INDUSTRIAL HEMP IN THE NETHERLANDS: THE EFFECTS OF CHANGES IN POLICIES AND SUBSIDY STRUCTURES

By

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To those I love unconditionally

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Writing a dissertation comes with times of procrastination, considerable insecurities, and a substantial amount of stress. Nevertheless it also brings lots of liberty and freedom to plan, structure and design your own independent research project. After half a year of struggling, thinking, deliberating, writing, consulting, correcting, rewriting and so on and so on the light at the end of the tunnel has suddenly become very bright. The process I refer to as ‘my own ‘little’ project’ has almost finished. Nevertheless, it is not completed without thanking those that have supported me along the way.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

CAP	Common Agricultural Policy
CDSA	Controlled Drug and Substance Act
CGE	Computable General Equilibrium
EC	European Commission
EEC	European Economic Community
EU	European Union
THC	Delta-9-tetrahydrocannabinol
US	United States of America

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Hemp as a crop has a long history. The first crops were already grown over 4,000 years ago. Industrial hemp is often confused with marijuana. Nevertheless, the applications are rather different. In the Netherlands, the hemp industry is still young and developing. This research examines what the consequences of recent policy changes are on the Dutch hemp industry. The main focus is laid on the elimination of processing aid and the consequences for processors. Through a two-input one-product multi-level market model the effect of subsidy elimination on prices and quantities of hemp straw and processed hemp is examined. Assuming there are no market failures, the quantities of hemp straw and processed hemp will decrease by six and twelve per cent. On the other hand, the prices of hemp straw and processed hemp will go down by nine and four per cent respectively. Whether the hemp industry will survive in the Netherlands will depend on the determination and innovative mind of processors and the policy frameworks of both the Netherlands and the European Union.

CHAPTER 1
INTRODUCTION

Problem Statement

The Cannabis plant has gained significant interest over the past couple of decades. The *Cannabis sativa* plant is well-known for its narcotic content. Nevertheless, attention for the cultivation of hemp plants for other purposes has grown over the past several years. One of the reasons for the growing interest in industrial hemp is its multi-functionality. Hemp is a multi-purpose crop since the seeds as well as the fibers and stalks can be used for processing. On top of that, new applications for the processed products are being found continuously. Also, hemp is a crop that is easy to grow and does not require any pesticides or a substantial amount of water.

Despite the potential of industrial hemp, the Dutch industrial hemp sector is still considered to be in a stage of infancy and requires protection in order to develop further and to become competitive on the market. The assumption is that further investments in technology and processing are required to overcome the stage of infancy and to become cost-efficient. Nevertheless, European policies regarding natural fiber production have changed significantly over the past three years. The question is what impacts will these policy changes have on the Dutch natural fiber sector. The main focus lies on the consequences for hemp processors.

As of the implementation of Regulation (EEC) No 1308/70 in 1970, the support of the flax and hemp market the European fiber market has been expanding. In the mid-1990s subsidization lead to speculative growth and an imbalance between hemp cultivated and hemp processed. Especially in Spain and also to some extent in Ireland, farmers were growing fiber crops without having any intention of further

processing. Hemp was solely cultivated for subsidies. Eventually the EU stopped providing subsidies to the respective growers. Nevertheless, the large-scale fiber subsidy fraud damaged the reputation of fiber growers significantly. The situation was restored partially by linking support to processing. Regulation (EC) 1672/2000 changed the subsidy structures for fibers significantly in 2000. It lowered the direct support to growers to levels that were comparable to alternative crops. However, to keep supporting the natural fiber industry, direct support was given to primary processors of fibers. Processors have been using the support to be able to offer the growers a competitive price in a market that was still young and developing. Nevertheless, the situation changed in 2012 when the processing aid was eliminated. It is the question what consequences this has for the Dutch hemp industry.

Objectives

The objective of this thesis is to assess the consequences of the 2012 changes in European fiber support programs under the Common Agricultural Policy (CAP). In 2006 Suijkerbuijk & Janszen published a report that examined the potential for industrial hemp in the Netherlands. Also De Bont, Jager & Janssens (2008) conducted a research that looked at the consequences of the elimination of support on hemp cultivation in the Netherlands. Nevertheless, an up-to-date report on the elimination of processing aid and the consequences for Dutch hemp processors specifically is still missing. This research attempts to fill the gap by focusing on the consequences for the processors.

Structure

In order to provide a basic understanding about the significance of hemp as a crop, Chapter 2 is devoted to explaining the history, characteristics and applications of hemp. Also it provides information about the cultivation, harvesting and processing

of the Cannabis sativa plant. Chapter 3 lays out the basics for the area of focus. It outlines the characteristics of the hemp industry in Europe and, more specifically, in the Netherlands. Also it gives an overview of the policies in place in Europe and the Netherlands. The geographical as well as the policy information is required in order to draw conclusions about the results of the analysis done later. Chapter 4 forms the theoretical basis for the model that will be explained in the next chapter. It analyses theory on the elimination of subsidies. Also it outlines earlier research on the potential for fiber crops in Europe and the Netherlands. On top of that, the views of both hemp growers and hemp processors are outlined in this section. Together, the theoretical background provides the hypotheses for Chapter 5. Chapter 5 tests the hypotheses of the previous chapter by means of a two-input one-product multi-level market model. Also it show the results of the sensitivity analysis conducted. Lastly, in Chapter 6 the results are summarized and conclusions about the prospects for the hemp industry in the Netherlands are drawn.

CHAPTER 2
HEMP AS A CROP

Industrial hemp is a crop about which many misconceptions exist. Although little research is conducted into the perception of hemp, Luginbuhl (2001) wrote about the foundations of the negative associations with the Cannabis plant. Automatically, fiber hemp is often linked to marijuana. Nevertheless, the applications of industrial hemp are completely different.

In order to avoid misconceptions and to be able to assess the value industrial hemp can have for society as a whole, this chapter is devoted to outlining the basics of the industrial hemp industry. It will shed a light on the history of hemp, the cultivation, harvesting and processing of the product, hemp applications and the value of hemp for society.

Hemp History

Hemp, *Cannabis sativa L.*, can be distinguished between industrial hemp and marijuana. The plants look identical. The one difference is the psychoactive *delta-9-tetrahydrocannabinol* (THC) content (Randall Fortenbery & Bennett, 2004 and Vantreese, 1998). This research will primarily focus on the industrial hemp industry. Therefore, for simplicity, when talking about *hemp* we refer to industrial hemp. If psychoactive hemp is being discussed this will be referred to as *marijuana*.

Years before farmers started growing flax and cotton, hemp was already cultivated. It is one of the oldest crops still existing. It is estimated that the first crops were grown between 4,000 and 6,000 years ago in China. Around 1500 the Europeans started importing hemp from China. Widespread cultivation in Russia as well as Great Britain followed soon. Also in the United States the production of hemp grew exponentially until it started to face strong competition from cotton, jute and

abaca in the 19th century. Eventually, under the Marijuana Act of 1937 hemp was placed under the control of the U.S. Treasury Department. Effectively this development led to a ban on hemp production in the United States in 1938 (Randall Fortenbery & Bennett, 2004:98).

In Canada hemp was prohibited under the Opium and Narcotics Act in 1938. The cultivation of hemp in the United States is still barred by the US Drug Enforcement Agency. In Canada, the Controlled Drug and Substance Act (CDSA) legalized the production of hemp in May 1997. The Industrial Hemp Regulations of the CDSA require the monitoring of the cultivation of hemp. To date, farmers need a license issued by Health Canada in order to grow, import or export hemp. On top of that, permits for each shipment are required. Also only seeds that are certified by Health Canada are allowed to be used. Regular unexpected controls on THC content of plants apply. Hemp plants in Canada must have a THC content that is smaller than 0.3 per cent. The Canadian government does not provide any extra support to the hemp industry (Amun Laate, 2012).

The policies regarding industrial hemp are different in the Europe. France, for instance, has never prohibited the production of hemp. The United Kingdom legalized it in 1993, the Netherlands in 1994 and Germany followed in 1996. The European Union (EU) has supported the growth of hemp and other natural fibers like flax since the ‘70s under the Common Agricultural Policy (CAP).

Hemp versus Marijuana

According to DeMeijer et al. (1992) only laboratory tests can differentiate between hemp and marijuana. Marijuana contains on average three to fifteen per cent THC whereas the THC content in industrial hemp is generally lower than one

per cent. The issues related to the similarity of the two varieties will have to be discussed in order to highlight possible obstacles to the development of the industrial hemp industry.

The U.S. government made the cultivation hemp in 1938 because it was considered a threat to society due to its resemblance with marijuana. Under the United Nations 1961 Single Convention on Narcotic Drugs, the North American Free Trade Agreement, and the General Agreement on Tariffs and Trade hemp is distinguished from marijuana. Still US law does not make the distinction between the two different Cannabis plants. Consequently, there are many misconceptions about the applications for hemp in the United States (Luginbuhl, 2001).

Although there are still lots of misunderstandings, the general perception of hemp in Europe is more positive than in the United States. Possibly, the fact that hemp cultivation is legal in European countries contributes to a more positive and informed environment. European farmers that grow hemp have to comply with strict EU regulations. Only full-time farmers are allowed to produce hemp. It is compulsory to seed a variety that is certified and has a THC content of less than 0.2 per cent (Vantreese, Hemp Support: Evolution in EU Regulation, 2002:3.).

In the Netherlands, the Food and Consumer Product Safety Authority is responsible for doing random THC control checks in the fields. Checks are conducted between twenty days before and ten days after the flowering of the hemp seeds. The crop can only be harvested when the authorities give their consent after having finished all random field checks (Dienst Regelingen, 2013).

Hemp Characteristics

Most of the Cannabis sativa plants are dioecious. This means that there are separate male and female plants. Nevertheless, monoecious varieties have been developed through selection programs. The quality of fiber of dioecious varieties differs significantly. Monoecious varieties offer more uniformity in quality. However, there exist fewer monoecious varieties than dioecious. Countries like Russia, China, Romania, Hungry, France and the Netherlands have set up different breeding programs to develop the seeds that are most productive in their respective climates. Some countries focus on breeding plants that generate a high yield in seed production. Others focus more on fiber production. The main factor determining the purpose of production is climate. In countries with milder, usually sea climates the summers are not long and warm enough for seed production. Hence, in the respective regions hemp is mainly grown for fiber production (Vantreese, Industrial Hemp: Global Operations, Local Implications, 1998).

Hemp is a multi-purpose product. The seeds and the interior as well as the exterior parts of the stalk are processed. The bast of the plant can be compared to other fiber plants like jute, flax and kenaf. The inner part of hemp contains fibers that are thicker and woodier. They are also referred to as hurds. The seeds of hemp are rich in oil. On average the percentage of oil is 29 to 34. Content wise hemp oil can be compared to linseed oil (U.S. Department of Agriculture, 2000).

Hemp Cultivation and Harvesting

Hemp is a crop that is relatively easy for farmers to grow. Hence, the crops can be cultivated in many areas over the world (Figure 2-1). Hemp plants only need nitrogen, water and sunlight to grow. Also hemp is immune to most plant diseases. Because of its high growth density, hemp leaves no space for weeds to grow.

Hemp's disease immunity and growth density contribute to a reduction in the use of pesticides and herbicides. Not only can this be advantageous for hemp but when crop diversification is applied it will also reduce the herbicide use of other crops grown on the same plot (Beerepoot, 2003).

When rotated with starch potatoes, hemp can positively contribute to more sustainable potato cultivation. Hemp plants overgrow herbicides. As a consequence it reduces the number of harmful nematodes, Colorado beetles, viruses and greenflies in the soils. Also the deep rooting, and relative late harvesting of hemp reduces sand-drifts. Lastly, hemp leaves more organic matter on the ground than potatoes and grain. This provides a positive effect on the soil structure (Beerepoot, 2003).

The planting strategy is dependent on the purpose of growing. When hemp plants are cultivated for fiber production the aim is to maximize the stalk size. Consequently, dense planting population is required. When grown for seed or for both seed and fiber, the plants are planted further apart from each other to allow for branching and the development of seeds. Because hemp fibers are very strong, mowing can be challenging and more intensive than regular mowing (U.S. Department of Agriculture, 2000).

Fiber hemp is harvested earlier in the season than hemp grown for the seeds. The main reason for early harvest is to allow for dry retting. Retting is the microbiological process of separating the stem from the bast of the hemp plant. Usually this chemical breaking of the fibers and woody parts is done on the fields. After harvest, the hemp is let on the fields to ret. The plan required some humidity to rot and break down. However, the crop should remain dry enough to allow for bailing. Also too much humidity affects the quality of the fibers negatively. Because the

summers in the northern parts of Europe, including the Netherlands, are usually shorter than in the southern parts, hemp is harvested earlier in the season. Because hemp seeds take longer to grow, one of the consequences of the Dutch climate is that hemp for seed production is not practiced in the Netherlands (Struik, Amaducci, Bullard, Stutterheim, Veturi, & Cromack, 2000).

Hemp Processing

Hemp is a multi-purpose product. After the stalks of the hemp plant are retted, dried and baled they are transported to the processing company. Here, the inner woody parts are separated from the fibers through processes called breaking and scutching (U.S. Department of Agriculture, 2000). HempFlax (2013) refers to the first process of separating the fibers from the core as ‘decortication’. The next process, ‘fiber refining’, cleans the fibers further to process the large fibers into smaller bundles. The degree of refining depends on the quality required. Paper grade fibers are the least sophisticated type of fibers. Insulation grade fiber, technical, automotive grade fiber and textile grade fiber, in the respective order, require higher quality fiber (HempFlax, 2013).

The ratio between seeds, dust, fibers and hemp straw generated from processing hemp differs and is dependent on the main purpose for harvesting. Dutch hemp, for instance, is produced for its fibers. Hence, seeds are omitted in the revenue data. According to Gjaltema (2013)[1] HempFlax produces on average 500 kilograms of shives, 250 kilograms of fiber and 250 kilograms of dust out of a ton of hemp straw. Appendix A shows the average break down of hemp plants that are cultivated for fiber production.

[1] Personal communication

Hemp Applications

The first copies of the Bible were written on hemp paper (Ranalli & Venturi, 2004). Also hemp was used in the 17th century for textile production. Nowadays, houses have also been constructed from the Cannabis plant (Haars, 2012). To date, more and more applications for hemp are being discovered. Appendix B gives a schematic overview of the different applications for hemp. In the 1990s hemp fibers were predominantly used for specialty pulp and paper. On the European market 55% of the hemp fibers are still processed into pulp and paper. 25.9% of the fiber goes to the production of isolation materials. Hemp isolation has some benefits with respect to the glass or mineral wool alternatives. It does not irritate like glass fibers. Also in terms of moisture flow and heat capacity hemp outperforms alternative isolation materials. However, hemp isolation is still 2 to 4 times more expensive than glass and mineral wools. Therefore, large-scale marketing is not applicable yet (Carus, Karst, & Kauffmann, 2013).

In Europe, 14.4% of the hemp fibers end up as bio composites. The main share of bio composites, 96%, consisted of automotive interior products. Germany is the leader in the field of hemp interior products. Also the industries in France and the Czech Republic use hemp fibers for cardboards (Carus, Karst, & Kauffmann, 2013). Currently, Fiat, Ford, Mercedes Benz, Opel, Peugeot, Renault, Volvo and VW car components consist partially of natural fibers. Table 2-1 specifies the application of natural fibers in automobile parts further.

The expectation is that the market for paper and pulp will not increase significantly over the next decade. Nevertheless, the demand for hemp isolation materials and bio composites is expected to increase. Due to the shorter seasons in Northern Europe, seeds do not generate any revenue there. In the south of Europe,

seeds are a by-product. Hemp production mainly for the seeds only occurs in Asia and Canada. Therefore, seeds are left out of the equation in this thesis (Carus, Karst, & Kauffmann, 2013).

At this moment the most common uses for hemp fibers in the Netherlands are paper and dashboard for the automotive industry. Just like at the European market, the hurds are mainly processed for pet and horse bedding. Dun Agro is experimenting with techniques to utilize the hemp leaves for shakes. If this succeeds a new market can be added to the product line (Suijkerbuijk & Janszen, 2006).

Hemp has a broad history. Although it is directly related to marijuana, the narcotic content and applications of the crop are very different. Hemp is a natural substitute for both synthetic and other natural fibers. In Europe most of the hemp goes to the paper and pulp, the automotive and the isolation industries. European hemp processors expect the demand for hemp building materials, hemp shives, and lime to increase. On the other hand, stagnation in the markets for bedding materials a pulp and paper is expected. Nevertheless, the growth of the hemp industry will also be dependent on economic and political factors (Carus, Karst, & Kauffmann, 2013). The specific political and economic issues will be discussed later. First, the area of focus is explained.

Figure 2-1. Suitable climate zones for hemp cultivation. Reprinted by permission from *HempFlax*. (2013), Retrieved July 24, 2013, from www.hempflax.com

Table 2-1. Kilograms of hemp in automobiles. Source: Holmes (2005)

Front door liners	1.2 – 1.8 kilograms
Rear door liners	0.8 – 1.5 kilograms
Boot liners	1.5 – 2.5 kilograms
Parcel shelves	< 2 kilograms

CHAPTER 3
AREA OF FOCUS

Hemp in Europe

Within Europe, France is the main producer of industrial hemp (Figure 3-1). Also Germany and the United Kingdom are main producers. Since the climate is slightly more advantageous in the southern part of Europe, the Mediterranean countries can also harvest hemp seeds generating extra added-value from one product.

Hemp in the Netherlands

The industrial hemp sector in the Netherlands started to develop in 1993. The first hemp was grown in Nagele in the Noordoostpolder. In 1994, production shifted to the Veenkoloniën[1]; a region in the north eastern part of the country. The HempFlax Group was founded in the town of Oude Pekela. Their aim was to set up an industry that was concerned with the cultivation and processing of fibers like flax and hemp. Because the processors take care of the harvest of hemp straw the cultivation of hemp takes place in a radius of fifty kilometers around Oude Pekela (Hempflax, 2005). Figure 3-2 and Figure 3-3 illustrate the location of Oude Pekela in the Netherlands and the fifty kilometers cultivation radius around Oude Pekela. Like becomes clear from Figure 3-3 a substantial area within the fifty kilometers radius lies in Germany. Due to the common European market, this does not directly have an effect on the consequences of the elimination of processing aid. Nevertheless, indirectly it could be harmful for the hemp industry. The issues related to that are discussed in section ‘Supply side’ in Chapter 4.

[1] In English referred to as ‘the Peat Districts’

The scale of production in the Netherlands has been modest so far. Approximately 800 hectares was cultivated in 2000. In 2002 this expanded to more than 2000 hectares. Between 2004 and 2006 hemp almost disappeared in the Netherlands due to the termination of contracts between growers and processors and the bankruptcy of the only processing company Hempro (Figure 3-4) (de Bont, Jager, & Janssens, Vlas en vezelhennep en herziening van het EU-beleid, 2008).

When the hemp industry declined to less than 500 hectares from 2004-08, the management group for the 'Agenda of the Veenkoloniën' initiated research into the possibilities for the continuation of hemp growth in the Peat Districts.[2] Albert Dun took on the Committee's positive advice and restarted the industry in the Northeast area of the Netherlands. HempFlax restarted its businesses as well, also in the town of Oude Pekela. In 2013, Dun Agro and HempFlax were the only two commercial hemp processors in the Netherlands. Together the companies' processing potential was estimated to be 4000 hectares annually. Nevertheless, less than half of the potential is currently cultivated.[3] The question is whether policy developments will further downscale production or, as stated by HempFlax employees, that production will continue to rise due to an increase in demand for hemp products and technological development.[4]

Policy in Europe

Historical Overview Policies

Cultivation of natural fibers has been supported by the EU since 1970. The aim of the support policies has been to create a natural fiber sector that is able to compete against the synthetic fiber and cotton industries. The initial support was

[2] Suijkerbuijk & Janszen (2006)
[3] Personal communication with Berg (2013)
[4] Personal communication with Mellema (2013)

based on the acreage of sown hemp (or flax). The yield per hectare was irrelevant to the amount of subsidy. Per hectare subsidies up to 450 euros were provided. Fifty per cent of the subsidy per hectare was received by the grower directly. The other fifty per cent went to the processor.

In 1998 Spanish and Irish farmers made use of loopholes in the fiber subsidies schemes. Farmers sowed flax seeds in order to obtain fiber subsidies. Nevertheless, although the seeds were planted, the plants were burnt down or left unharvested. The subsidies did not support the development of the sector in any way. When Brussels found out what farmers did with flax subsidies it brought the whole natural fiber sector negative publicity (Hempflax, 2005). To prevent misuse in the future the EU flax and hemp support schemes changed. In order to be eligible for a subsidy, a contract had to be set up between growers and processors in accordance with what is currently referred to as Commission Regulation (EC) No 507/2008 (Hoofdproductschap Akkerbouw, 2011). In 2000 the subsidy structures for hemp were reformed again. As of 2001/02, processors received an extra 90 euros per ton fibers processed. The hectare premium for growers became pegged to the grain yield in the respective region. In 2006 the support was decoupled from grain prices (de Bont, Jager, & Janssens, Vlas en vezelhennep en herziening van het EU-beleid, 2008).

In 2012 the payment structures were again reformed significantly for both processors and farmers. The consequences of these reforms will be the basis of the analysis for this research. For processors, the direct support was eliminated completely. In other words, processors lost €90 of extra income per ton of processed hemp as of 2012.

According to the Dienst Regelingen (2013) the only two Dutch hemp processors, HempFlax and Dun Agro, received respectively €72,305 and €52,993 in subsidies from the European Commission during the last year the subsidies were provided.

For farmers, regulations changed as well. Until 2012, support was pegged to the production of hemp. As of 2012 this was transformed into a direct payment system based on hectares of land cultivated. One of the consequences for hemp farmers is that they will receive a fixed hectare premium regardless of what crop is cultivated on the land whereas the previous subsidy was based on hectares of hemp grown. In other words, farmers have less of an incentive to grow hemp.

Profit Maximization Function

The profit maximization function for hemp cultivation is changing. Pre-2012 farmers that had traditionally been growing hemp could choose between two competing maximization functions:

$$Max.\ \pi^{gh} = P_x X + P_s X - P_c c$$

$$Max.\ \pi^{ga} = P_a A - P_c c$$

Max. π^{gh} and *Max.* π^{ga} are the maximization functions for growing hemp and an alternative crop respectively. *X* is hemp straw, P_s the subsidy per hectare of hemp and *c* the cost. P_a is the price of an alternative crop. Since the direct payments are still coupled to the production of hemp, P_s is added to the maximization function of hemp. Post-2011 the maximization function of growing hemp changed to:

$$Max.\ \pi^{g} = P_x X - P_c c.$$

Subsidies have been decoupled and transformed into hectare premiums. Because hectare premiums are paid out irrespective of the crop that is being

cultivated, there is no subsidy differentiation any more between growing hemp or alternative crops. Hence, the subsidies have been taken out of the post-2011 equations.

The direct consequence of the change in subsidy regime is significant. Since subsidies are no longer part of the equation, when maximizing profits farmers now only compare the price of hemp minus the marginal costs with the price of alternative crops minus its marginal costs.

De Bont, Jager, & Janssens (2008) consider grain (wheat) due to its growing characteristic to be the most suitable farming alternative to hemp. The marginal cost of wheat are assumed to be fairly similar to the marginal cost of hemp. Consequently, the main determinant for farmers in choosing which crop to grow is the sales price of their crops.

In order to guarantee a smooth transition 2012 was signified as a transition year. The support for processors already ceased to exist. However, European hemp farmers received a compensation. The Netherlands was assigned €930,000 based on a total of 3001 hectares of fiber crops grown in the Netherlands in 2011. Fiber hemp constituted 892 ha in 2011. Therefore, in total, Dutch hemp growers received €267.561 compensation in 2013.[5]

As of 2012 hemp farmers receive a hectare premium based on the registered hectares of cultivated hemp in 2008. For 2013 the reference value for hemp per hectare in the Netherlands was set at €393.63 (Dienst Regelingen, 2013). Additionally, farmers were paid regular hectare premiums. Initially, hemp farmers

[5] Personal communication with Mr. De Sturler (2013) from the Dienst Regelingen (Dutch National Service for the Implementation of Regulations at the Ministry of Economic Affairs, Agriculture and Innovation).

received more financial support. However, the assumption is that with the new CAP beginning in 2014 support will be gradually reduced. Because the support after the transition phase is not coupled to the production of hemp, it is hypothesized that hemp growers will monitor the market more closely to search for other more profitable crops.

Besides direct support for farmers and processors, there are indirect policies that could support the development of the hemp industry. The industry could potentially profit from what is referred to as the greening of the CAP. There is a continuous trend in Brussels to support farming initiatives that contribute to a greener, more sustainable EU. Hemp is a bio-based product. Hence, it should theoretically benefit from the EU aim of greening the CAP. Nevertheless Carus, Karst & Kauffmann (2013:8.) assert that 'the European Natural Fiber industry is suffering from the wrong policy framework'. There are two main reasons the hemp industry does not benefit from the greening policies. First of all, it is mainly biofuels and bio-energy that are being supported with green electricity regulations, tax incentives, and set biofuel and renewable energy quotas. In contrast, bio-based materials like hemp products are not as heavily supported. This creates unfair competition (Carus, Karst, & Kauffmann, 2013).

Also, there is no European protection from the import of fibers from mainly Asia. Cheap import of jute, kanaf and sisal from countries that do not have acceptable social and environmental standards is disadvantageous for the European fiber industry. In order to guarantee fair competition the European Industrial Hemp Association (EIHA) is therefore pleading for sustainability certification of hemp (Carus, Karst, & Kauffmann, 2013).

The political landscape in which the European hemp industries are operating is constantly changing. Direct and indirect forms of support were available for different actors in the industry. Nevertheless, direct support coupled to hemp cultivation and processing has been eliminated completely. Indirect support for creating a so-called green and bio-based economy is currently not necessarily advantageous for the industry. This section has outlined the hemp policies in place. Chapter 4 will continue with outlining research that has been conducted in order to assess the consequences of the policies on the Dutch hemp industry.

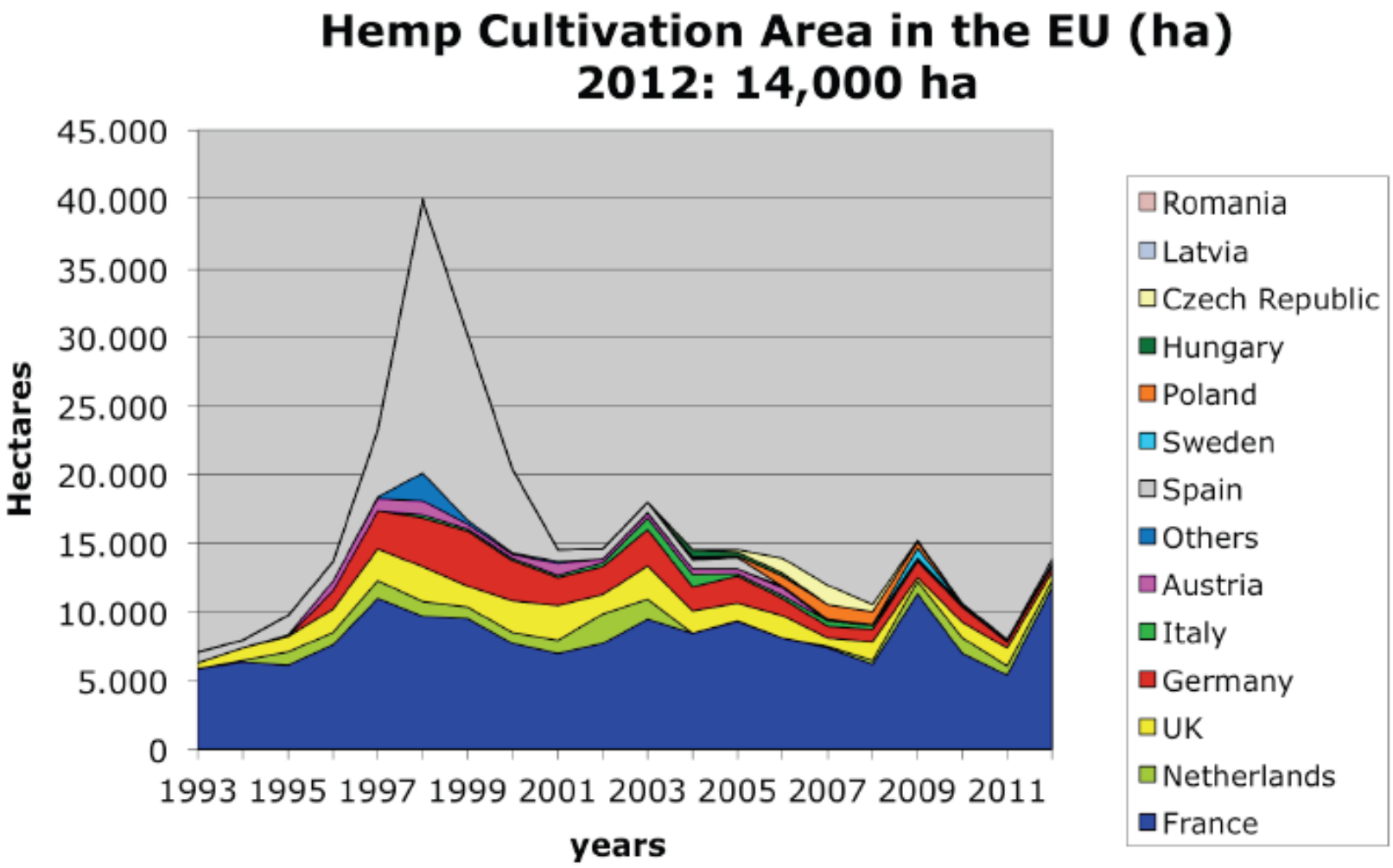

Figure 3-1. Acreage Hemp EU27 in hectares. Reprinted by permission from Carus, M., Karst, S., & Kauffmann, A. (2013), *The European Hemp Industry: Cultivation, processing and applications for fibers, shivs and seeds.* European Industrial Hemp Association (Page 2, Figure 1).

Figure 3-2. 50km radius around Oude Pekela.

Figure 3-3. 50km radius around Oude Pekela zoomed-in.

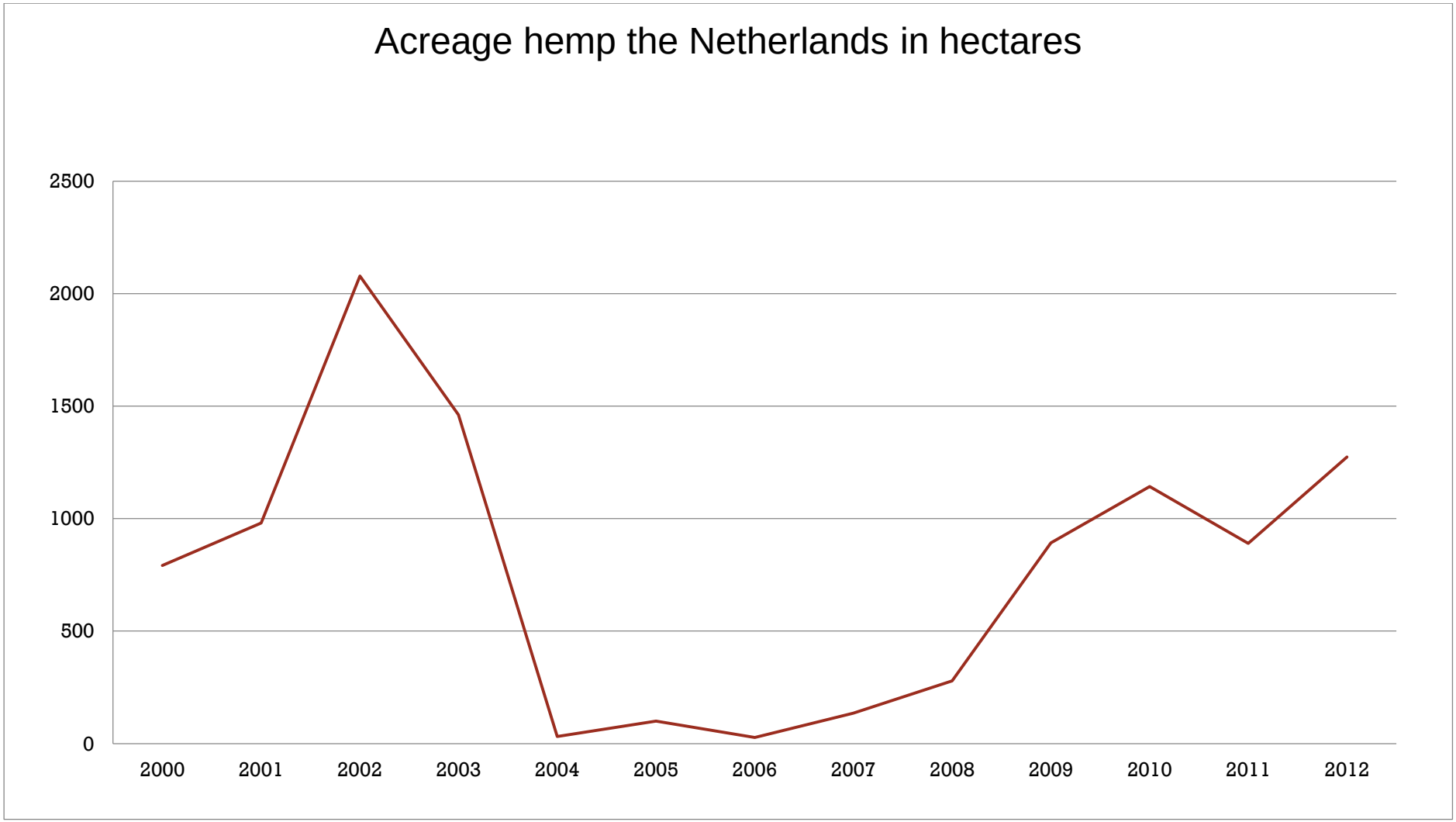

Figure 3-4. Acreage Hemp in the Netherlands. Adaptation from CBS. (2013, February 14), *Landbouw; gewassen, dieren en grondgebruik naar regio*. Retrieved March 18, 2013, from Centraal Bureau voor de Statistiek: www.cbs.nl

CHAPTER 4
THEORETICAL FRAMEWORK ELIMINATION FINANCIAL SUPPORT

Literature Overview

In order to evaluate the consequences of policy changes in the hemp sector, the complete industry needs to be examined. This section first describes what research has been conducted related to the elimination of subsidies in general. Second, an outline of research into the hemp industry in the Netherlands is provided. Then, other factors that influence the sector, like the passing through of support, will be discussed. This chapter finishes with an outline of the hypotheses that will be tested in Chapter 5.

Input Subsidies

Whereas the rational is different, the effects of abolishing processing aid can be compared with agricultural input subsidies. Usually, agricultural input subsidies are introduced to improve the affordability of inputs or to encourage farmers to utilize specific primary products. Agricultural input subsidies are most common in developing countries. In the case of natural fibers, the processing aid was introduced to counteract the misuse of subsidies by growers.

Despite the difference in purpose, the consequences of abolishing processing aid on endogenous variables can be compared to the elimination of an input subsidy. Hence, the theoretical framework around the consequences of eliminating input subsidies will be discussed in this section.

Takeshima and Lim Lee (Agricultural inputs subsidy and their developmental impact: Conventional wisdom, 2012:1) define a subsidy as '*a payment, generally made from public resources, that reduces the price that a buyer pays for a good or*

service below the price at which the seller provides it'. Elimination of agricultural input subsidies usually decreases the quantity demanded of the good that was subsidized. Subsidies are assumed to cause market distortions. Payments lead to inefficiencies when for instance good are subsidized that would be produced regardless of the subsidy. Also governmental payments can generate deadweight losses. Deadweight losses are created when the total cost of implementing a subsidy are greater than the aggregate benefits. The size of the deadweight loss depends on the elasticity of demand and supply. The higher the elasticity of demand, the greater the deadweight loss is assumed to be. If the elasticity of supply is small chances are great that the benefits of the subsidy do not end up at the receiver but by the supplier of the input. In the case of processing aid this implies that when the elasticity supply of hemp straw is low subsidy benefits are transferred from processors to growers (Takeshima & Lim Lee, Agricultural inputs subsidy and their developmental impact: Conventional wisdom, 2012). More on the pass-through of support is explained in section 4.3.1.

Takeshima and Lim Lee (Exit strategies for and potential alternatives to agricultural subsidy programs, 2012) discussed the exit strategies for agricultural input subsidy programs in Mozambique in a different policy note for the International Food Policy Research Institute. They assert that it is hard to reduce subsidy programs without negatively affecting the input markets. The aim of an input subsidy program should be to enable receivers of subsidies to acquire an economically independent position on the market. In other words, support ought to have a clear aim and exit strategy to avoid substantial negative effects on the input market.

Starch Potato Subsidy Elimination

Although there are many examples of subsidy elimination, the most up-to-date and relevant example is the elimination of starch potato subsidy. Zijlstra et al. (2011) examined the consequences of the abolishing of starch potato subsidies. The research is significant to the study of the Dutch hemp industry as well because, although the type of crop is different, other factors are rather similar. First, the starch potato industry in the Netherlands is also centered around the Peat Districts. Second, the EU starch potato subsidy scheme is comparable to the natural fiber payment policies. Like with natural fibers, payments were provided to growers as well as processors. Also, just like hemp, the payments to growers were decoupled and subsidies to processors eliminated in 2012. According to Zijlstra et al. (2011) 25% of the starch potato growers interviewed indicated they will keep production at the same level after the elimination of the subsidies. The interviewees expect that the reduction in acreage has consequences for the only Dutch potato processor AVEBE. Most likely, one out of the three factories will shut down. Nevertheless, the starch potato market is larger than the hemp industry. Whereas the average acreage of hemp grown is 1,000 hectare, approximately 50,000 hectares of starch potatoes are cultivated each year. 85 per cent of the starch potatoes in the Netherlands are cultivated in the Peat Districts. 40 per cent of the arable land in the Peat Districts is used to grow starch potatoes.

To summarize, the expected consequences of the elimination of payments to starch potato farmers and processors are that the starch potato acreage will be reduced and the profit of the processor AVEBE will shrink. Also the price of starch potatoes will most likely become more volatile (de Bont, Blokland, Prins, Roza, & Smit, 2007).

Dutch Hemp Industry

In 2006, after the bankruptcy of HempFlax, the hemp industry in the Netherland was virtually non-existent. The Agenda voor de Veenkoloniën[1] decided to request a re-evaluation of the potential for hemp cultivation in the Peat Districts. Suijkerbuijk and Janszen (2006) evaluated the possibilities for the industry. The main conclusions were that in order to generate positive business results for hemp processors, more research was required. Secondly, the greatest threats for the hemp processing sectors were market acceptance and unproved technology. The last conclusion was that hemp processing did not directly generate profit. Nevertheless, it is possible that when the industry as a whole is observed, hemp can be more profitable than alternative crops (Suijkerbuijk & Janszen, 2006).

Like has been mentioned in Chapter 3 the results of this study lead to the revival of the hemp industry in the Netherlands. Almost a decade later and after significant changes in EU support policies, it is the question which of the conclusions still holds.

At the request of the Dutch Ministry of Agriculture, Nature and Food Quality (nowadays the Ministry of Economic Affairs, Agriculture and Innovation) De Bont, Jager and Janssen (2008) examined the consequences of subsidy changes for the Dutch flax and hemp sector. The main focus was laid on the consequences for the cultivation and processing of the products and the impacts on affected regions in the Netherlands. Their main conclusions were that the decreased support for hemp farmers and processors may lead to a stop in the development of the Dutch hemp

[1] In English: Agenda for the Peat Districts; a collaboration between the provinces of Groningen and Drenthe, the municipalities Aa en Hunze, Borger-Odoorn, Emmen, Hoogezand-Sappemeer, Stadskanaal, Pekela, Veendam, Vlagtwedde and the water board districts Hunze en Aa's and Velt en Vecht to strengthen the socio-economic position of the Peat Districs.

sector. In the worst case scenario the sector will disappear completely. Alternatively, the processing industries could stay in the Netherlands when supply comes from other countries. De Bont et al. (2008) assert that the small scale of the hemp sector is a barrier to R&D investments. Generally, the infancy of the sector makes it difficult to say anything about future prospects. The demand looks promising. Nevertheless, the question is whether it will remain possible to offer competitive prices for hemp straw in order to sustain the supply.

Other Factors

Pass-through

To assess the impact of the elimination of processing subsidies it is essential to examine where aid ends up. There are three different possibilities. First, processing aid can be passed back to growers fully or, part of the aid can be passed-through. The last option is that growers do not receive any of the processing aid.

Anderson and Martin (2009) describe how protection to processors can be passed-through completely to the agriculture sector. As a consequence, the support raises the price of primary products by 'the amount of the rise in the processor price, divided by the proportional contribution of the primary product to the value of the processed product' (Anderson and Martin, 2009:451).

When processing takes place in a country other than where the primary production occurs, it is possible that aid is not passed back at all. However, Anderson and Martin (2009) state that when the price elasticity of farm supply is positive and the primary product itself cannot be traded directly, it is highly unlikely there is no passing-through occurs. Hemp growers are inclined to supply more when the price

increases. The elasticity of hemp straw is positive and therefore it is likely there is some passing-through effect.

Discussing the possibilities for the passing-through of subsidies, Anderson and Martin (2009) describe a third option in which only part of the support is passed back to growers. In this case the benefits of the subsidies are shared more equally along the complete value chain.

Supply Side

In order to determine the elasticity of supply required for the multi-level market analysis, this section will discuss the indicators of supply. The information provided is based on interviews with both hemp growers[2] and hemp processors[3] and existing literature.

On average, the processing aid amounted to 10-25% of the price of raw hemp. Thanks to the processing aid, HempFlax and Dun Agro were able to offer growers a competitive price.[4] Due to the changing farming landscapes the supply of hemp straw is highly elastic. Farms have become larger and farmers more and more profit-seeking. Hemp faces severe competition from maize and wheat. Hemp, as well as corn and wheat, does not require substantial capital investment because the harvest is taken care of by external parties. In the case of hemp, the processor is responsible for the harvesting. Corn and wheat growers can chose to invest in the required capital themselves or to hire wage workers to do the harvest.

Considering the fact that the cost of hemp and alternative crops are rather similar, farmers can base their choice of crops grown mostly on the sales price.

[2] M. Berg (2013) and S. Van Rijs (2013)
[3] D.J. Mellema (2013), A. Gjaltema (2013) and M. Reinders (2013)
[4] Personal communication with Mellema (2013)

Nevertheless, on the farmer's level, individual choices can also alter the cost function.[5]

Factors that determine profitability and the marginal cost function at the individual farmer's level are size of the farm and availability of fertilizer. In the saldi comparison between barley and hemp it is estimated that growers do not harvest themselves. According to de Wolf, van den Brink and Spruijt (2012) it is likely that especially at large farms growers have invested in harvesting materials and take care of the wheat harvest themselves. This will reduce the marginal cost of growing wheat. Hemp is always being harvested by processors. Therefore, the marginal cost function of hemp cannot be reduced the same way as the cost function of wheat.

Hemp requires nitrogen to grow. It can absorb more fertilizer than wheat. This can make a significant difference in the cost functions of wheat and hemp. Dependency on fertilizer can increase the marginal cost of hemp more than the marginal cost of wheat. On the other hand, hemp growers will benefit more from a negative price of organic fertilizer (de Wolf, van den Brink, & Spruijt, 2012). Especially in the Netherlands the price of organic fertilizer can make a difference. Due to highly intensive livestock production and land scarcity, the southern parts of the Netherlands have a substantial organic fertilizer surplus. Hence, livestock farmers pay for manure disposal.

Depending on the supply, hemp farmers can profit from taking over manure.[6] The negative price of organic fertilizer can decrease the marginal cost function of hemp more than the cost function of alternative crops.

[5] Personal communication with Gjaltema (2013)
[6] Personal communication with Berg (2013)

Also the price offered by processors is a factor that determines growers' crop choice. Because growers can rotate crops rather easily, farmers will only grow hemp when the price of hemp straw offered by processors makes it advantageous to grow the natural fiber crop. Consequently, the supply for the processors is very elastic, i.e., a slight increase in the price of hemp straw shifts growers away from hemp cultivation.

With the processing aid the processors were able to offer growers a hemp price more competitive with the price of grain. Nowadays, the processing aid has been taken away. Nevertheless, processors cannot lower the price of hemp straw because of its elastic supply. On top of that, the grain prices have increased significantly since 2011. One of the factors causing this increase in the prices of wheat in the north eastern part of the Netherlands is the competition with biomass plants just across the border in Germany. Germany's biofuel quotas stimulate the cultivation of wheat for biomass plants. European subsidies on bioenergy and biofuels and the lack of subsidies on bio-based materials like hemp distort the bio-market and affect hemp production negatively. Figure 4-1 shows the development of the price of wheat and barley[7] from November 2010 until August 2013. In January 2012 the processing support for natural fibers was eliminated.

As illustrated in Figure 4-1, the price of wheat increased more than thirty per cent since 2012. Currently, the price is decreasing again. Nevertheless, the price of wheat still 20 per cent higher than pre-2012 levels.

De Wolf, van den Brink, & Spruijt (2012) estimate that, without coupled subsidies, hemp can compete with barley in the Netherlands if the price of barley is

[7] Price change is indicated in euros per ton of wheat cultivated in Groningen, the Netherlands; the area where hemp is cultivated as well.

€180 per ton or lower. If the price of wheat or, more specifically barley, increases to €216 per ton the cultivation of barley generates on average €382 more revenue per hectare.

Several factors influence the grower's cost and production functions of hemp straw. The decision to grow hemp or an alternative crop is dependent on the price and the cost of the crops. One main determinant of the individual cost function is whether the grower has to hire external labor and capital to take care of the alternative crop's harvest or not. Also, it depends on whether the price of organic fertilizer is positive or negative. Considering the fact that growers are profit seekers and that it is easy to switch to alternative crops, farmers chose to grow the crop that generates the most revenue. Hence, the supply of hemp straw is considered to be highly elastic.

Demand Side

There is not a lot of room for price maneuvering on the supply side. On the demand side there seems to be a little bit more flexibility. The price of processed hemp is still demand elastic; clients tend to sort for substitutes when prices increase significantly. On top of that, hemp processors do not have a monopoly position. Even though there are only two processors in the Netherlands, in Europe they can still be considered competitive profit seekers and price takers. Nevertheless, the market is less rigid due to mutual dependency and fixed contracts.

Mutual dependency is a result of the relative infancy of the market. Applications for hemp products are still to be further discovered and developed. Primary processors and further processors are developing new markets together with

a mutual interest in maintaining the market. This is one factor that makes the demand side less elastic than the supply side.[8]

On top of the mutual dependency, HempFlax's main customer is BMW. Characteristic of the automotive industry is that contacts are long-term based. Commonly, production cycles take approximately seven years. This stabilizes the market demand. Consequently, HempFlax managed to pass on part of the burden of the elimination of the processing aid on to the customers by increasing the price by approximately 10%. Nevertheless, the processing aid was estimated to be 10-25% of the price of raw hemp. On top of that, the price of grain increased forcing the processors to increase the price of hemp straw to maintain supply. Therefore, it can be hypothesized that the greatest part of the burden falls on the processors.[9]

Hypotheses

After the theoretical framework around the elimination of support and developments in the hemp sector has been discussed, a set of hypotheses will be tested in Chapter 5 by using the multi-level market model. Hypothesis 1 states that the elimination of processing aid has no impact on the price of processed hemp. Hypothesis 2 says that the elimination of processing aid has no impact on the quantity of hemp processed. Hypothesis 3 is that the elimination of processing aid has no impact on the price of hemp straw. Hypothesis 4 says the elimination of processing aid has no impact on the quantity of hemp straw supplied.

[8] Personal communication with Gjaltema (2013)
[9] *Ibid.*

Figure 4-1. Price of wheat. Adaptation from Productschap Akkerbouw. (2013), *Marktprijs: Groningen - Tarwe*. Retrieved June 3, 2013, from http://www.productschapakkerbouw.nl/teelt/marktprijzen/marktprijs_details

CHAPTER 5
TWO-INPUT ONE-PRODUCT MODEL

In order to determine the effect of abolishing processing support on Dutch hemp processors and the Dutch hemp industry in general, a multi-level market single-output, two-input model is constructed. The model is based on Gardner's (1987) approach. It examines the effect of an exogenous (policy) shock on endogenous factors. In this research, the exogenous factor is the loss of payments and the endogenous factors are the input and output quantities and the prices of hemp straw and processed hemp.

Choice of the Model

Different simulation models can be used to estimate the impacts of policy reforms. This section will explain the choice of the single-output, two-input model to calculate the effects of the elimination of hemp subsidies.

Most commonly partial or computable general equilibrium (CGE) models are used to assess the impacts of policy changes. Partial equilibrium models model only direct effects assuming ceteris paribus. CGE models, in contrast, attempt to model the complete market. CGE models are, especially micro economically, more detailed. The drawback is that a substantial amount of data is required. Also the complexity of the model makes the interpretation of the results more difficult and sometimes less intuitively (Braverman, Hammer, & Gross, 1987).

Multi-market models are a combination of partial equilibrium and CGE models. They are more elaborate than partial equilibrium models because multi-market models also include indirect effects of policies through supply and demand responses.

On the other hand, multi-market models are not as complete as CGE models because external welfare changes are not considered in the analysis (Arulpragasam & Conway, 2003).

Gohin and Moschini (2006) tond the difference between partial equilibrium and CGE models in evaluating the effects of phasing-out CAP policies. The researchers applied the different models to similar data and compared the results. The conclusion is that the market effects of phasing-out subsidies are comparable across the models. The welfare effects, however, differ slightly.

This research looks primarily into the market effects of the elimination of one specific CAP policy. The aim is to also assess the changes in prices and quantities of both demand and supply. Hence, a partial equilibrium model will not be sophisticated enough for this research. A CGE model, on the contrary, is considered to be too complex and too data demanding. It has been taken into account that Gohin and Moschini (2006) assert that different models show similar results when testing for the market effects of changes in policy. Therefore, it has been decided that the intermediate solution of a multi-market model with two inputs and one output will be used to estimate the impact of the elimination of fiber subsidies.

Assumptions

The multi-level market model is constructed under five assumptions (1) “all hemp cultivated in the Netherlands for non-feed products are processed at either HempFlax or Dun Agro”; (2) “processors do not differentiate between hemp straw”. Hence, there is homogeneous input for hemp straw in a market with many sellers; (3) “the output market is competitive”.

As far as the input market concerns, the prices are fixed for all inputs other than hemp; (4) “producers maximize profits”; (5) “the complete hemp subsidy is passed-through to growers and can hence be represented as a percentage of the price of hemp straw”.

Another assumption of the model is that the processors are competitive and optimizing agents. Risk and market imperfections are not reflected in the model. For the purpose of this research the percentages leaves and stems coming from the hemp plant are considered to be fixed. As a consequence processed hemp is, despite its different eventual applications, considered to be a one output product. Also there is solely one input; hemp straw. Both the grower and the processer are assumed to be profit-seekers that attempt to maximize their profits. The processors’ profit function is:

$$Max.\ \pi^p = P_y Y - P_x X - P_c c + \lambda^p [Y - \varphi^p(X, c)] \qquad \text{Eq. (5-1)}$$

Equations

The profit maximization function for the processor consists of the revenue ($P_y Y$) minus the cost of hemp straw ($P_x X$) and the cost of extracting (*c* times the price of the cost P_c). Since profit is maximized and we are dealing with an optimization problem Lagrange multipliers come into the equation.

Production function processors: $Y = \varphi^p(X, c)$ Eq. (5-2)

Factor prices processors: $P_x = \varphi_x^p P_Y$ Eq. (5-3)

$P_c = \varphi_c^p P_Y$ Eq. (5-4)

Factor supplies processors: $c = g(P_c)$ Eq. (5-5)

$X = h(P_x)$ Eq. (5-6)

Product demand: $Y = D_p(P_Y)$ Eq. (5-7)

The elimination of direct payments to processors affects the processing cost. As a consequence the supply curve of the processors shifts. The subsidy changes Eq. 5-2 to $Y = \varphi^p(X, c) + T_s$. T_s represents the direct payment of €90.- per ton of hemp and is considered to be an exogenous shock to the supply and demand model. Up until 2012 the supply curve includes T_s. When the subsidy is eliminated in 2012, the supply curve shifts back to a position determined by the market conditions. The function changes to $Y = \varphi^p(X, c)$.

In accordance with the assumptions, Eq. 5-2 is linear homogeneous. This implies that the processors produce at the minimum of their average cost function. The elasticities of *Y* with respect to *X* and *c* are equal to the factor shares ($YP_y = XP_x + cP_c$).

The changes as a consequence of the abolishing of the processors aid will be tond. Hence, the differentials of Eqs. 5-2 through 5-4 are required.

$$dY = \varphi^p dX + \varphi^p dc \qquad \text{Eq. (5-8)}$$

$$dP_x = d\varphi_x^p P_Y + \varphi_x^p dP_Y$$

$$d\varphi_x^r = d\varphi_{xx}^p P_Y + d\varphi_{xc}^p P_Y$$

$$dP_x = d\varphi_{xx}^p P_Y + d\varphi_{xc}^p P_Y + \varphi_x^p dP_Y \qquad \text{Eq. (5-9)}$$

$$dP_c = d\varphi_{cc}^p P_Y + d\varphi_{cx}^p P_Y + \varphi_c^p dP_Y \qquad \text{Eq. (5-10)}$$

$$dc = g_c d(P_c) \quad \text{Eq. (5-11)}$$

$$dX = h_x d(P_x) \quad \text{Eq. (5-12)}$$

$$dY = D_Y d(P_Y) \quad \text{Eq. (5-13)}$$

The differential Eqs. 5-2 to 5-7 are simplified and converted into elasticity form:

$$EY = K_c E_c + K_X E_X \quad \text{Eq. (5-14)}$$

$$EP_X = -\frac{K_c}{\sigma} E_X + \frac{K_c}{\sigma} E_c + EP_Y \quad \text{Eq. (5-15)}$$

$$EP_c = -\frac{K_X}{\sigma} E_c + \frac{K_X}{\sigma} E_X + EP_Y \quad \text{Eq. (5-16)}$$

$$Ec = e_c EP_c \quad \text{Eq. (5-17)}$$

$$EX = e_x EP_x \quad \text{Eq. (5-18)}$$

$$EY = \eta EP_Y \quad \text{Eq. (5-19)}$$

Processing subsidies are a percentage of the price of hemp straw. Therefore it is assumed that the elimination directly affects the input function Eq. 5-18. The subsidy is represented by T_s.

$$ET_s = \frac{dT_s}{P_X}$$

In order to measure the effect of the exogenous shock, ET_s, all variables are divided by ET_s. This results in the following equations:

$$\frac{EY}{ET_s} = K_X \frac{EX}{ET_s} + K_c \frac{Ec}{ET_s} \quad \text{Eq. (5-20)}$$

$$\frac{EP_c}{ET_s} = \frac{K_X}{\sigma_Y}\frac{EX}{ET_s} - \frac{K_X}{\sigma_Y}\frac{Ec}{ET_s} + \frac{EP_Y}{ET_s} \quad \text{Eq. (5-21)}$$

$$\frac{EP_X}{ET_S} = -\frac{K_C}{\sigma_Y}\frac{EX}{ET_S} + \frac{K_C}{\sigma_Y}\frac{Ec}{ET_S} + \frac{EP_Y}{ET_S} \qquad \text{Eq. (5-22)}$$

$$\frac{Ec}{ET_S} = e_C \frac{EP_C}{ET_S} \qquad \text{Eq. (5-23)}$$

$$\frac{EX}{ET_S} = e_X \frac{EP_X}{ET_S} \qquad \text{Eq. (5-24)}$$

$$\frac{EY}{ET_S} = \eta_Y \frac{EP_Y}{ET_S} \qquad \text{Eq. (5-25)}$$

Solving this for the unknowns *EY*, EP_c, EP_x, *Ec*, *EX* and EP_y gives the following solution illustrated in Table 5-1. More details about the derivations can be found in Appendix C.

Graphical Analysis Payment Changes

This section will illustrate the effects of the changes in direct payments graphically. The elimination of financial support to processors affects the production function of hemp processors directly. The net costs of production do not change. However, the removed support makes the production relatively more expensive. Consequently, the supply function of the processors shifts back (Figure 5-1). This leads to a new equilibrium that reduces the quantity processed and increases the price of processing hemp.

What the consequences are on different endogenous variables depends on the elasticities of supply and demand. The more elastic the demand, the greater the effect of the elimination of the payments on the quantity processed. When the elasticities of supply and demand are equal, the increase in price is equal on the supply and demand side. At the extremes, when the elasticity of supply is great and the elasticity of demand small the price of processed hemp will be affected whereas the price of raw hemp does not change significantly and vice versa (Gardner, 1987).

There is a loss in both consumer and producer surplus. The loss is represented in Figure 5-2. With the subsidy in place, the consumer surplus was represented by the triangle fei. After the abolishing, the consumer surplus decreased to abi. Similarly, the producer surplus shrinks from feh to abg. The rectangle dcef represents the amount the government does not have to pay out any longer. Bce is the deadweight loss triangle that is gained from switching for a stage with subsidy to a market equilibrium situation without government support. In other words, the price of both hemp straw and processed hemp increases and the quantity processed decreases. Assuming there are no market failures, taxpayers gain because money is saved by not paying out subsidies anymore.

Data

This section presents the quantitative data used throughout the research. The data is split up in two parts. First, the financial overview goes into the company data used. Second, the parameter values used are explained.

Financial Overview

According to the hemp processors, the ratio hemp shives, fiber, dust is 2:1:1. Table 5-2 and Table 5-3 give the price information of hemp in 2013. The tables illustrate that under current circumstances without processing subsidies no profit is left for processors. The profit goes into offering farmers a competitive price. This used to be different in the past. Whereas the input and sales prices were lower, the subsidy gave some price leverage. To illustrate the contrast, Table 5-2 and Table 5-3 also show the prices and revenue of hemp in 2005.

Multi-market models are generally non-temporal and keep other price influencers like, for instance, inflation constant. Therefore, only the 2013 price data is required to calculate the effects of the elimination of subsidy.

Parameter Values

The elasticities of supply e_c and e_X are assumed to be fairly elastic. According to both interviews with hemp farmers and hemp processors, farmers switch to different crops easily when the price of hemp straw drops.

The product demand is also estimated to be elastic. Nevertheless, it is less elastic than the elasticity of supply due to long-term contracts on the demand side. Still, significant price changes will drift away consumers making the demand elastic. With constant returns to scale, the Allen elasticity of substitution is assumed to be equal to one (Allen, 1938).

The factor shares $K_c$and K_X are estimated based on the information provided by Hempflax. Because of the assumption of linear homogeneity, $K_c + K_X = 1$. Per ton processed hemp the 2013 cost (*c*) are estimated to be €155 and the price of raw straw (*X*) €180. Hence, $K_c$and K_X are estimated to be 0.46 and 0.54 respectively. Table 5-4 gives a schematic overview of all parameter values chosen.

Subsidy Two-input One-product Model Results

The effect of an exogenous shock on the endogenous variables is shown in Table 5-6. Effect subsidy on endogenous variables

According to Gjaltema (2013),[1] the processing aid of €90 per ton fiber amounts to approximately €22 per ton hemp straw delivered. The 2013 cost of hemp straw (X) is estimated to be €180 per ton. Although this is a post-subsidy elimination price, it is

[1] Personal communication

equivalent to the last pre-elimination price. This can be explained by the fact that hemp processors kept their price artificially above the market equilibrium price. This model will estimate the extent to which the price will change assuming there are no market failures and processors will not keep prices artificially high. Hence, we can consider ET_s to be 22/180 = 0.12. In other words, the subsidy consisted of 12% of the price of hemp straw and the results indicate how the equilibrium would be restored without market failures. With an $\mathrm{ET_s}$ of 0.12 the endogenous effect of the abolishing of the subsidy can be estimated using the formulas in Table 5-1. Table 5-6. Effect subsidy on endogenous variables

shows the changes in the endogenous variables as a consequence of a one per cent change in subsidy provided. Since the subsidy is estimated to be 12 per cent of $P_{X,}$ Table C-1 indicates the percentage change as a consequence of the complete elimination of processing aid. It turns out that elimination of the subsidy will increase the price of processed hemp by approximately 4.05% and decrease the quantity by 12.15%. This implies the price per kilogram of hemp fibers will rise from €0.70 to €0.73 due to the elimination of the subsidy. A kilogram of hemp shives will cost €0.33 instead of €0.32 leaving all other factors constant.

Figure 5-3 and Figure 5-4 graphically illustrate what happens to the price and quantities of *X* and *c* respectively. T_x represents the subsidy that is taken away. Consequently, the market equilibrium for *X* is restored. The price of *X* goes up whereas the quantity decreases. One of the indirect consequences of the elimination of subsidy is that the demand for *c* shifts back. Hence, the quantity as well as the price of *c* goes down.

The price of hemp straw is estimated to go up by 8.65% and the quantity will decrease by 6.35%. It should be noted that the price in increase is reflected in the demand curve of hemp straw. In other words, processors will face a price increase. However, growers will face an increase of $8.65 - 12 = -4.35$.

The price of hemp straw becomes more expensive for farmers because the subsidy is not included in the price anymore. On the other hand, hemp growers lose as well because the loss of the subsidy is depressing the supply price of hemp straw.

Effectively, without market failures the hemp straw price should increase from €180 to €202. The quantity reduces from 1274 hectares to 1180 hectares. $\sigma < -\eta$. This implies that the partial substitution effect is not as large as the effect of the elimination of the subsidy. Consequently, the decrease in *X* will not be substituted by *c.* Instead, the use of *c* will decline by 6.75%.

Sensitivity Analysis

Because there is no exact data on elasticities of supply and demand for hemp available, a sensitivity analysis is conducted to examine the potential error as a consequence of miscalculating elasticities. The range of elasticities chosen is again based on estimations about the supply and demand described in Chapter 5.[2]

Table D-1 in Appendix D illustrates that, when changing the elasticities from (–)1 to (–)10, the effect a 1% change in subsidy has on the price of processed hemp ranges from 0.07 to 0.49. In other words, the complete abolishing of the subsidy will lead to a price increase between 0.79% when $\eta = -10$, $e_c = 5$, and $e_X = 1$. If $\eta = -1$, $e_c = 5$, and $e_X = 10$, P_Y increases by 5.89%. The smaller the elasticity of demand, the lower the fluctuation of the price of processed hemp.

[2] i.g. supply and demand elasticities of hemp are never assumed to be inelastic. Hence, the lowest elasticity values used are 1 and -1.

Tables D-2 through D-6 in show the results of the sensitivity analysis of the other variables. It becomes clear that, due to the relatively low substitutability of *X* and *c,* e_c is not a large determinant of fluctuations in P_X. The price of *X* will increase the least when the elasticity of e_X is the lowest. With $\eta = -10$, $e_c = 5$, and $e_X = 10$ P_X increases with 10.91 per cent. When $\eta = -1$, $e_c = 5$, and $e_X = 1$ P_X increases with 2.46 per cent. This implies that the supply price of P_X decreases between 9.54 and 1.09 per cent.[3]

P_c increases slightly more when the elasticity of e_X is greater. When the elasticity of e_c becomes larger the price fluctuates less. With $\eta = -10$, $e_c = 1$, and $e_X = 5$ P_c decreases with 6.24 per cent. In contrast, when $\eta = -10$, $e_c = 5$, and $e_X = 1$ P_c decreases with 0.84 per cent.

There is a positive relation between the decrease in the quantities of *Y* and *c* and the elasticities of supply and demand. When $\eta = -10$, $e_c = 5$, and $e_X = 10$ *Y* decreases with 27.6 per cent and *c* decreases with 20.8 per cent. Due to the substitution effect the quantity of *X* decreases the most when e_c is low. When $\eta = -10$, $e_c = 1$, and $e_X = 5$ *X* decreases with 14.4 per cent.

There is little to no effect on the quantities of *Y, c* and *X* when the elasticity of demand is low. The price effect on *Y* is the smallest when the supply elasticities of *X* and *c* are small. For instance, when $\eta = -1$, $e_c = 5$, and $e_X = 1$ *Y* decreases with 3.24 per cent. With $\eta = -1$ the quantity change is *c* is estimated to be 0.

[3] It seems counterintuitive that when the elasticity of e_X is high the price fluctuation, P_X, is the greatest. However, it should be noted we are talking about an increase in the demand price of hemp straw. Hence, processors prefer the elasticity to be as low as possible. After all, the higher the elasticity the more likely it is that processors have to increase the price of hemp straw in order to guarantee a stable supply.

The effect on *X* is the smallest when the elasticities of supply are high. With both $\eta = -1$, $e_c = 5$, and $e_X = 1$ and $\eta = -1$, $e_c = 1$, and $e_X = 5$ the quantity *X* will decrease by 2.76 per cent.

Hypotheses

All of the hypotheses are all rejected. The elimination of processing aid increases the price of processed hemp by 4.05%. The quantity processed will decrease by 12.15%. The demand price of hemp straw increases by 8.65%. Last, the quantity of hemp straw demanded is expected to decrease by 6.35%.

Table 5-1. Effects of subsidy on endogenous variables

Endogenous variables	Exogenous variable $\boldsymbol{T_s}$
$\boldsymbol{P_Y}$	$\frac{K_x e_x (e_c + \sigma)}{D}$
$\boldsymbol{P_c}$	$\frac{K_x e_x (\sigma + \eta)}{D}$
$\boldsymbol{P_X}$	$\frac{e_x (e_c + K_x \sigma - K_a \eta)}{D}$
Y	$\frac{K_x \eta e_x (e_c + \sigma)}{D}$
c	$\frac{K_x e_c e_X (\sigma + \eta)}{D}$
X	$\frac{e_x \sigma \eta - e_c (K_c \sigma - K_x \eta)}{D}$

Note: In accordance with Gardner (1987:107), the entries show the effect of percentage changes in the exogenous variables on percentages changes in the endogenous variables, e.g.: $\%\Delta P_Y$ / $\%\Delta T_c$, or the elasticity EP_Y / ET_c.

D = det X = $e_c e_X - \eta(\sigma + K_c e_X + K_X e_c) + \sigma(K_c e_c + K_X e_X)$

$D > 0$ for $\eta < 0$, $e_c \geq 0, e_X \geq 0$

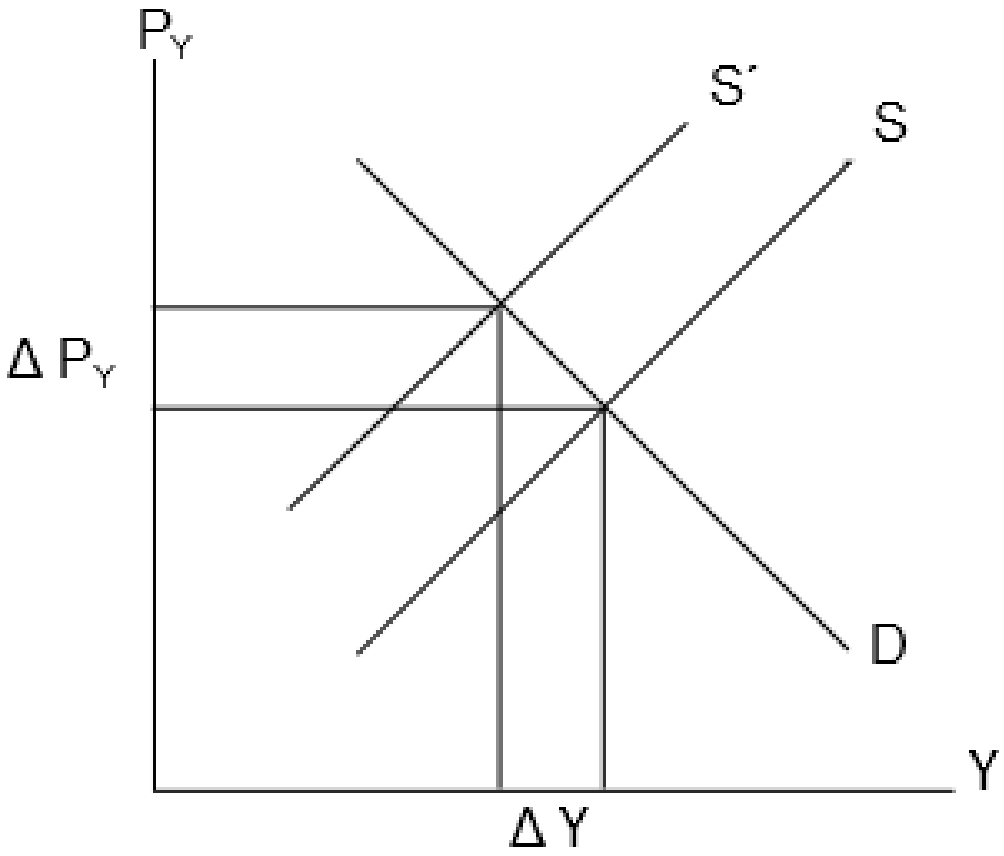

Figure 5-1. Graphical illustration effect abolishing processing aid

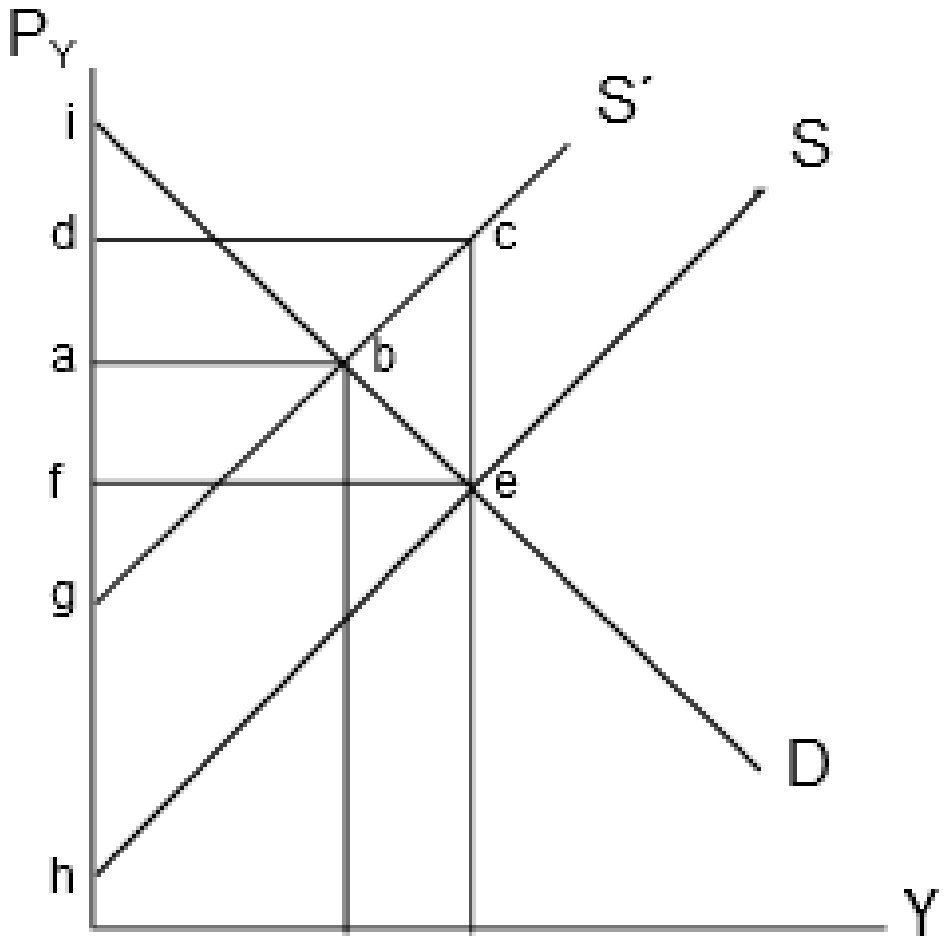

Figure 5-2. Consumer and producer surplus effects

Table 5-2. Prices hemp straw

Supply: Price hemp straw in euros per ton	
2005	130
2013	180

Table 5-3. Turnover

Demand: Price processed hemp per ton	Ratio processed products in kilograms	Price per kilogram in euros	Total revenue in euros	Revenue – price of straw	Turnover + subsidy	Turnover – cost (profit) €/ton
2005	500 shives	0.25	270	140	162	7
	250 fiber	0.50				
2013	500 shives	0.32	335	155	155	0
	250 fiber	0.70				

Table 5-4. Parameter values

Parameter	Value
e_c	5.00
e_X	5.00
σ	1.00
η_Y	-3.00
k_c	0.46
k_X	0.54

Table 5-5. Subsidy model results

%Δ	
$\frac{EP_Y}{ET_s}$	0.388
$\frac{EP_c}{ET_s}$	-0.113
$\frac{EP_X}{ET_s}$	0.721
$\frac{EY}{ET_s}$	-1.013
$\frac{Ec}{ET_s}$	-0.563
$\frac{EX}{ET_s}$	-0.529

Table 5-6. Effect subsidy on endogenous variables

	%
EP_Y	4.05
EP_c	-1.35
EP_X	8.65
EY	-12.15
Ec	-6.75
EX	-6.35

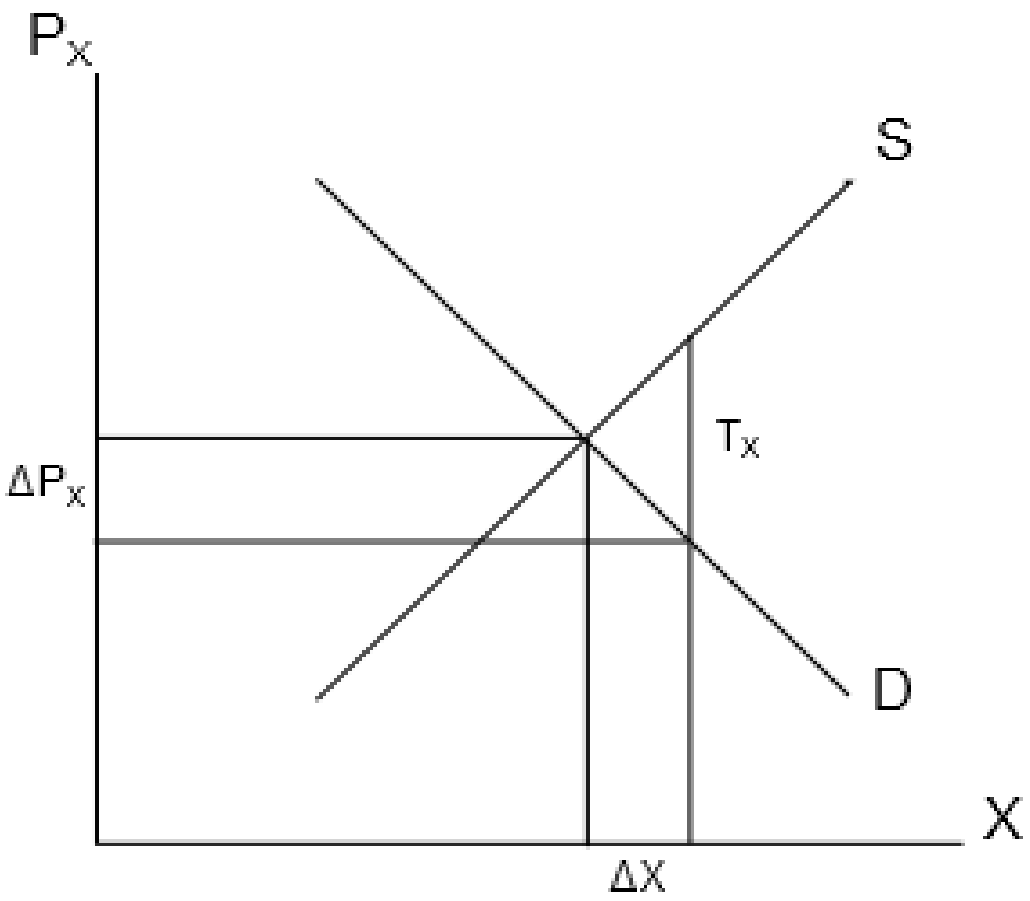

Figure 5-3. Effect on X and Px

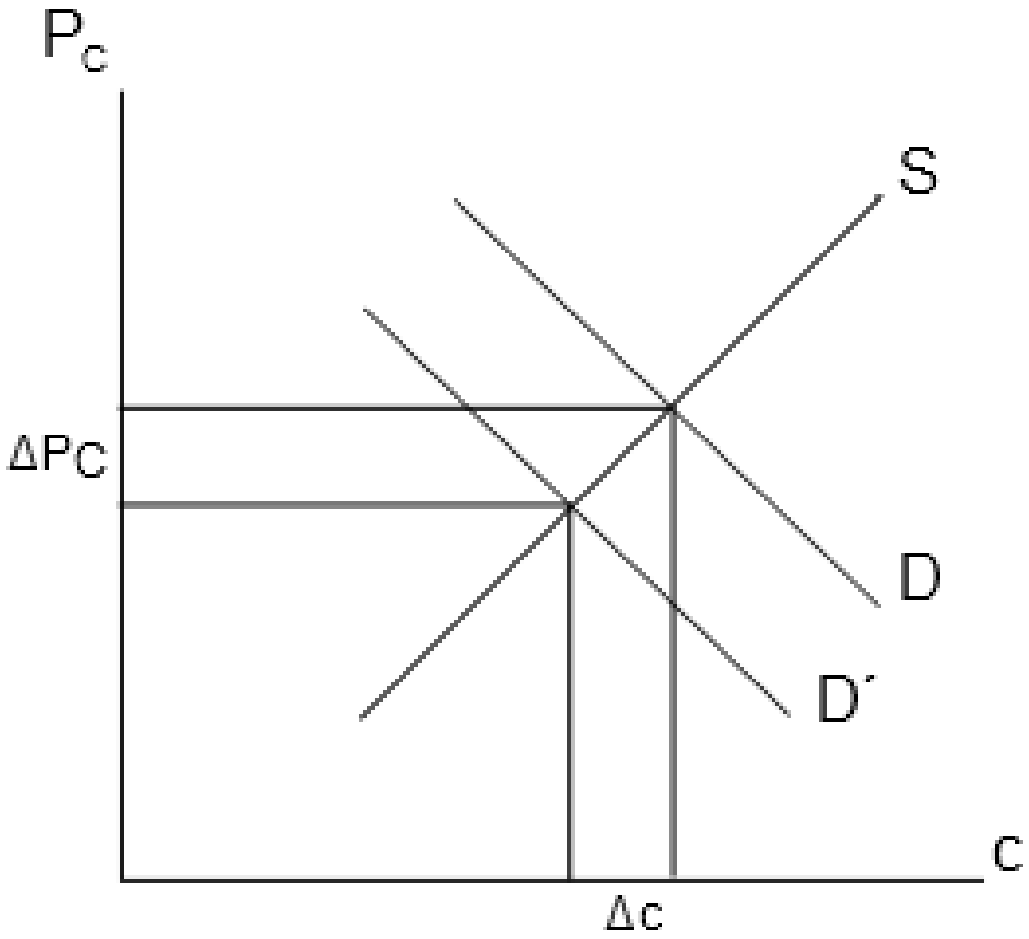

Figure 5-4. Effect on c and Pc

CHAPTER 6
CONCLUSION

In the final chapter of this thesis the research will be summarized. After the summary, the implications of the research, the limitations and possibilities for further research, and future perspectives will be discussed.

Summary

Although hemp has been cultivated for centuries, commercial cultivation of industrial hemp in the Netherlands has a relatively short history. After production started in 1996 and minimized in 2003, the commercial production only revived in 2005. This makes hemp a relatively new crop at the agricultural market. Hemp is considered to be a valuable product because it is a green alternative to a wide variety of less sustainable crops and products. Nevertheless, hemp has to compete against alternative crops in a competitive agricultural market. Therefore it is the question what the future perspectives are for hemp as a crop and hemp production in general in the Netherlands.

This research analyzed the consequences of changes in natural fiber subsidy structures under the CAP on the industrial hemp industry in the Netherlands. It primarily focused on the impacts of the elimination of hemp processing aid in 2012. In order to analyze the effects on the price and quantities of hemp straw and processed hemp a multi-level market two-inputs, one product model was set up.

Implications

The findings are in line with estimations of hemp processors Gjaltema (2013) and Mellema (2013)[1] and research conducted by De Bont et al. (2008). It is expected that due to the elimination of processing support the sales price of processed hemp increases. Furthermore, the quantities of hemp straw delivered and hemp processed will most likely decrease by substantial amounts.

Our finding are not completely in line with the results of the Suijkerbuijk and Janszen (2006) research. In 2006, market acceptance seemed to be one of the greatest threats to the development of the hemp sector in the Netherlands. Many of the potential threats came from the retailers' side of the equation. Currently, hemp has become more known as a product in multiple applications, the market is expanding and market acceptance is growing. However, supply of hemp straw appears to be more of the issue these days. Because of the elimination of support and severe competition of other crops it has become more difficult for processors to offer farmers a competitive price. Hence, the greatest threat is the supply of the dependency on the essential input hemp straw.

In line with the findings of Zijlstra et al. (2011) it appears that the small-scale of the Dutch hemp industry also poses a threat to future development. The larger the market share, the more leverage processors have to cut in the cost of production, to invest in technological development, and to co-determine the price of inputs.

It was not only the question what the market effects of the elimination of processing aid are. Also the impacts on the welfare of processors, growers and others are examined qualitatively by means of interviews. Because farmers can

[1] Both personal communication

change their crop rotations plans rather easily, growers' welfare is not affected directly. The more easily farmers can substitute hemp for an alternative crop, the greater the impact will be on the price of hemp straw.

Whereas it is assumed that growers suffer little from the elimination of processing aid, retailers are expected to lose some profit. The main reason for this is the fact that retailers set up long-term contracts with processors. Moreover, in contrast with growers, it is considered to be less easy to switch to alternatives. The more easily retailers switch to substitutes, the smaller the increase in price of processed hemp will be.

Processors are anticipated to be the largest losers of the elimination of processing aid. Some of the burden will be passed on to retailers. Nevertheless, processers will lose by far the most. When the price of growers' first substitute crop wheat remains high it becomes very difficult for processors to compete. Under current circumstances processors are left with zero profit.

The magnitude of the consequences of the elimination of processing aid is dependent on the extent to which a change in the price affect the quantities supplied or demanded. The more retailers are willing to invest in hemp products, the more of the burden of the elimination of the processing aid can be passed on to retailers. Also, like Zijlstra et al. (2011) concluded, the more growers are dependent on hemp as a crop, the more flexibility processors have in increasing the price of hemp straw. The finding are in line with Anderson and Martin's (2009) theory about the passing-through of support.

Limitations & Further Research

Like has been mentioned in Chapter 5 the model can be elaborated. Nevertheless that would require more data and time. One of the limitations of this model is that it does not directly account for price changes in alternative crops. This research does indicate that especially the price of wheat is a determinant factor for the profitability of the hemp industry. In further research the cross-price elasticities of hemp and wheat could be added to the model to account for this influencing factor.

Additionally, it should be noted that this model estimated the fluctuations in prices, quantities and welfare as a consequence of the elimination of processing aid. All other factors that might influence the price, quantity or welfare are not included in the model and considered *ceteris paribus*. The model can be developed further by including factors like evolvement over time or technological improvements to the model.

Furthermore, this model illustrated what the impact would be on the price and quantities of hemp assuming perfect market conditions. Market failures are not taken into consideration. Out of the interviews with the hemp processors it already became clear that the allocation of resources in the hemp industry is not completely efficient. Processors have kept the prices of hemp straw artificially higher than the market equilibrium to prevent farmers from switching to alternative crops massively and to guarantee the stable supply of processed hemp. Consequently, the current price of hemp straw purposely differs from the price estimations of the model. It illustrates the difference between a perfect market situation and the position currently preferred by processors.

Future Perspectives

What the future of industrial hemp in the Netherlands will look like depends on several factors. It has become clear that hemp processors in the Netherlands struggle to generate profits. The main factors causing the difficulties are infancy of the market, the current high price of alternative crops and the elimination of subsidies.

Processors attempt to lower the cost by focusing on new applications for hemp and reducing the processing waste. Also processors look at possibilities to lower the price of hemp straw by importing from Eastern European countries like for instance Romania.

Processors can attempt to reduce the cost but is also remains a socio-political question whether society should do something to help the Dutch hemp industry to overcome its stage of infancy and to preserve hemp cultivation and processing in the Netherlands. The main issue does not seem to be lack of the provision of subsidies but the unfair competition created by the introduction of subsidies. In line with De Wolf, van den Brink, & Spruijt (2012) this research concludes that the hemp industry suffers from high prices of maize and grains. It is very likely high prices are caused by subsidies on biofuels. In other words, subsidies for biofuels harm the bio-product industry. It is unequivocal that the prospects for hemp in the Netherlands would look brighter with a policy framework that restores the balance between support for biofuels and bio-products.

This research illustrated that after the elimination of processing aid, it becomes rather difficult for processors to stay competitive at the market. Whether hemp will still grow on the fields in the north east of the Netherlands the next decades will depend on the determination and innovative mind of processors and the policy frameworks of both the Netherlands and the European Union.

APPENDIX A
BREAKDOWN OF HEMP

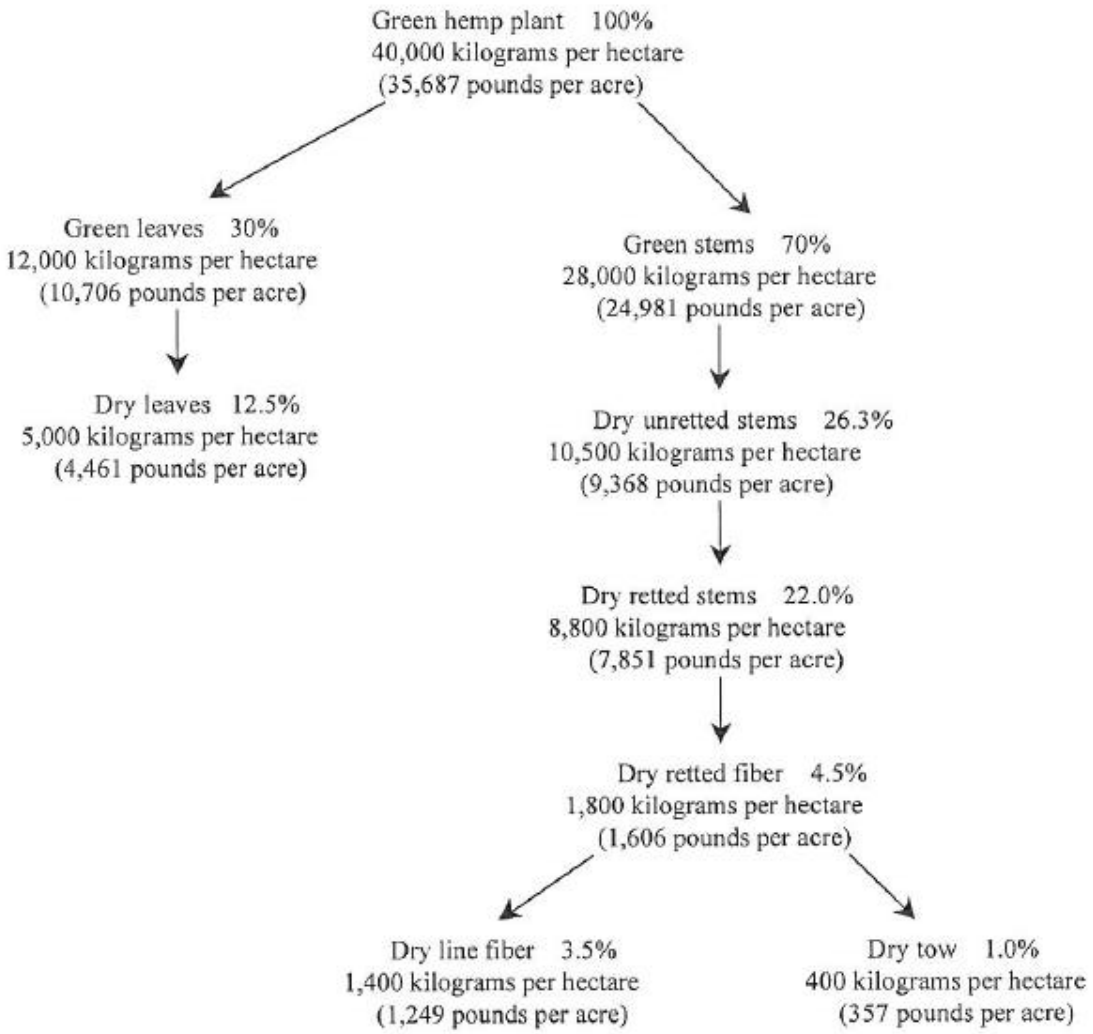

Figure A-1. Breakdown of hemp grown for fiber. Reprinted by permission from Dempsey, J. (1975), Hemp. In *Fibers Crops*. Gainesville: University of Florida (Page 82, Figure 3).

APPENDIX B:
APPLICATIONS AND BENEFITS HEMP

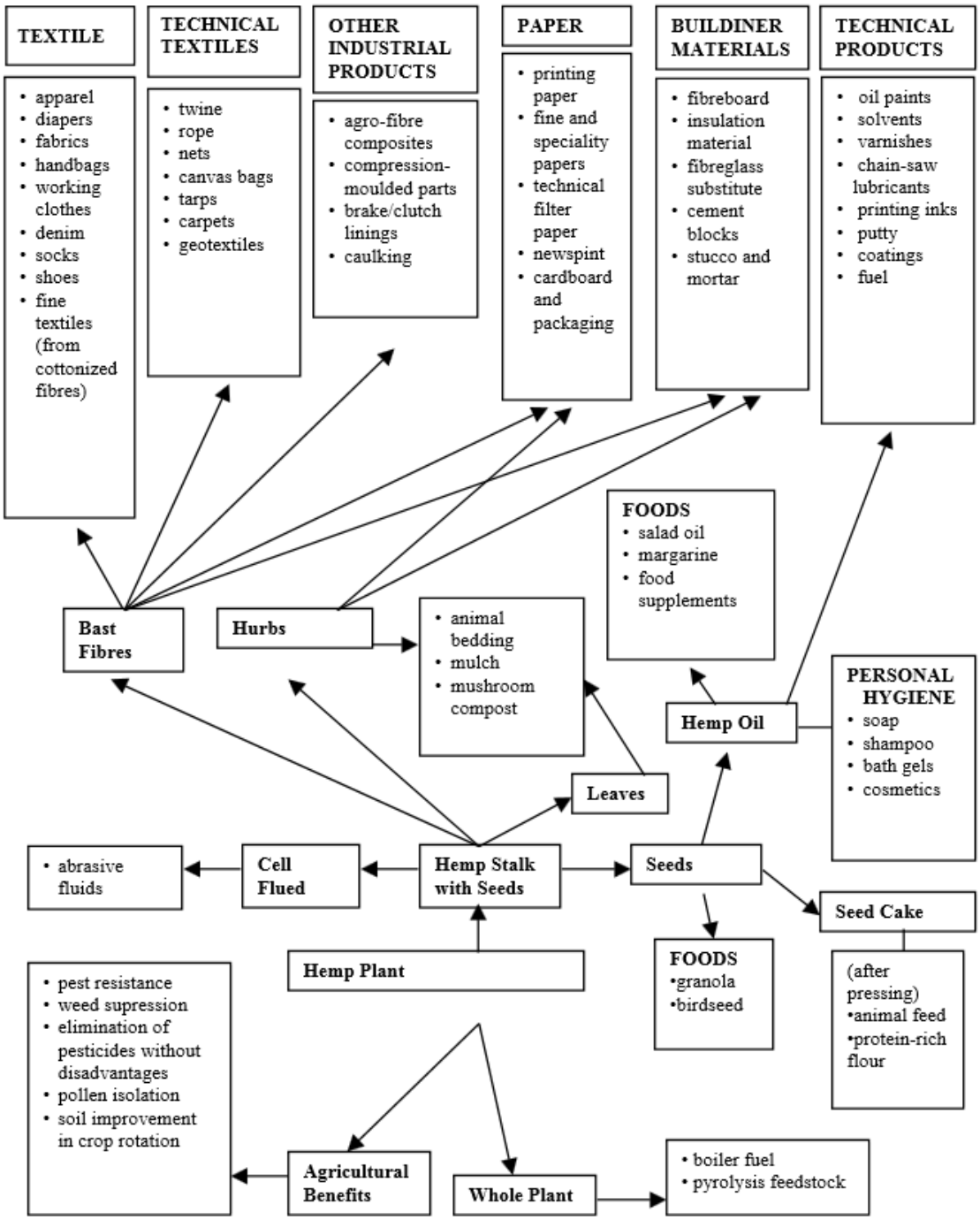

Figure B-1. Applications and benefits hemp. Reprinted by permission from Holmes, C. (2005), *Summary Report for the European Union.* York: IENICA (Page 54, Figure 3).

APPENDIX C:
DERIVATIONS TWO-INPUT ONE-PRODUCT MODEL

Processor's maximization problem

$$\pi^p = P_y Y - P_x X - P_c c \text{ with } Y = \varphi^p(X, c)$$

Lagrange

$$L = P_y Y - P_x X - P_c c + \lambda^p [Y - \varphi^p(X, c)] \qquad \text{Eq. (C-1)}$$

First order conditions

$$\frac{\partial L^p}{\partial Y} = P_y + \lambda^p = 0$$

$$P_y = -\lambda^p$$

$$\frac{\partial L^p}{\partial \lambda^p} = Y - \varphi^p(X, c) = 0$$

$$Y = \varphi^p(X, c) \qquad \text{Eq. (C-2)}$$

$$\frac{\partial L^p}{\partial X} = -P_x - \lambda^p \varphi_x^p = 0$$

$$P_x = -\lambda^p \varphi_x^p$$

$$P_x = P_y \varphi_x^p$$

$$\frac{P_x}{P_y} = \varphi_x^p$$

$$\frac{\partial L^p}{\partial c} = -P_c - \lambda^p \varphi_c^p = 0$$

$$P_c = -\lambda^p \varphi_c^p$$

$$P_c = P_y \varphi_c^p$$

$$\frac{P_c}{P_y} = \varphi_c^p$$

$g_c = \frac{\partial c}{\partial P_c}$ given that $e_c = \frac{\partial c}{\partial P_c} \frac{Pc}{c}$

$$g_c = e_c \frac{c}{P_c} \qquad \text{Eq. (C-3)}$$

$$h_x = e_x \frac{x}{P_x} \qquad \text{Eq. (C-2.4)}$$

$$\sigma_k = e_k \frac{k}{P_k} \qquad \text{Eq. (C-2.5)}$$

Partial derivative of profit with respect to prices of inputs *c* and *X* and output *Y*

$$\frac{\partial \pi^p}{\partial P_c} = c\ ;\ \ c = g(P_c)$$

$$\frac{\partial \pi^p}{\partial P_X} = X\ ;\ \ X = h(P_X)$$

$$\frac{\partial \pi^p}{\partial P_Y} = Y\ ;\ \ Y = D(P_Y)$$

Subsidy percentage change

$$ET_s = \frac{dET_s}{P_X}$$

Percentage changes

$Y = \varphi^p(X, c)$

$$dY = d\varphi^p(X, c)$$

$$dY = \varphi_X^p dX + \varphi_X^p dc \qquad because\ \frac{P_x}{P_y} = \varphi_x^p \rightarrow$$

$$\frac{dY}{Y} = \frac{XP_X}{YP_X}\frac{dX}{X} + \frac{cP_c}{YP_Y}\frac{dc}{c}$$

$$K_x = \frac{XP_x}{YP_Y}\ and\ K_c = \frac{cP_c}{YP_Y}\ factor\ shares;\ K_x + K_c = 1$$ [1]

$$EY = K_X EX + K_c Ec$$

$$\frac{EY}{ET_s} = K_X \frac{EX}{ET_s} + K_c \frac{Ec}{ET_s} \qquad \text{Eq. (C-6)}$$

[1] Assuming linear homogeneity

$$P_c = \varphi_c^p P_Y$$

$$dP_c = P_Y d\varphi_c^p + \varphi_c^p dP_Y$$

$$dP_c = P_Y \varphi_{cX}^p + P_Y \varphi_{cc}^p + \varphi_c^p dP_Y$$

$$dP_c = P_Y \left(\frac{\varphi_X^p \varphi_c^p}{Y \sigma_{Xc}}\right) dX + P_Y \left(\frac{-X \varphi_X^p \varphi_c^p}{cY \sigma_{Xc}}\right) dc + \varphi_c^p dP_Y$$

$$dP_c = P_Y \left(\frac{P_X P_c}{P_Y P_Y Y \sigma_{Xc}}\right) dX + P_Y \left(\frac{-X P_X P_c}{c P_Y P_Y \sigma_{Xc}}\right) dc + \frac{P_c}{P_Y} dP_Y$$

$$\frac{dP_c}{P_c} = \frac{P_c P_Y}{P_c P_Y}\left(\frac{X P_X}{P_Y Y \sigma_{Xc}}\right)\frac{dX}{X} + \frac{P_c P_Y}{P_c P_Y}\left(\frac{-X P_X}{P_Y Y \sigma_{Xc}}\right)\frac{dc}{c} + \frac{P_c}{P_c}\frac{dP_Y}{P_Y}$$

$$EP_c = \frac{K_X}{\sigma_Y} EX - \frac{K_X}{\sigma_Y} Ec + EP_Y$$

$$\frac{EP_c}{ET_s} = \frac{K_X}{\sigma_Y}\frac{EX}{ET_s} - \frac{K_X}{\sigma_Y}\frac{Ec}{ET_s} + \frac{EP_Y}{ET_s} \qquad \text{Eq. (C-7)}$$

$P_X = P_Y \varphi_X^p$

$$dP_X = P_Y d\varphi_X^p + \varphi_X^p dP_Y$$

$$dP_X = P_Y \varphi_{XX}^p + P_Y \varphi_{Xc}^p + \varphi_X^p dP_Y$$

$$dP_X = P_Y \left(\frac{-c\varphi_X^p \varphi_c^p}{XY\sigma_{Xc}} \right) dX + P_Y \left(\frac{\varphi_X^p \varphi_c^p}{Y\sigma_{Xc}} \right) dc + \varphi_X^p dP_Y$$

$$dP_X = P_Y \left(\frac{-cP_X P_c}{XP_Y P_Y \sigma_{Xc}} \right) dX + P_Y \left(\frac{P_X P_c}{P_Y P_Y \sigma_{Xc}} \right) dc + \frac{P_X}{P_Y} dP_Y$$

$$\frac{dP_X}{P_X} = \frac{P_x P_Y}{P_x P_Y} \left(\frac{-cP_c}{P_Y \sigma_{Xc}} \right) \frac{dX}{X} + \frac{P_x P_Y}{P_x P_Y} \left(\frac{cP_c}{P_Y Y \sigma_{Xc}} \right) \frac{dc}{c} + \frac{P_X}{P_x} \frac{dP_Y}{P_Y}$$

$$EP_x = -\frac{K_c}{\sigma_{Xc}} EX + \frac{K_c}{\sigma_{Xc}} Ec + EP_Y$$

$$\frac{EP_x}{ET_s} = -\frac{K_c}{\sigma_Y} \frac{EX}{ET_s} + \frac{K_c}{\sigma_Y} \frac{Ec}{ET_s} + \frac{EP_Y}{ET_s} \qquad \text{Eq. (C-8)}$$

$c = g(P_c)$

$$dc = dg(P_c)$$

$$dc = \frac{\partial c}{\partial P_c} dP_c \quad \rightarrow e_c = \frac{\partial c}{\partial P_c} \frac{P_c}{c}$$

$$dc = e_c \frac{c}{P_c} dP_c$$

$$\frac{dc}{c} = e_c \frac{c}{c} \frac{dP_c}{P_c}$$

$$Ec = e_c EP_c$$

$$\frac{Ec}{ET_c} = e_c \frac{EP_c}{ET_c} \qquad \text{Eq. (C-9)}$$

$$\frac{EX}{ET_s} = e_X \frac{EP_X}{ET_s} \qquad \text{Eq. (C-10)}$$

$Y = D(P_Y)$

$$dY = D'(P_Y)$$

$$dY = \frac{\partial Y}{\partial P_Y} dP_Y$$

$$\eta_Y = \frac{\partial Y}{\partial P_Y} \frac{P_Y}{Y}$$

$$dY = \eta_Y \frac{Y}{P_Y} dP_Y$$

$$\frac{dY}{Y} = \eta_Y \frac{Y}{Y} \frac{dP_Y}{P_Y}$$

$$\frac{EY}{ET_s} = \eta_Y \frac{EP_Y}{ET_s} \qquad \text{Eq. (C-11)}$$

This results into the following matrix system of equations:

$$\begin{bmatrix} 1 & -\eta & 0 & 0 & 0 & 0 \\ 1 & 0 & -K_c & -K_X & 0 & 0 \\ 0 & 1 & K_X/\sigma & -K_X/\sigma & 1 & 0 \\ 0 & 1 & -K_c/\sigma & K_c/\sigma & 0 & 1 \\ 0 & 0 & -1/e_c & 0 & 1 & 0 \\ 0 & 0 & 0 & -1/e_X & 0 & 1 \end{bmatrix} \begin{bmatrix} EY/ET_s \\ EP_Y/ET_s \\ Ec/ET_s \\ EX/ET_s \\ EP_c/ET_s \\ EP_X/ET_s \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 1 \end{bmatrix}$$

This can be expressed as $B_{6\times6}X_{6\times1} = Z_{6\times1}$ is solved for the variables $X = B^{-1}Z$. That generates a system of equations in which the variables *X* are solved as a function of parameters *B* and exogenous variables *Z* (Gardner, 1987). The results are as follows:

Table C-1. Effect of exogenous shock on endogenous variables

Endogenous variables	Exogenous variable $\boldsymbol{T_s}$
$\boldsymbol{P_Y}$	$\frac{K_x e_x(e_c + \sigma)}{D}$
$\boldsymbol{P_c}$	$\frac{K_x e_x(\sigma + \eta)}{D}$
$\boldsymbol{P_X}$	$\frac{e_x(e_c + K_x\sigma - K_a\eta)}{D}$
Y	$\frac{K_x \eta e_x(e_c + \sigma)}{D}$
c	$\frac{K_x e_c e_X(\sigma + \eta)}{D}$
X	$\frac{e_x\sigma\eta - e_c(K_c\sigma - K_x\eta)}{D}$

Note: In accordance with Gardner (1987:107), the entries show the effect of percentage changes in the exogenous variables on percentages changes in the endogenous variables, e.g.: $\%\Delta P_Y$ / $\%\Delta T_c$, or the elasticity EP_Y / ET_c.

D = det *X* = $e_c e_X - \eta(\sigma + K_c e_X + K_X e_c) + \sigma(K_c e_c + K_X e_X)$

D > 0 for $\eta < 0$, $e_c \geq 0, e_X \geq 0$

APPENDIX D:
RESULTS SENSITIVITY ANALYSIS

Table D-1. Sensitivity analysis effect EP_Y

		Elasticity of demand η_Y					
		$\eta_Y = -1$	$\eta_Y = -2$	$\eta_Y = -3$	$\eta_Y = -5$	$\eta_Y = -8$	$\eta_Y = -10$
Elasticities of supply e_c and e_X	$e_c = 1$ $e_X = 5$	0.45	0.34	0.27	0.20	0.14	0.12
	$e_c = 2$ $e_X = 5$	0.45	0.36	0.30	0.23	0.17	0.14
	$e_c = 3$ $e_X = 5$	0.45	0.37	0.32	0.25	0.18	0.16
	$e_c = 5$ $e_X = 5$	0.45	0.39	**0.34**	0.27	0.21	0.18
	$e_c = 8$ $e_X = 5$	0.45	0.39	0.35	0.29	0.23	0.20
	$e_c = 10$ $e_X = 5$	0.45	0.40	0.36	0.29	0.23	0.21
	$e_c = 5$ $e_X = 1$	0.27	0.20	0.16	0.11	0.08	0.07
	$e_c = 5$ $e_X = 2$	0.36	0.29	0.24	0.18	0.13	0.11
	$e_c = 5$ $e_X = 3$	0.41	0.33	0.28	0.22	0.16	0.14
	$e_c = 5$ $e_X = 5$	0.45	0.39	**0.34**	0.27	0.21	0.18
	$e_c = 5$ $e_X = 8$	0.48	0.42	0.38	0.31	0.25	0.22
	$e_c = 5$ $e_X = 10$	0.49	0.44	0.39	0.33	0.26	0.23

Note: The numbers in bold indicate the estimated outcome based on the initial elasticities. The outcome multiplied by 12 gives the percentage change in the variable as a consequence of the complete subsidy elimination that amounts to 12% of the price of *X*.

Table D-2. Sensitivity analysis effect EP_x

		Elasticity of demand η_Y					
		$\eta_Y = -1$	$\eta_Y = -2$	$\eta_Y = -3$	$\eta_Y = -5$	$\eta_Y = -8$	$\eta_Y = -10$
Elasticities of supply e_c and e_X	$e_c = 1$ $e_X = 5$	0.83	0.78	0.74	0.70	0.67	0.66
	$e_c = 2$ $e_X = 5$	0.83	0.77	0.73	0.68	0.64	0.62
	$e_c = 3$ $e_X = 5$	0.83	0.77	0.73	0.67	0.62	0.60
	$e_c = 5$ $e_X = 5$	0.83	0.77	**0.72**	0.65	0.59	0.56
	$e_c = 8$ $e_X = 5$	0.83	0.77	0.72	0.64	0.57	0.54
	$e_c = 10$ $e_X = 5$	0.83	0.77	0.71	0.64	0.56	0.52
	$e_c = 5$ $e_X = 1$	0.50	0.40	0.34	0.27	0.22	0.21
	$e_c = 5$ $e_X = 2$	0.67	0.57	0.51	0.43	0.37	0.34
	$e_c = 5$ $e_X = 3$	0.75	0.67	0.61	0.53	0.46	0.44
	$e_c = 5$ $e_X = 5$	0.83	0.77	**0.72**	0.65	0.59	0.56
	$e_c = 5$ $e_X = 8$	0.89	0.84	0.81	0.75	0.70	0.67
	$e_c = 5$ $e_X = 10$	0.91	0.87	0.84	0.79	0.74	0.72

Note: The numbers in bold indicate the estimated outcome based on the initial elasticities. The outcome multiplied by 12 gives the percentage change in the variable as a consequence of the complete subsidy elimination that amounts to 12% of the price of *X*.

Table D-3. Sensitivity analysis effect *EPc*

Elasticities of supply e_c and e_X	Elasticity of demand η_Y					
	$\eta_Y = -1$	$\eta_Y = -2$	$\eta_Y = -3$	$\eta_Y = -5$	$\eta_Y = -8$	$\eta_Y = -10$
$e_c = 1$, $e_X = 5$	0	-0.17	-0.27	-0.39	-0.49	-0.52
$e_c = 2$, $e_X = 5$	0	-0.12	-0.20	-0.30	-0.39	-0.42
$e_c = 3$, $e_X = 5$	0	-0.09	-0.16	-0.25	-0.32	-0.36
$e_c = 5$, $e_X = 5$	0	-0.06	**-0.11**	-0.18	-0.24	-0.27
$e_c = 8$, $e_X = 5$	0	-0.04	-0.08	-0.13	-0.18	-0.20
$e_c = 10$, $e_X = 5$	0	-0.04	-0.06	-0.11	-0.15	-0.17
$e_c = 5$, $e_X = 1$	0	-0.03	-0.05	-0.08	-0.09	-0.10
$e_c = 5$, $e_X = 2$	0	-0.05	-0.08	-0.12	-0.15	-0.16
$e_c = 5$, $e_X = 3$	0	-0.06	-0.09	-0.15	-0.19	-0.21
$e_c = 5$, $e_X = 5$	0	-0.06	**-0.11**	-0.18	-0.24	-0.27
$e_c = 5$, $e_X = 8$	0	-0.07	-0.13	-0.21	-0.29	-0.32
$e_c = 5$, $e_X = 10$	0	-0.07	-0.13	-0.22	-0.30	-0.35

Note: The numbers in bold indicate the estimated outcome based on the initial elasticities. The outcome multiplied by 12 gives the percentage change in the variable as a consequence of the complete subsidy elimination that amounts to 12% of the price of *X*.

Table D-4. Sensitivity analysis effect *EY*

		Elasticity of demand η_Y					
		$\eta_Y = -1$	$\eta_Y = -2$	$\eta_Y = -3$	$\eta_Y = -5$	$\eta_Y = -8$	$\eta_Y = -10$
Elasticities of supply e_c and e_X	$e_c = 1$ $e_X = 5$	-0.45	-0.68	-0.82	-0.99	-1.11	-1.16
	$e_c = 2$ $e_X = 5$	-0.45	-0.72	-0.91	-1.14	-1.33	-1.41
	$e_c = 3$ $e_X = 5$	-0.45	-0.75	-0.96	-1.24	-1.48	-1.58
	$e_c = 5$ $e_X = 5$	-0.45	-0.77	**-1.01**	-1.35	-1.66	-1.80
	$e_c = 8$ $e_X = 5$	-0.45	-0.79	-1.05	-1.44	-1.81	-1.98
	$e_c = 10$ $e_X = 5$	-0.45	-0.80	-1.07	-1.47	-1.87	-2.06
	$e_c = 5$ $e_X = 1$	-0.27	-0.40	-0.48	-0.57	-0.63	-0.66
	$e_c = 5$ $e_X = 2$	-0.36	-0.57	-0.71	-0.89	-1.03	-1.09
	$e_c = 5$ $e_X = 3$	-0.405	-0.67	-0.85	-1.10	-1.31	-1.39
	$e_c = 5$ $e_X = 5$	-0.45	-0.77	**-1.01**	-1.35	-1.66	-1.80
	$e_c = 5$ $e_X = 8$	-0.48	-0.84	-1.13	-1.55	-1.96	-2.15
	$e_c = 5$ $e_X = 10$	-0.49	-0.87	-1.18	-1.63	-2.09	-2.30

Note: The numbers in bold indicate the estimated outcome based on the initial elasticities. The outcome multiplied by 12 gives the percentage change in the variable as a consequence of the complete subsidy elimination that amount to 12% of the price of *X*.

Table D-5. Sensitivity analysis effect *Ec*

		Elasticity of demand η_Y					
		$\eta_Y = -1$	$\eta_Y = -2$	$\eta_Y = -3$	$\eta_Y = -5$	$\eta_Y = -8$	$\eta_Y = -10$
Elasticities of supply e_c and e_X	$e_c = 1$ $e_X = 5$	0	-0.17	-0.27	-0.39	-0.49	-0.52
	$e_c = 2$ $e_X = 5$	0	-0.24	-0.40	-0.61	-0.78	-0.85
	$e_c = 3$ $e_X = 5$	0	-0.28	-0.48	-0.74	-0.97	-1.07
	$e_c = 5$ $e_X = 5$	0	-0.32	**-0.56**	-0.90	-1.21	-1.35
	$e_c = 8$ $e_X = 5$	0	-0.35	-0.62	-1.02	-1.41	-1.59
	$e_c = 10$ $e_X = 5$	0	-0.36	-0.65	-1.07	-1.49	-1.68
	$e_c = 5$ $e_X = 1$	0	-0.17	-0.27	-0.38	-0.46	-0.49
	$e_c = 5$ $e_X = 2$	0	-0.24	-0.40	-0.59	-0.75	-0.82
	$e_c = 5$ $e_X = 3$	0	-0.28	-0.47	-0.73	-0.95	-1.05
	$e_c = 5$ $e_X = 5$	0	-0.32	**-0.56**	-0.90	-1.21	-1.35
	$e_c = 5$ $e_X = 8$	0	-0.35	-0.63	-1.03	-1.43	-1.61
	$e_c = 5$ $e_X = 10$	0	-0.36	-0.65	-1.09	-1.52	-1.73

Note: The numbers in bold indicate the estimated outcome based on the initial elasticities. The outcome multiplied by 12 gives the percentage change in the variable as a consequence of the complete subsidy elimination that amounts to 12% of the price of *X*.

Table D-6. Sensitivity analysis effect *EX*

		Elasticity of demand η_Y					
		$\eta_Y = -1$	$\eta_Y = -2$	$\eta_Y = -3$	$\eta_Y = -5$	$\eta_Y = -8$	$\eta_Y = -10$
Elasticities of supply e_c and e_X	$e_c = 1$ $e_X = 5$	-0,50	-0,73	-0,87	-1,03	-1,15	-1,20
	$e_c = 2$ $e_X = 5$	-0,39	-0,58	-0,72	-0,88	-1,02	-1,07
	$e_c = 3$ $e_X = 5$	-0,33	-0,51	-0,63	-0,79	-0,93	-0,99
	$e_c = 5$ $e_X = 5$	-0,28	-0,42	**-0,53**	-0,68	-0,82	-0,88
	$e_c = 8$ $e_X = 5$	-0,24	-0,36	-0,46	-0,60	-0,73	-0,79
	$e_c = 10$ $e_X = 5$	-0,23	-0,34	-0,43	-0,56	-0,69	-0,75
	$e_c = 5$ $e_X = 1$	-0,50	-0,60	-0,66	-0,73	-0,78	-0,79
	$e_c = 5$ $e_X = 2$	-0,39	-0,52	-0,60	-0,71	-0,79	-0,83
	$e_c = 5$ $e_X = 3$	-0,33	-0,47	-0,57	-0,69	-0,80	-0,85
	$e_c = 5$ $e_X = 5$	-0,28	-0,42	**-0,53**	-0,68	-0,82	-0,88
	$e_c = 5$ $e_X = 8$	-0,24	-0,39	-0,50	-0,67	-0,83	-0,91
	$e_c = 5$ $e_X = 10$	-0,23	-0,37	-0,49	-0,66	-0,84	-0,92

Note: The numbers in bold indicate the estimated outcome based on the initial elasticities. The outcome multiplied by 12 gives the percentage change in the variable as a consequence of the complete subsidy elimination that amounts to 12% of the price of *X*.

LIST OF REFERENCES

Allen, R. (1938), *Mathematical Analysis for Economists.* London: Macmillen and co.

Amun Laate, E. (2012, June 29), *Industrial Hemp Production in Canada.* Retrieved March 3, 2013, from Alberta Agriculture and Rural Development: http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/econ9631

Anderson, K., & Martin, W. (2009), The impact of distortions in food processing on agricultural NRAs. In *Distortions to Agricultural Incentives in Asia* (451-452). Washington, D.C.: The World Bank.

Arulpragasam, J., & Conway, P. (2003), Partial Equilibrium Multi-Market Analysis. In F. Bourguigon, & L. Pereira da Silva, *The Impact of Economic Policies on Poverty and Income Distribution: Evaluation Techniques and Tools* (12.1-12.16). Washington DC: Copublication of the World Bank and Oxford University Press.

Beerepoot, L. (2003), *Haalbaarheidsstudie vezelhennep voor textieltoepassing.* Wageningen: Beerepoot Consultancy.

Braverman, A., Hammer, J., & Gross, A. (1987), Multimarket analysis of agricultural price policies in an operational context. *World Bank Economic Review, 1* (337-356).

Carus, M., Karst, S., & Kauffmann, A. (2013), *The European Hemp Industry: Cultivation, processing and applications for fibers, shivs and seeds.* European Industrial Hemp Association.

CBS. (2013, February 14), *Landbouw; gewassen, dieren en grondgebruik naar regio*. Retrieved March 18, 2013, from Centraal Bureau voor de Statistiek: www.cbs.nl

de Bont, C., Blokland, P., Prins, H., Roza, P., & Smit, A. (2007), *Zetmeelaardappelen en herziening EU-beleid.* Den Haag: LEI.

de Bont, C., Jager, J., & Janssens, S. (2008), *Vlas en vezelhennep en herziening van het EU-beleid.* Wageningen: LEI.

de Wolf, P., van den Brink, L., & Spruijt, J. (2012), *Inkomensvergelijking vezelgewassen versus graan.* Wageningen: Wageningen UR.

DeMeijer, E. v. (1992), Characterization of Cannabis Axxessions with Regard to Cannabinoid Content and Relation to Other Plant Characters. *Euphytica, 62*(3) (187-200).

Dempsey, J. (1975), Hemp. In *Fibers Crops* (46-89). Gainesville: University of Florida.

Dienst Regelingen. (2013), *DR-Loket*. Retrieved July 4, 2013, from Hennep: http://www.hetlnvloket.nl/onderwerpen/bedrijfstoeslag/dossiers/dossier/uitbetalen-toeslagrechten/hennep

Dienst Regelingen. (2013), *Publicatie subsidiegegevens landbouw en visserij.* Retrieved May 21, 2013, from http://www.drloket.nl/onderwerpen/gemeenschappelijk-landbouwbeleid/dossiers/dossier/publicatie-subsidiegegevens-landbouw-en-visserij

European Commission Agriculture and Rural Development. (2009, February 26), *European Commision: Hemp and Flax, AGRI C5.* Retrieved March 18, 2013, from European Industrial Hemp Association: http://eiha.org/attach/553/09-02_C1_Flax_hemp_presentation_26_February_2009_circa.pdf

Gardner, B. (1987), *The Economics of Agricultural Policy.* New York: Macmillan Publishing Company.

Gohin, A., & Moschini, G. (2006), Evaluating the market and welfare impacts of agricultural policies in developed countries: Comparison of partial and general equilibrium measures. *Review of Agricultural Economics, 28*(2) (195-211).

Haars, A. (2012, June 23), *Groningers bouwen huis van hennep.* Retrieved March 18, 2013, from BNR: http://www.bnr.nl/meernieuws/755330-1207/groningers-bouwen-huis-van-hennep

Hempflax. (2005), *De Nederlandse Vezelhennepsector.*

HempFlax. (2013), Retrieved July 24, 2013, from www.hempflax.com

Holmes, C. (2005), *Summary Report for the European Union.* York: IENICA.

Hoofdproductschap Akkerbouw. (2011), *Steunregeling verwerking vlas en hennpe & steunregeling productie zaaizaad van vezelvlas.*

Karus, M. (February 2005), *Europäische Hanfwirtschaft 2001 bis 2004: Anbau, Rohstoffe, Produkte und Trends.* European Industrial Hemp Association.

Luginbuhl, A. (2001), Industrial hemp (Cannabis sativa L): The geography of a controversial plant. *Journal of California Geographical Society, 41* (1-14).

Oliver, A., & Howard, J. (April 1999), *Industrial Hemp Fact Sheet.* Kamloops, Canada: British Columbia Ministry of Agriculture and Food.

Piotrowski, S., & Carus, M. (2001), *Possible support instruments for industrial hemp in the framework of the Common Agricultural Policy (CAP).* Hürth: nova-Institut.

Productschap Akkerbouw. (2013), *Marktprijs: Groningen - Tarwe*. Retrieved June 3, 2013, from http://www.productschapakkerbouw.nl/teelt/marktprijzen/marktprijs_details

Ranalli, P., & Venturi, G. (2004), Hemp as raw material for industrial applications. *Euphytica, 140* (1-6).

Randall Fortenbery, T., & Bennett, M. (2004), Opportunities for Commercial Hemp Production. *Review of Agricultural Economics, 26*(1) (97-117).

Struik, P., Amaducci, S., Bullard, M., Stutterheim, N., Veturi, G., & Cromack, H. (2000), Agronomy of fiber hemp (Cannabis sative L.) in Europe. *Industrial Crops and Products, 11* (107-118).

Suijkerbuijk, W., & Janszen, F. (2006), *Haalbaarheidsonderzoek verwerking hennep in de Veenkoloniën.* Wezep: New Engine.

Takeshima, H., & Lim Lee, H. (2012), *Agricultural inputs subsidy and their developmental impact: Conventional wisdom.* Washington, DC.: International Food Policy Research Insitute.

Takeshima, H., & Lim Lee, H. (2012), *Exit strategies for and potential alternatives to agricultural subsidy programs.* Washington, DC: International Food Policy Research Institute.

U.S. Department of Agriculture. (2000), *Industrial Hemp in the United States: Status and Market Potential.* Washington: USDA.

Vantreese, V. (1998), *Industrial Hemp: Global Operations, Local Implications.* Department of Agricultural Economics, University of Kentucky.

Vantreese, V. (2002), Hemp Support: Evolution in EU Regulation. *Journal of Industrial Hemp, 7*(2) (17-31).

Zijlstra, J., de Wolf, P., Prins, H., Doornewaard, G., Smit, A., Daatselaar, C., van Cooten, W. (2011), *Meer groei dan vergroening.* Wageningen: Wageningen UR.

BIOGRAPHICAL SKETCH

Sandra Ronde is born in Canada and raised in the Netherlands. She obtained her degrees under the Atlantis Dual-Degree Program in Agricultural Economics and Rural Development. Due to the high mobility of the Atlantis Program, students get to opportunity to obtain theoretical as well as practical knowledge about agriculture and rural development on both sides of the Atlantic Ocean. Sandra pursued the first year of her Master Degree at Ghent University in Belgium and Humboldt University in Berlin, Germany. The second year Sandra studied at the University of Florida in the United States of America. The European universities award the International Master of Science in Rural Development. The Master of Science of Food and Resource Economics is obtained at the University of Florida.

Prior to her Master program, Sandra obtained a Bachelor of Arts Degree in Liberal Arts and Science at University College Roosevelt in Middelburg, the Netherlands. For her bachelor's, Sandra specialized in economics, law, political science and statistics. Sandra graduated cum Laude.

After her studies, Sandra hopes to use the knowledge obtained with both her undergraduate and graduate studies to make a meaningful contribution to society.