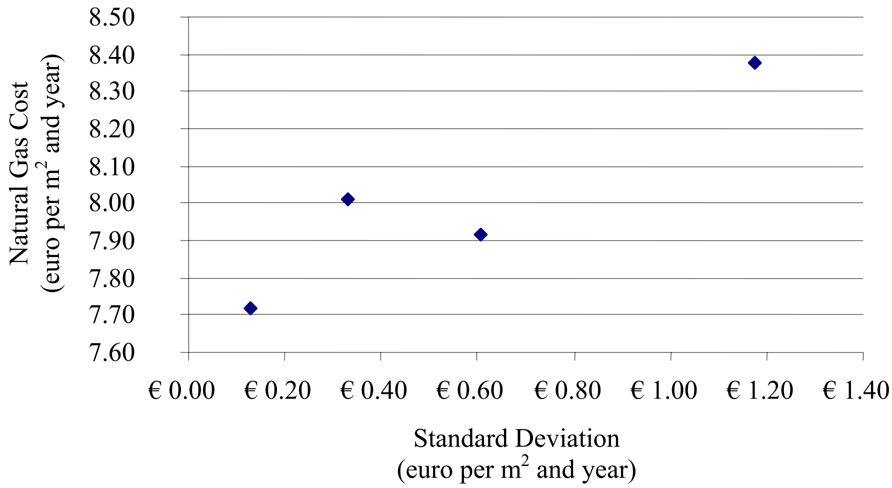

Figure 6.2 Average strategy cost & standard deviation

Figure 6.3 extends the analysis of the previous chart to utilise a stochastic dominance framework (Goncalo, 2006; Rothschild, Stiglitz, 1970, 1971; Hanoch, Levy, 1969; Hadar and Russell, 1969). In this case study we have analysed four years of procurement strategies and derived a mean and a variance for each strategy. If we assume that the distribution of returns for each strategy are normal and follow the mean and variance observed in our case study analysis we can plot the cumulative distribution function of each strategy.

Stochastic dominance theory can be a useful tool to analyse an entrepreneur's preference among several strategy choices. First order stochastic dominance theory suggests that if all points from a strategy's distribution are to the left of the distribution plot of a second strategy, the first strategy is said to dominate the second. If we have two return distributions with cumulative density functions F(x) and G(x) respectively, then F(x) first order stochastically dominates G(x) if and only if $G(x) \geq F(x)$ for a points of x. In that case F(x) will have both a more favorable mean and variance.

Second order stochastic dominance can be used to analyse a dominant strategy in the case where the cumulative density function plots of the distributions cross. F(x) is said to stochastically dominate G(x) if its area to the left of G(x) is greater. In this case F(x) is more likely to yield a more favorable result (i.e. a lower procurement price in this case).

The strategies considered here are variable price, fixed price, maximum price and collar price procurement strategies. We can see that the strategies all intersect at different points. We can use this chart to help determine which strategy is the dominant strategy. Here we see that the maximum price strategy is most likely to yield the best natural gas purchase price, thus it can be said that the maximum price strategy is second order stochastically dominant.

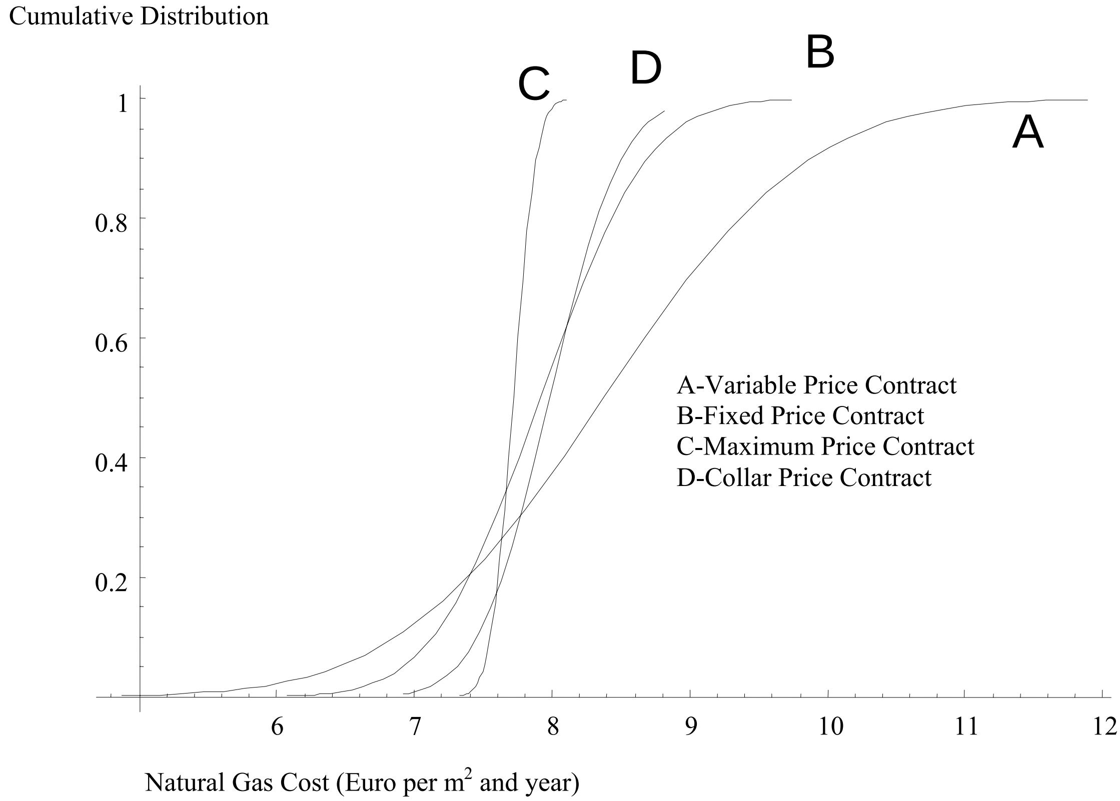

Figure 6.3 Strategy cumulative distribution functions

Another way to consider this information is to eliminate strategies which are not dominant. In this case the variable price strategy is clearly the worst choice. It is the 'do-nothing' strategy and offers the worst price outcome with the most volatility. Mr. Wagen may want to consider the other three strategies in light of the overall goals of his firm. For example, cash flow, contracting knowledge and expertise or other factors may play a role in determining Mr. Wagen's procurement choice. It is also possible that Mr. Wagen would utilise some combination the three remaining strategies, fixed price, maximum price and collar price.

Considering Strategy Selection Given Entrepreneur Risk Preferences

A risk neutral entrepreneur is one who will select a strategy based on the optimal procurement price. In this case the maximum price contract offers the lowest procurement price. Therefore, an entrepreneur who is risk neutral will rationally select the maximum price contract strategy.

A risk averse entrepreneur is one who weights his selection between risk and the likely outcome. Such an entrepreneur's utility function can be viewed as a convex curve where he trades return for risk in a decreasing way. The risk averse entrepreneur would seek the strategy or set of strategies which maximise his utility given his unique risk and return trade-off function. In this case a rational risk averse entrepreneur would also select the maximum price contract since it offers both the lowest risk and the lowest procurement price.

Business Implications

One part of the value of employing customised derivates to Mr. Wagen's business enterprise can be to lower procurement costs. Here we found that for the period from 2002 to 2005 Mr. Wagen could have enjoyed a savings of €0.66 per m^2 by employing a maximum price contract strategy instead of a variable price strategy. This equates to an average annual savings of €12,540 for Mr. Wagen's greenhouse business or a savings of approximately 1% of total production costs (€12,540/€1,052,600, Section IV annual costs).

Another advantage of the derivative strategies is the reduction in the variability of commodity procurement costs. In the case of Mr. Wagen, we see that the derivative strategies cut the standard deviation of the natural gas cost per m^2 substantially. For example the variable price contract method produces a standard deviation of €1.17 per m^2 whereas the fixed price, maximum price and collar price strategies yield standard deviations of €0.61, €0.13 and €0.32, respectively. This reduced procurement volatility can benefit an entrepreneur in tangible and intangible ways. A business with lower input cost volatility may be able to achieve more favorable financing terms or other business benefits.

7. A simulation analysis

In this section we will use price simulation to compare the performance of several natural gas procurement strategies in a typical green house operation. The purpose of this simulation is to gain further understanding into the volatility of input costs when using various procurement strategies. This simulation should not be used to draw any conclusions about the mean procurement price.

Simulation Framework

Futures and forward commodity prices are generally considered to be log normally distributed. In fact the log normal distribution of prices is one of the assumptions of Black's Option Pricing Model (Black, 1976). The simulation will employ a log normal price distribution of natural gas prices. The simulation will use the average price of natural gas in the Netherlands for greenhouse operators from 2000 to 2005 as the mean of the distribution (μ = 18.30 eurocents) and the standard deviation from the same period (σ = 2.68).

The simulation will be used to generate 10,000 pseudo random observations from the price distribution. These observations can be viewed as market prices one year after our procurement decision. Each observation generated in the simulation represents one year. This simulation will use Black's Option Model for Futures and Forwards to price the options used in the simulation (See appendix 4 for strategy data for simulation analysis).

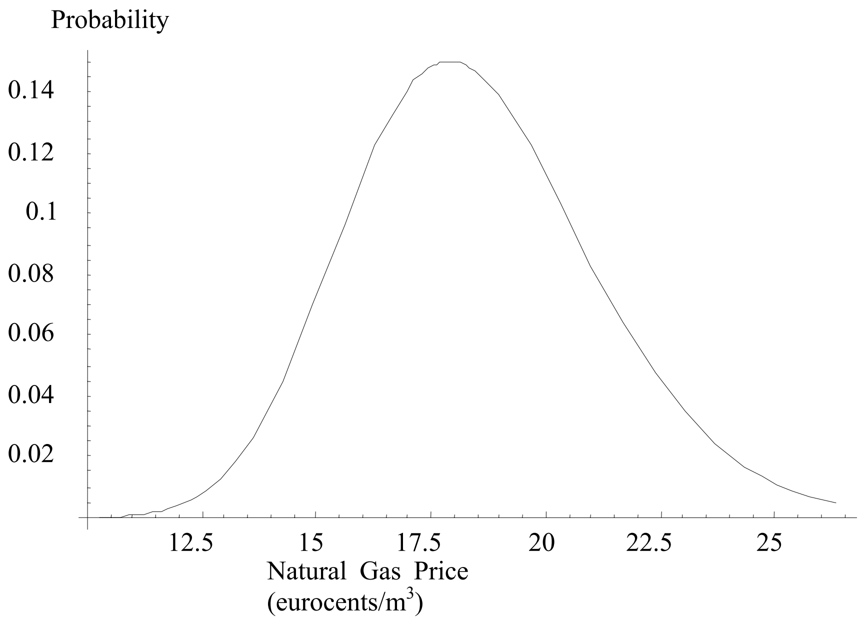

Figure 7.1 Natural Gas Price Distribution. Lognormal Probability Density Function μ=18.30, σ = 2.68

The procurement strategies considered in the simulation are a variable price contract, a maximum price contract and a collar contract. In this case, we do not consider a fixed price contract since we are interested in the variance of returns produced by the derivative strategies relative to the variable price contract strategy. The structure of each contract considered is the same as outlined in sections 5 and 6. The contracts under consideration are applied to the 10,000 observations generated in the price simulation. From this analysis we can develop a distribution of outcomes for each strategy.

We expect the mean for the maximum price contract and the collar price contract to be approximately €18.30/m^3. The mean of each strategy should be similar to the mean of the distribution due to the definition of each strategy and the use of a log normal distribution. Slight differences may occur in the means of each strategy since we only use 10,000 observations.

Figure 7.1 shows the probability density function of the price distribution being used for the simulation. Figure 7.2 plots 10,000 random draws from the distribution shown in figure 7.1. Figure 7.2 represents the price and volatility one would experience by using variable price contract.

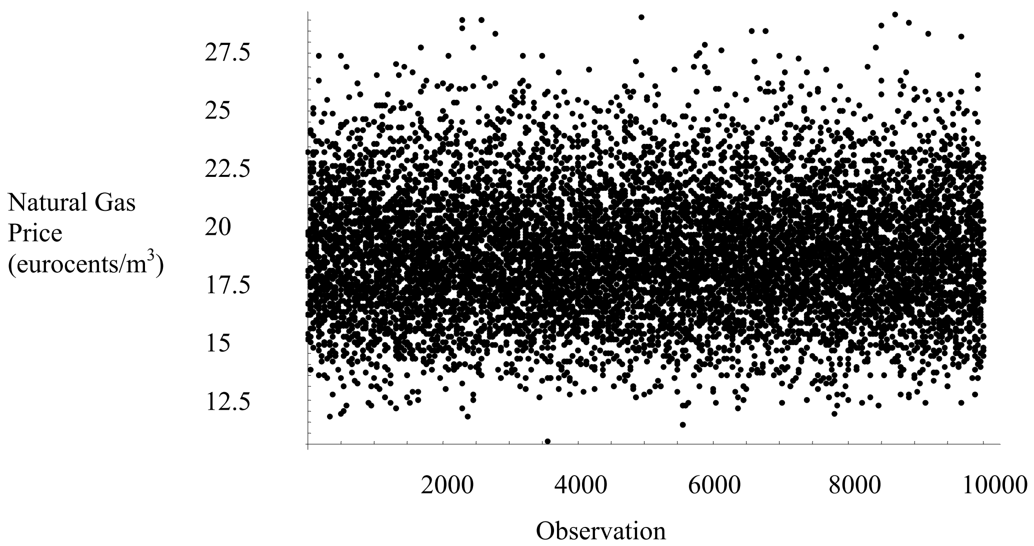

Figure 7.2 Variable price contract simulation. Plof of random 10,000 observations of lognormal distribution

Figure 7.3 is a plot of the same 10,000 draws from figure 7.2 with the maximum price contract parameters applied to each plot point. The option premium used in the maximum price contract is 1.02 eurocents and the maximum price is therefore 19.32 eurocents per m^3.

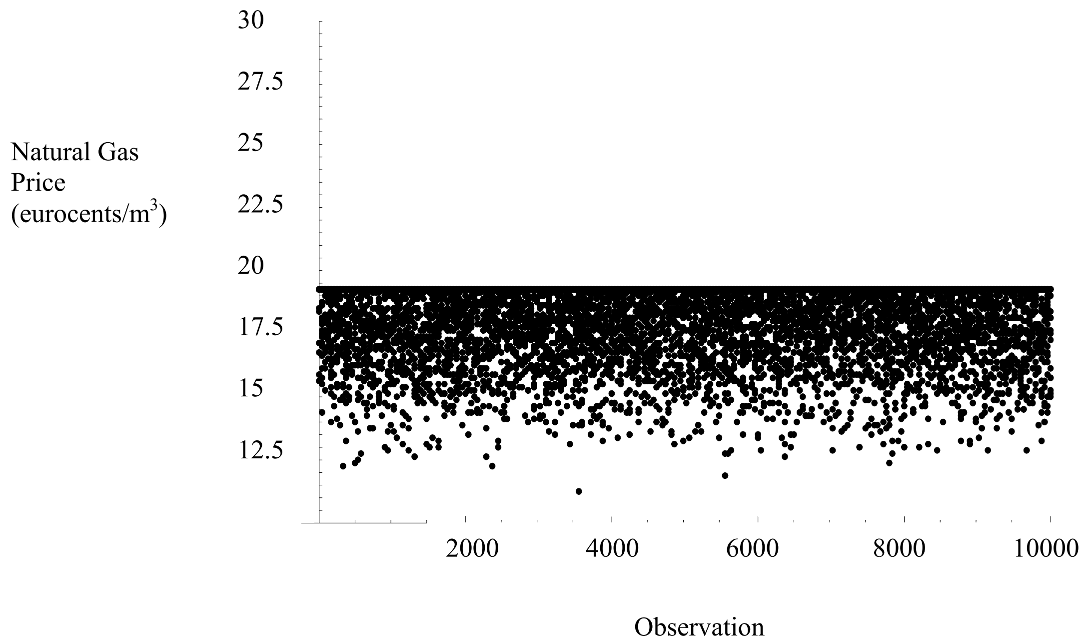

Figure 7.3 Maximum price contract simulation plot of 10,000 random observations

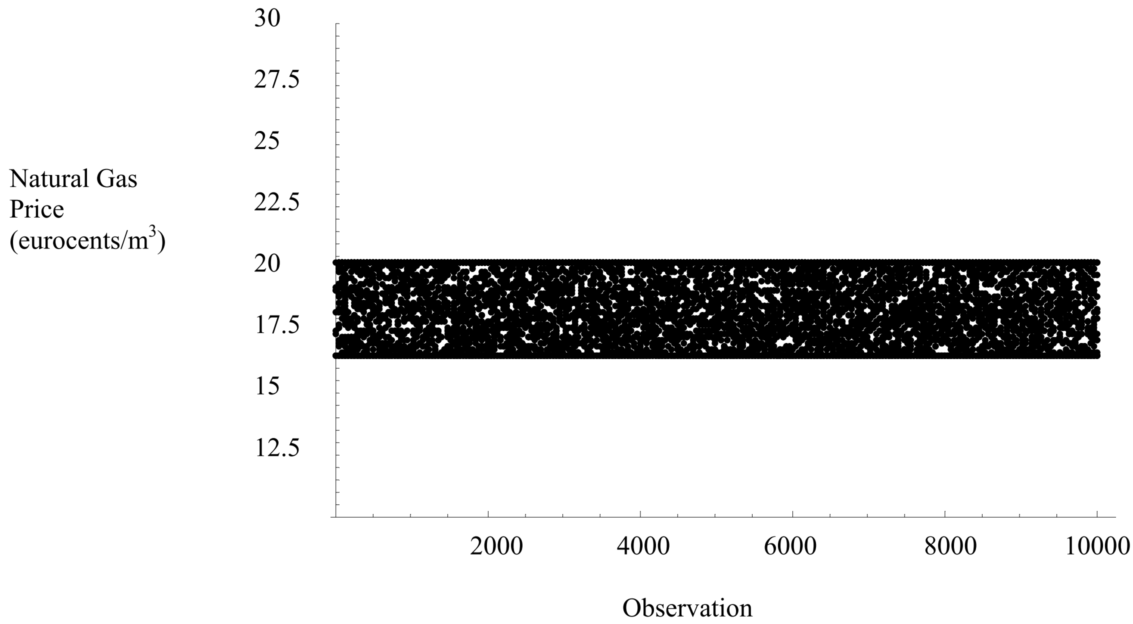

Figure 7.4 Collar price contract simulation plot of 10,000 random observations

Figure 7.4 is a plot which represents the prices that one would have paid under the collar price contract. The same data used in figure 7.2 is used here and the collar price contract structure is applied to each observation. The collar contract has a maximum price of 20.30 eurocents per m^3 and a minimum price of 16.60 eurocents per m^3.

Figure 7.5 shows a plot for each of the three procurement strategies analysed. Here the natural gas prices realized for each strategy are sorted by magnitude and plotted.

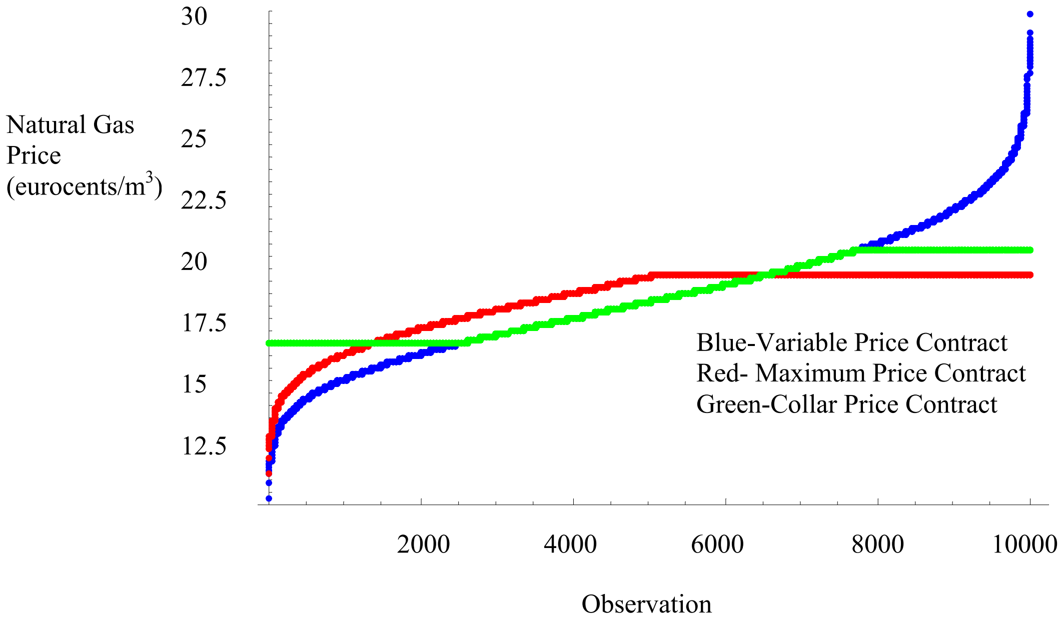

Figure 7.5 Price contract simulation comparison sorted plot of 10,000 random observations

Table 7.6 Natural Gas Cost & Standard Deviation

	Contract type		
	variable price	maximum price	collar price
Average cost (eurocents per m^3)	18.41	18.31	18.35
Standard Deviation (eurocents per m^3)	2.69	1.41	1.49

Table 7.6 shows the natural gas cost and the standard deviation under each procurement strategy considered. Here we can see that the average cost of each strategy is approximately the same which is exactly what we would expect in a simulation like this. The volatility of each strategy is quite different. The variable price strategy has the highest standard deviation (2.69) of prices and both strategies with imbedded optionality have substantially lower standard deviations (1.41 and 1.49 for the maximum price and the collar price strategies, respectively).

8. Conclusions

In this research we show that the horticulture sector in the Netherlands could find significant value by utilising natural gas price derivatives to manage the volatility risk and price risk of natural gas. The case study analysis for the period 2001-2005 shows us that the cost of natural gas can be reduced through the prudent use of derivatives when compared with a variable price procurement strategy. Furthermore, all natural gas derivative strategies considered here offer less procurement cost volatility in both the case study analysis and simulation analysis. Of course these results are no guarantee that the use of derivatives will realise similar savings for further periods.

Price Performance

In the case study in section 6, the variable price strategy resulted in a natural gas cost of €8.38 per square meter of production. The fixed price, maximum price and collar price contracts resulted in a cost of €7.91/m^2, €7.72/m^2 and €8.02/m^2, respectively. This research shows that the best natural gas price for the last 4 years would have been achieved using a maximum price contract strategy.

Risk Performance

The case study analysis showed that the standard deviation of natural gas costs was €1.17/m^2 for the variable price strategy. The fixed price, maximum price and collar price strategies yielded standard deviations of costs of €0.61/m^2, €0.13/m^2, €0.32/m^2, respectively. In the case study all derivative contracts were less risky than the variable price contract strategy, with the least risky strategy being the maximum price strategy.

We conducted a simulation analysis to further test the impact of procurement strategies on the procurement price volatility for the variable price, maximum price and collar contracts. The simulation analysis was conducted using 10,000 data simulation points. The simulation supports the conclusions of the case study, that one can decrease procurement price volatility with the use of derivatives. In the simulation the standard deviation of natural gas prices for the variable contract strategy was 1.18 eurocents/m^3. The maximum price and collar price contracts showed standard deviations of 0.62 eurocents/m^3 and 0.66 eurocents/m^3, respectively. Once again, the least risky strategy is the maximum price strategy.

Business Benefits

The savings in natural gas costs observed in the case study in the period 2001-2005 comparing derivative procurement strategies compared to the variable price procurement strategy ranged from 5.5% to 8.5% savings in the cost of natural gas. The business impact of incorporating customised derivatives into the procurement and risk management plan of one's business appears to be a substantial reduction in the input cost volatility and approximately a 1% cost savings for the business as a whole. The use of derivatives leads to a strong decrease of volatility which means that the farm income is stabilised. This can lead to lower interest rates for loans or could increase the possibility for extra loans.

9. Considerations for offering customised derivatives

Here we offer a list of conditions which we believe ought to be present for the development of additional customised derivatives.

- Commodity price availability and tradability. The creator of a derivative must have a way to manage the risk inherent with such offering. Most often a firm will prefer a tradable benchmark similar to the underlying commodity upon which the derivative is being offered. For example, a natural gas derivative would most likely be hedged and managed by using the futures or forward markets in natural gas. However, already there is a great deal of innovation underway where derivative firms are creating models that allow them to offer derivatives on commodities that can be related to a different set of underlying prices. For example, if there is no trade in a hog futures market but there is very liquid trade in grain and protein products, a company could construct a model where the input price is a combination of grain and soy protein plus a production factor and plus a margin factor to arrive at an approximate live hog value. Using such a model, one may offer live hog derivatives which could be a useful tool for pork producers and processors. This technique is being applied in the agriculture and food industries in other countries. For example, high fructose corn syrup can be purchased based on corn prices plus processing costs plus a margin factor. The same concept can and is being used in other processed products.
- Price volatility. There should be a significant price risk present.
- Price variation should impact farm or firm income. The commodity price volatility should have a noticeable impact on farm or firm income which will incent producers and firms to manage the price risk by using customised derivatives.
- The market size should be considered. It is important for derivative creators and sellers to identify markets which meet a minimum size that provides an acceptable possibility to reward them for their efforts. Thus, one must consider the aggregate market size in determining which derivatives to offer.
- There should be willingness by derivative firms and entrepreneurs to experiment and innovate in the realm of financial tools offered and used for commodity purchases and sales.

10. Suggestions for further research

Customised derivatives are just beginning to be offered for use in agriculture in the Netherlands. This research shows that there is promise for their use in the horticulture sector for natural gas procurement. It is likely that there are many more applications in other sectors where customised derivatives could be useful in managing commodity price risk inherent in a business. The development of these customised derivative tools will likely require a combined effort by skilled researchers, innovative entrepreneurs and a responsive and committed financial derivative sector. We offer suggestions for further research in this topic which may be helpful for the continued commercial development and application of customised derivatives.

- Research could be undertaken to create a modelling tool for entrepreneurs to analyse the value and impact of incorporating the use of customised derivatives into their businesses.
- Case study research utilising actual cases of the use of customised derivatives may be useful for entrepreneurs.
- Further analysis of more exotic derivatives structures may offer additional benefits.
- Research into the business implications of the use of customised derivatives could be helpful.
- Research should be completed on decision tools for determining optimal derivative selection or optimal combinations of derivatives, including considering more detailed analysis of derivative selection under varying entrepreneur risk preferences. Also simulation with different strike prices or collar prices gives insight in the relation between premiums for lowering the risks and the change in volatility of costs or income.
- Research into other implications of using customised derivatives such as cash flow considerations would be insightful.
- Research into the further development of customised derivative tools in other commodities areas would help expand the knowledge and potential development of derivatives in other sectors.
- Research other business models for introduction of derivatives in the market. For example the derivates studied in this paper could be offered by energy companies instead of a bank (the developer of the derivatives).

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Appendix 1 Black's option pricing model for futures and forwards ('BOPM')

$C = e^{-rt}$ [F N(d1) – X N(d2)]

where: d1 = (ln (F/X) + (σ^2 / 2) t / σ√t

d2 = d1 – σ√t

and:

C is the price of the call option,
F is the futures price,
X is the strike price,
t is the time remaining,
σ is the standard deviation of returns or volatility,
r is the risk free rate,
ln denotes the natural logarithm, and
N is the standard normal distribution function.

Assumptions of the BOPM:

1. There are no transaction costs.
2. The interest rate remains known and constant.
3. Prices are log normally distributed.
4. Volatility is constant over the life of the option.

Appendix 2 Volatility calculations, quarterly and annual

Table A2.1 Price volatility (in eurocents per m³)

Date	Volatility calculation		
	Mean price	quarterly volatility (T)	annual volatility (T)
Q1 2001	18.63	0.15	
Q2 2001	18.74	0.01	
Q3 2001	18.78	0.00	
Q4 2001	18.16	0.07	0.06
Q1 2002	16.49	0.18	
Q2 2002	15.80	0.08	
Q3 2002	17.01	0.15	
Q4 2002	18.13	0.13	0.14
Q1 2003	19.79	0.18	
Q2 2003	20.70	0.09	
Q3 2003	19.58	0.11	
Q4 2003	18.59	0.10	0.12
Q1 2004	18.05	0.06	
Q2 2004	16.90	0.13	
Q3 2004	16.40	0.06	
Q4 2004	16.05	0.04	0.07
Q1 2005	21.00	0.62	
Q2 2005	21.50	0.05	
Q3 2005	22.65	0.11	
Q4 2005	25.30	0.23	0.25

Appendix 3 Case study data

Table A3.1 Case study data (eurocents per m^3))

Quarter	Variable price contract	Fixed price contract	Maximum price contract		Collar price contract		
			option value	realized a)	min.	max.	realized b)
Q1 2002	16.49	18.58	0.38	16.87	16.88	20.58	16.88
Q2 2002	15.80	18.58	0.38	16.18	16.88	20.58	16.88
Q3 2002	17.01	18.58	0.38	17.39	16.88	20.58	17.01
Q4 2002	18.13	18.58	0.38	18.51	16.88	20.58	18.13
Q1 2003	19.79	16.86	0.82	17.68	15.16	18.86	18.86
Q2 2003	20.70	16.86	0.82	17.68	15.16	18.86	18.86
Q3 2003	19.58	16.86	0.82	17.68	15.16	18.86	18.86
Q4 2003	18.59	16.86	0.82	17.68	15.16	18.86	18.86
Q1 2004	18.05	19.67	0.84	18.89	17.97	21.67	18.05
Q2 2004	16.90	19.67	0.84	17.74	17.97	21.67	17.97
Q3 2004	16.40	19.67	0.84	17.24	17.97	21.67	17.97
Q4 2004	16.05	19.67	0.84	16.89	17.97	21.67	17.97
Q1 2005	21.00	16.85	0.43	17.28	15.15	18.85	18.85
Q2 2005	21.50	16.85	0.43	17.28	15.15	18.85	18.85
Q3 2005	22.65	16.85	0.43	17.28	15.15	18.85	18.85
Q4 2005	25.30	16.85	0.43	17.28	15.15	18.85	18.85

a) Realized Maximum Price = Minimum (Fixed Price + Option Value, Variable Price + Option Value);
b) Realized Collar Price = If [Variable Price > Collar Maximum Price, Collar Maximum Price, If[Variable Price < Collar Minimum Price, Collar Minimum Price, If[Collar Minimum Price ≤ Variable Price ≤ Collar Maximum Price, Variable Price]]].

Natural Gas Usage By Quarter Per Square Meter Of Production ($M^3_{ng}/m^2_{Production}$)

Q1	18
Q2	8
Q3	4
Q4	14

Annual Natural Gas Cost (€/M^2)

Year	Vari price Contract	Fixed price Contract	Max price Contract	Collar price Contract
2002	7.45	8.17	7.62	7.61
2003	8.60	7.42	7.78	8.26
2004	7.50	8.65	7.87	7.92
2005	9.95	7.41	7.60	8.29
Average	8.38	7.91	7.72	8.02
StDev	1.17	0.61	0.13	0.32

Appendix 4 Strategy data for simulation analysis

Maximum Price Contract

Call := f [f, x, σ, t, i]

where:

Call := f [18.30, 18.30, .1466, 1, .05] = 1.02 .

Thus,

Maximum Price Contract =f [Min (Variable Price Contract +1.02, Strike Price + 1.02)]

Collar Price Contract

Collar Price Contract := f [Which (Variable Price ≥20.30, 20.30,

16.60<Variable Price <20.30, Variable Price,

Variable Price ≤16.60, 16.60)]