

THREE ESSAYS IN INTERNATIONAL TRADE: MARKET  
INTEGRATION, SUBSIDIZATION AND ANTIDUMPING

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## ABSTRACT

This thesis contains three essays on topics in agricultural economics. The research is focused on the economic effects of different trade policies applied within the US, Canada and the European Union.

Essay one evaluates the accession of Austria, Finland and Sweden to the single EU common market. The degree of integration of these three countries in agricultural trade in the EU has not previously been evaluated. Trade theory suggests that one of the outcomes resulting from a regional trade agreement is increased market integration among markets in member states. The cointegration of the commodity prices across countries is tested using time-series techniques. This method is important as it can be applied to questions relating to globalization.

Essay two examines the biofuel industry in Canada and US from a trade perspective. The development of a large market for biofuels is judged to have two main benefits for North America: environmental benefits in Canada and energy security in the US. A theoretical model is developed using the option value theory to determine whether the two distinct motivating factors can lead to different levels of optimal subsidies in each country. While the development of a biofuel industry is viewed as extremely important in a number of countries, the trade laws on subsidies with respect these products lacks clarity. This research represents an important step in understanding the economics of biofuels and the situations where trade disputes can be expected to appear in the future.

Dumping is the subject of the third essay where the strategies of firms in the face of an anti-dumping action are examined using game theory. The possibility of free riding in case of an anti-dumping petition is investigated in two situations: the benefits of the anti-dumping case are considered either a public good or a joint product. The second situation can be applied only for US, because of so-called Byrd Amendment. The theoretical model developed represents an important contribution to trade policy and it can be easily applied when examining the effects of other trade or domestic policies.

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# INTRODUCTION

The first essay evaluates the accession of Austria, Finland and Sweden to the single EU common market (they joined EU in the same year, 1995). The nature of market integration prior to and after accession is empirically investigated for a number of key agricultural products. Trade theory suggests that one of the outcomes resulting from a regional trade agreement is increased market integration among member states. Market integration then becomes a necessary, but not sufficient, condition to initiate the movement of resources from inefficient into efficient industries among those countries engaged in trade liberalization – the central process that brings economic gains from trade. If market integration does not arise, trade-liberalizing initiatives would not function as predicted. This essay addresses the following issues: 1) Are agricultural markets in these three new acceding countries integrated with those in the EU and among themselves? and 2) Is there evidence of market integration in the pre-EU and/or post-EU period? Price movements are studied for rye, soft wheat, barley, oats and potatoes. The products chosen for analysis differ with respect to their relative importance. For example, the first four products listed above are heavily supported by Common Agriculture Policy (CAP), while the fifth product (potatoes) is not. The EU offers an intervention price for rye, wheat and barley, while the exports of oats from Finland and Sweden are highly subsidized. The movement of commodity prices across countries is tested using time-series techniques. Cointegration analysis consists of two steps; first, the cointegrating relationship is investigated to see if prices are related by a long-run relationship; second, to determine if two countries belong to the same market, an adjustment process to short-run shocks must be investigated. The long-run relationship between the prices under

consideration is tested using the Johansen procedure, while the short-run dynamics of the prices is modeled using an error-correction model. We found that cointegration analysis can be applied to four of these products (rye, soft wheat, barley and oats). The prices of these commodities were highly cointegrated after the three countries joined the EU. Of the four markets tested, the rye and barley markets proved to be most tightly integrated with the German (EU) market, while the oats market was the least integrated. In the pre-EU period, cointegration among prices was found for rye, soft wheat and barley between Austria and Germany. This method is important as it can be applied to questions relating to the globalization of markets as well as the efficacy of trade liberalization initiatives..

The second essay examines the biofuel industry in Canada and US from a trade perspective. The development of a large market for biofuel is judged to have two main benefits for North America. The first is a reduction of Greenhouse Gas Emissions (GHG) for Canada, while the U.S. is developing a biofuels industry to reduce dependence on imported oil from economically and politically volatile areas. The main disadvantage of using biofuels at the moment is its high cost relative to petroleum. Even at current petroleum prices, a biofuel market will not grow without being highly subsidized by governments. A theoretical model is developed using option value theory to determine whether the same governmental policy (subsidization) can lead to different levels of optimal subsidies in each country, where the subsidy policy is driven by two distinct motivating factors: energy security and environmental commitments. Note that if the level of subsidies for the development of biofuels industry in the two countries differs considerably, the likelihood of a trade dispute arising increases. The optimal biofuel subsidy in Canada is a function of price and quantity of biofuel consumed, and the

quantity of oil that is replaced by biofuel. In contrast, the US optimal biofuel subsidy is a function of the same parameters plus the price of oil. Based on our theoretical model, we conclude that the levels of the optimal subsidies would be different in general, save for two situations: first, when there is no demand for biofuels, in which case we concluded that the optimal subsidies would also be zero, and second, when the price of oil internalizes the externality which is produced by the consumption of oil. While the development of biofuel industry is viewed as extremely important in a number of countries, trade laws on subsidies with respect these products lacks of clarity. The primary problem regarding the biofuels is their definition and classification under WTO. Definition of the products is a central question. The rules for industrial products specified under the WTO Subsidy and Countervailing Measures (SCM) agreement set greater constraints on subsidy levels, while the rules for agricultural products specified under the WTO Agreement on Agriculture (AoA) place fewer constraints on subsidies. However, if biofuels were to be categorized as industrial products by the WTO and the current levels of subsidies continue in the industry and are administered in the same way, there exists considerable potential for trade disputes in the future. However, if biofuels were to be categorized as agricultural goods, trade disputes will be a function of whether the subsidies are included in the so-called “green box” or not. If they are included in the green box being used for environmental reasons, they will not be actionable or limited, so there will be no trade problems. In this case, there needs to be scientific evidence that environmental benefits are provided and, second, the industry is subsidized because the biofuels are not priced competitively. Further complications would arise if biofuels are considered environmental goods, energy goods or goods subsidized for national security

reasons. The importance of developing the biofuels market suggests a need to analyze the changes that should take place at the domestic and international level in this industry.

This research represents a vital step in better understanding the economics of biofuels and the situations where trade disputes can be expected to appear in the future.

Dumping is the subject of the third essay where the strategies of firms in the face of an anti-dumping action are examined using game theory. The possibility of free riding in case of an anti-dumping (AD) petition is investigated for two situations. First, the benefits of an anti-dumping case are considered to be a public good, meaning that all firms in the industry benefit from restricted trade while only the petitioners pay the costs. The AD benefits are non-rivalous when one firm's consumption of a unit of benefits does not subtract from the consumption opportunities available to the other firms in the industry from the same unit. In fact, AD benefits are non-excludable as they are accessible to all firms in the industry and they cannot be provided just to the petitioners. In this case, it is expected that the free riding will be high. Secondly, the anti-dumping benefits are considered a joint product, a situation that can be applied only for US because of so-called Byrd Amendment. According to the Amendment, any duties assessed from an anti-dumping case will be shared among the firms that supported the original petitions. Therefore, the firm-specific benefits represent an incentive for firms to participate in the lobbying process, and, thus, the free rider problem would diminish. The theoretical model is a two-stage lobbying game of protection with heterogeneous firms, which is solved using backward induction. Thus, in the second stage, given the AD duty, the domestic and foreign firms set their output levels by playing a Cournot-Nash game. In

the first stage, the domestic firms play the non-cooperative lobbying game that determines the AD duty rate. Hence, in each stage, a Nash equilibrium is obtained for the specific sub-game. One of the main conclusions of this research is that before the Byrd Amendment was implemented, a petition was supported financially only by the minimum number of firms necessary to initiate a petition, while all the others would free ride. These firms are assumed to be the most efficient producers in the industry. After the enactment of the Byrd Agreement, free riding is reduced and for some of the fringe firms, the marginal private benefit would be high enough to represent an incentive to participate in the lobbying action. As well, an increase in the degree of heterogeneity of domestic firms would lead to more free riding among the fringe firms. Thus, those fringe firms with marginal cost of production close to the petitioners' marginal cost of production will find it beneficial not to free ride. The theoretical model developed represents an important contribution to trade policy and it can be easily applied when examining the effects of other trade or domestic policies that generate benefits that cannot be internalized to the individual initiating the trade action. This research also provides insights into what to expect from anti-dumping actions initiated in the US that are often faced by firms in Canada.

# ESSAY 1: MARKET INTEGRATION: AN EMPIRICAL STUDY OF AGRICULTURAL TRADE IN THE EU

## 1.1 Introduction

One of the central ideas upon which the European Union (EU) was founded was that common economic policies would lead to the integration of spatially separated product markets. In particular, the principles of the Common Agriculture Policy (CAP) were designed to ensure that agricultural and food markets in Europe would become integrated. These principles supported free trade within the EU, and specified centralized budgets and common external tariffs. Even after accession to the EU, however, when formal barriers to trade in agricultural goods were removed, for many countries barriers to market integration remained. Among factors that might further impede market integration in the EU are the absence of arbitrage mechanisms among agricultural markets in the member states, along with barriers to efficient arbitrage (imperfect information, risk aversion) and imperfect competition in these markets (Zanias, 1993).

Stylized facts about trade tell us that one of the outcomes that should result from a regional trade agreement is increased market integration among the member states. Market integration then becomes a necessary, but not sufficient condition to ensure the movement of resources from inefficient into efficient industries among those countries engaged in trade liberalization. It is this movement of resources that provide the gains from trade. If market integration does not arise, trade-liberalizing initiatives cannot function as predicted (Moodley et al. 2000).

Market integration can be measured in different ways, including the movement of goods or tracking investment flows (Moodley et al, 2000). In this paper, our definition of market integration is founded on the law of one price (LOP). Markets are considered spatially integrated for a specific good if there is a causal relationship among prices in different markets. An absolute version of LOP states that market prices will equalize between regions as long as transport costs, trade restrictions and other transaction costs are taken into account.

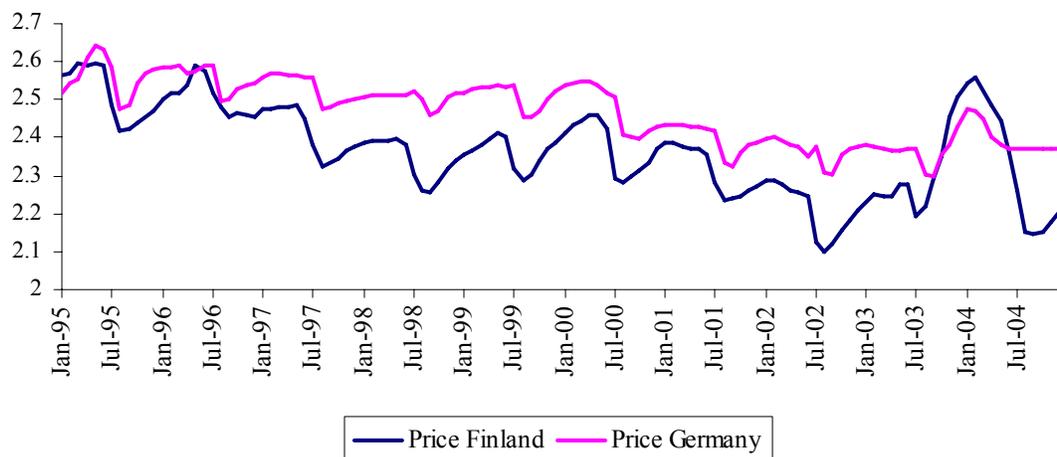
Market integration captures a long-run relationship between spatially separated prices. Thus, even when prices temporarily deviate from each other in the short-run, they should still be consistent with the notion of an integrated market. A central concept in understanding market integration is spatial arbitrage: as price increases in one region, product will eventually be imported into that region from a region with lower prices. This creates a shortage in the exporting region, and, as a result, the good's price increases in

the exporting region as well. Spatial arbitrage explains why prices of homogenous goods will track together in spatially separated markets.

To date, most applied econometric trade studies have concentrated on testing market integration rather than adherence to the LOP. Considering LOP, we offer that prices of similar goods actually moving together across spatially distinct markets is a better indication of market integration than examining whether or not prices equalize across regions (Flacker and Goodwin, 2000).

Figure 1.1 is based on barley prices for Germany and Finland for the period Jan 1995 – Dec 2004 and is an illustration of integrated market prices. Throughout the time period shown, prices in each market follow the same pattern.

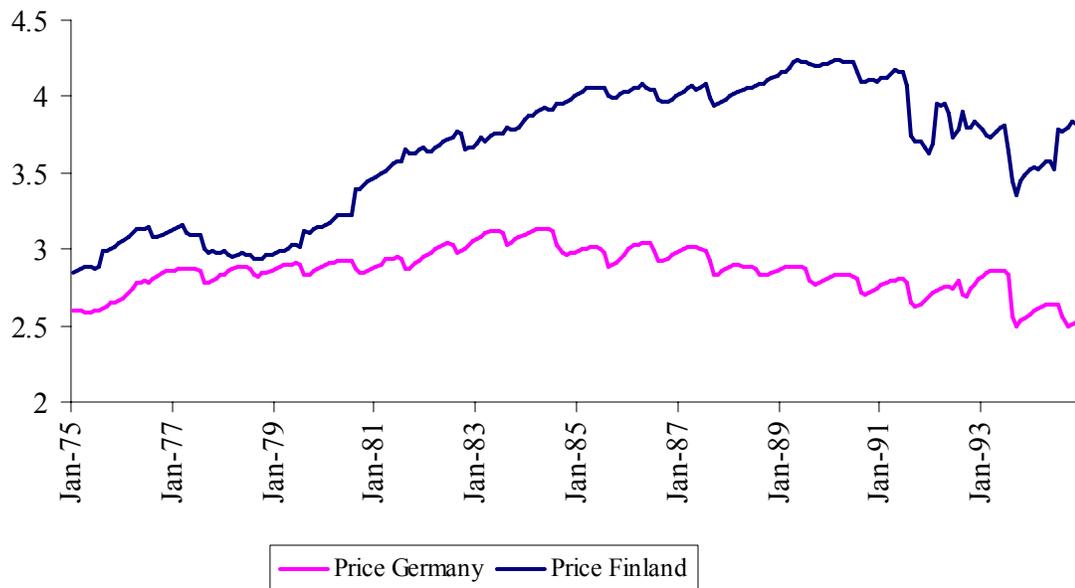
Figure 1.1 Example of integrated markets



Source: author's calculations

Conversely, Figure 1.2 is based on rye prices in Germany and Finland for the period Jan 1975 – Dec 1994, and it is an example of non-integrated market prices. It is easy to see that the two price series in Figure 1.2 possess distinct patterns over the chosen time interval.

Figure 1.2 Example of non- integrated markets



Source: author's calculations

The literature on market integration is rich, but the empirical studies are overwhelmingly based on US or international data. The European agricultural markets have received less attention. Since this issue is important for trade policy and analysis, the aim of this chapter is to analyze price transmission in particular agricultural markets for three countries that joined the European Union (EU) in the same year, Austria, Finland and Sweden. For these countries, this is the first study using LOP to document how key agricultural markets were affected by joining the EU. In this light, the empirical investigation will consist of two parts. In the first part, we address the following issues:

1) Are agricultural markets in these three new acceding countries integrated with those in the EU?; and 2) Is there evidence of market integration in the pre-EU and/or post-EU period? The second part of this study will concentrate on the analysis of the acceding countries individually to determine if their agricultural markets were integrated with the other acceding countries in the pre-EU and/or post-EU period.

Since there are several particular issues of policy that could impact price integration in the chosen markets, we expect some variation in our price cointegration results. In addition, the products chosen for analysis differ with respect to their relative importance. For instance, minimum price support is offered only for rye, wheat and barley, while exports of oats from Finland and Sweden are highly subsidized. The final product (potatoes) chosen for this analysis is not covered by CAP policies.

A finding of price convergence for rye, soft wheat and barley markets after these countries joined the EU could be influenced by minimum price supports. Colman (1985) showed that common intervention prices might have helped market integration, but without efficient arbitrage, full market integration would not be possible as the transmission of price policy is necessarily imperfect. Alternatively, price convergence might be observed because these new EU members gained open access to the German market, the biggest producer of barley and rye in the EU.

Finding non-convergence in prices for oats might be explained by the small traded quantities of this commodity within the EU. During the period of analysis, oats were used

primarily on farm for animal feed in the country of origin. Alternately, the emergence of Eastern European markets after 1989 created the possibility of new EU trade with these agricultural markets, and they are among the biggest producers of oats in the world.

In summary, with respect to agricultural prices among these three acceding countries, if we find that they do not share a common long-run equilibrium over both periods, this situation could be explained by high price supports offered by governments in the pre-EU period, coupled with access to a set of larger and new markets subsequent to joining the EU.

The chapter is organized as follows. Section II highlights the most important characteristics of the agri-food sector in the three countries that acceded to the EU in 1995 (Austria, Finland and Sweden). Section III reviews contributions to market integration and price transmission literature. Section IV describes the data used in the analysis along with the methodology, while the last section will present and describe the empirical results. The chapter ends with a series of concluding remarks.

## 1.2 The EU Agricultural Sector

The primary objective for creating a common agricultural market within the EU was to facilitate movement of goods and factors of production between EU member states. It was this idea of a common market that influenced the initial design of CAP. CAP was established in 1957 and it was focused on the development of a set of common policy instruments along with setting common prices (i.e. target, threshold and intervention prices). Common prices were set with respect to a common currency and this situation

influenced each member country in different ways, with specific effects depending on market exchange rates.

Monetary Compensatory Amounts (MCA's) were introduced in the EU and became a means to tax or subsidize exports, compensating for currency fluctuations and facilitating agricultural trade among the EU countries (Zanias, 1993). MCA's were used for more than twenty years and preserved protection levels in member states at previous exchange rates, thus impeding free trade and market integration. Even though they were supposed to be temporary measures, MCA's became a source of conflict among the member countries. The MCAs were replaced by the European Currency Unit (ECU) in 1979 as part of the European Monetary system (EMS). The ECU represented a basket of the EC member countries' currencies. It was mostly introduced to determine the overvaluation/undervaluation of individual currencies and, as well, it represented a unit of account for the central banks that were participating in the EMS. Even the ECU was an artificial denomination, its use in private commercial transactions developed rapidly as the ECU exchange rate was more stable than those of the currencies included in ECU (Plummer, 2006). The agricultural ECU was 14% more valuable than the ECU. However, in January 1999 the euro replaced the ECU on a one-for-one basis. This represented the first stage of the European Monetary Unification (EMU).

Through the McSharry reforms of 1992, guaranteed agricultural prices were replaced with a new system of direct compensating payments for farmers, activated if prices fell below a certain level. The CAP was further reformed under Agenda 2000. These reforms

came into effect in March 2003 and production subsidies were replaced with a set of direct payments, linked with standards on food safety, animal rights and environmental concerns. The newest element of this latest reform is the introduction of the “Single Farm Payment”, which replaces a vast array of direct payment schemes.

To date, there have been some difficulties associated with the accession process in the EU agricultural sector. These stem from differential levels of farm support along with particular regional circumstances, including extreme climate and geophysical conditions which characterize agriculture in some acceding countries. Austria, Finland and Sweden became full members of EU in 1995.

Austria is one of the wealthiest European countries, with a highly developed economy possessing an important service sector (65% in 2002). Just 17% of Austria’s land is arable, a situation that motivates highly intensive forms of crop production. Agriculture, however, does not play a very important role in the economy, accounting only for 2% of GDP. As shown in Appendix A, Table 1.A.1, for the agricultural products considered in this analysis, rye accounts for the highest production in Austria as a percentage of production in EU-15. Traditionally, Austria is an agri-food importer, but in recent years its agri-food exports increased faster than its imports. The main trading partners for Austrian agri-food products are its EU neighbors. Germany is at the top of this list, accounting for 42% of Austrian imports and 35.9% of exports in 2003 (Agriculture and Agri-Food Canada, 2004).

Finland is the northernmost agricultural producer in the EU, and only 6% of the total land area is considered to be arable. The main crops produced in Finland are barley and oats (Appendix A, Table 1.A.2). Due to its climate, agriculture does not occupy an important role in the Finnish economy, contributing to about 3% of the GDP (Agriculture and Agri-Food Canada, 2004). The main trading partner for Finnish agri-food products is also Germany.

Finally, Sweden is the third largest country by area in Western Europe, but only 6% of its land is arable. Crop production is dominant in central Sweden, with the main crops produced being cereals and fodder crops. As can be seen in Appendix A, Table 1.A.3, barley, wheat and oats represent the main crops produced in Sweden. Agriculture accounts for just 2% of GDP (Agriculture and Agri-Food Canada, 2004). The most important trading partners are EU countries such as Denmark, the Netherlands, Norway and Germany.

The accession to the EU affected the agricultural sector of these three countries in different ways. Firstly, under the Accession Agreement, new members had to adjust their prices to EU levels. This adjustment caused a price drop of about 40 to 45 percent in the cereal, livestock and dairy sectors in Austria and Finland. The situation was different in Sweden, where agricultural support declined significantly after 1991 and the gap between domestic and international prices was smaller<sup>1</sup>. After accession, cereal prices in Sweden increased, dairy prices remained stable, while in the livestock sector prices decreased sharply. Secondly, as a result of lowered prices for agricultural products, farmers in the

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<sup>1</sup> Sweden reduced its agricultural support primarily through currency devaluation in this time period.

three new EU member countries faced increased competition from more efficient EU producers.

### 1.3 Price transmission and market integration

There is a considerable literature in international economics that examines market integration across countries by testing the law of one price (LOP) or absolute purchasing power parity (PPP) at an aggregate level<sup>2</sup>. The LOP is based on the idea of international commodity arbitrage in efficient markets, implying that each good has a single price expressed in a common currency throughout the world (Isard, 1977). PPP also implies that by aggregating all the goods, the overall price index between two countries should be the same, after conversion to the same currency. Many studies have shown that the behavior implied by LOP is not often observed.

Ardeni (1989) showed that one of the shortcomings of earlier empirical studies in finding evidence that supports perfect arbitrage for commodity prices is the failure to consider the time-series properties of the analyzed variables (nonstationarity) and by the improper use of transformations on these variables (first differences). The failure of LOP in his study is explained by institutional factors, including cost of arbitrage, errors in data and in the definition of prices.

Engel (1993) measures the variation in the price of the same good across countries and the variation of different goods within a country. He shows that the first type of variation, which rejects the LOP is usually larger than the second variation.

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<sup>2</sup> An early example can be found in Casel, 1918.

Engel and Rogers (1996) provided some explanations for deviations from LOP observed in the data. They showed that even the distance between markets could explain most of the variation in prices of similar goods in different areas, when considering two cities located in different countries, the variation of the prices is much higher than for two equidistant cities in the same country. They suggest this could be due to sticky nominal prices.

Another large body of research has applied various quantitative techniques to measure market and price integration. Gordon et al. (1993) examined the nature of integration for the British and French lamb market during the period 1983-1986. To test for price integration, they employed a Holmes and Hutton causality test (Holmes and Hutton, 1988), a modified version of the Granger causality testing procedure (Granger, 1969). They reached the conclusion that the markets are integrated for the specified period, but the response of one price to the change in the other price was surprisingly slow. Slow adjustments in prices may be explained by non-tariff barriers, differences in product quality as well as uncertainty surrounding the final price received.

Zanias (1993) tested the LOP using time series data on four agricultural products produced within the European Community. The products chosen (soft wheat, dairy milk, potatoes and pig carcasses) are very different in terms of product characteristics and the policy framework within which their markets operate. Zanias found that a single price existed in soft wheat markets, but suggested this was the result of minimum intervention prices and efficient arbitrage. With milk, the markets were not found to be integrated.

This result was explained by the importance of non-tariff barriers in milk markets and by imperfect competition in this industry. For potatoes and pig carcasses, the lack of consistent data series did not allow the inclusion of many countries, so among those included, the results differed from case to case.

Diakosavvas (1995) examined market integration between Australian and U.S. beef prices at the farmgate level. He tested for cointegration and used a time-varying parameter estimation procedure with a Kalman filter (Kalman, 1960). This method is useful because it describes both the extent and timing of convergence. His cointegration analysis found that the two markets are cointegrated (although not fully), whereas the time-varying procedure indicated that the convergence between prices did not increase substantially over time. He concluded that Australian beef could not be adopted as a world price in empirical analysis.

Moodley et al. (2000) evaluated the Canada-US Trade Agreement (CUSTA) from the perspective of market integration. Previous work indicated that markets in US and Canada were not integrated before CUSTA, so this empirical work addressed two basic questions - were these markets integrated, and was there evidence of market convergence after CUSTA? The latter could be interpreted as evidence that the trade agreement had critical effects on the product markets. The methodology they used was based on the Johansen maximum likelihood procedure (Johansen, 1988) using a Kalman filter. Their analysis found that a cointegrated price system existed after the introduction of CUSTA. Additionally, their approach showed that price convergence occurred before the

introduction of CUSTA, leading them to conclude that it was likely easier to ratify CUSTA given that many of the expected trade adjustments in these markets had already taken place.

Subsequently, Mohanty and Langley (2003) examined grain (wheat and barley) price integration between the US and Canada, using cointegration analysis and an error correction model. They tested whether policy changes, such as the North American Free Trade Agreement (NAFTA) and the Western Grain Transportation Act (WGTA) affected the degree of integration between these grain markets. They found that the markets are in fact integrated, and that the post-NAFTA and post-WGTA periods were characterized by improved market integration.

A number of studies on market integration and price transmission (both spatially and vertically) have highlighted several factors that impede price transmission. For example, border and domestic policies in the form of price support mechanisms weaken the link between international and domestic markets. Different agricultural policy instruments as well as exchange rate policies hinder the full transmission of international price signals (Knetter, 1993). Other policies among the border measures are non-tariff barriers, which may have strong effects on the price transmission phenomenon (Zanias, 1993; Thompson et. al., 2002).

Apart from policies, domestic markets can also be partly insulated by large marketing margins that arise due to high transport and transaction costs. This factor has strong

effects, especially in developing countries where poor infrastructure and transport services give rise to large marketing margins due to high costs of delivering traded commodities. High transfer costs hinder the transmission of price signals, as they may prevent or discourage arbitrage (Sexton, Kling and Carman, 1991; Badiane and Shively, 1998). Market power can also hinder market integration, in the sense that the price differences between international and domestic prices may be higher than those determined by transfer costs alone (Dhar and Cotteril, 1998). This literature also concentrates on the extent to which changes in exchange rates facilitate price discrimination among destinations (Froot and Klemperer, 1989; Knetter, 1993).

There is a large body of literature that tests the co-movement of prices using different econometric techniques. The latest advances in econometrics, including cointegration and error correction models became a standard tool in analyzing the spatial market integration. There are also criticisms regarding these time series methods: they are linear tests for market integration, while there can be non-linearities in market relationships driven by arbitrage conditions, discontinuous trade, unsynchronized price cycles and non-stationary transfer costs (Blauch, 1997; Barret and Li, 2002). Even if there is some merit to the above criticism, as long as the framework tested is appropriate and the results are interpreted correctly, the time series analysis provides useful insights into co-movement of prices. Time series models have small data requirements (only prices) compared with other methodologies and they are important in signaling market failures and the direction and magnitude of welfare effects of different trade policies. Cointegration and error

correction models represent an analytical tool that helps testing the co-movement and completeness of adjustment and the dynamics of changes (speed of adjustment).

Different methods were used in the literature to capture the non-linear price relationships. Goodwin and Pigot (2001) used an asymmetric, threshold autoregression and error correction model to evaluate the spatial price linkages among regional corn and soybean markets in North Carolina. Serra, Gil and Goodwin (2006) concentrated on a non-parametric method to analyze price transmission in the EU pork markets during the time period 1994-2004. They compared the results obtained using a parametric technique (threshold model) with the results from a non-parametric technique (local polynomial model). Both methods showed that the EU pork markets are spatially integrated, however the non-parametric technique suggested a higher degree of price transmission.

#### 1.4 Description of the data and empirical methodology

Empirical analysis is conducted for a few key agricultural commodities from Austria, Sweden and Finland. We study price movements in rye, soft wheat, barley, oats and potatoes.

The first four products listed above are heavily supported by CAP, while the fifth product (potatoes) is not. Note that the EU is by far the largest single exporter of rye, with the vast majority of production coming from Germany. Rye production has become an important issue for EU policymakers, with the intervention price support being €101.31/t in 2001-2002 – the same as the intervention price for wheat and barley. The major exporters of barley are the EU, Russia and the Ukraine. Among the EU producers of

barley, most of the production comes from France, Germany and Spain. In Finland, barley and oats are the main crops produced, while in Sweden, cereal crops and fodder crops are the most important, with emphasis on barley, wheat and oats.

Unlike the situation for wheat, barley and rye, the EU does not offer an intervention price nor maintain intervention stocks for oats. However, in recognition of the importance of the oats trade to Sweden and Finland, special provisions were made when they joined the EU for subsidies on their oats exports (as of 1997). We note that oats are still a very thinly traded commodity, being mostly used on farm for animal feed in their country of origin. However, human consumption is an important part of distribution in the UK, Germany and the US. Within the EU, Finland, Sweden and Germany are the main producers of oats and, in general, trade of oats is limited to intra-EU trade and exports from Finland and Sweden to the US (Agriculture and Agri-Food Canada, 2000, 2001, 2002, 2003, 2004).

The absolute producer price series comprise monthly data, collected for a period of thirty years, from 1975:1 – 2004:12. The data for 1975:1 – 1994:12 were obtained from the boards of agriculture in each country and were expressed in their respective national currencies. For the period 1995:1 – 2004:12, the data were extracted from Eurostat and were expressed in EUROS. The data were all converted to ECUs using the market exchange rates from Eurostat. One additional characteristic of the data is that from 1999:1, Austria and Finland joined the monetary union, while Sweden kept its own currency. So starting with 1999:1, the prices in Austria and Finland are expressed in

EUROS at the fixed exchange rate, while the prices in Sweden are expressed using a flexible market exchange rate.

Since the first question to be addressed is whether the three acceding countries' markets and the EU market are integrated, a reference EU producer price should be used. As there is no dominant EU price, we chose German producer prices because Germany is the most important trading partner for the three countries. The producer price series for Germany are loaded from Eurostat and are expressed in ECU until 1995, and in EUROS after 1995.

With producer prices  $p_{taus}$ ,  $p_{tfin}$ ,  $p_{tsw}$  and  $p_{tger}$  for each agricultural product in the four countries under study, and with  $e_{aus}$ ,  $e_{fin}$ , and  $e_{sw}$  as the corresponding exchange rates, the following price series will be tested for cointegration:

$$P_{aus} = f(P_{ger}), P_{fin} = f(P_{ger}), P_{sw} = f(P_{ger}) \text{ and } P_{aus} = f(P_{fin}, P_{sw})$$

*where :*

$$P_{aus} = \ln(e_{aus} p_{taus}), P_{fin} = \ln(e_{fin} p_{tfin})$$

$$P_{sw} = \ln(e_{sw} p_{tsw}), P_{ger} = \ln(p_{tger})$$

Given that the data employed in the analysis are expressed in logarithms, the estimated parameters will be directly interpreted as “transmission elasticities”, for one price with respect to another. The cointegration of these commodity prices across countries will be

tested using time-series techniques. First, we pretest all variables to assess their order of integration. The data are plotted to see if a linear trend is present and, afterwards, a unit root test will be applied for both periods (1975:01-1994:12 and 1995:01-2004:12) to check if the variables are stationary. Cointegration analysis consists of two steps; first, the cointegrating relationship is investigated to see if prices are related by a long-run relationship; second, to determine if two countries belong to the same market, an adjustment process to short-run shocks must be investigated.

Cointegration analysis (Engle and Granger, 1987) provides methods for dealing with nonstationary variables. If a linear combination of integrated variables is stationary, the variables are said to be co-integrated. This can be formally stated in the following manner: the components of the variable vector  $x_t = (x_{1t}, x_{2t}, \dots, x_{nt})$  are cointegrated of order  $d, b$  if all the components of  $x_t$  are integrated of order  $d$  and there is a vector

$\beta = (\beta_1, \beta_2, \dots, \beta_n)$  such that the linear combination  $\sum_{i=1}^n \beta_i x_{it}$  is integrated of order  $d - b$ ,

where  $b > 0$  (Enders, 2004). The cointegrated vector defines the long-run relationship among the nonstationary variables. Obviously, cointegration does not mean that the variables cannot deviate from the long-run equilibrium, but we expect that the deviations will be temporary and market forces will bring the variables to their cointegrated equilibrium.

There are two established methods to test for cointegration. There is the well-known Engle and Granger (1987) methodology, which determines whether the residuals of the

equilibrium relationship are stationary, while the Johansen (1988) and Stock-Watson (1988) methodologies determine the number of the cointegrated vectors. For this analysis, the Johansen procedure will be used to determine if a long-run relationship between the prices under consideration exists.

It is also well known that such results are quite sensitive to the lag length chosen. Most commonly, one estimates a vector autoregression using the undifferenced data, and then a number of tests (Akaike, Schwartz or Hannan-Quinn Information Criteria)<sup>3</sup> allow the choice of the right lag length. The last two are preferred over Akaike because they penalize to a greater degree as more variables are introduced.

Finding a cointegrated system does not exclude the possibility of observing short-run deviation of the individual series. The short-run dynamics of the prices can be modeled using an error-correction model. Vector autoregression (VAR)<sup>4</sup> is commonly used for forecasting systems of interrelated time series. While a vector error correction (VEC) model is a restricted VAR that has cointegration restrictions built into the specification, the VEC specification restricts the long-run behavior of the endogenous variables to converge to their cointegrating relationships while allowing short-run dynamics.

### 1.5 Empirical results

The first step in estimation is to test whether the individual price series have unit roots.

The existence of unit roots is evaluated using a Phillips-Perron test (Phillips and Perron,

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<sup>3</sup> See Akaike (1974,1976), Schwartz (1978) and Hannan-Quinn (1979)

<sup>4</sup> See Greene (2003)

1988). This test is non-parametric and it is considered more powerful as it is robust to heteroskedasticity and autocorrelation of unknown form.

The Phillips-Perron test is shown in Eq. (1.1):

$$\Delta p_{it} = \delta_t + \gamma p_{it-1} + \sum_{j=1}^l \phi_j \Delta p_{it-j} + \varepsilon_t \quad (1.1)$$

where  $\Delta$  is the difference operator,  $\delta_t$  can be either 0 or  $\mu$  (intercept) or  $\mu + \beta T$  (intercept plus time trend). The null hypothesis is that the series has unit root, where this is based on the significance of a  $\gamma$  t-statistic. The results of Phillips-Perron test are sensitive to the functional form chosen in Eq. (1.1) - the inclusion of a time trend and intercept being crucial. On the basis of our log-level series plots (see Appendix A, Figure 1.B.1-1.B.10), we will determine if a time trend is present in the data-generating process.

For the sample period 1975:01-1994:12, a model with intercept and linear trend was assumed for rye, soft wheat, barley and oats in Austria, Finland and Sweden, while for potatoes we used a model without a linear trend. Even though the price series for the period 1995:01-2004:12 show a decreasing trend, a model without trend was assumed as we know that after joining the EU, the products were under CAP restrictions and these prices were not determined by market conditions. The same situation is applied for Germany for the whole sample, as Germany has been a long-time member of the EU. In addition, the plots in Appendix 1 show evidence of seasonality for rye, soft wheat, barley and oats in case of Austria for the period 1975:01-1994:12. So before our market

integration tests are performed, the series are adjusted for seasonality using the Census X12-ARIMA algorithm (US Census Bureau).

Table 1.1 reports the results for unit root test in individual prices for the sample period 1975:01-1994:12. In column three of Table 1.1, the Phillips-Perron statistic for each log-level price series is reported.

Table 1.1: Unit root results using Phillips-Perron test for the period 1975:01-1994:12			
Product	Variable	Phillips-Perron test statistics	
		Levels	First difference
<b>RYE</b>	P <sub>AUS</sub>	1.391938	-18.12459**
	P <sub>FIN</sub>	-1.26604	-12.6864**
	P <sub>SW</sub>	-0.968481	-13.06892**
	P <sub>GER</sub>	-1.89526	-9.90374**
<b>SOFT WHEAT</b>	P <sub>AUS</sub>	1.999242	-17.39801**
	P <sub>FIN</sub>	-0.85251	-13.9149**
	P <sub>SW</sub>	-1.259256	-13.17305**
	P <sub>GER</sub>	-2.13023	-11.1439**
<b>BARLEY</b>	P <sub>AUS</sub>	-0.397064	-18.16899**
	P <sub>FIN</sub>	-0.7355	-11.7298**
	P <sub>SW</sub>	-1.145253	-12.91914**
	P <sub>GER</sub>	-2.03728	-8.52152**
<b>OATS</b>	P <sub>AUS</sub>	-0.115277	-16.95419**
	P <sub>FIN</sub>	-0.67439	-12.4998**
	P <sub>SW</sub>	-1.246490	-13.11995**
	P <sub>GER</sub>	-1.96146	-9.15561**
<b>POTATOES</b>	P <sub>AUS</sub>	-4.30075**	-
	P <sub>FIN</sub>	-4.01324**	-
	P <sub>SW</sub>	-5.78775**	-
	P <sub>GER</sub>	-3.8403**	-

\* (\*\*) Indicates rejection of null hypothesis of nonstationarity or unit roots at 5% (1%) significance level. Critical value considering a trend is -3.428819 (-3.997083), while without a trend is -2.873492 (-3.457747).

P<sub>AUS</sub>=natural logarithm of Austrian product price

P<sub>FIN</sub>=natural logarithm of Finnish product price

P<sub>SW</sub>=natural logarithm of Swedish product price

P<sub>GER</sub>=natural logarithm of German product price

Save for the four potato price series, the null hypothesis of unit root is accepted. In

column four of Table 1.1, the Phillips-Perron statistic is reported for the individual price

series in first differences. From this, we conclude that the prices of rye, soft wheat, barley and oats are integrated of order 1 (I(1)), while the prices for potatoes are integrated of order 0 (I(0)). For this sample period, cointegration analysis can be applied to rye, soft wheat, barley and oats. .

The same stepwise procedure described above is applied for the price series for the period 1995:01-2004:12. The results are reported in Table 1.2.

Table 1.2 Unit root results using Phillips-Perron test for the period 1995:01-2004:12			
Product	Variable	Phillips-Perron test statistics	
		Levels	First difference
<b>RYE</b>	P <sub>AUS</sub>	-2.059131	-12.14050**
	P <sub>FIN</sub>	-1.371684	-12.54577**
	P <sub>SW</sub>	-1.833217	-8.882729**
	P <sub>GER</sub>	-2.770590	-16.08212**
<b>SOFT WHEAT</b>	P <sub>AUS</sub>	-2.759568	-8.033900**
	P <sub>FIN</sub>	-0.652043	-12.31182**
	P <sub>SW</sub>	-2.303182	-10.05821**
	P <sub>GER</sub>	-2.330827	-6.707567**
<b>BARLEY</b>	P <sub>AUS</sub>	-1.934424	-9.004237**
	P <sub>FIN</sub>	-1.360947	-10.58690**
	P <sub>SW</sub>	-1.850434	-9.621257**
	P <sub>GER</sub>	-2.298978	-4.909118**
<b>OATS</b>	P <sub>AUS</sub>	-2.170823	-14.45530**
	P <sub>FIN</sub>	-1.220573	-6.786966**
	P <sub>SW</sub>	-0.852152	-10.27385**
	P <sub>GER</sub>	-1.764156	-10.09480**
<b>POTATOES</b>	P <sub>AUS</sub>	-2.933975*	-
	P <sub>FIN</sub>	-3.852493**	-
	P <sub>SW</sub>	-3.756979**	-
	P <sub>GER</sub>	-2.608746	-5.730786**

\* (\*\*) Indicates rejection of null hypothesis of nonstationarity or unit roots at 5% (1%) significance level. Critical value is -2.885863 (-3.486064).

P<sub>AUS</sub>=natural logarithm of Austrian product price

P<sub>FIN</sub>=natural logarithm of Finnish product price

P<sub>SW</sub>=natural logarithm of Swedish product price

P<sub>GER</sub>=natural logarithm of German product price

Once again, the price series for rye, soft wheat, barley and oats are integrated of order 1 (I(1)), while the price series for potatoes are integrated of order 0 (I(0)). In this light, long-run relationships will be investigated and estimated for all the series that have been identified as integrated of the first order.

Cointegration analysis cannot be applied in case of potatoes, as this method is useful only in models with non-stationary variables and, thus, there is no long-run convergence between potatoes' prices. The movement of prices in case of potatoes can be analyzed using normal estimation techniques (regression).

Next, we test whether nonstationary variables are cointegrated using the Johansen procedure. Johansen (1988, 1995) develops a maximum likelihood estimation procedure, which relies on the relationship between the rank of a matrix and its characteristics roots. In fact, the Johansen procedure has some advantages over the regression procedure of Engle and Granger. First, it does not assume that the cointegrated vector is unique and, second, it allows testing of restricted versions of the cointegrated vectors along with the speed of adjustment parameters.

Consider first the univariate case:

$$y_t = a_1 y_{t-1} + \varepsilon_t \tag{1.2}$$

Subtracting  $y_{t-1}$  from both sides yields

$$\Delta y_t = (a_1 - 1)y_{t-1} + \varepsilon_t \quad (1.3)$$

If  $a_1 - 1 = 0$ , the process  $y_t$  has a unit root. The process can be generalized to the multivariate case:

$$X_t = A_1 X_{t-1} + E_t \quad (1.4)$$

where  $X_t$  and  $E_t$  are  $(n \times 1)$  vectors and  $A_1$  is a  $(n \times n)$  matrix of parameters. Subtracting  $X_{t-1}$  from both sides as in Eq. (1.3) yields

$$\Delta X_t = (A_1 - I)X_{t-1} + E_t = \Pi X_{t-1} + E_t \quad (1.5)$$

where  $I$  is  $(n \times n)$  identity matrix and  $\Pi = A_1 - I$ . The rank of  $\Pi$  shows us the number of cointegrating vectors. If the rank of  $\Pi$  is zero, as in the univariate case, there is no stationary linear combination in  $X$ . Thus, the variables are not cointegrated. However, if the rank of  $\Pi$  matrix is different than zero, at least one linear combination of the variables in  $X$  exists which is stationary.

The multivariate model can also be generalized to account for higher-order autoregressive process.

$$X_t = A_1 X_{t-1} + A_2 X_{t-2} + \dots + A_p X_{t-p} + E_t \quad (1.6)$$

Adding and subtracting  $A_p X_{t-p+1}$  to the right-hand side of Eq. (1.6) yields

$$X_t = A_1 X_{t-1} + A_2 X_{t-2} + \dots + (A_{p-1} + A_p) X_{t-p+1} - A_p \Delta X_{t-p+1} + E_t \quad (1.7)$$

Continuing the process of adding and subtracting terms, the result is

$$\Delta X_t = \Pi X_{t-1} + \sum_{i=1}^{p-1} \pi_i \Delta X_{t-i} + E_t \quad (1.8)$$

where  $\Pi = -(I - \sum_{i=1}^p A_i)$  and  $\pi_i = -\sum_{j=i+1}^p A_j$ . As in Eq. (1.5), the rank of the matrix  $\Pi$

tells us the number of independent cointegrating vectors. The rank of the matrix  $\Pi$  equals the number of its characteristic roots different than zero. For a rank between 1 and  $n$ , there are multiple cointegrating vectors.

As the variables of interest are represented by prices, Eq. (1.2) is estimated using the Johansen method:

$$\Delta P_t = \Pi P_{t-1} + \sum_{i=1}^{p-1} \pi_i \Delta P_{t-i} + E_t \quad (1.9)$$

The optimal lag length is determined by minimizing the Schwarz Information Criterion (SIC) among the estimated VARs from 1 to 24 lags (Enders, 2004). However, for

samples of 100-200 observations, SIC and Hannah-Quinn Criterion perform almost equally well. As E-views<sup>5</sup> reports the first difference lag order, in running the cointegration analysis the lag number will be reduced by one.

The next step before proceeding with Johansen estimation is to determine the correct set of deterministic regressors in Eq. (1.9), as the cointegrating equations may have intercepts and deterministic trends. Choosing an option on constants and trends affects cointegration test results (by imposing inappropriate restrictions or loss of the power of the test by including irrelevant variables).

Selecting appropriate options for trends and intercepts requires a careful evaluation of the type of variables in the model, examining plots of the data, and understanding what theory indicates about the model and the behavior of variables. With respect to the cointegration analysis of price series for sample period 1975:01-1994:12, we specified our series with linear trends and our cointegrating equations only with intercepts. For sample period 1995:01-2004:12, when the data do not have a deterministic trend, we test for the presence of an intercept in the cointegrating vector versus the alternative of an unrestricted drift term. The test for the presence of an intercept in the cointegrating vector is done by estimating the unrestricted and the restricted forms of the model in Eq. (1.9).

The ordered characteristics roots of the unrestricted  $\Pi$  matrix are denoted

by  $\hat{\lambda}_1, \hat{\lambda}_2, \dots, \hat{\lambda}_n$ , while the characteristics roots of the restricted model by  $\hat{\lambda}_1^*, \hat{\lambda}_2^*, \dots, \hat{\lambda}_n^*$ .

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<sup>5</sup> EViews is a software package that provides tools for data analysis, regression, and forecasting and it has an object-oriented design.

Assuming that the unrestricted form of the model (i.e. no intercept) has  $r$  nonzero characteristics roots, the test statistic

$$-T \sum_{i=r+1}^n \left[ \ln \left( 1 - \hat{\lambda}_i^* \right) - \ln \left( 1 - \hat{\lambda}_i \right) \right] \quad (1.10)$$

has a  $\chi^2$  distribution with  $(n - r)$  degrees of freedom, where  $n$  represents the number of variables (Enders, 2004). The null hypothesis, which is the presence of an intercept, is accepted for small values of the test statistic.

In this analysis, the presence of an intercept is tested for those cases where the unrestricted form (i.e. no intercept) of the model has nonzero characteristics roots. The results are presented in Table 1.3.

Table 1.3 Test for the presence of an intercept in the cointegrating vector (1995:01-2004:12)						
Product	Cointegrating vectors		Test statistic	Chi-square	Conclusion	
	Restricted <sup>a</sup>	Unrestricted <sup>b</sup>				
<b>RYE</b>	P <sub>GER</sub> , P <sub>AUS</sub>	r=1	r=1	1.76	3.84	Intercept
	P <sub>GER</sub> , P <sub>FIN</sub>	r=1	r=1	1.71	3.84	Intercept
	P <sub>GER</sub> , P <sub>SW</sub>	r=1	r=1	2.28	3.84	Intercept
	P <sub>AUS</sub> , P <sub>FIN</sub> , P <sub>SW</sub>	r=0	r=1 (5%)	0.97	5.99	Intercept
<b>SOFT WHEAT</b>	P <sub>GER</sub> , P <sub>AUS</sub>	r=0	r=1 (5%)	8.72	3.84	No intercept
	P <sub>GER</sub> , P <sub>FIN</sub>	r=0	r=1 (5%)	0.93	3.84	Intercept
	P <sub>GER</sub> , P <sub>SW</sub>	r=1 (5%)	r=1 (5%)	7.28	3.84	No intercept
	P <sub>AUS</sub> , P <sub>FIN</sub> , P <sub>SW</sub>	r=1 (5%)	r=2 (5%)	0.63	3.84	Intercept
		r=0 (1%)	r=1 (1%)	0.80	5.99	
<b>BARLEY</b>	P <sub>GER</sub> , P <sub>AUS</sub>	r=1	r=1 (5%)	5.79	3.84	No intercept
	P <sub>GER</sub> , P <sub>FIN</sub>	r=1 (5%)	r=1 (5%)	5.63	3.84	No intercept
	P <sub>GER</sub> , P <sub>SW</sub>	r=1	r=1	4.4	3.84	No intercept
	P <sub>AUS</sub> , P <sub>FIN</sub> , P <sub>SW</sub>	r=0	r=0	-	-	Intercept
<b>OATS</b>	P <sub>GER</sub> , P <sub>AUS</sub>	r=1 (5%) r=0 (1%)	r=1	1.91	3.84	Intercept
	P <sub>GER</sub> , P <sub>FIN</sub>	r=0	r=1 (5%)	3.43	3.84	Intercept
	P <sub>GER</sub> , P <sub>SW</sub>	r=0	r=0	-	-	Intercept
	P <sub>AUS</sub> , P <sub>FIN</sub> , P <sub>SW</sub>	r=0	r=2 (5%)	0.17	3.84	Intercept

<sup>a</sup> the model has an intercept

<sup>b</sup> the model does not have an intercept

As Table 1.3 shows, the null hypothesis of an intercept in the cointegrating vector is rejected in several cases. As the number of optimal lags and the correct deterministic regressors from Eq. (1.9) are determined, the cointegrating relationship is estimated using the Johansen procedure. It was shown by Johansen, that two procedures can be used to test for the number of significant vectors,  $r$ , the Trace test and the Maximum Eigenvalue test. The Trace statistic tests the null hypothesis that the number of distinct cointegrating vectors is less than or equal to  $r$  against a general alternative.

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^n \ln \left( 1 - \hat{\lambda}_i \right) \quad (1.11)$$

where  $\hat{\lambda}_i$  are the estimated characteristics roots (eigenvalues) obtained from the estimation of  $\Pi$  matrix and  $T$  is the number of usable observations.

The Maximum Eigenvalue statistic tests the null that the number of cointegrating vectors is  $r$  against the alternative of  $r + 1$  cointegrating vectors.

$$\lambda_{max}(r, r + 1) = -T \ln \left( 1 - \hat{\lambda}_{r+1} \right) \quad (1.12)$$

In case that the results of  $\lambda_{trace}$  and  $\lambda_{max}$  are in conflict, the result of  $\lambda_{max}$  would be preferred, as the statistic has a specific alternative hypothesis (Enders, 2004). The critical values for the trace statistics and maximum eigenvalue statistics are reported by Osterwald-Lenum (1992). Johansen procedure treats all the variables included in Eq. (1.9) as endogenous, thus avoiding an arbitrary assumption of exogeneity.

The cointegration analysis is conducted for both the pre- and post-EU periods in these countries (i.e. 1975:01 to 1994:12 and 1995:01 to 2004:12). Test results are listed in Tables 1.4 and 1.5.

Table 1.4 Johansen cointegration test for pre EU period

Product	Variables	Null hypothesis	Maximum eigenvalue statistics	Critical values		Null hypothesis	Trace statistics	Critical values	
				5%	1%			5%	1%
RYE	P <sub>GER</sub> ; P <sub>AUS</sub>	r = 0	14.32419*	14.07	18.63	r = 0	16.72869*	15.41	20.04
		r = 1	2.404502	3.76	6.65	r ≤ 1	2.404502	3.76	6.65
	P <sub>GER</sub> ; P <sub>FIN</sub>	r = 0	6.861240	14.07	18.63	r = 0	8.470600	15.41	20.04
		r = 1	1.609360	3.76	6.65	r ≤ 1	1.609360	3.76	6.65
P <sub>GER</sub> ; P <sub>SW</sub>	r = 0	6.780094	15.67	20.20	r = 0	9.381943	19.96	24.60	
	r = 1	2.601848	9.24	12.97	r ≤ 1	2.601848	9.24	12.97	
P <sub>AUS</sub> ; P <sub>FIN</sub> ; P <sub>SW</sub>	r = 0	16.76746	20.97	25.52	r = 0	24.13477	29.68	35.65	
	r = 1	5.095585	14.07	18.63	r ≤ 1	7.367310	15.41	20.04	
	r = 2	2.271725	3.76	6.65	r ≤ 2	2.271725	3.76	6.65	
SOFT WHEAT	P <sub>GER</sub> ; P <sub>AUS</sub>	r = 0	14.12487*	14.07	18.63	r = 0	16.17749*	15.41	20.04
		r = 1	2.052613	3.76	6.65	r ≤ 1	2.052613	3.76	6.65
	P <sub>GER</sub> ; P <sub>FIN</sub>	r = 0	9.201595	14.07	18.63	r = 0	12.34198	15.41	20.04
		r = 1	3.140382	3.76	6.65	r ≤ 1	3.140382	3.76	6.65
P <sub>GER</sub> ; P <sub>SW</sub>	r = 0	10.65503	15.67	20.20	r = 0	13.02903	19.96	24.60	
	r = 1	2.373999	9.24	12.97	r ≤ 1	2.373999	9.24	12.97	
P <sub>AUS</sub> ; P <sub>FIN</sub> ; P <sub>SW</sub>	r = 0	18.63476	20.97	25.52	r = 0	32.37041*	29.68	35.65	
	r = 1	11.61126	14.07	18.63	r ≤ 1	13.73564	15.41	20.04	
	r = 2	2.124388	3.76	6.65	r ≤ 2	2.124388	3.76	6.65	
BARLEY	P <sub>GER</sub> ; P <sub>AUS</sub>	r = 0	23.25085**	14.07	18.63	r = 0	26.47401**	15.41	20.04
		r = 1	3.223160	3.76	6.65	r ≤ 1	3.223160	3.76	6.65
	P <sub>GER</sub> ; P <sub>FIN</sub>	r = 0	9.127694	14.07	18.63	r = 0	11.97395	15.41	20.04
		r = 1	2.846252	3.76	6.65	r ≤ 1	2.846252	3.76	6.65
P <sub>GER</sub> ; P <sub>SW</sub>	r = 0	10.36354	15.67	20.20	r = 0	13.47736	19.96	24.60	
	r = 1	3.113817	9.24	12.97	r ≤ 1	3.113817	9.24	12.97	
P <sub>AUS</sub> ; P <sub>FIN</sub> ; P <sub>SW</sub>	r = 0	16.23317	20.97	25.52	r = 0	26.54422	29.68	35.65	
	r = 1	8.905791	14.07	18.63	r ≤ 1	10.31104	15.41	20.04	
	r = 2	1.405250	3.76	6.65	r ≤ 2	1.405250	3.76	6.65	
OATS	P <sub>GER</sub> ; P <sub>AUS</sub>	r = 0	13.56934	14.07	18.63	r = 0	15.89471*	15.41	20.04
		r = 1	2.325369	3.76	6.65	r ≤ 1	2.325369	3.76	6.65
	P <sub>GER</sub> ; P <sub>FIN</sub>	r = 0	7.417295	14.07	18.63	r = 0	10.31587	15.41	20.04
		r = 1	2.898573	3.76	6.65	r ≤ 1	2.898573	3.76	6.65
P <sub>GER</sub> ; P <sub>SW</sub>	r = 0	7.938016	15.67	20.20	r = 0	11.19545	19.96	24.60	
	r = 1	3.257434	9.24	12.97	r ≤ 1	3.257434	9.24	12.97	
P <sub>AUS</sub> ; P <sub>FIN</sub> ; P <sub>SW</sub>	r = 0	18.48395	20.97	25.52	r = 0	31.36059*	29.68	35.65	
	r = 1	11.00145	14.07	18.63	r ≤ 1	12.87664	15.41	20.04	
	r = 2	1.875190	3.76	6.65	r ≤ 2	1.875190	3.76	6.65	

(\*\*) indicates rejection of the hypothesis at the 5%(1%) significance level.

P<sub>AUS</sub>=natural logarithm of Austrian product price

P<sub>FIN</sub>=natural logarithm of Finnish product price

P<sub>SW</sub>=natural logarithm of Swedish product price

P<sub>GER</sub>=natural logarithm of German product price

Table 1.5 Johansen cointegration test for post EU period

Product	Variables	Null hypothesis	Maximum eigenvalue statistics	Critical values		Null hypothesis	Trace statistics	Critical values	
				5%	1%			5%	1%
RYE	P <sub>GER</sub> ; P <sub>AUS</sub>	r = 0	29.27685**	15.67	20.20	r = 0	31.67487**	19.96	24.60
		r = 1	2.398024	9.24	12.97	r ≤ 1	2.398024	9.24	12.97
	P <sub>GER</sub> ; P <sub>FIN</sub>	r = 0	27.35790**	15.67	20.20	r = 0	29.46642**	19.96	24.60
		r = 1	2.108525	9.24	12.97	r ≤ 1	2.108525	9.24	12.97
P <sub>GER</sub> ; P <sub>SW</sub>	r = 0	26.56315**	15.67	20.20	r = 0	29.62237**	19.96	24.60	
	r = 1	3.059219	9.24	12.97	r ≤ 1	3.059219	9.24	12.97	
P <sub>AUS</sub> ; P <sub>FIN</sub> ; P <sub>SW</sub>	r = 0	19.46638	22.00	26.81	r = 0	29.14376	34.91	41.07	
	r = 1	8.171255	15.67	20.20	r ≤ 1	9.677386	19.96	24.60	
	r = 2	1.506131	9.24	12.97	r ≤ 2	1.506131	9.24	12.97	
SOFT WHEAT	P <sub>GER</sub> ; P <sub>AUS</sub>	r = 0	11.92683*	11.44	15.69	r = 0	12.55025*	12.53	16.31
		r = 1	0.623417	3.84	6.51	r ≤ 1	0.623417	3.84	6.51
	P <sub>GER</sub> ; P <sub>FIN</sub>	r = 0	13.56540	15.67	20.20	r = 0	15.18045	19.96	24.60
		r = 1	1.615052	9.24	12.97	r ≤ 1	1.615052	9.24	12.97
P <sub>GER</sub> ; P <sub>SW</sub>	r = 0	15.25212*	11.44	15.69	r = 0	15.40898*	12.53	16.31	
	r = 1	0.156858	3.84	6.51	r ≤ 1	0.156858	3.84	6.51	
P <sub>AUS</sub> ; P <sub>FIN</sub> ; P <sub>SW</sub>	r = 0	26.04667*	22.00	26.81	r = 0	40.74322*	34.91	41.07	
	r = 1	11.85768	15.67	20.20	r ≤ 1	14.69656	19.96	24.60	
	r = 2	2.838877	9.24	12.97	r ≤ 2	2.838877	9.24	12.97	
BARLEY	P <sub>GER</sub> ; P <sub>AUS</sub>	r = 0	12.72486*	11.44	15.69	r = 0	13.39576*	12.53	16.31
		r = 1	0.670897	3.84	6.51	r ≤ 1	0.670897	3.84	6.51
	P <sub>GER</sub> ; P <sub>FIN</sub>	r = 0	14.75417*	11.44	15.69	r = 0	14.75501*	12.53	16.31
		r = 1	0.000832	3.84	6.51	r ≤ 1	0.000832	3.84	6.51
P <sub>GER</sub> ; P <sub>SW</sub>	r = 0	24.19633**	11.44	15.69	r = 0	24.49687**	12.53	16.31	
	r = 1	0.300541	3.84	6.51	r ≤ 1	0.300541	3.84	6.51	
P <sub>AUS</sub> ; P <sub>FIN</sub> ; P <sub>SW</sub>	r = 0	17.05145	22.00	26.81	r = 0	36.40928*	34.91	41.07	
	r = 1	14.52906	15.67	20.20	r ≤ 1	19.35783	19.96	24.60	
	r = 2	4.828767	9.24	12.97	r ≤ 2	4.828767	9.24	12.97	
OATS	P <sub>GER</sub> ; P <sub>AUS</sub>	r = 0	19.81510*	15.67	20.20	r = 0	22.68128*	19.96	24.60
		r = 1	2.866175	9.24	12.97	r ≤ 1	2.866175	9.24	12.97
	P <sub>GER</sub> ; P <sub>FIN</sub>	r = 0	11.74989	15.67	20.20	r = 0	15.57570	19.96	24.60
		r = 1	3.825813	9.24	12.97	r ≤ 1	3.825813	9.24	12.97
P <sub>GER</sub> ; P <sub>SW</sub>	r = 0	10.39560	15.67	20.20	r = 0	12.17894	19.96	24.60	
	r = 1	1.783334	9.24	12.97	r ≤ 1	1.783334	9.24	12.97	
P <sub>AUS</sub> ; P <sub>FIN</sub> ; P <sub>SW</sub>	r = 0	19.90930	22.00	26.81	r = 0	36.84807*	34.91	41.07	
	r = 1	15.67184	15.67	20.20	r ≤ 1	16.93878	19.96	24.60	
	r = 2	1.266940	9.24	12.97	r ≤ 2	1.266940	9.24	12.97	

\*(\*\*) indicates rejection of the hypothesis at the 5%(1%) significance level.

P<sub>AUS</sub>=natural logarithm of Austrian product price

P<sub>FIN</sub>=natural logarithm of Finnish product price

P<sub>SW</sub>=natural logarithm of Swedish product price

P<sub>GER</sub>=natural logarithm of German product price

In particular, Tables 1.4 and 1.5 address questions germane to this chapter. First, with respect to cointegration between each new acceding country's product price and prices in

Germany, both tests accepted the null hypothesis of zero cointegrating vectors for the pre-EU sample period. The only exception was found with the price pair ( $P_{GER}$ ,  $P_{AUS}$ ) in the case of rye, soft wheat and barley. In these cases, the null was rejected, providing evidence that prices were cointegrated even before Austria joined the EU.

For the post-EU period, the null of zero cointegrating vectors was rejected in many of the cases. The only cases for which cointegration was not observed were for the pair ( $P_{GER}$ ,  $P_{FIN}$ ) for soft wheat, along with price pairs ( $P_{GER}$ ,  $P_{FIN}$ ) and ( $P_{GER}$ ,  $P_{SW}$ ) for oats. These results are evidence of agricultural price cointegration after the three countries joined EU. With the exception of oats, where cointegration appears only in case of Austria, for the rest of the chosen products, producer prices in the three countries share a long-run relationship with the EU price ( $P_{GER}$ ). The convergence in prices might be also influenced by the operation at minimum intervention prices (Zanias, 1993), even the price support was reduced as a result of the MacSharry based reforms (Hubbard and Ritson, 1997) and Agenda 2000 (van Meijl, 2002) reforms.

There still exists the possibility that producer prices in each country's market deviate from the long-run equilibrium, but the deviations will be temporary. Short-run dynamics will be examined in the final segment of the analysis.

We note that an interesting situation concerns cointegration results among the three acceding countries. The producer prices in these countries do not share a long-run equilibrium in two periods, and this is evidence of no market integration (except for soft

wheat in the post-EU period). This could be explained by the fact that producer prices in the three acceding countries were highly supported by government in the pre-EU period, meaning that prices were not the product of market forces. Being small agricultural markets, by joining the EU these countries suddenly had access to wider markets and the price discipline that this entailed. Consider also that each of these countries increased agricultural trade with former Eastern European countries around the time of their EU integration (Breuss, 2005).

Provided that one or more cointegrating relationships exists, the final step of empirical work involves the estimation of a Vector Error Correction (VEC) model containing the cointegrating relationship(s) and lagged first differences of the variables in the cointegrating relationship(s).

According to the Granger representation theorem (Engle and Granger, 1987), between two cointegrated variables,  $x_t$  and  $y_t$ , a valid error correction representation exists given by

$$\begin{aligned}\Delta y_t &= \theta_1 + \alpha_1 (y_{t-1} - \beta x_{t-1}) + \sum_{l=1}^{p_1} \delta_{11,l} \Delta y_{t-l} + \sum_{l=1}^{p_2} \delta_{12} \Delta x_{t-l} + \varepsilon_{1t} \\ \Delta x_t &= \theta_2 + \alpha_1 (y_{t-1} - \beta x_{t-1}) + \sum_{l=1}^{p_3} \delta_{21,l} \Delta y_{t-l} + \sum_{l=1}^{p_4} \delta_{22} \Delta x_{t-l} + \varepsilon_{2t}\end{aligned}\tag{1.13}$$

where  $\Delta$  denotes the first-order time difference, the lag lengths  $p_i, i = 1, \dots, 4$  are chosen such that  $\varepsilon_t = (\varepsilon_{1t}, \varepsilon_{2t})'$  are i.i.d. (independently and identically distributed).  $\beta$  is the

cointegrating parameter and  $\alpha_i$  are the loading or speed of adjustment parameters. The second term in each equation represents the disequilibrium levels of  $y_t$  and  $x_t$  in the previous period.

As the variables of interest in our case are represented by the prices, Eq. (1.13) would become

$$\Delta p_{it} = \theta_i + \alpha_i (p_{i,t-1} - \beta p_{j,t-1}) + \sum_{l=1}^{p_i} \delta_{i1,l} \Delta p_{i,t-l} + \sum_{l=1}^{p_j} \delta_{i2,l} \Delta p_{j,t-l} + \varepsilon_{it} \quad (1.14)$$

As we have shown before,  $\Delta p_{it}$  is stationary, thus the left hand side of Eq. (1.14) is I(0).

To be able to estimate the model, the right-hand side of Eq. (1.14) should be I(0) as well.

Given that  $\varepsilon_{it}$  is stationary and the lagged differences of prices are stationary as well, it follows that the linear combination  $p_{i,t-1} - \beta p_{j,t-1}$  must also be stationary and this takes place when the two prices are cointegrated with the cointegrating vector  $(1, -\beta)$ . Hence, all the variables of the model are stationary and the normal estimation techniques will bring non-spurious results.

Large values for the speed of adjustment parameters,  $\alpha_i$ , show that the response to the previous period's deviation from long-run equilibrium is fast, while very small values show unresponsiveness of prices to last period's equilibrium error. At least one of the

speed of adjustment parameters should be different than zero, otherwise there is no long-run equilibrium relationship among prices.

Tables 1.6-1.9 report the results of our error correction model estimates. The first rows show the normalized cointegrating vector parameters, while the last rows list the estimated speed of adjustment parameters. The cointegrating vectors are normalized with respect to the Austrian, Finnish or Swedish prices, as Germany represents the dominant agricultural market and it is unlikely that markets in Germany would react to price movements in these smaller markets.

A key item to note here is that the lag structure of prices for all estimated models in the post-EU period is short, never exceeding a 1-month lag (in levels). This indicates that any deviations from long-run equilibrium in these markets are restored quickly by market forces (Gordon, Hannesson, Kerr, 2001). The estimated results for the other terms of error correction model in case of lag length greater than 0 are presented in Appendix C.

a) Rye market

Cointegration Equations					
$P_{AUS}(-1)^a$	1.000000	$P_{FIN}(-1)$	1.000000	$P_{SW}(-1)$	1.000000
$P_{GER}(-1)$	-1.093492* (0.16146) <sup>b</sup>	$P_{GER}(-1)$	-0.877316* (0.11076)	$P_{GER}(-1)$	-0.914093* (0.11555)
Constant	0.256788 (0.38347)	Constant	-0.560613* (0.26305)	Constant	-0.242092 (0.27443)
Speed of adjustment	$D(P_{GER})^c$	Speed of adjustment	$D(P_{GER})$	Speed of adjustment	$D(P_{GER})$
	0.265304* (0.05546)		0.351577* (0.08587)		0.427597* (0.08029)
	$D(P_{AUS})$		$D(P_{FIN})$		$D(P_{SW})$
	-0.119234* (0.04737)		-0.068847* (0.02894)		-0.004842 (0.03178)

$P_{AUS}$ =natural logarithm of Austrian product price

$P_{FIN}$ =natural logarithm of Finnish product price

$P_{SW}$ =natural logarithm of Swedish product price

$P_{GER}$ =natural logarithm of German product price

<sup>a</sup>  $P(-1)$  = one period lagged price

<sup>b</sup> Standard errors are in the parentheses

<sup>c</sup>  $D(P)$  = first difference price

\* indicates statistical significance at 5%

As the cointegration test showed, there is one cointegrating vector for each of the pairs(  $P_{GER}, P_{AUS}$  );(  $P_{GER}, P_{FIN}$  );(  $P_{GER}, P_{SW}$  ), so error correction estimation was applied only in these three cases. The optimal lag length used in the cointegration regression for rye market is zero in levels.

The cointegrating regression of prices in Austria on prices in Germany (plus a constant) indicates that when prices in Germany rise by one percent, the corresponding Austrian price decreases by 1.09 percent in the long run. In case of each of (Germany, Finland) and (Germany, Sweden), results show that for a one percent increase in German price, the Finnish price decreases by 0.88 percent, while the Swedish price falls by 0.91 percent. One economic interpretation of the inclusion of the intercept term might be price

differences between the time series in the long run, which may fully incorporate transportation costs.

An important finding is the statistical significance of the error correction or speed of adjustment term in most of the cases. This suggests that the prices tend to always return to their long-run relationship from any deviations from their normal relationships. However, higher values for the speeds of adjustment parameters are observed for Germany in all three cointegration equations, meaning that the adjustment process is relatively fast with about 26%, 35% and, respectively, 43% of divergence from the long-run equilibrium being corrected monthly. This result might be explained by the fact that Germany is the biggest producer of rye in EU as well as the biggest exporter, and, thus, the adjustment to the equilibrium level is obtained much faster. In case of Austria and Finland, the adjustment process is pretty slow with 12% and, respectively, 7% of divergence being corrected each month. The error correction term in case of Sweden is not statistically significant, meaning that the Swedish price is unresponsive to last period's equilibrium error. One factor that might influence the result obtained in case of Sweden is the flexible exchange rate as Sweden did not join the Monetary Union together with the other two countries.

In case of rye, the prices for (Germany, Austria) are also cointegrated before 1995. The results of our error correction estimation are presented in Table 1.C.1 in Appendix C. The long-run transmission elasticity implied in the cointegrated vector decreased from 2.39 in the pre-EU period to 1.09 in the post-EU period. This suggests market integration

decreased during the post-EU period. Conversely, the optimal lag length for the pre-EU model is 14, showing that the temporary deviations from the long-run equilibrium are restored more slowly in the pre-EU period than in the post-EU period. The same conclusion is apparent when we compare the speed of adjustment parameters in the two periods.

Summarizing these findings, it is evident that rye prices in the EU and the three acceding countries are cointegrated, and these markets have a long run relationship. This result supports our supposition about an integrated European market for certain agricultural products. Examining the short run response to the long run equilibrium we can see that, in general, the adjustments are very quick.

b) Soft wheat market

<b>Cointegration Equations</b>					
$P_{AUS}(-1)^a$	1.000000	$P_{SW}(-1)$	1.000000	$P_{AUS}(-1)$	1.000000
$P_{GER}(-1)$	-0.972424* (0.00623) <sup>b</sup>	$P_{GER}(-1)$	-1.000682* (0.00552)	$P_{FIN}(-1)$	-0.689137* (0.22949)
				$P_{SW}(-1)$	-0.472887* (0.19538)
Constant	-	Constant	-	Constant	0.570488 (0.45386)
<b>Speed of adjustment</b>	<b>D(P<sub>GER</sub>)<sup>c</sup></b>	<b>Speed of adjustment</b>	<b>D(P<sub>GER</sub>)</b>	<b>Speed of adjustment</b>	<b>D(P<sub>AUS</sub>)</b>
	0.114771* (0.05061)		0.139076* (0.05588)		- 0.135377* (0.04856)
	<b>D(P<sub>AUS</sub>)</b>		<b>D(P<sub>SW</sub>)</b>		<b>D(P<sub>FIN</sub>)</b>
	-0.087057 (0.06020)		-0.068971 (0.06117)		0.074235* (0.02358)
				<b>D(P<sub>SW</sub>)</b>	0.103298* (0.04864)

$P_{AUS}$ =natural logarithm of Austrian product price

$P_{FIN}$ =natural logarithm of Finnish product price

$P_{SW}$ =natural logarithm of Swedish product price

$P_{GER}$ =natural logarithm of German product price

<sup>a</sup>  $P(-1)$  = one period lagged price

<sup>b</sup> Standard errors are in the parentheses

<sup>c</sup>  $D(P)$  = first difference price

\* indicates statistical significance at 5%

Cointegration testing showed that there is one cointegrating vector in each of the price pairs  $(P_{GER}, P_{AUS})$ ,  $(P_{GER}, P_{SW})$ ,  $(P_{AUS}, P_{FIN}, P_{SW})$ . The optimal lag length used in the cointegrating regression between prices in Germany and the two acceding countries for soft wheat is one in levels, while for the cointegrating regression among the three acceding countries, the chosen lag length is zero in levels.

The normalized cointegrating vectors show that for a one percent increase in German price, the long run Austrian price will decrease by 0.97 percent and the long run Swedish

price by 1.00 percent.<sup>6</sup> As the Finnish and Swedish price increase by one percent, the Austrian price, respectively, decreases by 0.69 and 0.47 percent.

Tables 1.C.2 and 1.C.3 in Appendix C provide the results of vector error correction estimation for Germany-Austria and Germany-Sweden. The results using price in Germany as the dependent variable indicate that a one percent increase in prices in Austria and Sweden in the preceding period yield, respectively, an increase of 0.40 percent and a decrease of 0.03 percent of the price level in Germany in the present period. However, the Swedish estimate is not statistically significant, so we conclude that the price in Germany reacts only to price changes in Austria that occurred in the previous time period. The speed of adjustment parameter estimates further imply that a deviation from the long-run equilibrium in Austria and in Sweden in the preceding time period was adjusted for, respectively, by 11 percent and 14 percent in Germany in the following period.

Turning our attention to the results when Austrian and Swedish prices are used as dependant variables, we find that for a one percent increase in the German price in the preceding period, the Austrian price increased by 0.23 percent in the current period, while the Swedish price increased by 0.35 percent. In both equations, the speed of adjustment parameters are not statistically significant. Regarding the short-run relationship among Austria, Finland and Sweden, all adjustment parameters are statistically significant.

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<sup>6</sup> In case of Austria, Finland and Sweden, the cointegrating vector was normalized with respect to the Austrian price.

We find that prices for soft wheat in Germany and Austria are cointegrated even before 1995. The results of error correction estimation are presented in Table 1.C.4 in Appendix C. Long-run transmission elasticities decreased from 2.42 in the pre-EU period to 0.97 in the post-EU time period, indicating that integration decreased during the post-EU period. The optimal lag length for the pre-EU model is 13, which together with the speed of adjustment parameters, is evidence that the temporary deviations from the long-run equilibrium were restored more slowly in the pre-EU period than in the post-EU period.

Summarizing the soft wheat results, there is evidence of market integration except for the Finnish market. When examining the short-run dynamics, the speed of adjustment increased in the post-EU period compared with the pre-EU period. For the pair of (Germany, Austria) there was evidence of market integration before Austria joined the EU, meaning that the prices were in the process of convergence prior to joining the EU (Moodley et.al., 2000). The results of the error correction model show that adjustment was faster in the post-EU period, while the level of market integration has decreased, meaning that even the long run equilibrium is restored slower in the post-EU time period, the short run adjustments are faster.

c) Barley

Cointegration Equations					
$P_{AUS}(-1)^a$	1.000000	$P_{FIN}(-1)$	1.000000	$P_{SW}(-1)$	1.000000
$P_{GER}(-1)$	-0.981450* (0.00686) <sup>b</sup>	$P_{GER}(-1)$	-1.046173* (0.00797)	$P_{GER}(-1)$	-1.007382* (0.00447)
<b>Speed of adjustment</b>	<b>D(P<sub>GER</sub>)<sup>c</sup></b>	<b>Speed of adjustment</b>	<b>D(P<sub>GER</sub>)</b>	<b>Speed of adjustment</b>	<b>D(P<sub>GER</sub>)</b>
	0.063043 (0.05046)		0.147313* (0.03801)		0.216457* (0.05133)
	<b>D(P<sub>AUS</sub>)</b>		<b>D(P<sub>FIN</sub>)</b>		<b>D(P<sub>SW</sub>)</b>
	-0.109280 (0.05966)		-0.011666 (0.02679)		-0.063640 (0.04772)

$P_{AUS}$ =natural logarithm of Austrian product price

$P_{FIN}$ =natural logarithm of Finnish product price

$P_{SW}$ =natural logarithm of Swedish product price

$P_{GER}$ =natural logarithm of German product price

<sup>a</sup>  $P(-1)$  = one period lagged price

<sup>b</sup> Standard errors are in the parentheses

<sup>c</sup>  $D(P)$  = first difference price

\* indicates statistical significance at 5%

According to the Johansen test results, cointegration relationships for barley were found for the following price pairs ( $P_{GER}, P_{AUS}$ ), ( $P_{GER}, P_{FIN}$ ), ( $P_{GER}, P_{SW}$ ). The optimal lag length used in the error correction model for the barley market is unity in levels.

The cointegrating vectors in Table 1.8 indicate that for a one percent increase in the German price, the Austrian, Finnish and Swedish prices decreased in the long-run by, respectively, 0.98, 1.05 and 1.01 percent. Tables 1.C.5, 1.C.6 and 1.C.7 from Appendix C show our estimates of the short-run parameters. Considering the equation where German price is the dependant variable, we find German prices did not react to price changes in Austria, Finland and Sweden - all the estimates are insignificant. The speed of adjustment parameter estimates imply that a deviation from the long-run equilibrium in Finland in the preceding time period is adjusted by 15 percent in Germany the following period,

while for a temporary price deviation in Sweden, the price in Germany is adjusted by 22 percent in the next period. Germany does not react to short-run deviations in Austrian price, as the speed of adjustment is insignificant. Looking at the other short-run equation estimates, German price in a prior period influences barley prices in Austria, Finland and Sweden in the subsequent period, and the speed of adjustment parameters are all insignificant.

In case of barley, prices for (Germany, Austria) were cointegrated even before Austria joined the EU in 1995. Error correction estimates are presented in Table 1.C.8 in Appendix C. Optimal lag length for the model is 2, and the speed of adjustment parameters as well as the long-run transmission elasticities show that even though the two markets were integrated before 1995, the degree of market integration did increase after Austria joined the EU.

Summarizing these results for barley, prices are cointegrated in the post-EU period, and we interpret this as evidence of long-run equilibrium. With respect to the short-run dynamics, in general, there is no evidence of adjustment, as the parameter estimates are insignificant.

d) Oats

Table 1.9 Error correction estimates for oats: 1995:01-2004:12	
Cointegration Equations	
$P_{AUS}(-1)^a$	1.000000
$P_{GER}(-1)$	-1.091145* (0.18899) <sup>b</sup>
Constant	0.261235 (0.44067)
Speed of adjustment	$D(P_{GER})^c$
	0.051527 (0.04062)
	$D(P_{AUS})$
	-0.198938* (0.04808)

$P_{AUS}$ =natural logarithm of Austrian product price

$P_{FIN}$ =natural logarithm of Finnish product price

$P_{SW}$ =natural logarithm of Swedish product price

$P_{GER}$ =natural logarithm of German product price

<sup>a</sup>  $P(-1)$  = one period lagged price

<sup>b</sup> Standard errors are in the parentheses

<sup>c</sup>  $D(P)$  = first difference price

\* indicates statistical significance at 5%

In case of oats, there is only one cointegrating vector and that is for the pair of prices ( $P_{GER}, P_{AUS}$ ). Note that the optimal lag length chosen for the oats market is zero in levels. The cointegrated vector shows that for a one percent change in the German price, the Austrian price decreased by 1.091 percent in the long-run. In turn, the speed of adjustment parameter estimates imply that a deviation from price equilibrium in Germany in the preceding time period is adjusted by 20 percent in Austria the following period, while Germany does not react to short-run deviations in Austrian price (speed of adjustment is insignificant). We conclude that the European market for oats did not become integrated with the inclusion of these countries into the EU.

## 1.6 Summary and conclusions

The study of market integration is important with respect to evaluating the success of particular trade agreements. The process of price transmission from one market to another is central in understanding the extent of the integration of economic agents into the market process. Conversely, the absence of market integration has important implications for economic welfare. Incomplete price transmission arises from either trade barriers or other protectionist policies, or can be due simply to transaction costs such as poor transport and communication infrastructure. This results in a reduction in the price information available to economic agents and consequently can lead to decisions that contribute to economically inefficient outcomes.

In theory, spatial price determination models suggest that if two markets are linked by trade in a free market regime, excess demand or supply shocks in one market will have an equal impact on price in both markets. In general, the existence of import tariffs allows price changes to be fully transmitted to other markets in relative terms. However, with a prohibitively high tariff, changes in one price would be only partly (if at all) transmitted to the other market. Furthermore, this price will likely be close to the autarky (no trade) price level and will prohibit all opportunities for spatial arbitrage. Regarding price support policies such as intervention mechanisms and floor prices, changes in one price will have no effect on the other market only when the price falls below that level at which the floor price has been set. However, any changes in the price above the floor price level will be transmitted to the other market. Apart from such policies, there are other factors

that can impede market integration, for example high transfer costs and non-competitive behavior.

The primary objective for the formation of CAP was the integration of agricultural markets in this spatial sense. The Treaty of Rome from 1958 established that “The Common Market shall extend to agriculture and trade in agricultural products” (Article 38) and eventually, all the barriers to trade between member states will be eliminated (Ritson, 1997). In turn, the two guiding principles of the Single European Market (SEM) are non-discrimination and mutual recognition. As mutual recognition proved to be insufficient, common harmonization directives were adopted. These were focused on health, safety, and environmental protection. Finally, an important obstacle for the existence of increased market integration is the insistence of some member states (especially the UK) on having national sovereignty over important macroeconomic matters (e.g. monetary policy, fiscal measures).

The accession of Austria, Finland and Sweden to the European Union (EU) is assessed from the perspective of market integration in key agricultural sectors. The analysis addresses two important questions in this regard: 1) are the markets in these three new acceding countries integrated with those in the EU and 2) are the three markets integrated among each other? If we found market integration only in the post-EU period, this would represent strong evidence that the accession to the single market had an important effect on these agricultural goods markets.

Upon accession, the new members had to adopt EU laws and regulations, including agricultural policies and external tariff levels. Under the Accession Agreement, the new members were required to align their prices to EU levels and this adjustment led to a price drop of about 40 to 45 percent in the cereal, livestock and dairy sectors in Austria and Finland. The overall effect on the farm sector in Sweden was not as severe because Sweden had already reformed its agricultural sector in 1991-1992 by lowering prices and reducing subsidies. For Sweden, cereal prices increased and dairy prices remained stable, while prices in the livestock sector dropped sharply. On the other hand, many farmers in these new member states began to face competition from more efficient EU producers. These two factors led to reduced farm production and self-sufficiency in some key sectors, with increased dependence on outside suppliers.

With this in mind, our empirical investigation examines a set of important agricultural products (rye, soft wheat, barley, oats and potatoes) for two time periods. The sub-samples include the time from 1975:01-1994:12 (the pre-EU period) and 1995:01-2004:12 (post-EU period). The existence of market integration both between the countries and within the EU is examined using time-series tests. Observing a long-run equilibrium between prices does not exclude the possibility of short-run deviations in the individual series. Thus, part of this analysis consists of estimating an error correction model to check for long-run impacts of price deviations.

We found that cointegration analysis could be applied to four of these products (rye, soft wheat, barley and oats), while for a fifth product (potatoes) standard estimation

techniques can be applied because this price variable was stationary. In turn, we found that the prices of these commodities were highly cointegrated after the three countries joined EU. Of the four markets tested, the rye and barley markets proved to be most tightly integrated with the German (EU) market, while the oats market was the least integrated.

These results are somewhat unexpected, as all four products (except for potatoes) are under CAP support. A minimum price support is offered only for wheat, barley and rye, while exports of oats from Finland and Sweden are highly subsidized. Thus the observed convergence in prices for rye, soft wheat and barley might be influenced by operation at a minimum price, even though this situation would not likely be observed without markets being linked through efficient arbitrage. On the other hand, oats are thinly traded and we might expect that efficient arbitrage does not take place. Since Germany is the biggest producer of barley and rye in the EU, after joining the EU, the three new members had full access to this large market. Alternately, access to markets in Eastern Europe after 1989 was accompanied by asymmetric tariff liberalization with the Europe Agreements. This created new “emerging agricultural markets” in the immediate neighborhood, including Russia, Poland or the Ukraine, which are each among the biggest producers of oats in the world.

In the pre-EU period, cointegration among prices was found for rye, soft wheat and barley between Austria and Germany. This can be explained by the fact that the two countries are actually neighboring countries with a reasonably open border and strong

transportation ties. Furthermore, oat production was not significant in any of the countries under consideration, and it appears that price arbitrage in this commodity does not take place.

Even though the countries under study were part of the European Free Trade Agreement (EFTA) before joining EU, there was certainly no evidence of market integration for agricultural products in the pre-EU period. Based on our findings, we expect that the situation would be the same in case of the Central and Eastern European countries (CEEC), which joined EU in 2004 (plus Romania and Bulgaria in 2007). However, the situation in these latter countries is different compared to our sample in three ways.

Firstly, agriculture makes up a large share of employment - the two largest CEEC countries alone (Poland and Romania) contain almost half the agricultural area as the EU-15. Secondly, CAP would clearly be applied in stages to the new members over a ten-year period, rendering the transition as smooth as possible. Lastly, CAP itself will be reformed further as a result of World Trade Organization's (WTO) liberalizing measures pertaining to agriculture.

Given that the main objective of the EU was the establishment of an integrated market, it is quite surprising that the European agricultural markets have not received a great deal of attention in the literature. The results of a survey carried in the EU regarding the market integration for different consumer goods were that borders are still playing an important role in Europe and there are 15 separate markets for supermarket goods (European Commission, 2002). Finding convergence in prices for different European commodities

would represent strong evidence that the single EU market is functioning well, while non-convergence in prices would send a signal to the policy makers that there are still barriers to trade among the EU countries.

APPENDIX A – PRODUCTION OF AGRICULTURAL COMMODITIES IN AUSTRIA, FINLAND AND SWEDEN

Table 1.A.1 Production of agricultural commodities in Austria (1990-2005) as percentage of production in EU-15

<b>AUSTRIA</b>	<b>1990</b>	<b>1991</b>	<b>1992</b>	<b>1993</b>	<b>1994</b>	<b>1995</b>	<b>1996</b>	<b>1997</b>	<b>1998</b>	<b>1999</b>	<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>
Cereals	2.68%	2.56%	2.39%	2.34%	2.52%	2.48%	2.62%	2.40%	2.24%	2.36%	2.08%	2.39%	2.22%	2.25%	2.32%	2.14%
Soft wheat and spelt	1.64%	1.60%	1.62%	1.28%	1.57%	1.57%	1.44%	1.49%	1.35%	1.48%	1.33%	1.76%	1.47%	1.38%	1.62%	1.49%
Rye and meslin	7.16%	7.44%	7.73%	6.83%	7.03%	5.28%	2.81%	3.48%	3.76%	4.05%	3.41%	3.47%	3.71%	4.33%	4.56%	4.67%
Barley	2.73%	2.52%	2.85%	2.32%	2.72%	2.45%	2.06%	2.40%	2.35%	2.37%	1.66%	2.11%	1.79%	1.89%	1.94%	2.02%
Oats and summer cereal mixture	3.54%	3.68%	3.79%	3.17%	3.02%	3.09%	2.58%	3.24%	2.94%	2.93%	2.02%	2.37%	1.85%	2.10%	2.30%	2.48%
Potatoes	1.61%	1.75%	1.45%	1.83%	1.42%	1.66%	1.53%	1.42%	1.50%	1.47%	1.43%	1.55%	1.48%	1.37%	1.45%	1.59%

Source: EUROSTAT

Table 1.A.2 Production of agricultural commodities in Finland (1990-2005) as percentage of production in EU-15

<b>FINLAND</b>	<b>1990</b>	<b>1991</b>	<b>1992</b>	<b>1993</b>	<b>1994</b>	<b>1995</b>	<b>1996</b>	<b>1997</b>	<b>1998</b>	<b>1999</b>	<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>
Cereals	2.18%	1.74%	1.43%	1.85%	1.93%	1.85%	2.06%	1.82%	1.30%	1.41%	1.89%	1.81%	1.84%	1.99%	1.58%	1.79%
Soft wheat and spelt	0.77%	0.52%	0.27%	0.47%	0.44%	0.47%	0.55%	0.53%	0.42%	0.28%	0.56%	0.59%	0.60%	0.83%	0.78%	0.85%
Rye and meslin	4.14%	0.56%	0.68%	1.33%	0.44%	0.93%	1.50%	0.78%	0.77%	0.43%	1.96%	1.01%	1.52%	2.23%	1.27%	0.96%
Barley	3.09%	3.15%	2.82%	3.55%	4.26%	4.06%	3.53%	3.83%	2.55%	3.22%	3.86%	3.71%	3.62%	3.64%	3.32%	4.71%
Oats and summer cereal mixture	18.69%	14.70%	16.50%	16.18%	16.16%	17.63%	16.94%	17.30%	14.49%	15.47%	19.84%	19.68%	20.13%	18.07%	14.57%	19.84%
Potatoes	1.79%	1.48%	1.32%	1.61%	1.73%	1.83%	1.52%	1.58%	1.37%	1.64%	1.62%	1.64%	1.69%	1.51%	1.30%	1.54%

Source: EUROSTAT

Table 1.A.3 Production of agricultural commodities in Sweden (1990-2005) as percentage of production in EU-15

<b>SWEDEN</b>	<b>1990</b>	<b>1991</b>	<b>1992</b>	<b>1993</b>	<b>1994</b>	<b>1995</b>	<b>1996</b>	<b>1997</b>	<b>1998</b>	<b>1999</b>	<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>
Cereals	3.29%	2.64%	2.05%	2.80%	2.42%	2.67%	3.32%	2.87%	2.64%	2.42%	2.62%	2.66%	2.55%	2.82%	2.41%	2.22%
Soft wheat and spelt	2.76%	1.79%	1.79%	2.27%	1.74%	1.93%	2.45%	2.35%	2.38%	1.86%	2.51%	2.82%	2.24%	2.78%	2.40%	2.42%
Rye and meslin	5.67%	3.27%	3.49%	4.87%	3.42%	3.33%	2.87%	2.28%	2.50%	2.12%	3.39%	2.85%	2.67%	3.62%	2.72%	3.02%
Barley	3.81%	3.42%	2.67%	3.53%	3.81%	4.13%	4.01%	3.98%	3.27%	3.80%	3.18%	3.42%	3.70%	3.32%	3.26%	3.68%
Oats and summer cereal mixture	19.62%	20.22%	14.57%	18.32%	15.02%	15.87%	17.47%	18.72%	17.62%	17.41%	17.26%	15.64%	16.47%	16.30%	13.92%	13.49%
Potatoes	2.77%	2.27%	2.47%	2.64%	2.53%	2.46%	2.38%	2.54%	2.77%	2.05%	2.02%	2.07%	1.98%	2.09%	2.05%	1.96%

Source: EUROSTAT

## APPENDIX B – AGRICULTURAL COMMODITIES' PRICES

Figure 1.B.1 Log-level prices for rye. Sample: 1975:01-1994:12

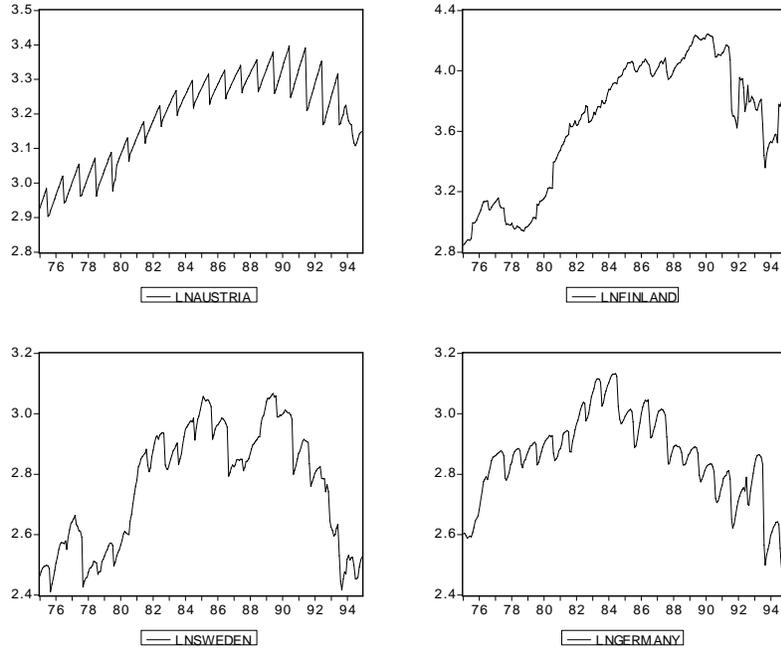


Figure 1.B.2 Log-level prices for rye. Sample 1995:01-2004:12

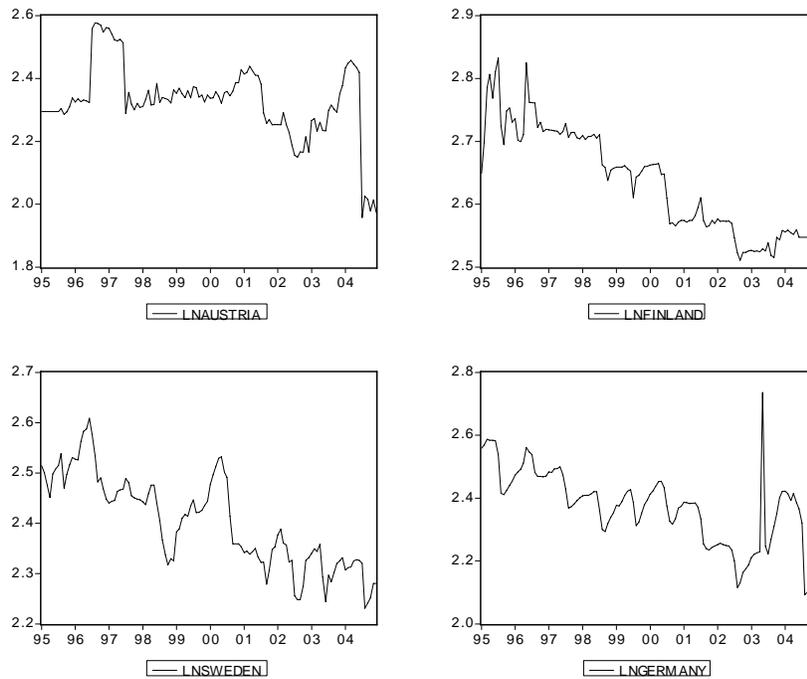


Figure 1.B.3 Log-level prices for soft wheat. Sample: 1975:01-1994:12

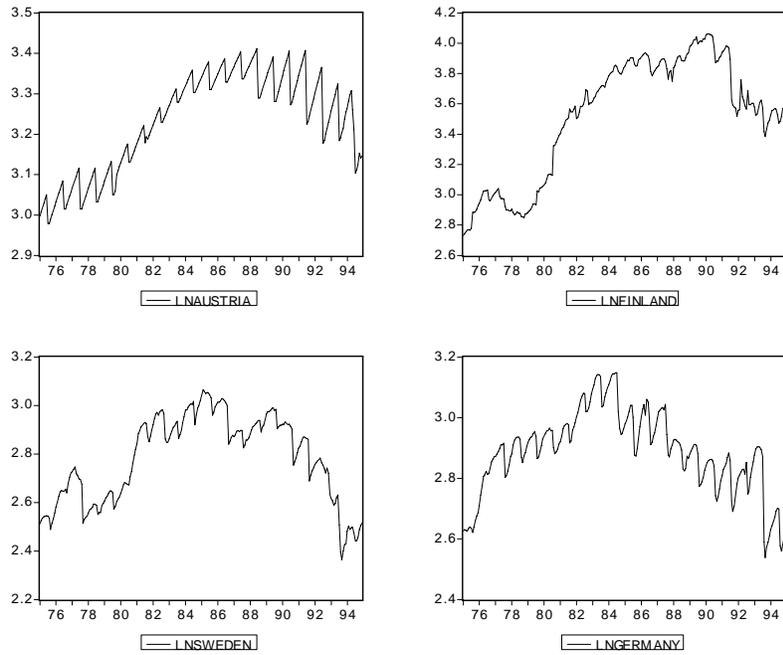


Figure 1.B.4 Log-level prices for soft wheat. Sample: 1995:01-2004:12

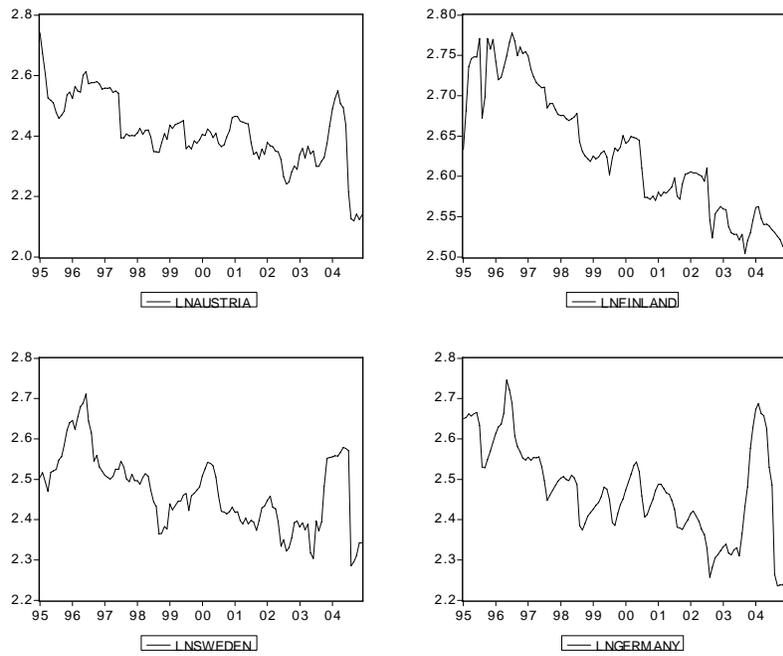


Figure 1.B.3 Log-level prices for barley. Sample: 1975:01-1994:12

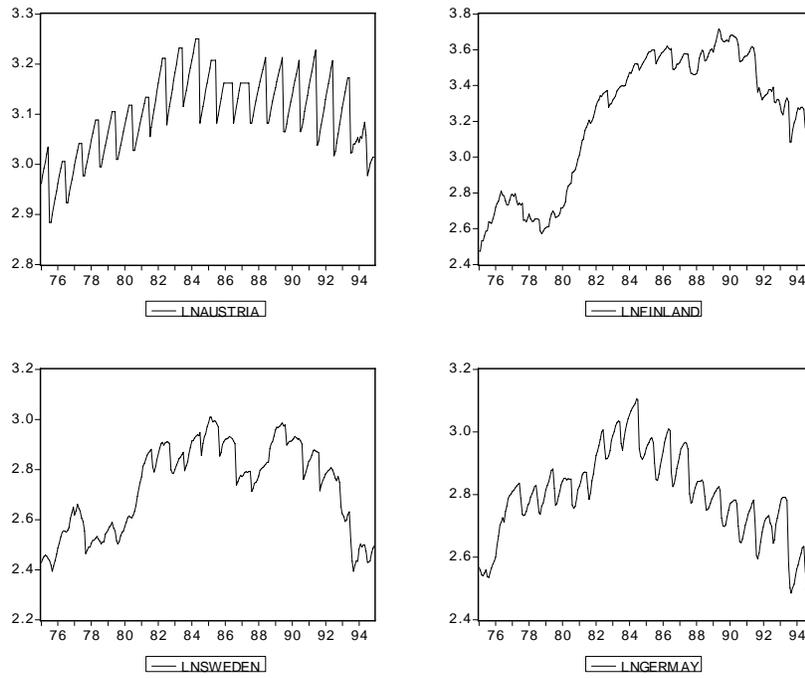


Figure 1.B.4 Log-level prices for barley. Sample: 1995:01-2004:12

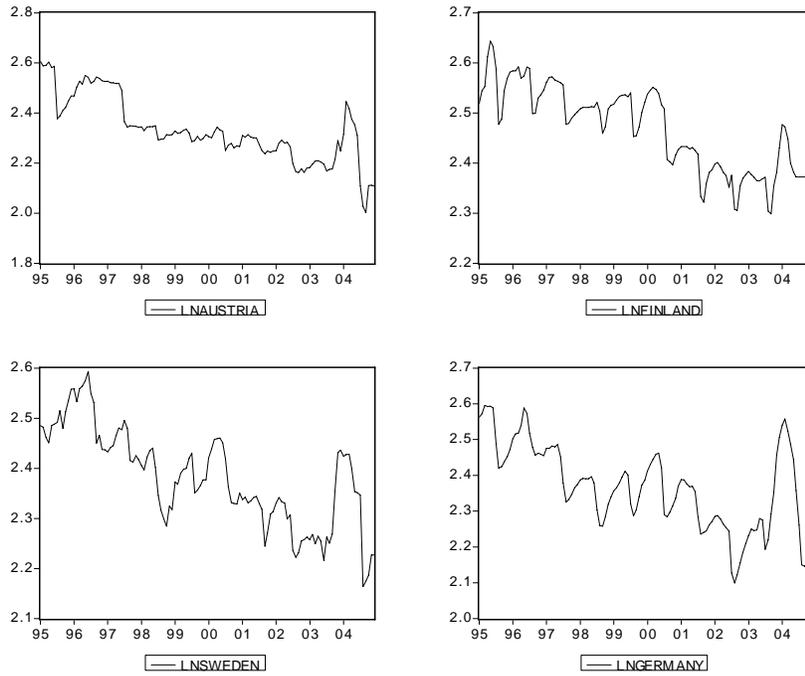


Figure 1.B.5 Log-level prices for oats. Sample: 1975:01-1994:12

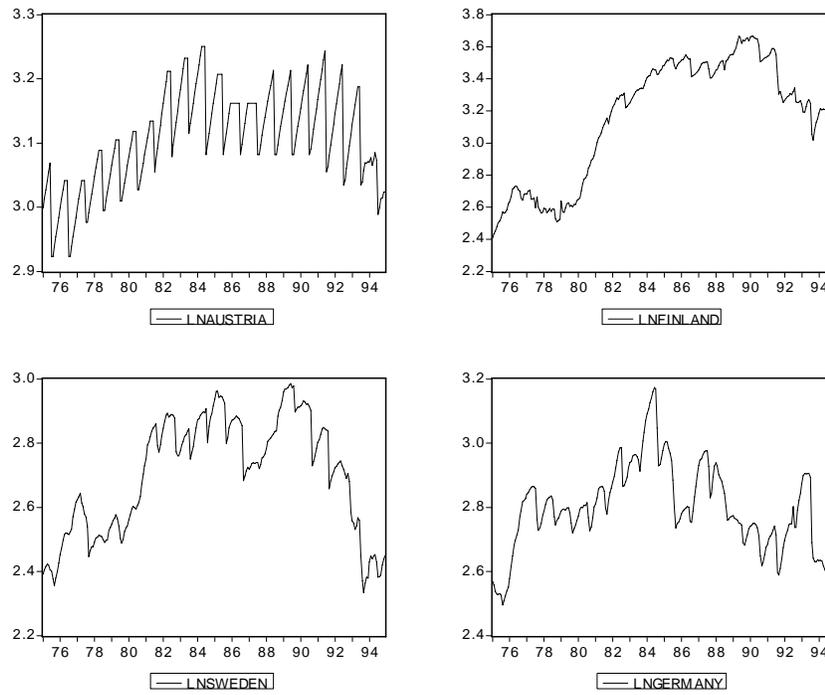


Figure 1.B.6 Log-level prices for oats. Sample: 1995:01-2004:12

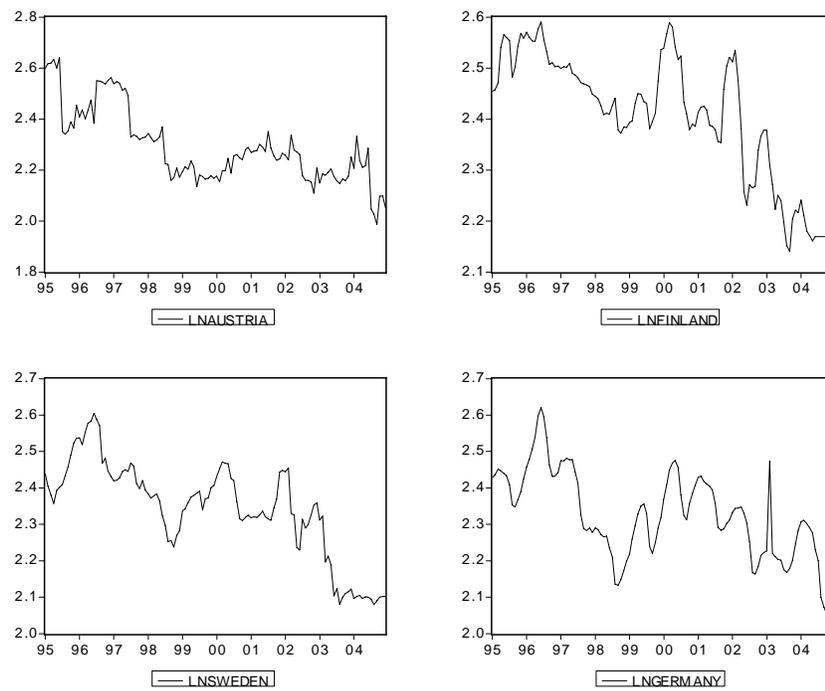


Figure 1.B.7 Log-level prices for potatoes. Sample: 1975:01-1994:12

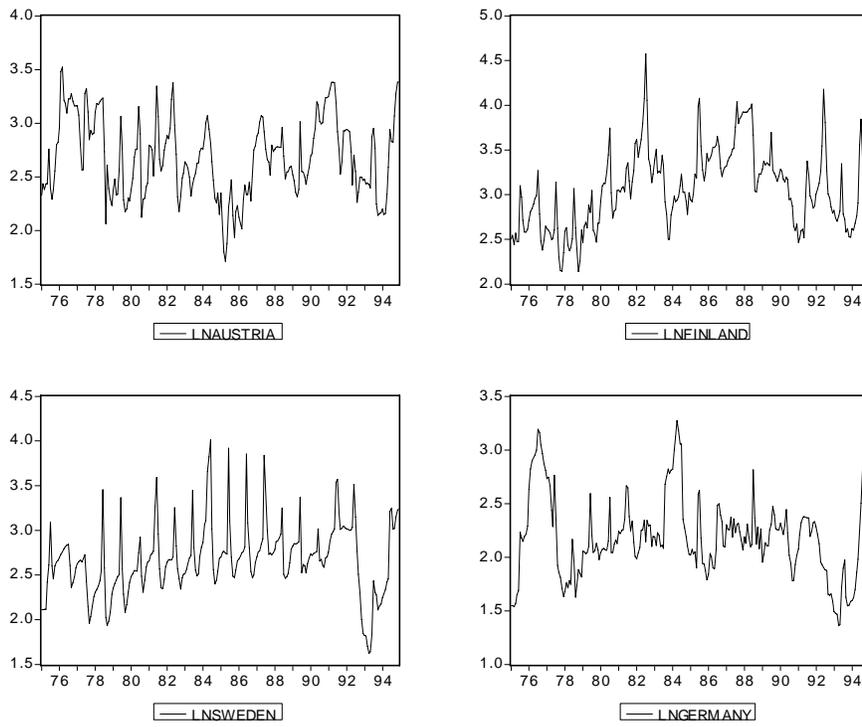
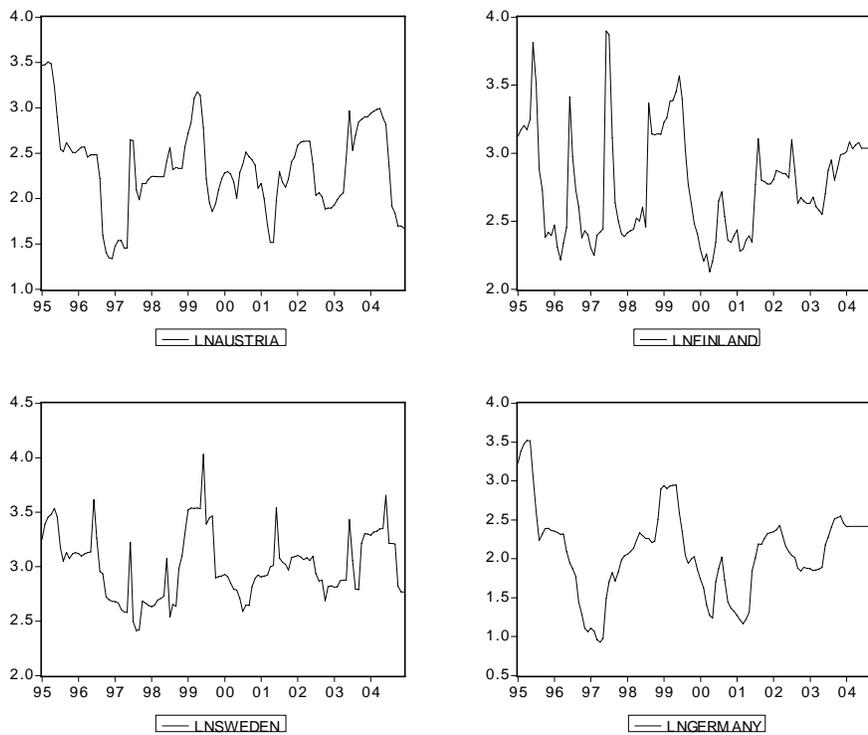


Figure 1.B.8 Log-level prices for potatoes. Sample: 1995:01-2004:12



APPENDIX C – VECTOR ERROR CORRECTION RESULTS

Table 1.C.1 Vector Error Correction Estimates for rye (1975:01-1994:12)

Cointegrating Eq:	CointEq1	
LNAUSTRIA_SA(-1)	1.000000	
LNGERMANY(-1)	-2.387617 (0.56146) [-4.25249]	
C	3.656612	
Error Correction:	D(P <sub>AUS</sub> )	D(P <sub>GER</sub> )
Speed of adjustment	-0.011612 (0.00375) [-3.09888]	0.012073 (0.00737) [ 1.63745]
D(P <sub>AUS</sub> (-1))	-0.126906 (0.07041) [-1.80241]	0.675871 (0.13854) [ 4.87851]
D(P <sub>AUS</sub> (-2))	-0.099763 (0.07279) [-1.37055]	-0.385448 (0.14323) [-2.69118]
D(P <sub>AUS</sub> (-3))	-0.058438 (0.06856) [-0.85231]	-0.074546 (0.13491) [-0.55256]
D(P <sub>AUS</sub> (-4))	-0.104268 (0.06855) [-1.52102]	0.120293 (0.13489) [ 0.89181]
D(P <sub>AUS</sub> (-5))	-0.150286 (0.06724) [-2.23500]	-0.005727 (0.13231) [-0.04329]
D(P <sub>AUS</sub> (-6))	-0.229130 (0.09506) [-2.41034]	-0.112938 (0.18705) [-0.60379]
D(P <sub>AUS</sub> (-7))	-0.123595 (0.09625) [-1.28404]	-0.032965 (0.18940) [-0.17405]

D(P <sub>AUS</sub> (-8))	0.017453 (0.10118) [ 0.17250]	0.116843 (0.19908) [ 0.58692]
D(P <sub>AUS</sub> (-9))	0.055998 (0.10206) [ 0.54867]	0.225313 (0.20082) [ 1.12196]
D(P <sub>AUS</sub> (-10))	-0.025946 (0.10395) [-0.24961]	0.071016 (0.20453) [ 0.34722]
D(P <sub>AUS</sub> (-11))	-0.217969 (0.10630) [-2.05059]	0.109319 (0.20915) [ 0.52267]
D(P <sub>AUS</sub> (-12))	0.556090 (0.10910) [ 5.09712]	0.181020 (0.21467) [ 0.84325]
D(P <sub>AUS</sub> (-13))	-0.035260 (0.11422) [-0.30870]	0.530963 (0.22475) [ 2.36245]
D(P <sub>GER</sub> (-1))	0.014111 (0.03376) [ 0.41803]	0.467657 (0.06642) [ 7.04073]
D(P <sub>GER</sub> (-2))	0.001134 (0.02742) [ 0.04134]	-0.112275 (0.05396) [-2.08089]
D(P <sub>GER</sub> (-3))	-0.011060 (0.02742) [-0.40341]	0.026159 (0.05395) [ 0.48491]
D(P <sub>GER</sub> (-4))	0.005033 (0.02745) [ 0.18334]	-0.056608 (0.05402) [-1.04799]
D(P <sub>GER</sub> (-5))	0.024471 (0.02911) [ 0.84061]	-0.020859 (0.05728) [-0.36416]
D(P <sub>GER</sub> (-6))	0.037602	-0.029301

	(0.02928) [ 1.28407]	(0.05762) [-0.50852]
D(P <sub>GER</sub> (-7))	0.011365 (0.02931) [ 0.38777]	-0.027965 (0.05767) [-0.48490]
D(P <sub>GER</sub> (-8))	0.005972 (0.02923) [ 0.20430]	-0.045203 (0.05752) [-0.78584]
D(P <sub>GER</sub> (-9))	0.068548 (0.02922) [ 2.34564]	-0.035023 (0.05750) [-0.60908]
D(P <sub>GER</sub> (-10))	0.077384 (0.02958) [ 2.61595]	-0.073441 (0.05821) [-1.26174]
D(P <sub>GER</sub> (-11))	-0.137512 (0.03007) [-4.57289]	0.020725 (0.05917) [ 0.35026]
D(P <sub>GER</sub> (-12))	0.074316 (0.03121) [ 2.38152]	0.670344 (0.06140) [ 10.9174]
D(P <sub>GER</sub> (-13))	-0.033486 (0.03610) [-0.92747]	-0.299393 (0.07104) [-4.21433]
C	0.001015 (0.00079) [ 1.28394]	-0.002104 (0.00156) [-1.35218]

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Table 1.C.2 Vector Error Correction Estimates for soft wheat (1995:01-2004:12)

Error Correction:	D(P <sub>AUS</sub> )	D(P <sub>GER</sub> )
Speed of adjustment	-0.087057 (0.06020) [-1.44608]	0.114771 (0.05061) [ 2.26753]
D(P <sub>AUS</sub> (-1))	0.222827 (0.10163) [ 2.19250]	0.405043 (0.08545) [ 4.74026]
D(P <sub>GER</sub> (-1))	0.233453 (0.10119) [ 2.30705]	0.250344 (0.08508) [ 2.94255]

Table 1.C.3 Vector Error Correction Estimates for soft wheat (1995:01-2004:12)

Error Correction:	D(P <sub>SW</sub> )	D(P <sub>GER</sub> )
Speed of adjustment	-0.068971 (0.06117) [-1.12755]	0.139076 (0.05588) [ 2.48886]
D(P <sub>SW</sub> (-1))	-0.117207 (0.11109) [-1.05510]	-0.031205 (0.10148) [-0.30750]
D(P <sub>GER</sub> (-1))	0.349963 (0.11294) [ 3.09879]	0.496069 (0.10317) [ 4.80829]

Table 1.C.4 Vector Error Correction Estimates for soft wheat (1975:01-1994:12)

Cointegrating Eq:	CointEq1	
LNAUSTRIA_SA(-1)	1.000000	
LNGERMANY(-1)	-2.416728 (0.54232) [-4.45626]	
C	3.767258	
Error Correction:	D(P <sub>AUS</sub> )	D(P <sub>GER</sub> )
Speed of adjustment	-0.010627 (0.00322) [-3.30275]	0.014279 (0.00949) [ 1.50536]
D(P <sub>AUS</sub> (-1))	-0.178970 (0.06675) [-2.68101]	0.333223 (0.19679) [ 1.69332]
D(P <sub>AUS</sub> (-2))	-0.148675 (0.06773) [-2.19515]	-0.566570 (0.19966) [-2.83769]
D(P <sub>AUS</sub> (-3))	-0.098320 (0.06743) [-1.45801]	-0.500195 (0.19879) [-2.51618]
D(P <sub>AUS</sub> (-4))	-0.099454 (0.06469) [-1.53749]	-0.147368 (0.19069) [-0.77282]
D(P <sub>AUS</sub> (-5))	0.012428 (0.06455) [ 0.19253]	-0.012874 (0.19029) [-0.06766]
D(P <sub>AUS</sub> (-6))	0.114219 (0.06597) [ 1.73133]	0.011183 (0.19448) [ 0.05750]
D(P <sub>AUS</sub> (-7))	0.098130 (0.07258) [ 1.35198]	-0.003978 (0.21397) [-0.01859]
D(P <sub>AUS</sub> (-8))	0.042332	0.168170

	(0.08061) [ 0.52513]	(0.23763) [ 0.70768]
D(P <sub>AUS</sub> (-9))	0.024980 (0.08052) [ 0.31024]	0.362271 (0.23736) [ 1.52625]
D(P <sub>AUS</sub> (-10))	-0.108174 (0.08041) [-1.34525]	0.285960 (0.23705) [ 1.20634]
D(P <sub>AUS</sub> (-11))	-0.223024 (0.08074) [-2.76209]	0.325951 (0.23803) [ 1.36938]
D(P <sub>AUS</sub> (-12))	0.333601 (0.08103) [ 4.11702]	0.161101 (0.23887) [ 0.67443]
D(P <sub>GER</sub> (-1))	0.001347 (0.01829) [ 0.07366]	0.157004 (0.05392) [ 2.91164]
D(P <sub>GER</sub> (-2))	-0.014468 (0.01855) [-0.78005]	-0.038365 (0.05468) [-0.70168]
D(P <sub>GER</sub> (-3))	0.003364 (0.01846) [ 0.18221]	0.011552 (0.05443) [ 0.21222]
D(P <sub>GER</sub> (-4))	0.007926 (0.01833) [ 0.43250]	-0.015719 (0.05402) [-0.29097]
D(P <sub>GER</sub> (-5))	0.007313 (0.01861) [ 0.39297]	-0.014779 (0.05486) [-0.26938]
D(P <sub>GER</sub> (-6))	0.011278 (0.01866) [ 0.60440]	-0.013131 (0.05501) [-0.23872]
D(P <sub>GER</sub> (-7))	-0.001966 (0.01855) [-0.10598]	-0.005729 (0.05470) [-0.10474]

D(P <sub>GER</sub> (-8))	-0.008374 (0.01844) [-0.45414]	0.000198 (0.05435) [ 0.00364]
D(P <sub>GER</sub> (-9))	0.063622 (0.01833) [ 3.47175]	-0.034585 (0.05402) [-0.64020]
D(P <sub>GER</sub> (-10))	0.068360 (0.01872) [ 3.65240]	-0.042602 (0.05517) [-0.77213]
D(P <sub>GER</sub> (-11))	-0.018444 (0.01919) [-0.96106]	0.013641 (0.05657) [ 0.24111]
D(P <sub>GER</sub> (-12))	0.029311 (0.01875) [ 1.56354]	0.764172 (0.05526) [ 13.8278]
C	0.000617 (0.00062) [ 1.00085]	-0.001051 (0.00182) [-0.57812]

Table 1.C.5 Vector Error Correction Estimates for barley (1995:01-2004:12)

Error Correction:	D(P <sub>GER</sub> )	D(P <sub>AUS</sub> )
Speed of adjustment	0.063043 (0.05046) [1.24928]	-0.109280 (0.05966) [-1.83161]
D(P <sub>GER</sub> (-1))	0.541971 (0.10493) [ 5.16521]	0.305387 (0.12406) [ 2.46169]
D(P <sub>AUS</sub> (-1))	0.050180 (0.09868) [ 0.50853]	-0.001733 (0.11667) [-0.01485]

Table 1.C.6 Vector Error Correction Estimates for barley (1995:01-2004:12)

Error Correction:	D(P <sub>GER</sub> )	D(P <sub>FIN</sub> )
Speed of adjustment	0.147313 (0.03801) [3.87588]	-0.011666 (0.02679) [-0.43552]
D(P <sub>GER</sub> (-1))	0.660829 (0.08215) [ 8.04406]	0.529290 (0.05790) [ 9.14148]
D(P <sub>FIN</sub> (-1))	-0.084987 (0.10442) [-0.81390]	-0.061421 (0.07359) [-0.83459]

Table 1.C.7 Vector Error Correction Estimates for barley (1995:01-2004:12)

Error Correction:	D(P <sub>GER</sub> )	D(P <sub>SW</sub> )
Speed of adjustment	0.216457 (0.05133) [4.21707]	-0.063640 (0.04772) [-1.33371]
D(P <sub>GER</sub> (-1))	0.699600 (0.08666) [ 8.07289]	0.431634 (0.08056) [ 5.35786]
D(P <sub>SW</sub> (-1))	-0.105737 (0.09800) [-1.07899]	-0.124872 (0.09110) [-1.37073]

Table 1.C.8 Vector Error Correction Estimates for barley (1975:01-1994:12)

Cointegrating Eq:	CointEq1	
$P_{AUS}(-1)$	1.000000	
$P_{GER}(-1)$	-0.598883 (0.09587) [-6.24692]	
C	-1.423289	
Error Correction:	$\bar{D}(\bar{P}_{AUS})$	$D(P_{GER})$
Speed of adjustment	-0.037273 (0.01036) [-3.59706]	0.099145 (0.02928) [ 3.38587]
$D(P_{AUS}(-1))$	-0.139047 (0.06381) [-2.17907]	0.226207 (0.18032) [ 1.25448]
$D(P_{GER}(-1))$	-0.028750 (0.02082) [-1.38071]	0.494149 (0.05884) [ 8.39783]
C	0.000296 (0.00067) [ 0.44498]	-6.57E-05 (0.00188) [-0.03490]

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## ESSAY 2: SUBSIDIZATION OF THE BIOFUEL INDUSTRY: SECURITY VS. CLEAN AIR?

### 2.1 Introduction

Today, countries face critical decisions regarding both climate change mitigation and energy security. Agriculture will likely play a role both in reducing greenhouse gas emissions (GHG) and dependence on imported oil from economically and politically volatile areas since a range of crops can be used as inputs for the production of substitute biofuels. In addition to these two main benefits, there is a hope that a vibrant biofuel industry will contribute to rural development by creating new markets for agricultural commodities, expanding employment in the rural sector and increasing farm income.

In light of these developments, governments around the world are supporting the establishment of a biofuels industry. Biofuel production is expanding rapidly and it is at varying levels of development in different countries. In addition, governments heavily subsidize the industry since at the current level of industry development and historic

fossil fuel price levels, the cost of biofuels is still considerably greater than fossil fuel alternatives. In North America, the US and Canada possess very different motivations with respect to biofuel development. For the US, the key factor appears to be energy security, whereas within Canada increased use of biofuels is directly related to possible Kyoto commitments. Given these very different motivations, the optimal level of subsidies will likely be different in the two countries. This situation has the potential to create trade problems in the future.

If we assume that subsidizing development of the biofuel industry in the present is equivalent to buying an option on its use for future objectives – energy security or reduced GHG emissions – an economic model can be developed to examine whether or not the same government policy (subsidization) will yield different results (different level of subsidies) if the option is based on different current objectives. The theoretical model will be developed using financial option value theory, while optimal levels of energy subsidy will be generated using numerical simulations in future research. The possibility of trade problems and trade disputes over this issue will also be analyzed within the framework of current international trade law.

The chapter is organized as follows: in Section II, the characteristics of biofuel industry are presented with respect to the industries in Canada and US. In Section III, we conduct a brief literature review of option theory. The next section illustrates the results, followed by some potential empirical analysis. The paper will end with trade and policy implications and some concluding remarks.

## 2.2 Biofuels Market Characteristics

It is important to summarize the main characteristics of the biofuels industry in North America as the markets are at different levels of development in the US and Canada. By outlining the uncertainties that characterize the two markets and the main motivations of each country in developing its market, our impetus in studying and applying the real option theory for determining the optimal levels of subsidies that the governments should use in stimulating the market's development will be explained. Using data from the biofuels' market, the real option models will be quantified in future research and conclusions will be drawn about the main trade conflicts pertaining to biofuels that will be likely to appear in the near future. There are two primary types of biofuels: ethanol and biodiesel. Since production of biodiesel is currently far short of domestic requirements in both the US and Canada, this research will concentrate on ethanol market.

### 2.2.1 Ethanol Market

Fuel ethanol is a high octane, water-free alcohol produced from any biological feedstock that contains sugar, or any materials that can be converted into sugar (starch, cellulose). Most of the world's ethanol is produced from sugar cane or sugar beets. Fuel ethanol can be used by itself as a fuel, but, normally, it is blended with gasoline in concentrations of 5, 10 up to 85 percent (commonly known as gasohol). The most common blend contains 10 percent ethanol (E10). Ethanol is obtained through two production processes: wet milling and dry milling. The difference between the two methods of production lies in the initial treatment of the grain.

The two main advantages of using ethanol are, first, that it reduces the dependence on imports of foreign oil and, second, it has environmental benefits, including reduction of greenhouse gases and ground level ozone (Table 2.1). Other secondary advantages of ethanol are that it is completely biodegradable. As well, being renewable, it helps to conserve resources. Finally, it could lead to the creation of new markets for agricultural commodities, helping rural development by creating new jobs in rural sector and by increasing farm income.

Table 2.1 Emission reductions from ethanol blends

<b>Emission</b>	<b>Low-level blends (E10)</b>	<b>High-level blends (E85)</b>
Carbon Monoxide (CO)	25-30% decrease	25-30% decrease
Carbon Dioxide (CO <sub>2</sub> )	10% decrease	up to 100% decrease
Nitrogen Oxides (NO <sub>x</sub> )	5% increase/decrease	up to 20% decrease
Volatile Organic Carbons (VOC):		
Exhaust	7% decrease	30% or more decrease
Evaporative	-	decrease
Sulphur Dioxide (SO <sub>2</sub> ) and particulate matter	Decrease	significant decrease
Aldehydes	30-50% increase (but negligible due to catalytic converter)	-
Aromatics (Benzene and Butadiene)	Decrease	more than 50% decrease

Source: Canadian Renewable Fuels Association

At present, the major disadvantage of ethanol is its high production cost. Without being highly subsidized, an ethanol market would not exist. Even with a high level of support from federal and state/provincial governments, the cost of ethanol is higher than the price of gasoline. Simply put, ethanol produced from a grain feedstock using conventional conversion processes is not likely to compete with gasoline unless world oil price rises considerably. Other secondary disadvantages are its high volatility - limiting its use in hot weather, that it has lower energy content per litre than gasoline and that it has the

potential to impair engine operation and generate corrosion in fuel system components in the case of phase separation<sup>7</sup>.

There are varying estimates of the potential energy and GHG emissions impacts of ethanol. Assumptions pertaining to overall fuel production process efficiency, the type of process energy used, estimates of vehicle fuel economy, the types of GHG considered, the land use etc. differ (Table 2.2).

Table 2.2 Energy and GHG impacts of ethanol: estimates from corn and wheat to ethanol studies

	Feedstock	Ethanol production efficiency (litres/tonne of feedstock)	Fuel process energy efficiency (energy in/out)	Well-to-wheels GHG emissions: compared to base (gasoline) vehicle (per km traveled)	
				Fraction of base vehicle	% reduction
GM/ANL, 2001	Corn	372.8	0.50	n/a	n/a
GM/ANL, 2001	Corn	417.6	0.55	n/a	n/a
Pimentel, 2001/91	Corn	384.8	1.65	1.30	-30%
Levelton, 2000	Corn	470.0	0.67	0.62	38%
Wang, 2001	Corn-dry mill	387.7	0.54	0.68	32%
Wang, 2001	Corn-wet mill	372.8	0.57	0.75	25%
Levy, 1993	Corn	367.1	0.85	0.67	33%
Levy, 1993	Corn	366.4	0.95	0.70	30%
Marland, 1991	Corn	372.8	0.78	0.79	21%
Levington, 2000	Wheat	348.9	0.90	0.71	29%
ETSU, 1996	Wheat	346.5	0.98	0.53	47%
EC, 1994	Wheat	385.4	1.03	0.81	19%
Levy, 1993	Wheat	349.0	0.81	0.68	32%
Levy, 1993	Wheat	348.8	0.81	0.65	35%

Source: IEA, 2004

Niven (2005) reviews the literature on environmental impact of ethanol and he

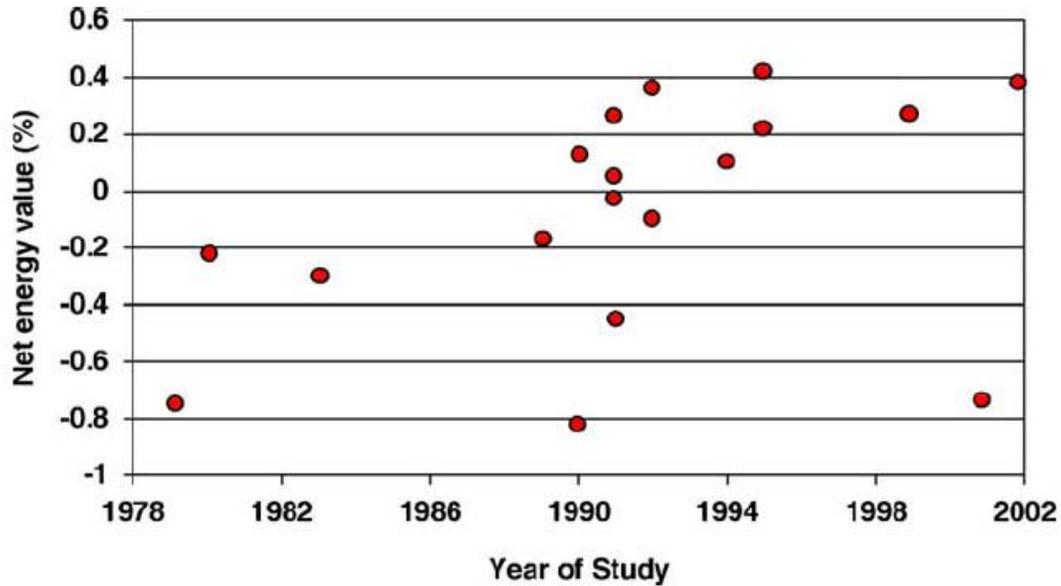
determined that E10 reduces GHG emissions only slightly, by 1% to 5%, when the

<sup>7</sup> The phase separation can occur if excessive water is absorbed by ethanol. The result would be a mixture of alcohol and water in the bottom of a fuel tank.

complete fuel life-cycle is considered, including ethanol production, transportation and combustion. Even E10 is slightly more environmentally friendly than pure gasoline, its reduced energy content leads to increased consumption of fuel, which results in an overall increase in GHG emissions. He points out as well that the choice of feedstock does not have an important impact on emission reductions. However, for E20, the GHG emission reductions are between 2% and 11%, while for E85, the reduction is substantial from 19% to 70%. Niven's (2005) review also suggests that ethanol production increases the risk of soil and groundwater contamination and the production of smog.

The net energy value of ethanol (NEV) is calculated as "its fuel energy minus the energy used for its production and transportation" (Niven, 2005, 11). Thus, Niven (2005) presents the results regarding the NEV of different studies sourced mainly from the US and mostly for ethanol produced from corn (Figure 2.1). Several studies have suggested that the energy balance is negative, with an upward trend of NEV over time, which might be the result of different assumptions or an improvement in the ethanol manufacturing process over time.

Figure 2.1 Net energy value of ethanol as a percentage of its fuel energy, showing results of many studies



Source: Niven, 2005

Another study by Pimentel (2003) has concluded that it takes 29% more energy to produce a gallon of ethanol than the content of energy in one gallon of ethanol, without taking into account energy needed to transport the ethanol. Other conclusions of Pimentel (2003) are that corn based ethanol causes greater soil erosion than the ethanol produced from other crops, it requires more nitrogen than other crops, thus contributing to groundwater contamination. A final criticism is related to the quantity of waste-water arising from the production of ethanol. However, the debate regarding the environmental benefits and energy balance of ethanol continues. Different assumptions, different crops, different researchers reach to different results.

In the US, the primary feedstock for ethanol is corn. Currently, there are 95 commercial ethanol plants in the US and other 33 under construction, with most of them concentrated

in the Midwest states (Olfert and Weseen, 2007). Production of ethanol increased from 175 millions gallons in 1980 to 3.5 billion gallons in 2004, 4.2 billion gallons in 2005 and 4.8 billion gallons in 2006 (RFA, 2005a). The increase in production can be explained by the high level of support offered by the US federal and state governments for the development of the industry, as well as through the ban on the use of MTBE (methyl tertiary-butyl ether) as a gasoline additive in some states (California, New York and Connecticut) as of January 2004 (the federal ban of MTBE was postponed for 10 years). Through the Energy Policy Act of 2005, programs and policies were created that are intended to increase and diversify domestic energy production. The 2005 Act includes a renewable fuels standard (RFS) provision, which requires a minimum amount of renewable fuel each year. This starts at 4 billion gallons in 2006, reaching 7.5 billion gallons in 2012. After this time, the production of renewable fuel is expected to grow at roughly the same rate as gasoline production (Duffield and Collins, 2006).

Currently, there is a federal tax exemption of 5.1 US cents per US gallon (1.34 US cents/litre) for ethanol/gasoline blends that are 10 percent ethanol. For lower ethanol blends, the tax exemption is reduced proportionally. Thus, the tax exemption for 1 US gallon of ethanol is 51 US cents (5.1 US cents per blended gallon). In 1998, the Federal tax exemption was 5.4 US cents per blended gallon and it was extended until 2008, but was reduced to 5.3 US cents per blended gallon in 2001, to 5.2 US cents in 2004 and 5.1 US cents in 2005. The tax exemption of 5.1 US cents per blended gallon was subsequently extended until December 2010. In addition to the subsidies that the government provides for biofuels, producers are protected from foreign competition

through tariffs. Thus, the US ad valorem tariff is 2.5% of the product value plus 54 US cents per gallon as a secondary duty (RFA, 2005b). The secondary duty is mostly targeted for the Brazilian imports of ethanol (Olfert and Weseen, 2007).

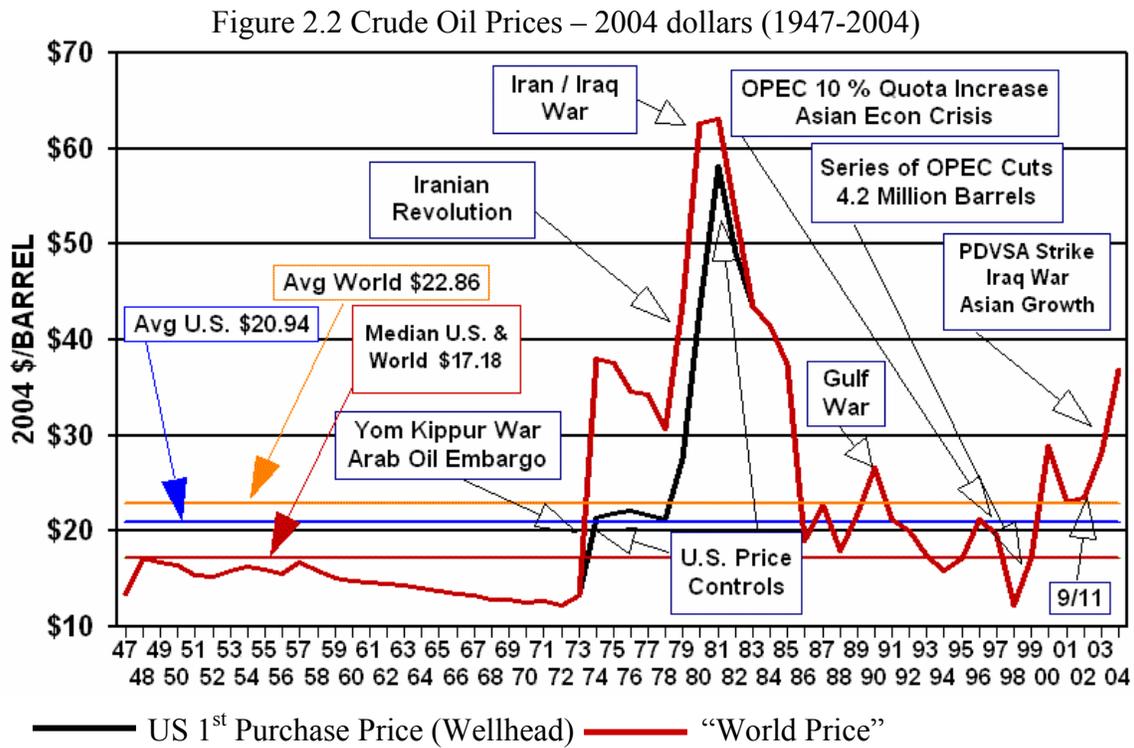
In addition to the federal tax exemption, at least 30 states have decided to subsidize the ethanol industry in different ways. The incentive for ethanol production ranges from 5 US cents/gallon to 30 US cents/gallon. At least three states, Minnesota, Montana and Hawaii, have ethanol consumption mandates (Olfert and Weseen, 2007). Another method is to offer an exemption from gasoline taxes when a blended product is sold. Direct subsidies to the producers of ethanol are also used. In addition, some states provide low-interest loans and require government vehicles to use ethanol. However, it was estimated that the total subsidies for ethanol production in the US amount to US \$2.5 billion per year (Olfert and Weseen, 2007). Differing reasons for providing subsidies to the ethanol industry are provided by state governments (i.e. rural development, supporting prices etc). These state level motivations differ from the principal rationale of the US government with respect to subsidizing the biofuels industry – energy security.

In different periods of time, various arguments have been offered to justify federal subsidization of alternative fuels. In the early 1970s, oil price and supply shocks were held responsible (Klass, 1995). In the 1980s, the “farm crisis” provided another argument for the development and use of corn-based ethanol (Duncan, 2004). The 1990 Clean Air Act Amendments (CAAA90) gave ethanol another boost because it can be used as a clean-air additive. To reduce the amount of carbon monoxide being released into the

environment, the US Congress mandated the use of oxygenated fuels. The oxygen level from gasoline is increased if it is blended with methyl tertiary butyl ether (MTBE) or with ethanol. While ethanol is more expensive than MTBE, the level of oxygen that is produced by ethanol in gasoline is twice the level of oxygen produced by MTBE. Thus, ethanol competes with MTBE for the wintertime oxygenate market. Recently, research has shown that MTBE can contaminate the ground water and, as a result, some states banned the use of MTBE. One problem is that most of the production of ethanol takes place in the US Midwest and the greatest use of oxygenated fuels is in the large metropolitan areas on the east and west coasts. Ethanol has to be transported by rail and blended at the location of use, which increases the costs of using it. Rask (1998) estimated the supply and demand for ethanol in the US for the period 1984-1993. He showed that without the high level of support from the government, high transport costs make ethanol less competitive in these clean-air markets. He concluded that US corn based ethanol will not play an important role as a clean-fuel.

In this century, oil price shocks are again being used as an argument for the development of a steady supply of alternative fuels. It is well known that oil prices have been characterized by high volatility over the last 25 years. In this period, the price of crude oil increased considerably compared with the late 1990s. Crude oil prices have been between \$22 and \$28 per barrel for the OPEC basket price for most of 2003, reaching an average expected level of \$27 per barrel in 2004 (Figure 2.2). However, in August 2005, the price of oil rose to over \$60/barrel; during 2006 the price of oil was relatively stable, while in

early 2007 it had fallen to between \$50 and \$60/barrel, followed by an increase to \$92/barrel in October 2007.



Source: WTRG Economics

This behavior is the result of numerous unforeseen natural, economic and political events: a sudden decrease of the Venezuelan exports of oil because of the Chavez regime, internal conflict in Nigeria and the war in Iraq. Even if the first two situations that created the boom in prices are over, the crude oil price is not expected to decrease because of low oil inventories, increasing consumption in Asia and instability in Iraq (EIA). Some other reasons for the oil price increase starting in 2005 were North Korea’s missile launches, the crisis between Israel and Lebanon, the US concern about the Iranian nuclear energy and a decline in petroleum reserves.

Furthermore, increases in the price of oil are not typically a long-term phenomenon, because high real prices deter consumption of oil, increase the consumption of other energy sources and spur investments in finding new sources of fossil fuels.

According to the US EIA, US dependency on foreign oil is estimated to grow from 62% in 2002 to more than 77% by 2025. Two thirds of the US petroleum demand was used in the transportation sector in 2002, and projections show that this percentage will increase. And while the domestic supply of oil in US currently follows a decreasing trend, imports are increasing. US oil reserves declined from 39 billion barrels in 1970 to 22.7 billion barrels at the end of 2002. Domestic oil production is estimated to decrease further from 9.2 million barrels per day in 2002 to 8.6 million barrels per day in 2025, while oil consumption is expected to rise from 19.6 million barrels per day in 2002 to 28.3 million barrels per day in 2025. This decline of US oil reserves and the projected increases in US demand for oil make it difficult for the US to increase energy security by using domestic oil supply (US Department of Energy).

Terrorist activity and political instability for some major world producers of oil are raising questions about the security of oil supply in the US. The US does not currently have any control over oil supply disruptions and oil price volatility. In order to keep a stable imported oil supply, the US relies on its diplomatic efforts and at times military actions. Political analysts have concluded that keeping an uninterrupted oil supply from the Persian Gulf, costs the US annually from \$0.5 to \$70 billion. To this amount, should be added the cost of the actual military action in the Persian Gulf: in 1990, the US

military action in Persian Gulf cost \$61 billion not to mention significant loss of life (US Department of Energy).

“President George W. Bush has stated, ‘...America cannot have homeland security without energy independence’” (Dinneen, B., RFA President)<sup>8</sup>. Reducing the transportation sector’s reliance on oil, in particular, and improving vehicle fuel efficiency using biofuels, would reduce the demand for imported oil (by an estimated 1.6 million barrels by 2012) and also energy dependency on a politically volatile part of the world (Renewable Fuel Association, 2004 – RFA). Thus, while biofuels cannot eliminate US oil dependence anytime soon, the increasing production of biofuels would reduce this dependence and improve national response to oil supply disruptions.

In Canada, the development of the fuel ethanol industry has been far slower than in Brazil or the US. In Canada, ethanol is obtained from corn (73%), wheat (17%), barley (3%) and agricultural and forestry waste (7%).

Canada is a net exporter of petroleum based fuels and, as a result, does not have an energy security motivation for promoting biofuels. The domestic production of oil increased from 1.8 million barrels per day in 1980 to 3.1 million barrels per day in 2004, while the consumption of oil increased from 1.9 million barrels per day in 1980 to 2.3 million barrels per day in 2004. In 2004, Canada was the world’s seventh-largest oil producer and consumer (EIA). However, in 2006, the overall production of Canadian oil

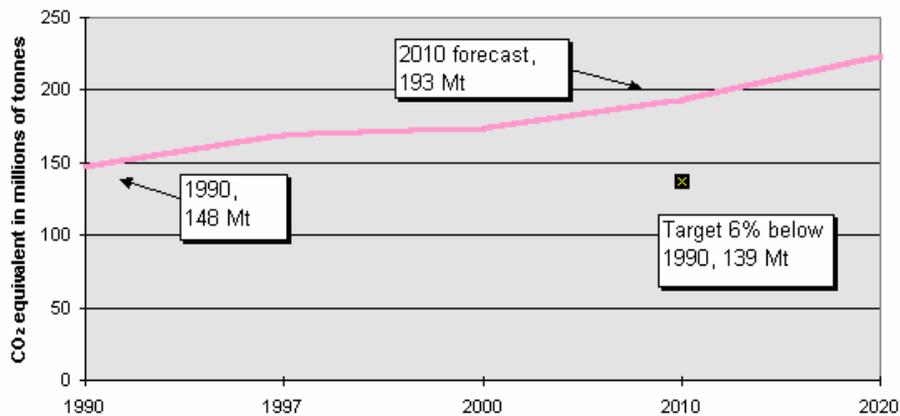
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<sup>8</sup> “Small producer credit amendment sought in economic stimulus bill”, <http://www.ethanolrfa.org/ereports/er102401.html>

was about 1.2 gigabarrels, imports amounted 0.44 gigabarrels, consumption 0.8 gigabarrels, while exports to the US were 0.84 gigabarrels. In January 2007, proven oil reserves in Canada were estimated at 179.2 gigabarrels, after the oil sands deposits in Alberta were recognized as oil reserves. Thus, Canada was placed second in proven reserves after Saudi Arabia, and the largest supplier of oil to the US.

In December 2002, however, the Government of Canada ratified the Kyoto Protocol. Under Kyoto, Canada has agreed to a GHG emissions reduction target of 6 percent below 1990 levels during the period 2008 to 2012. This means Canada was committed to reduce 240 megatons of GHG emissions (Figure 2.3).

Figure 2.3 Canada's GHG emissions



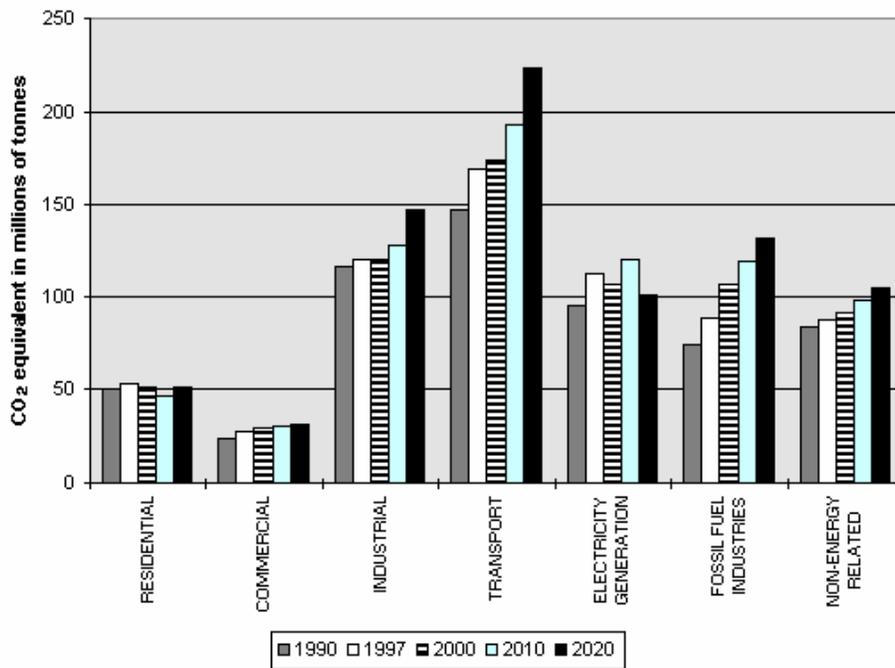
Source: Transport Canada (1999)

To support the ratification decision, the Government of Canada released a report entitled “*Climate Change Plan for Canada*” as a framework for action. During 1997 -2002, the Government of Canada initiated a series of activities targeting the reduction of GHG emissions, including *Action Plan 2000*. *Action Plan 2000* proposed to achieve 65

megatons GHG emissions reduction per year during the commitment period 2008-2012.

Figure 2.4 outlines Canada’s GHG emissions converted to CO<sub>2</sub> equivalents by sector. For instance, the transportation sector is expected to account for 10% of the total reduction (Government of Canada). The 2003 federal budget committed \$2 billion to climate change, of which \$1.3 billion was allocated to a series of concrete environmental policy measures to be implemented by the summer 2003.

Figure 2.4 Kyoto Protocol implications transport sector GHG emissions projections: 1990-2020



Source: Transport Canada, 1999

In order to reduce GHG emissions to the specified level, the government planned to increase the production and consumption of ethanol. Table 2.3 shows the production capacity for ethanol in Canada.

Table 2.3 Ethanol production in Canada

Plant Name	City	Province	Feedstock	Capacity
Permolex	Red Deer	AB	Wheat	40,000,000 L
Husky Energy	Lloydminster	SK	Wheat	130,000,000 L
Terra Grain Fuels*	Belle Plain	SK	Wheat	150,000,000 L
Poundmaker	Lanigan	SK	Wheat	12,000,000 L
NorAmera Bioenergy	Weyburn	SK	Wheat	25,000,000 L
Husky Energy	Minnedosa	MB	Wheat	10,000,000 L
Husky Energy*	Minnedosa	MB	Wheat	130,000,000 L
Iogen	Ottawa	ON	Wheat Straw	2,000,000 L
IGPC*	Aylmer	ON	Corn	150,000,000 L
Greenfield Ethanol*	Hensall	ON	Corn	200,000,000 L
Greenfield Ethanol	Tiverton	ON	Corn	26,000,000 L
Greenfield Ethanol	Chatham	ON	Corn	150,000,000 L
Greenfield Ethanol*	Johnstown	ON	Corn	200,000,000 L
Greenfield Ethanol	Varennes	QC	Corn	120,000,000 L
Collingwood Ethanol*	Collingwood	ON	Corn	50,000,000 L
Suncor Energy	St. Clair	ON	Corn	200,000,000 L

\* plant currently under construction

Source: Canadian Renewable Fuels Association

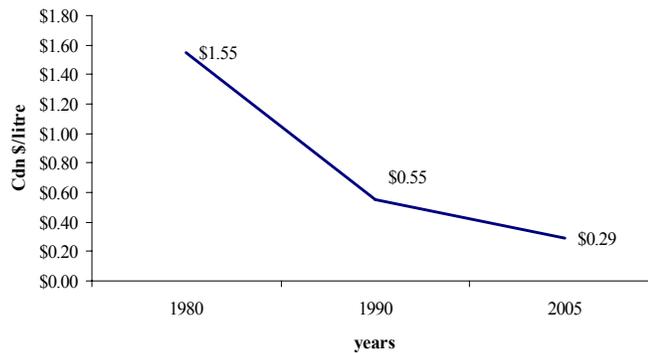
As can be seen, most of ethanol is produced in Ontario and Saskatchewan. On July 15, 2002, the Saskatchewan's Ethanol Fuel Act mandated the use of ethanol: starting with July 1, 2004, fuel volumes must contain 2.5% ethanol, reaching a percentage of 7.5 by April 2005 and the distributors must purchase 30% of ethanol from small plants. Further, in Manitoba the Biofuel Act mandates that by September 2005, 85% of the gasoline sold in the province should contain 10% ethanol (Berg, 2004).

In terms of consumption, to reach the Kyoto commitments, E10 blends have to reach 35% market penetration by 2010, which represents 1.33 bln litres per year. With 40% CO<sub>2</sub> reduction from grain ethanol, this equals the replacement of 1.33 megatons of CO<sub>2</sub>,

which represents approximately 0.5% of the total reduction that Canada is committed to achieve (Berg, 2004).

Even if ethanol production became more efficient over the years, it is still not likely to be price competitive with the gasoline without a high level of support from the federal and provincial governments. In 1991, the cost of producing ethanol dropped to 35% of the 1980 level and, in 2000s, the price is in the range of \$0.35-\$0.45/litre (Figure 2.5).

Figure 2.5 Ethanol production cost



Source: Climate Change Saskatchewan

The federal government supports the development of the ethanol industry through a variety of measures (Climate Change Saskatchewan). These include R&D programs for market development of technologies; \$0.10 CAD/litre tax exemption for the ethanol portion of blended gasoline; the use of ethanol by federal government vehicles and Future Fuels initiatives, with an increase of 750 million litres in Canada's annual capacity to produce ethanol, yielding a 25% increase of Canada's total gasoline supply containing 10% ethanol. Another major initiative of the federal government is the Ethanol Expansion Program (EEP) that was initiated in August 2003. The EEP program supports

the development of the ethanol industry in different ways: \$140 million as contingent loan guarantees, \$100 million as direct financing to production facilities, \$3 million for public awareness and mandated usage (Klein et al, 2004). The federal government encouraged farmers' participation in ethanol production with \$200 million under the Capital Formation Assistance Program and it invested in R&D \$145 million under the Agricultural Bioproducts Innovation Program, both initiated in 2006. Also, the 2007 Federal Budget allocated \$2 billion over 7 years to support biofuels production, while the 2008 Federal Budget gave \$10 million over 2 years for R&D on biofuels emissions. Except the support for the producers, the federal government implemented a consumption mandate of 5% renewable content (ethanol) by 2010.

Provincial support in Canada depends on the goals of each province. For instance, Saskatchewan and Manitoba are interested in developing their rural economies, while British Columbia wants to stimulate the production of cellulose-based ethanol using forest wastes. Alberta, on the other hand, has shown little interest in the ethanol industry due to the size of the provincial conventional reserves (Klein et al, 2004). Thus, not all Canadian provinces have reductions of GHG emissions as an objective for providing support to the biofuel industry. Except for the fuel tax exemptions at the provincial level outlined in Table 2.4, provincial governments support the development of the industry through mandated usage regulations and financial contributions for ethanol start-ups.

Table 2.4 Tax exemption for fuel ethanol by province

Govt.	Provincial fuel tax exemptions (cents/litre)	Eligibility for the subsidy	Duration
AB	9.0	No restriction on ethanol source	5 years after the start-up of an ethanol production plant
BC	14.5	For E85 to E100 and E5 to E25. Ethanol must be produced in BC	-
ON	14.7	No restriction on ethanol source	Until 2010
SK	15.0	Ethanol must be produced and consumed in SK	5 years
QC	16 to 20 (under project)	Ethanol must be produced in QC	1999-2012
MN	20.0 until Aug. 2007 15.0, Sept. 2007-Aug. 2010 10.0, Sept. 2010-Aug. 2013 (also, 1.5 cents/litre excise tax reduction for gasoline blended with 10% MN-made ethanol)	Ethanol must be produced and consumed in MN	No duration specified
Federal	10.0	No restriction on ethanol source	No duration specified

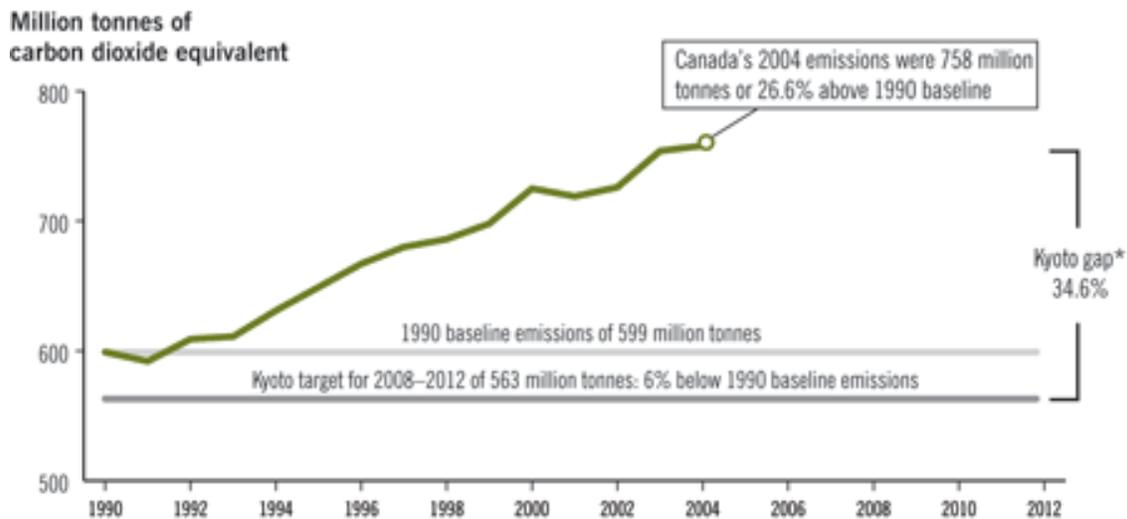
Source: Klein et al, 2004

The development of the ethanol market in Canada is still impeded by important interprovincial barriers to trade that are the result of provincially competitive programs. For example, the only ethanol plant in AB would export almost all its production to the US, as SK's tax exemption applies only to ethanol produced and consumed in SK. On the other side, SK's ethanol is sold in AB, as AB does not have any restriction on the ethanol source. The only two provinces that do not have any restriction on the source of ethanol are AB and ON, but this might change if they would follow the example of the other provinces that protect their industry. At the national level, domestic producers are protected against the ethanol imports by a tariff of 19 US cents per gallon (RFA, 2005b).

However, in 2006, the new conservative government realized that Canada is not able to respect its Kyoto commitments and, in fact, Canada's GHG emissions are nearly 33%

above 1990 levels. In absolute terms, Canada emits approximately 747 Mt CO<sub>2</sub> per year and the Kyoto commitment would see this capped at 596Mt (Environment Canada, 2007).

Figure 2.6 The gap between Canada's greenhouse gas emissions and its Kyoto target is growing



Source: Office of the Auditor General of Canada

Thus, the government came up with a “made-in-Canada” approach to reduce emissions (2 billion over 5 years), which includes Canada’s Clean Air Act (CAA). CAA proposes changes to three existing federal acts: Canadian Environmental Protection Act (CEPA), which includes regulations related to indoor and outdoor air pollutants and GHG; it establishes, monitors and reports air quality objectives; regulates the blending of fuels, which represents a step towards meeting the 5% renewable fuel content in motor fuels by 2010; Energy Efficiency Act (EEA), under which energy efficiency standards and labeling requirements are set for a wide range of consumer and commercial products; and Motor Vehicle Fuel Consumption Standards Act, under which the government sets

mandatory fuel consumption standards. The CCAA does not have short-term commitments, but the long-term one is an absolute reduction in GHG between 45-65% from 2003 levels by 2050.

In sum, the basic arguments used to justify a high level of governmental support for the development of an ethanol market in Canada are, first of all, environmental targets that need to be reach and, second, rural development and the need for new markets for agricultural products.

### 2.3 Investment strategies and real options

Under certainty, there is no option value. Thus, a decision to invest can be made based on a simple Net Present Value (NPV) rule - invest when the present discounted value of the investment is greater than or equal to the investment cost. Traditional valuation methods in capital budgeting, as NPV and other discounted cash flow (DCF) techniques, are developed based on value maximization in a world without uncertainty and flexibility.

In reality, however, investment decisions have three important characteristics that fall outside the applicability of DCF (Dixit and Pindyck, 1994). Investments are often partially or completely irreversible - the cost of investment is partially sunk; investments are often undertaken under uncertainty over the future rewards; and investments can typically be postponed to get more information. The latter means that even a project with a negative NPV can be valuable as long as the investment can be postponed and new favorable information can arrive.

### 2.3.1 Real options and financial options

By definition, a financial option gives the owner the right, but not the obligation to sell (put option) or to purchase (call option) a security at a specified price (strike price) during a specified period of time. The seminal work of Black and Scholes (1973) first analyzed the valuation of financial options. The Black-Scholes formula prices an European put or call option (meaning the option can be exercised only on the expiration date) on a stock that does not pay a dividend, and Black-Scholes assumes that the stock price follows a geometric Brownian motion<sup>9</sup> with constant volatility. One other important assumption of this model is that the underlying asset is tradable, allowing for the use of risk-neutral valuation.

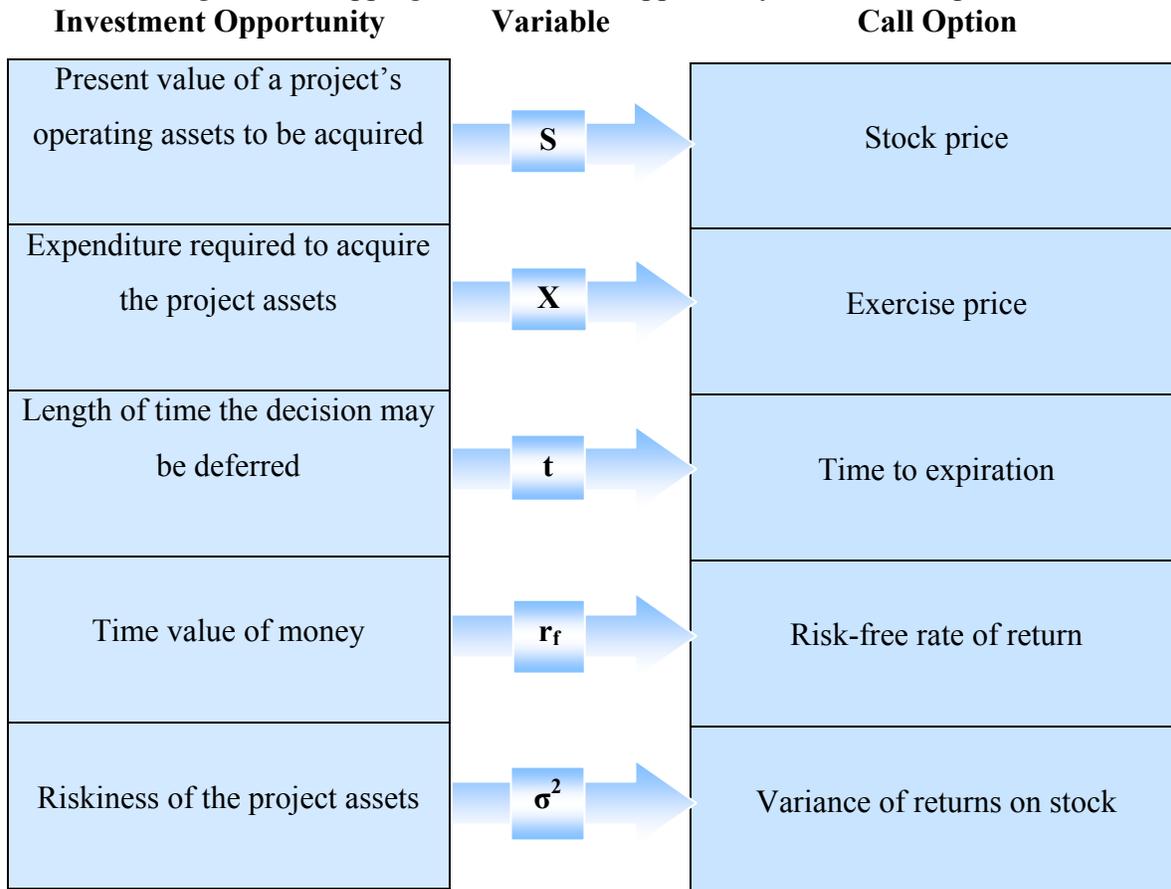
Subsequent research has shown that the same basic definition of an option can be applied to other situations that do not involve the use of a financial asset. Thus, a firm that has the opportunity to invest holds an option, which is similar to a financial option. It possesses the right, but does not have an obligation to buy or sell an asset at some future time.

When firms make an irreversible investment, they give up the possibility of waiting for new information, which might affect the desirability and timing of the expenditure. This lost option is an opportunity cost that should be included in the cost of investment.

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<sup>9</sup> Dixit and Pindyck (1994)

Figure 2.7 Mapping an Investment Opportunity onto a Call Option



Source: Luehrman, T.A. (1998)

Such non-financial options are called “real options”, stressing the strong link with financial options (Figure 2.7). The value of a real option increases as the stock price ( $S$ ), time to expiration ( $t$ ), risk-free rate of return ( $r_f$ ) and variance of returns ( $\sigma^2$ ) increase, and the exercise price ( $X$ ) decreases.

As discounted-cash-flow (DCF) approaches (e.g. NPV) applied in investment projects cannot capture the value of management having the flexibility to revise decisions according to the changes and uncertainty that characterize the marketplace, returns from the projects will most probably differ from what management expected. As new

information arrives, management should be able to adapt to the conditions and to react accordingly to minimize losses, so managerial flexibility in this manner is very important in an investment. Trigeorgis (1993) defines managerial flexibility as a collection of real options - the option to defer, to abandon, to contract, to expand or to switch the investment.

Table 2.5 describes the most common categories of encountered real options and the industries for which they have been found useful.

Table 2.5 Common Real Options

<b>Category</b>	<b>Description</b>	<b>Important in</b>
<b>Option to defer</b>	Management holds a lease on (or an option to buy) valuable land or resources. It can wait (x years) to see if output prices justify constructing a building or plant, or developing a field.	All natural resource extraction industries; real estate development; farming; paper products.
<b>Time to build option (staged investment)</b>	Staging investment as a series of outlays creates the option to abandon the enterprise in midstream if new information is unfavorable. Each stage can be viewed as an option on the value of subsequent stages, and valued as a compound option.	All R&D intensive industries, especially pharmaceuticals; long-development capital-intensive projects, e.g., large-scale construction or energy-generating plants; start-up ventures.
<b>Option to alter operating scale (e.g., to expand; to contract; to shut-down and restart)</b>	If market conditions are more favorable than expected, the firm can expand the scale of production or accelerate resource utilization. Conversely, if conditions are less favorable than expected, it can reduce the scale of operations. In extreme cases, production may temporarily halt and start up again.	Natural resource industries such as mine operations; facilities planning and construction in cyclical industries; fashion apparel; consumer goods; commercial real estate.
<b>Option to abandon</b>	If market conditions decline severely, management can abandon current operations permanently and realize the resale value of capital equipment and other assets in secondhand markets.	Capital intensive industries, such as airlines and railroads; financial services; new product introductions in uncertain markets.
	If prices or demand change,	<i>Output shifts:</i>

<p><b>Option to switch (e.g., outputs or inputs)</b></p>	<p>management can change the output mix of the facility (“product” flexibility). Alternatively, the same outputs can be produced using different types of inputs (“process” flexibility).</p>	<p>any good sought in small batches or subject to volatile demand, e.g., consumer electronics; toys; specialty paper; machine parts; autos. <i>Input shifts:</i> all feedstock-dependent facilities, e.g., oil; electric power; chemicals; crop switching; sourcing.</p>
<p><b>Growth options</b></p>	<p>An early investment (e.g., R&amp;D, lease on undeveloped land or oil reserves, strategic acquisition, information network/infrastructure) is a prerequisite or link in a chain of interrelated projects, opening up future growth opportunities (e.g., new generation product or process, oil reserves, access to new market, strengthening of core capabilities). Like interproject compound options.</p>	<p>All infrastructure-based or strategic industries, especially high-tech, R&amp;D, or industries with multiple product generations or applications (e.g., computers, pharmaceutical); multinational operations; strategic acquisitions.</p>
<p><b>Multiple interacting options</b></p>	<p>Real-life projects often involve a “collection” of various options, both upward-potential enhancing calls and downward-protection put options present in combination. Their combined option value may differ from the sum of separate option values, i.e., they interact. They may also interact with financial flexibility options.</p>	<p>Real-life projects in most industries discussed above.</p>

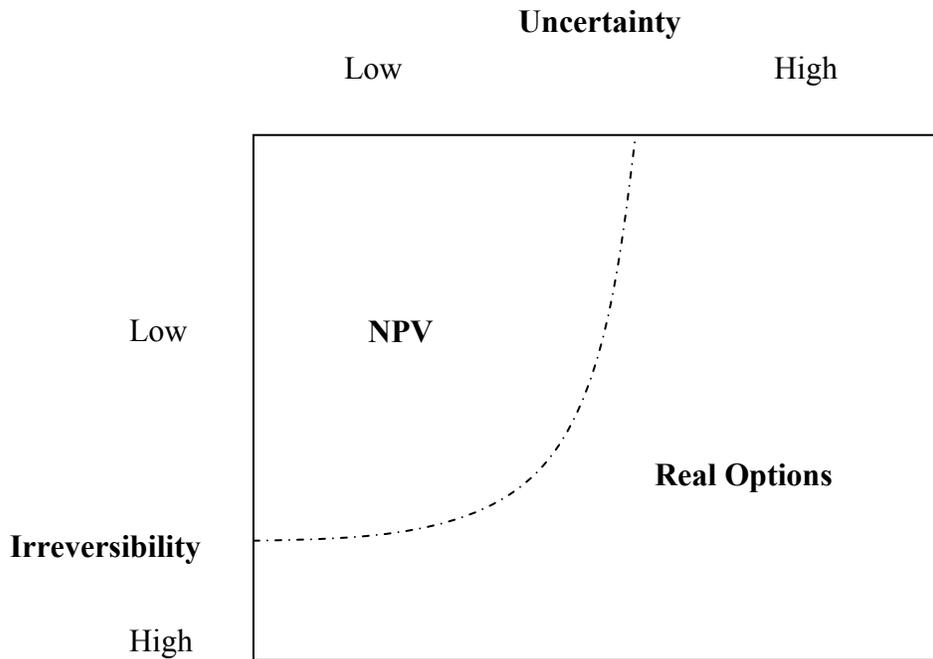
Source: Trigeorgis (2001)

Most of the literature focuses on the boundaries between real options applications and the NPV method. For investment choices characterized by high uncertainty and irreversibility, real options valuation provides a better characterization of the investment decision than an NPV calculation as the former takes into account the possibility of delaying the investment (Figure 2.8).

Less literature concentrates on the boundaries between real options applications and path-dependent investments. According to Adner and Levinthal (2004), activities can be

characterized as real option processes only when the target market and the technical agenda are fixed. Otherwise, investments fit more the characteristics of path-dependent processes such as probe and learn, incremental search and innovation journeys.

Figure 2.8 Boundaries of applicability for Net Present Value and Real Options

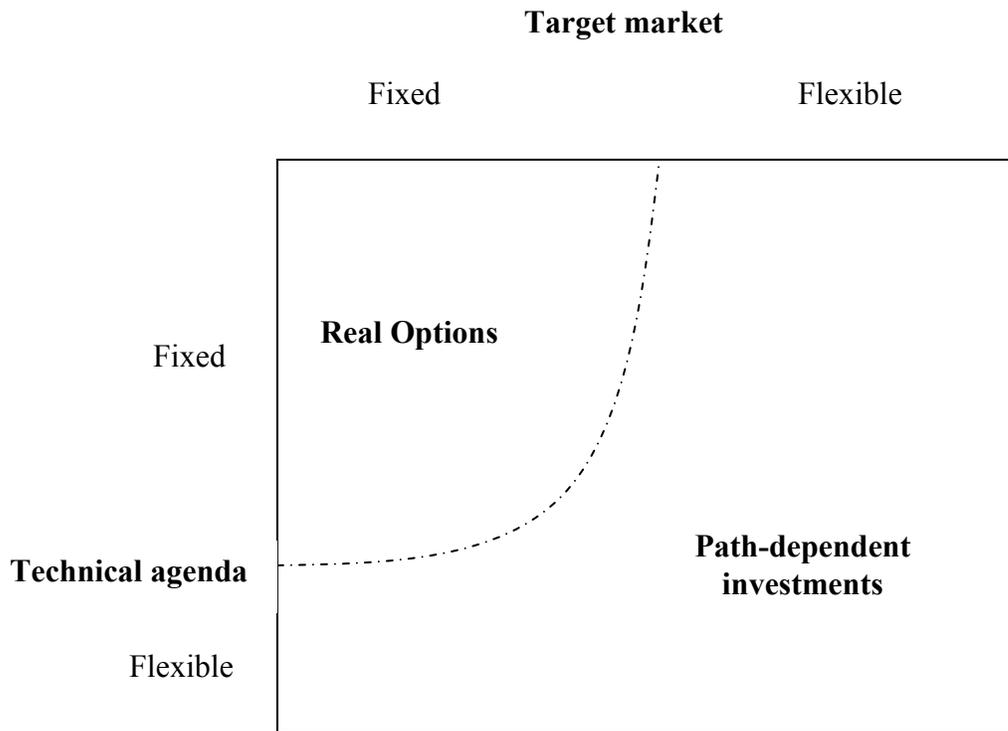


Source: Adner and Levinthal (2004)

Therefore, a real option application would characterize situations where all the opportunities are fixed a priori, before the project begins and, thus, the possibility to abandon the investment is clearly articulated (Figure 2.9). The possibility of abandonment gives the investment's flexibility. Thus, as the abandonment decision is less clearly defined, the flexibility of the investment is less valid. The authors consider that the project abandonment is more complicated by the organizational resource allocation and by the different incentives stakeholders have at different levels of organization.

On the other side, McGrath, Ferrier and Mendelow (2004) consider that there is no advantage in differentiating the path-dependent and the real option investments and, in fact, they are complementary processes. They take into account four definitions of real option: option value as a component of the firm's total value; an investment proposal with optionlike characteristics; choices that may fit different proposals; and options used as strategies. This is the first criticism that their paper brings to Adner and Levinthal's (2004) research, which concentrates only on one definition of real options: a project in isolation from the other firm's resources.

Figure 2.9 Boundaries for applicability for Real Options and Path-Dependent Opportunities



Source: Adner and Levinthal (2004)

However, the main difference between the two papers is that McGrath, Ferrier and Mendelow (2004) consider that a project's flexibility is given by other characteristics (and not only by the choice of abandoning the project), such as "changing scale or designing for different latter usage" (p. 90). By specifying the abandonment criteria a priori, it is considered that knowledge does not evolve and there is no learning. Also, flexibility involves the consideration of different courses of action, one of which can be exit as well, but not a specification in advance of success or failure. One other important distinction between the two papers is that Adner and Levinthal (2004) consider that endogenous to the firm's uncertainty, which is called by Dixit and Pindyck (1994) "technical uncertainty", creates the pressure to invest and not to wait for new information, and, thus, it should not be treated as a real option process. On the other side, McGrath, Ferrier and Mendelow (2004) outline the fact that both conditions, "wait and see", which characterizes exogenous uncertainty, and "act and see", which shows endogenous uncertainty, are determinants of the economic outcomes and are important for the development of the real options.

### 2.3.2 Literature review

Option value theory has led to a rich literature pertaining to empirical applications that analyze investment opportunities. The method has been utilized in a number of studies of the environment and in agriculture. Purvis et al (1995) examined the adoption of free-stall dairy housing for Texas producers, using stochastic milk production and feed costs. Khanna et al (2000) studied the adoption of site-specific crop management under stochastic output prices and expectations of declining fixed costs of the equipment, while

Isik (2004) analyzed the impact of the uncertainty in cost-share subsidy policies on the adoption of site-specific technologies. With respect to energy policy, Hasset and Metcalf (1995) analyzed residential energy investments considering that the energy prices follow a Brownian motion, while Millock and Nauges (2004) estimate an option value model on a firms' actual abatement choice, with the major uncertainty facing the firm being the future energy price.

The investment problem studied here can be included in a category of real options referred to by Trigeorgis (2001) as a time to build option (staged investment). This is important for R&D intensive industries and long-development capital-intensive projects. The development of a new market (e.g. biofuel market) has the following three characteristics: 1) decisions and cash outlays take place sequentially over time; 2) there is a maximum rate of investment; and 3) there are no returns until the project is completed (Majd and Pindyck, 1987).

This work builds on several related studies in the real options literature. Roberts and Weitzman (1981) constructed a model of a "sequential development project" (SDP) which has the same features outlined above. By their definition, the project can be stopped in any stage and as the investment takes place, the cost of completing the project and its uncertainty (variance) are reduced. These authors derive an optimal sequential decision rule for R&D or exploration projects and they show that even if NPV is negative, the investor should go ahead with the first stages of the project. Weitzman, Newey and Rabin (1981) apply the sequential methodology to examine whether the

development of liquid synthetic fuels from the coal market should be subsidized by the US government. McDonald and Siegel (1986) considered a basic model of irreversible investment with two stochastic variables, each of which evolves in geometric Brownian motion - the sunk cost and the value of the project. Their results show that the optimal investment in this case is reached by waiting until the benefits are twice the investment cost.

Grossman and Shapiro (1986) studied optimal dynamic R&D investments considering that the total effort to reach a payoff is unknown. Their work concentrates more on the rate of investment rather than the decision to invest or not, considering that the rate of progress is a concave function of effort. They model the uncertainty in returns as a Poisson process with the arrival rate as a function of the cumulative effort expended. They find that when uncertainty is introduced in the model, firms prefer risky projects rather than the safe ones when both have the same level of expected cost of effort.

Majd and Pindyck (1987) determine an optimal investment rule for a sequential investment, when a firm can invest at a maximum rate, and the value of the project follows geometric Brownian motion. An important characteristic of their model is that expenditure flow can be adjusted as new information arrives. They show that the largest effects of time to build appear when uncertainty is very high, the opportunity cost of delay is high and when the maximum rate of investment is low.

Emery and McKenzie (1996) evaluated the subsidy granted to the Canadian Pacific Railway (CPR) from an “ex ante” perspective. They considered that the “ex post” studies which concluded that the subsidy was too large are limited by ignoring the uncertainty that existed at that time. They employed a real option approach to see the importance of timing in “once-and-for-all” investment decisions in an uncertain environment. They concluded that the “ex-ante” value of the subsidy is lower than the required level that it is necessary to compensate the company for forgoing its investment options and, also, the value of the subsidy is lower as the income stream becomes riskier.

Finally, Schwartz and Moon (2000) analyzed investment in R&D (the development of a new drug) considering three sources of uncertainty - uncertainty about investment cost, future payoffs and the possibility that a catastrophic event can stop the project. Their findings describe not only the value of the project, but also the optimal values for the state variables at which the investment should proceed.

The study that has inspired this research is “Investments of uncertain cost” by Robert S. Pindyck in 1993. Pindyck (1993) exploited the same idea as in Majd and Pindyck (1987) with the exception that the cost of completing the project is uncertain as opposed to the value of the project. An extension of the paper considers the situation where both, the value of the project and the cost of investment, are characterized by uncertainty. Except for the uncertain cost, the investment is also considered irreversible, meaning that the investment cost is sunk. Thus, in his study, Pindyck (1993) determines a decision rule for irreversible investments given the cost uncertainty and allowing for the possibility of

abandoning the project midstream. He considered that the cost of completing the project includes two different kinds of uncertainty - technical uncertainty, which is related to the physical difficulty of completing the project, and this type of uncertainty can be solved only by undertaking the project; and input cost uncertainty, which is external to what the firm does and it is highly nondiversifiable as it might be related to the general economic activity. He makes clear that even both types of uncertainties increase the investment opportunity value, technical uncertainty makes investing more attractive<sup>10</sup>, while input uncertainty has the opposite effect<sup>11</sup>. The optimal investment rule is found using contingent claim analysis as the cost's risk can be spanned by the existing assets. The optimal investment rule is that the investment should be undertaken as long as the cost of investment is below a critical number. The critical cost level and the investment value opportunity are found as solutions of the sequential real option problem. By numerically solving the real options model, Pindyck (1993) has concluded that for large industrial projects, input cost uncertainty is important, while technical uncertainty does not play a major role. For these types of projects, increasing input cost uncertainty will lead to investment reductions. On the other hand, for R&D projects, the opposite is true, meaning that technical uncertainty plays an important role. Pindyck (1993) applies the model for a specific example: the decision to build a nuclear power plant in the context of very uncertain market conditions (late 1982, 1983). In order to estimate the expectation, variance and variance decomposition of cost, Pindyck (1993) used the Tennessee Valley

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<sup>10</sup> Even a project with a negative NPV value can still be economically viable as only by investing, the information about costs will be revealed and, thus, there is a shadow value that reduces the expected cost of investment (the same idea with a shadow value of production from a learning curve). There is no value of waiting.

<sup>11</sup> Even a project with a positive NPV value can still be uneconomically viable as the input costs might change and there is a value of waiting for new information.

Authority (TVA) survey data on individual nuclear plant costs and a cross-section regression published by Perl (Pindyck, 1993). His results show that both types of uncertainty should be taken into account, but the input cost uncertainty has greater effect on the investment decision.

#### 2.4 A Real Option Model of Biofuel Investment by Government

To our knowledge, there is only one prior study, Emery and McKenzie (1996), which uses a real option valuation model to assess a governmental policy. Their study is more simplistic, as they consider uncertainty only over the investment's future returns. Further, existing environmental policy analyses study the behavior of firms in those cases when investments have environmental benefits.

To start, a subsidy for the biofuel industry is considered as a normal investment that is undertaken by the government, and not by a firm. The goal of government in this case is to maximize the investment value of the project. We note that we do not consider any benefits that agricultural support programs could bring to producers and consumers through increased crop prices or employment. Therefore, this model will capture only the primary motives sought after by respective governments - environmental benefits (Canada) and decreased energy dependence (the US).

At a given period of time, the value of government investment is measured by the increase in the project value due to the new investment. Assuming that without subsidy there will be no market for biofuels, the investment value associated with the biofuel

industry in the case of no subsidy will be 0. The investment value would appear as in Eq. 2.1.

$$V(I) = P * Q - wx - \tilde{S} + O * y + D(y)^{12} \quad (2.1)$$

where,

V(I) = investment value in a certain time period;

P = the price of biofuels without subsidy;

Q = the quantity consumed of biofuels;

w = per unit cost of inputs;

x = input quantity used in producing the biofuels;

$\tilde{S}$  = the total subsidy used by governments to help the industry;

O = the unit price of oil;

y = the quantity of oil that is replaced by biofuels;

D = environmental benefit function.

Before describing the real option model, it is important to outline why an NPV analysis would not lead to the correct result. As it was mentioned above, the investment problem researched in this study is a sequential investment problem that can be temporarily or

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<sup>12</sup> The model is kept simple to show the main focus of our study, the subsidy. The model can be explained as a simple investment problem at a specific point in time, t. Before the market started to be subsidized, the costs of investment would be greater than the revenues (obtained from selling the biofuels) and without intervention, the market would not be developed. Thus, the government intervenes with the subsidy, which will make the net revenues positive. Environmental and energy security benefits are secondary effects of the subsidy.

permanently suspended without incurring any cost. Thus, as an example, it is considered that the government investment requires a first phase investment cost of \$1 mil. Then, with a probability of 0.5, the project will be finished and with a probability of 0.5, a second phase is required, which costs the government other \$7 mil. Considering that the benefits of consuming biofuels can be quantified, the completion of the project will yield benefits of \$2.8 mil. with a probability of 0.5 and \$5 mil. with probability 0.5. Thus, the expected cost of investment is \$4.5 mil., while the expected benefits of the project are \$3.9 mil. Since the expected cost of the project is higher than the expected benefits, the conventional NPV is negative, and, thus, the project would not be undertaken. However, the conventional NPV does not take into account the possibility to abandon the project after the first phase. If the project is abandoned before the second phase, the expected costs will be \$1 mil., while the expected benefits will be \$1.95 mil. ( $0.5 * \$3.9 \text{ mil.}$ ). Thus, the correct NPV is \$0.95 mil. and the government can proceed with at least the first phase. This simple example shows that the conventional NPV will lead to non-investment in the biofuel market and, thus, it is important to consider the investment in a real option framework.

On the other hand, following the research by McGrath, Ferrier and Mendelow (2004), our investment problem fits the characteristics of a real option application. The technical uncertainty that characterizes our investment problem, even it does not give any waiting value for new information, it is a determinant of the economic outcome. As well the government has the possibility of changing the course of action during the investment period, including the abandonment solution.

Different variables outlined in the model are considered to be stochastic and, thus an introduction to stochastic processes is provided.

#### 2.4.1 Stochastic processes

Stochastic processes are represented by events governed by probabilistic laws (Karlin and Taylor, 1981). Dixit and Pindyck (1994) define a stochastic process as “a variable that evolves over time in a way that is at least in part random” (p. 60). Thus, the main characteristics of a stochastic process are time and randomness. Stochastic processes can be discrete-time processes, when the variables change their values only at discrete points in time, in contrast with the continuous-time processes, which are characterized by variables that vary continuously over time. Any stochastic variable has a value term (drift term) and a random term (volatility term).

A Wiener process (Brownian motion) is a stochastic process that has three characteristics. First, it is a Markov process, meaning that the probability distribution of the future values of the process depends only on its current value and not on any past values or any other current information. Second, it has independent increments, meaning that the change in one time interval is independent of any other time interval (nonoverlapping). Third, changes in the process are normally distributed over any finite interval of time (Dixit and Pindyck, 1994).

The properties of a Wiener process can be shown formally using an example.

Considering that  $z_t$  is a Wiener process, than any change in  $z$  corresponding to an

infinitesimal time interval or the increment of a Wiener process satisfies the following properties:

1. The relationship between the change in the variable and the change in time is:

$$dz = \varepsilon_t \sqrt{dt} \quad (2.2)$$

where  $\varepsilon_t$  is a normally distributed random variable with mean 0 and standard deviation 1.

2. The random variable  $\varepsilon_t$  is serially uncorrelated:

$$E(\varepsilon_s \varepsilon_t) = 0 \text{ for } t \neq s \quad (2.3)$$

An Ito process is a generalized Wiener process with drift and variance coefficients being functions of the current state and time. Thus, given a random variable  $x$ , the Ito process for the value of the variable is:

$$dx = a(x,t)dt + b(x,t)dz \quad (2.4)$$

where  $dz$  is the increment of a Wiener process, while  $a(x,t)$  and  $b(x,t)$  are nonrandom functions known as drift and variance respectively. Considering the mean and the variance of the increments of this process, they would equal:

$$E(dx) = a(x, t)dt \text{ and } Var(dx) = b^2(x, t)dt \quad (2.5)$$

Two important special cases of Brownian motion that are going to be used in this chapter are geometric Brownian motion and mean-reverting processes. For a geometric Brownian motion process, the drift term,  $a(x, t)$ , equals  $\alpha x$  and the standard deviation,  $b(x, t)$ , equals  $\sigma x$ ,  $\alpha$  and  $\sigma$  being constants. Thus,

$$dx = \alpha x dt + \sigma x dz \text{ or } \frac{dx}{x} = \alpha dt + \sigma dz \quad (2.6)$$

Geometric Brownian motion is a process with constant expected returns and a constant variance of return. The change in a variable modeled using the geometric Brownian motion is lognormally distributed. Thus, the expected value of  $x$ , in the case that  $x(0) = x_0$ , is given by:

$$E[x(t)] = x_0 e^{\alpha t}, \quad (2.7)$$

while the variance of  $x(t)$  is given by:

$$Var[x(t)] = x_0^2 e^{2\alpha t} (e^{\sigma^2 t} - 1) \quad (2.8)$$

Geometric Brownian motion is usually used to model securities prices, interest rates, wage rates, output prices and other economic and financial variables (Dixit and Pindyck, 1994).

The mean-reverting process is used in modeling variables that fluctuate randomly in short-run, but they tend to revert back to an equilibrium level in long-run. One example would be the price of oil, which in short-run fluctuates randomly up and down, being affected by external factors such as strengthening or weakening of OPEC cartel or wars in oil producing countries, while in the long-run it tends to revert back towards the marginal cost of producing oil. Thus, the mean-reversion process is a log-normal diffusion process with a variance growing unproportional to the time interval.

The simplest mean-reverting process is known as Geometric Ornstein-Uhlenbeck process or the Dixit and Pindyck model and it can be written as (Dixit and Pindyck, 1994):

$$dx = \eta(\bar{x} - x)dt + \sigma dz \quad (2.9)$$

where  $\eta$  is the speed of reversion,  $\bar{x}$  is the long-run equilibrium at which the random variable tends to revert. This process satisfies the Markov property, but it does not have independent increments. Thus, the expected value of  $x$ , in case that the current value of  $x$  is  $x_0$ , is given by:

$$E(x_t) = \bar{x} + (x_0 - \bar{x})e^{-\eta t} \quad (2.10)$$

while the variance of  $(x_t - \bar{x})$  is:

$$\text{var}(x_t - \bar{x}) = \frac{\sigma^2}{2\eta}(1 - e^{-2\eta t}) \quad (2.11)$$

A main tool for stochastic calculus is represented by Ito's Lemma. Ito's Lemma is used to construct differential equations of stochastic variables, and is similar to a Taylor series expansion for ordinary calculus. Thus, considering that  $x_i(t)$ , with  $i$  from 1 to  $m$ , are stochastic processes and defining a function  $F(x_1, x_2, \dots, x_m, t)$  that is at least twice differentiable in  $x_i$  and once in  $t$ , the total differential of the function  $F$  is (Dixit and Pindyck, 1994):

$$dF = \frac{\partial F}{\partial t} dt + \sum_i \frac{\partial F}{\partial x_i} dx_i + \frac{1}{2} \sum_i \sum_j \frac{\partial^2 F}{\partial x_i \partial x_j} dx_i dx_j \quad (2.12)$$

#### 2.4.2 Variables' description

We assume here that  $P$  and  $Q$  are uncertain. By developing the biofuels market, in the future, the price of biofuels would decrease, while the quantity consumed would increase. Since prices cannot be negative, we let  $P$  follow a process of geometric Brownian motion with drift to reflect stochastic innovations as well as any long-term trend in price evolution:

$$dP(t) = \alpha_P P(t)dt + \sigma_P P(t)dz_P(t) \quad (2.13)$$

where  $dz_P$  is the increment of a Wiener process:  $dz_P = \varepsilon\sqrt{dt}$ ,  $\varepsilon \sim N(0,1)$ ;  $\alpha_P$  is the drift parameter, which represents the rate of growth, and  $\sigma_P$  is the volatility in the drift parameter.

Q also follows a process of geometric Brownian motion to reflect stochastic innovations:

$$dQ(t) = \alpha_Q Q(t)dt + \sigma_Q Q(t)dz_Q(t) \quad (2.14)$$

The parameter  $\alpha_Q$  is the expected rate of demand growth, while  $\sigma_Q$  is the standard deviation of the expected percentage change in demand. The variable  $dz_Q$  is a standard Wiener process with zero mean and standard deviation of  $dt$ . The relationship between Q and P is reflected in  $E[dz_P dz_Q] = \rho_{PQ} dt$ , where  $-1 \leq \rho_{PQ} \leq 0$  is the instantaneous correlation between Q and P. Clearly, negative correlation implies a downward sloping demand curve.

The cost of investment, represented by the subsidy  $\tilde{S}$ , is considered uncertain as well.

Uncertainty of  $\tilde{S}$  can be justified by the fact that developing an energy market is a large project that takes considerable time. On top of being an uncertain cost, this kind of investment is also irreversible. For various reasons, such as insufficient demand for the

product or excessive costs, the government cannot recover the money spent on trying to develop the ethanol market.

As developed here, the uncertainty in project costs is called technical uncertainty (Pindyck, 1993). As mentioned above, technical uncertainty is related to the physical difficulty of completing the project, including both time and effort. In fact, the total cost of the project can be known only when it is completed. There is no value of waiting in this case, as all the information about cost arrives as the investment takes place.

Next, following the investment model of Pindyck (1993) we consider the expected cost of completing the project  $S = E(\tilde{S})$ . Changes in the expected cost of investment S are captured using the following controlled diffusion process:

$$dS = -I dt + \sigma_S (IS)^{1/2} dz_S \quad (2.15)$$

where I represents the rate of investment, and  $dz_S$  is a Wiener process. Note in Eq. (2.15) the expected cost to completion declines with the rate of investment, and also changes stochastically. This functional form for expected cost is very easy to manipulate and yields just two solutions - no investment or investment at the maximum rate  $I_m$ . Notice that if  $I=0$ ,  $dS=0$  and there is no technical uncertainty over the level of S required to develop the market. The stochastic term in Eq. (2.15) has a mean of 0, meaning that the expected level of S is unbiased. We find that the variance of S is:

$$\sigma_S^2(S) = \left( \frac{\sigma_S^2}{2 - \sigma_S^2} \right) S^2 \quad (2.16)$$

The solution for the mean and the variance of S (Pindyck, 1993) are presented in Appendix A.

Eq. (2.16) shows that as S decreases, uncertainty in S decreases, which reflects a process of learning with investment.

Further, the revenue obtained by replacing the imported oil with biofuels:  $y^*O$ , is considered here to be a benefit. The future price of oil, O, is a stochastic variable that can be represented either by a simple random walk with a mean reversion or by a random walk with mean reversion and a jump process. We offer that the mean-reversion process is the natural choice for modeling oil price. Even though oil price suffers short-term shocks, historically it has tended to revert back to a normal long-term equilibrium (WTRG Economics, Figure 2.2 in our study). The situation where the change in price of oil is modeled as a random walk with mean reversion and a jump process is presented in Appendix C.

On that note, the simplest mean-reverting process known also as Geometric Ornstein-Uhlenbeck or Dixit and Pindyck model (Dixit and Pindick, 1994) is:

$$\frac{dO}{O} = \eta \left( \bar{O} - O \right) dt + \sigma_O dz_O \quad (2.17)$$

where the first term is the mean-reverting drift,  $\bar{O}$  is the long-run equilibrium mean and  $\eta$  is the speed of reversion. The second term represents continuous time uncertainty, where  $\sigma_O$  is the volatility, while  $dz_O$  is a Wiener increment.

As biofuels are increasingly used as a substitute for oil, there may be a relationship between the price of oil and the biofuel quantity consumed. Ceteris paribus, as the price of oil increases, the quantity consumed of biofuels should increase as well. Thus, we represent the relationship between  $O$  and  $Q$  by  $\rho_{OQ}$ , the correlation coefficient between the two variables, with  $0 \leq \rho_{OQ} \leq 1$ .

The last term of Eq. (2.1) above is an environmental benefits function. Each unit of oil consumed produces an amount of GHG emissions. Let us assume  $e$  is the total emissions released by oil consumption, and each unit of oil consumed releases  $\gamma_i$  units of GHG emissions ( $\text{CO}_2$ ,  $\text{NO}_x$ ,  $\text{SO}_2$  etc.). It follows that:  $e = y * \gamma_i$ . It is assumed that the development of the biofuel industry does not increase the emission coefficient, so  $\gamma_1 \leq \gamma_0$  ( $\gamma_1$  and  $\gamma_0$  are the emission coefficients both before and after the introduction of biofuel) (Millock and Nauges, 2004). Under this specification, a reduction in GHG emissions represents an environmental benefit for society. In our case, the environmental benefits function is equal to the product between the total reduction in GHG emissions,  $e$ , and the price per unit of GHG emissions,  $\tau$ :  $D(y) = e * \tau$ .

As the total emission,  $e$ , is a function of the quantity of oil consumed, we consider  $y$  to be a stochastic variable. The quantity of biofuel consumed is unknown, rendering the quantity of oil that it replaces a random variable. Assuming further that  $y$  follows a Brownian motion process, this leads to the following specification for our stochastic environmental benefits function:

$$dD = \gamma_i \tau ( \alpha_y y dt + \sigma_y y dz_y ) \quad (2.18)$$

where  $\alpha_y$  is a drift parameter,  $\sigma_y$  is the volatility in the drift parameter, and once again,  $dz_y$  is a Wiener process with the property that  $dz_y = \varepsilon \sqrt{dt}$ ,  $\varepsilon \sim N(0,1)$ .

Also, the relationship between  $y$  and  $O$  is reflected in  $E[dz_y dz_o] = \rho_{yo} dt$  where  $-1 \leq \rho_{yo} \leq 0$  is the instantaneous correlation between  $y$  and  $O$ . Clearly, negative correlation implies a downward sloping demand curve for oil.

We can derive decision rules for irreversible investment knowing that total cost is technically uncertain and that the value of the investment represented by returns is stochastic. Our decision rule also accounts for the possibility that the project could be abandoned. The rule we follow here is that government will invest in developing the biofuel market as long as the expected cost of the investment is less than some specified critical value (Pindyck, 1993). Furthermore, the investment value function does not

include an environmental benefits function in case of the US, while for Canada, this function does not include the benefits from imported oil replacement.

Ultimately, this problem is characterized by a compound option. It is a sequential investment problem with technical uncertainty. We have a compound option because each annual investment,  $I$ , creates a new investment option on the present value of cost savings from the investment already done, with a diminished exercise price  $S-I$ . In fact, this kind of investment program can be temporarily or permanently suspended without cost. In the following section, optimal investment rules for the US and Canada will be derived, results that represent the contribution of this research compared to the previous literature.

The technical cost uncertainty increases the value of the investment opportunity. This can be explained by the fact that the payoff function is  $\max[O, V]$ , where  $V$  represents the investment value. The investment opportunity is like a call option; the owner can purchase an asset worth an uncertain amount  $S$  (the cost of investment) for an uncertain 'exercise price', which is represented by the value of the completed project given by the benefits of biofuels. The value of the option is increased by an increase in the variance of the price of the underlying asset, thus as the benefits become more and more uncertain, the value of the option is increased. However, as Pindyck (1993) has outlined, in these types of models, the government has a more complicated compound option given by the fact that "it can spend an uncertain amount of money in return for an option to continue the partially completed project" (p. 55).

## 2.4.3 Optimal investment rules

### 2.4.3.1 The case of the US

The US case shall be considered the general situation as it includes all the variables considered stochastic. Using the assumptions outlined above for the US, we want to estimate the value of the biofuel investment that the government will maximize. This is represented by the investment value:

$$V(I) = P(t) * Q(t) + O(t) * y(t) - w * x - \tilde{S}(t) \quad (2.19)$$

An optimal investment rule can be found using contingent claim analysis. Note that the model has five stochastic variables: P, Q, O, y and S. The variables w and x are considered deterministic because they do not affect the value of the subsidy. Changes in each of the stochastic variables follow a geometric Brownian motion, save for the price of oil where we assume first a mean-reverting process, while in Appendix C we use a jump-diffusion process. These changes are expressed by the Eq. (2.13), (2.14), (2.17), (2.18) and (2.15). Furthermore, we assume that the risks in P, Q, O, y and S are spanned by existing assets, an assumption crucial to this method (Trigeorgis, 1993). We can make this assumption in this case since the product being developed is closely related to commodities (oil) that are usually traded on spot and future markets. So, following Dixit and Pindyck (1993), we consider a portfolio for which we hold the option to invest, and the opportunity to invest is worth  $F(P, Q, O, y, S)$ . Appendix B shows that the investment opportunity  $F(P, Q, O, y, S)$  must satisfy the following stochastic differential equation:

$$\begin{aligned}
\max_{I(t)} rF = & \frac{1}{2} F_{PP} \sigma_P^2 P^2 + \frac{1}{2} F_{QQ} \sigma_Q^2 Q^2 + \frac{1}{2} F_{OO} \sigma_O^2 O^2 + \frac{1}{2} F_{yy} \sigma_y^2 y^2 + \\
& + \frac{1}{2} F_{SS} \sigma_S^2 IS + F_{PQ} \sigma_P \sigma_Q PQ \rho_{PQ} + F_{yO} \sigma_y \sigma_O yO \rho_{yO} + \\
& + F_{OQ} \sigma_O \sigma_Q OQ \rho_{OQ} + F_P P(r - \delta_p) + F_Q Q(r - \delta_q) + \\
& + F_O O(r - \delta_o) + F_y y(r - \delta_y) - IF_S - I
\end{aligned} \tag{2.20}$$

Eq. (2.20) is similar to a Bellman equation found using stochastic dynamic programming. The only differences are that the riskless interest rate  $r$ , which is specified endogenously<sup>13</sup> in our model, is used in place of an exogenously specified discount rate, and the growth rate  $\alpha$  of the geometric Brownian motion is replaced by  $r - \delta$ , where  $\delta$  represents an opportunity cost of delaying the construction of the project and keeping the option to invest alive (Dixit and Pindyck, 1994). Thus, in the case of contingent claim analysis,  $\mu = \alpha + \delta$  represents the total expected rate of growth. The total expected rate of return  $\mu$  represents the compensation that investors obtain for taking risk, noting that the critical risk here is nondiversifiable risk. The rate-of-return for the price of oil equals

$$\mu = \eta(\bar{O} - O) + \delta_o.$$

Eq. (2.20) is linear in  $I$ , so the maximization problem gives us just two solutions:

$$I(t) = \begin{cases} I_m, & \frac{1}{2} F_{SS} \sigma_S^2 S - F_S - 1 \geq 0 \\ 0, & \text{otherwise} \end{cases} \tag{2.21}$$

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<sup>13</sup> We considered an endogenous interest rate as it represents a general situation. However, an optimal investment rule can be found using dynamic programming, subject to some exogenous discount rate.

Interpreting this solution, we note that government should invest as long as the expected cost to complete the project falls below a critical value. The general solution also indicates that the market should be developed as long as the total subsidy (the cost of the project) is less or equal to the critical value  $S^*(P, Q, O, y)$ . If this is the case, government should invest at the maximum rate  $I_m$ . In the case where the total subsidy is greater than  $S^*(P, Q, O, y)$ , investment should not be undertaken. Next, the value of  $S^*$  can be found as part of the solution of  $F(P, Q, O, y, S)$ . Note as well that Eq. (2.20) is an elliptic partial differential equation with a free boundary along the space  $S^*(P, Q, O, y)$ . To determine  $S^*(P, Q, O, y)$  and  $F(P, Q, O, y, S)$ , we need to solve (20) subject to the following boundary conditions:

$$F(P, Q, O, y, 0) = V(P, Q, O, y) \quad (2.22)$$

$$\lim_{P \rightarrow 0} F(P, Q, O, y, S) = 0 \quad (2.23)$$

$$\lim_{Q \rightarrow 0} F(P, Q, O, y, S) = 0 \quad (2.24)$$

$$\lim_{O \rightarrow 0} F(P, Q, O, y, S) = 0 \quad (2.25)$$

$$\lim_{y \rightarrow 0} F(P, Q, O, y, S) = 0 \quad (2.26)$$

$$\lim_{S \rightarrow \infty} F(P, Q, O, y, S) = 0 \quad (2.27)$$

$$\frac{1}{2} F_{SS}(S^*, P, Q, O, y) \sigma_S^2 S^{*2} - F_S(S^*, P, Q, O, y) - 1 = 0 \quad (2.28)$$

$$F(P, Q, O, y, S) \text{ continuous at } S^*(P, Q, O, y) \quad (2.29)$$

To summarize the boundary conditions, Eq. (2.22) implies that at the end of the project, when the amount of subsidy would be 0, the payoff would be  $V(P, Q, O, y)$  – exactly the value of the project. Eq. (2.23), (2.24), (2.25) and (2.26) show that a value of 0 is the absorbing barrier for  $P, Q, O$  and  $y$ , whereas Eq. (2.27) shows that when  $S$  is very large, the probability of beginning the project in some finite time approaches 0. Eq. (2.28) is derived from Eq. (2.20) and is equivalent to the so-called “smooth pasting” condition (Pindyck, 1993) that  $F_S(S^*, P, Q, O, y)$  is continuous at  $S^*(P, Q, O, y)$ . Finally, Eq. (2.29) is the “value matching” condition, meaning that  $F(P, Q, O, y, S)$  is continuous at  $S^*(P, Q, O, y)$ .

Eq. (2.20) together with the boundary conditions specified above can be solved numerically using simulations. This means finding  $S^*(P, Q, O, y)$  and  $F(P, Q, O, y, S)$  at the same time. In order to perform such a simulation, however, we need to obtain relevant data. We do not consider the case where the investment rate is 0 as without being subsidized, the market for biofuels would not be developed.

However, related to the option value, the greater the uncertainty, the greater value of opportunity to invest and the larger the maximum expected cost for which investing is economical. The option value is also related to the maximum investment rate  $I_m$ , as the maximum rate of investment is larger, the value of the investment opportunity is greater because the expected benefits are received earlier and they would be discounted less. In the same time, as the investment opportunity is worth more, the critical value of investment,  $S^*$ , will be larger.

#### 2.4.3.2 The case of Canada

In the case of Canada, the investment value that government will maximize is expressed via the following equation:

$$\begin{aligned}
 V(t) &= P(t) * Q(t) + D(y)(t) - w * x - \tilde{S}(t) = \\
 &= P(t) * Q(t) + y(t) * \gamma_i * \tau - w * x - \tilde{S}(t)
 \end{aligned}
 \tag{2.30}$$

Once again, an optimal investment rule can be found using contingent claim analysis. In fact, this equation has four stochastic variables: P, Q, D and S. Once again, changes in each variable are assumed to follow a geometric Brownian motion using the processes in Eq. (2.13), (2.14), (2.18) and (2.15), and the risks in P, Q, D and S are spanned by existing assets in the same manner as for the US. Finally, the opportunity to invest is worth  $F(P, Q, D, S)$ .

The partial differential equation objective function that Canada's investment opportunity should satisfy is obtained in the same manner as for the US. Practically, the investment

opportunity function for Canada is a special case of the one for the US, by not taking into account the price of oil. However, Appendix B shows the steps followed in finding the objective function.

$$\begin{aligned}
\max_{I(t)} rF = & \frac{1}{2} F_{PP} \sigma_P^2 P^2 + \frac{1}{2} F_{QQ} \sigma_Q^2 Q^2 + \frac{1}{2} F_{DD} \sigma_y^2 y^2 \gamma_i^2 \tau^2 + \\
& + \frac{1}{2} F_{SS} \sigma_S^2 IS + F_{PQ} \sigma_P \sigma_Q PQ \rho_{PQ} + F_P P(r - \delta_p) + F_Q Q(r - \delta_q) + \\
& + F_D y \gamma_i \tau(r - \delta_d) + F_S I - I
\end{aligned} \tag{2.31}$$

In this case, the rate-of-return in each variable equals  $\mu = \alpha + \delta$ . Since Eq. (2.31) is linear in  $I$ , this maximization problem again yields a corner solution, as follows:

$$I(t) = \begin{cases} I_m, \frac{1}{2} F_{SS} \sigma_S^2 S - F_S - 1 \geq 0 \\ 0, \text{otherwise} \end{cases} \tag{2.32}$$

Not surprisingly, we obtain the same fundamental investment rule as that found for the US. The government should invest at the maximum rate  $I_m$  as long as  $S \leq S^*(P, Q, D)$ , where  $S^*$  represents a critical value of subsidy. However, the investment should not be continued if  $S > S^*(P, Q, D)$ . The critical value  $S^*$  can be found as part of the solution of  $F(P, Q, D, S)$ . Once again, Eq. (2.31) is elliptic with a free boundary along the space  $S^*(P, Q, D)$ . In this case we have boundary conditions that together with Eq. (2.31) will help us finding  $S^*(P, Q, D)$  and  $F(P, Q, D, S)$ :

$$F(P, Q, D, 0) = V(P, Q, D) \quad (2.33)$$

$$\lim_{P \rightarrow 0} F(P, Q, D, S) = 0 \quad (2.34)$$

$$\lim_{Q \rightarrow 0} F(P, Q, D, S) = 0 \quad (2.35)$$

$$\lim_{D \rightarrow 0} F(P, Q, D, S) = 0 \quad (2.36)$$

$$\lim_{S \rightarrow \infty} F(P, Q, D, S) = 0 \quad (2.37)$$

$$\frac{1}{2} F_{SS}(S^*, P, Q, D) \sigma_S^2 S^* - F_S(S^*, P, Q, D) - 1 = 0 \quad (2.38)$$

$$F(P, Q, D, S) \text{ continuous at } S^*(P, Q, D) \quad (2.39)$$

Eq. (2.31) together with the boundary conditions shall be solved numerically, by finding  $S^*(P, Q, D)$  and  $F(P, Q, D, S)$  at the same time. The value of opportunity to invest will be greater as the uncertainty is greater and as the maximum investment rate is larger.

#### 2.4.3.3 Comparison of the optimal investment rules

The following two partial differential equations were obtained in the two cases studied above:

a) Canada:

$$\begin{aligned}
& \frac{1}{2} F_{PP} \sigma_P^2 P^2 + \frac{1}{2} F_{QQ} \sigma_Q^2 Q^2 + \frac{1}{2} F_{DD} \sigma_y^2 y^2 \gamma_i^2 \tau^2 + \\
& + \frac{1}{2} F_{SS} \sigma_S^2 IS + F_{PQ} \sigma_P \sigma_Q PQ \rho_{PQ} + F_P P(r - \delta_p) + F_Q Q(r - \delta_q) + \\
& + F_D y \gamma_i \tau (r - \delta_d) + F_S I_m - I_m - rF = 0
\end{aligned} \tag{2.40}$$

b) US (using a mean-reverting process for the change in the price of oil):

$$\begin{aligned}
& \frac{1}{2} F_{PP} \sigma_P^2 P^2 + \frac{1}{2} F_{QQ} \sigma_Q^2 Q^2 + \frac{1}{2} F_{OO} \sigma_O^2 O^2 + \frac{1}{2} F_{yy} \sigma_y^2 y^2 + \\
& + \frac{1}{2} F_{SS} \sigma_S^2 IS + F_{PQ} \sigma_P \sigma_Q PQ \rho_{PQ} + F_{yO} \sigma_y \sigma_O yO \rho_{yO} + \\
& + F_{OQ} \sigma_O \sigma_Q OQ \rho_{OQ} + F_P P(r - \delta_p) + F_Q Q(r - \delta_q) + \\
& + F_O O(r - \delta_o) + F_y y(r - \delta_y) - I_m F_S - I_m = rF
\end{aligned} \tag{2.41}$$

These two equations, which contain four and, respectively, five stochastic variables, should be solved subject to a set of boundary conditions in order to determine the critical value of the governmental subsidy and the opportunity to invest. For interpretation and comparison purposes, we rewrite the above equations using the multiplication rule for stochastic variables.

Thus, since the returns  $R(t)$  equal  $P(t) * Q(t)$ , they would be stochastic and knowing that:

$$\frac{\partial^2 R}{\partial P^2} = \frac{\partial^2 R}{\partial Q^2} = 0 \text{ and } \frac{\partial^2 R}{\partial P \partial Q} = 1 \quad (2.42)$$

from Ito's Lemma and the processes used to model the change in price and quantity of biofuels (Eq. (2.13), (2.14)), we have:

$$dR(t) = P(t)dQ(t) + Q(t)dP(t) + dP(t)dQ(t) \quad (2.43)$$

Substituting for dP(t) and dQ(t) and rearranging Eq. (2.43), we obtain:

$$dR = (\alpha_P + \alpha_Q + \rho\sigma_P\sigma_Q)Rdt + (\sigma_P dz_P + \sigma_Q dz_Q)R \quad (2.44)$$

Thus, R follows also a Brownian motion process:

$$dR = ARdt + ERdz_R, \text{ where} \quad (2.45)$$

$$A = \alpha_P + \alpha_Q + \rho\sigma_P\sigma_Q, E = \sqrt{\sigma_P^2 + \sigma_Q^2 + 2\rho_{PQ}\sigma_P\sigma_Q} \text{ and} \quad (2.46)$$

$$dz_R = \frac{\sigma_P dz_P + \sigma_Q dz_Q}{\sqrt{\sigma_P^2 + \sigma_Q^2 + 2\rho_{PQ}\sigma_P\sigma_Q}} \quad (2.47)$$

Since the environmental benefit function is  $D(t) = y(t) * \gamma_i * \tau$ , representing the product between a stochastic variable and two deterministic variables, we can rewrite the change in the environmental function as:

$$dD(t) = \gamma_i * \tau * (\alpha_y ydt + \sigma_y ydz_y) = \alpha_y Ddt + \sigma_y Ddz_y = BDdt + FDdz_D \quad (2.48)$$

Thus, the change in D follows a Brownian motion process, where:

$$B = \alpha_y; F = 1 \text{ and } dz_D = \sigma_y dz_y \quad (2.49)$$

Following the same method that has been used to calculate the change in biofuels returns, the change in the total cost of oil,  $U = O * y$ , can be expressed as:

$$dU = CUdt + GUdz_U \quad (2.50)$$

Thus, the change in U follows a Brownian motion process, where:

$$\begin{aligned} C &= \eta(\bar{O} - O) + \alpha_y + \sigma_O \sigma_y \rho_{yO} \\ G &= \sqrt{\sigma_O^2 + \sigma_y^2 + 2\rho_{yO} \sigma_O \sigma_y} \\ dz_U &= \frac{\sigma_O dz_O + \sigma_y dz_y}{\sqrt{\sigma_O^2 + \sigma_y^2 + 2\rho_{yO} \sigma_O \sigma_y}} \end{aligned} \quad (2.51)$$

Using the derived Eq. (2.45), (2.48) and (2.50), the partial differential equations, which will give us the critical values for the subsidy levels in the two countries, become:

a) Canada:

$$\begin{aligned} & \frac{1}{2} F_{RR} \sigma_R^2 R^2 + \frac{1}{2} F_{DD} \sigma_D^2 D^2 + \frac{1}{2} F_{SS} \sigma_S^2 I_m S + \\ & + F_R R(r - \delta_R) + F_D D(r - \delta_D) + F_S I_m - I_m - rF = 0 \end{aligned} \quad (2.52)$$

b) US:

$$\begin{aligned} & \frac{1}{2} F_{RR} \sigma_R^2 R^2 + \frac{1}{2} F_{UU} \sigma_U^2 U^2 + \frac{1}{2} F_{SS} \sigma_S^2 I_m S + F_{OQ} OQ \sigma_o \sigma_Q \rho_{oQ} + \\ & + F_R R(r - \delta_R) + F_U U(r - \delta_U) + F_S I_m - I_m - rF = 0 \end{aligned} \quad (2.53)$$

As the main question of this study is to check whether the levels of the critical subsidies are different in the two countries, we can make some deductions from the above two derived equations. From a theoretical point of view, the equations differ from each other because of terms related with the price of oil and the environmental function: Eq. (2.52) contains terms related to the environmental function, while Eq. (2.53) includes terms related with the total cost of oil that is replaced by biofuels.

There are only two situations when these two equations would yield the same solutions for the critical values of the subsidy levels:

a) when the total environmental damage created by the consumption of oil and the total cost of replaced oil are 0, which means that  $D(t) = y(t) * \gamma_i * \tau = 0$  and  $U(t) = y(t) * O(t) = 0$ . The two terms can be 0 at the same time only when the total quantity of oil

replaced by biofuels  $y(t)$  equals 0, which is equivalent to the fact that there is no consumption of biofuels. Having no consumption of biofuels means that the revenues obtained from selling biofuels,  $R(t)$  are 0.

Thus, the levels of the critical subsidies would be equal in the two countries when there is no demand for biofuels. This situation is not likely to occur, as there is no reason to continue to subsidize the market development with a zero demand for the specific product. Hence, in this situation, the critical levels of subsidies would equal 0.

b) when the terms related to the total environmental benefits in Canada equal the terms related to the total cost of replaced oil in the US. We obtain the following equalities:

$$\begin{aligned}
 F_{DD} * \sigma_D^2 &= F_{UU} * \sigma_U^2 \\
 D^2 &= U^2 \\
 F_D * (r - \delta_D) &= F_U * (r - \delta_U) \\
 D &= U
 \end{aligned}
 \tag{2.54}$$

While most of the terms in the above equalities are related via stochastic calculus and thus we cannot draw any definitive conclusions for our study, we can concentrate on the forth relationship, which shows that the total environmental benefits created by the replacement of oil with biofuels equals the total cost of replaced oil.

$$D(t) = U(t) \Rightarrow y(t) * \gamma_i * \tau = y(t) * O(t) \Rightarrow \gamma_i * \tau = O(t)
 \tag{2.55}$$

Eq. (2.55) says that the critical values of subsidies in the two countries are equal when the total price of GHG emissions per unit of oil consumed equals the total unit price of oil (the unit can be considered to be a barrel). In other words, the two levels of subsidies are the same when the price of oil internalizes the externality produced by consuming the oil.

## 2.5 Possible empirical analysis

Some data for the model variables are available. However, prior studies indicate that it is difficult to estimate a damage cost for CO<sub>2</sub> and other greenhouse gases because the damage due to global warming is just beginning to occur, so data are not available to estimate damage costs. Still, the damage cost of GHG is estimated for US, OECD countries, countries of International Energy Agency and for the world.

To this end, Murphy and Delucchi (1998) review the literature on the social cost of motor vehicle use in the US. Among all the studies reviewed, only three estimate damage cost of GHG emissions. Mackenzie et al (1992) estimated the annual cost for GHG not borne by drivers for 1989 at US \$27 billion; Ketcham and Komanoff (1992) estimated the climate change costs of roadway transportation borne by non-users for 1990 at US \$25 billion and the California Energy Commission (1994) used carbon emissions control costs of US \$28 per-ton of carbon to represent carbon value.

Tol (1999) estimated the marginal cost of GHG emissions for the world using the FUND model. The estimates are between US\$9 and US\$23/tC, depending on the discount rate.

The Federal Office for Scientific, Technical and Cultural Affairs (2001) in Belgium estimated the external costs of transport use in Belgium. Part of the environmental costs were represented through the impact from greenhouse gases, which were estimated using the Open Framework and the FUND simulation model. Their estimates (Table 2.6) cover the period 2000-2009, with costs discounted to the year 2000.

Table 2.6 Recommended marginal costs of GHG emissions

	<b>Minimum</b>	<b>Low</b>	<b>Central estimates</b>	<b>High</b>	<b>Maximum</b>
CO <sub>2</sub> (€/tCO <sub>2</sub> )	0.1	1.4	2.4	4.1	16.4
N <sub>2</sub> O(€/tN <sub>2</sub> O)	24.3	440.2	748.3	1,272.1	5,242.1
CH <sub>4</sub> (€/tCH <sub>4</sub> )	1.9	28.2	44.9	71.5	257
N(€/kgN)	-5.5	198.2	337	527.9	1,270.2
S(€/kgS)	-35.8	-16.6	-9.8	-5.8	0.0

Source: Federal Office for Scientific, Technical and Cultural Affairs, Belgium (2001)

In a subsequent study done by the Victoria Transport Policy Institute (2004) in British Columbia, vehicle air pollution costs in British Columbia urban areas were assessed (Table 2.7).

Table 2.7 Recommended shadow prices (1996 Canadian Cents per km)

	<b>PM<sub>2.5</sub></b>	<b>Ozone</b>	<b>CFCs (With AC)</b>	<b>Total (With AC)</b>	<b>Total (Without AC)</b>
Light Gasoline Vehicle	0.6-1.0c	0.1c	2.7c	3.4-3.8c	0.7-1.1c
Light Diesel Vehicle	2.5-6.3c	0.1c	2.7c	5.3-9.1c	2.6-6.4c
Heavy Gasoline Vehicle	2-4c	0.1c	2.7c	4.8-6.8c	2.1-4.1c
Heavy Diesel Vehicle	9-27c	0.1c	2.7c	11.8-29.8c	9.1-27.1c

Source: Victoria Transport Policy Institute, 2004

The latter study also lists the European Commission estimates of greenhouse gas cost for 14 countries of US\$0.18 to US\$0.56 per gallon of gasoline or US\$0.009 to US\$0.028 per mile.

Some of the previous related research has solved real options models with one or two uncertain variables. Real option pricing solutions rely on numerical techniques, as only a small ratio of partial differential equations have analytical solutions. The numerical techniques used in valuing real option models can be classified in three categories. First, there are the studies that use the Finite Difference Method (FDM) to solve Partial Differential Equations (PDE). By using FDM, the continuous state variables are transformed in a network of discrete points (Grigoriu, 2002). Second, this literature includes studies that use the so-called lattice method to evaluate real option models. Under the lattice method, an appropriate discrete-time model is chosen for a corresponding continuous-time model such that both have the same moment generating function (Mun, 2003). However, for several state variables, as is the case for our research (Canada's model includes four state variables, while the US's model has five state variables), these real option models suffer from what are called by Dias (2000) the curse of dimensionality and the curse of modeling. The curse of dimensionality<sup>14</sup> is related to the several sources of uncertainty, while the curse of modeling<sup>15</sup> refers to the "details from the changing practical reality" (Dias, 2000, 1). When using the above mentioned

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<sup>14</sup> "Curse of dimensionality is the exponential computational time explosion with the problem dimension. Consider three state variables (two stochastic variables plus the time), one element of a three-dimensional grid has  $2^3$  or 8 points, one in each vertex. For 5 state variables, the grid element has  $2^5$  points (= 32) leading to serious practical problems." (Dias, 2000, 2)

<sup>15</sup> "Curse of modeling is a problem formulation with an explicit system. Changing some aspects of the model is necessary to change all the optimization procedure." (Dias, 2000, 2)

methods, FDE and lattice methods, for models with more than three state variables several difficulties arise and they are not very practical. Thus, the third category of numerical methods that can be used in valuating real option problems is represented by Monte Carlo simulation combined with an optimization method. Monte Carlo simulation addresses the problems of the curse of dimensionality and the curse of modeling, but leaves open the optimization problem. Thus, Dias (2000) proposed a new method for optimization of a Monte Carlo simulation of real options problems, by using an evolutionary computing approach and, more specifically, genetic algorithms (GA). A GA is a search technique that it is used to find an exact or an approximate solution to an optimization problem. GAs were first developed by John Holland in 1975 and they are a particular class of evolutionary algorithms that use techniques inspired by evolutionary biology. The GA method that could be used in this model is described by Dias (2000). Practically, the GA method is used to estimate a threshold curve for a real option application together with the real option value. The threshold curve is guessed by the GA and each trial is evaluated by a Monte Carlo simulation. As Dias (2000) points out, each trial is considered to be an “organism”, while each “fitness” function represents the real option value or the so-called “dynamic net present value” (Dias 2000, 8). The simulation would be performed only for valid organisms, which are represented by the ones that satisfy the restrictions of the model. By using the above specified method, in future research we would be able to quantify the optimal levels of subsidies for the US and Canada and to draw more specific conclusions regarding the potential for future trade disputes.

## 2.6 Trade and policy implications

The spectacular increase in biofuels production in recent years leads to questions related to the possibility of trading biofuels. Based on the theoretical results obtained in this research, another important question is whether or not the levels of subsidies that governments use to help the development of this industry would lead to trade disputes in the near future. This section outlines the way biofuels are treated under World Trade Organization (WTO) rules and discusses possible trade disputes that might arise in the future.

Before discussing the possible trade disputes that might arise in the biofuel market, it is important to outline the level of trade in biofuels. Another important aspect is whether or not there is any grounds to believe that countries will be willing to consider it advantageous to start trading biofuels.

Presently, most biofuels are produced and consumed in domestic markets. There is a limited amount of trade in biofuels - exports of ethanol from Brazil and some intra-EU trade of biodiesel (IPC and REIL, 2006). Given some of the reasons for which countries boost their production of biofuels, such as energy security, rural development and increased opportunities for agricultural commodities, it is quite obvious that the push for biofuels production is focused on domestic production and use. However, countries interested in the environmental benefits of biofuels, mostly the Kyoto signatories, might also look for more cost-efficient producers beyond their borders. Thus, there is a potential for trade in biofuels, especially if we take into account the fact that the countries where

biofuels can be produced more efficiently and cheaper are not the same as the countries where biofuels consumption is being mandated and encouraged (IPC and REIL, 2006). The demand for biofuels in developed countries is currently rising, mostly because of ambitious biofuels mandates set by governments. However, most of the industrialized countries do not have the necessary land availability to meet demand with domestically produced biofuels. Those industrialized countries that could satisfy demand with domestic supply of biofuels would still not be producing biofuels in the most cost efficient or environmentally sustainable ways. On the other side, research has shown that the most energy efficient biofuel feedstocks are sugarcane and oil palm trees, which are mostly located in developing countries from tropical and sub-tropical regions. Thus, developing countries have a comparative advantage in producing biofuels due to the longer growing seasons, large areas of arable land and much lower labour costs. Some of these countries have already shown an interest in developing local production of biofuels, which is mostly seen as a development tool, since their markets for agricultural commodities would expand, significant rural development would take place and much of their expenditures on fossil fuels would be reduced. At the same time, developing countries are in a disadvantaged position compared to developed countries. They do not have the financial resources to offer the same government support as the biofuels industry receives in the developed countries. They would then have to rely on private investment, which leads us to conclude that even if there is a strong potential for broader trade in biofuels, there is also a need for a transparent and global trading regime (IPC and REIL, 2006).

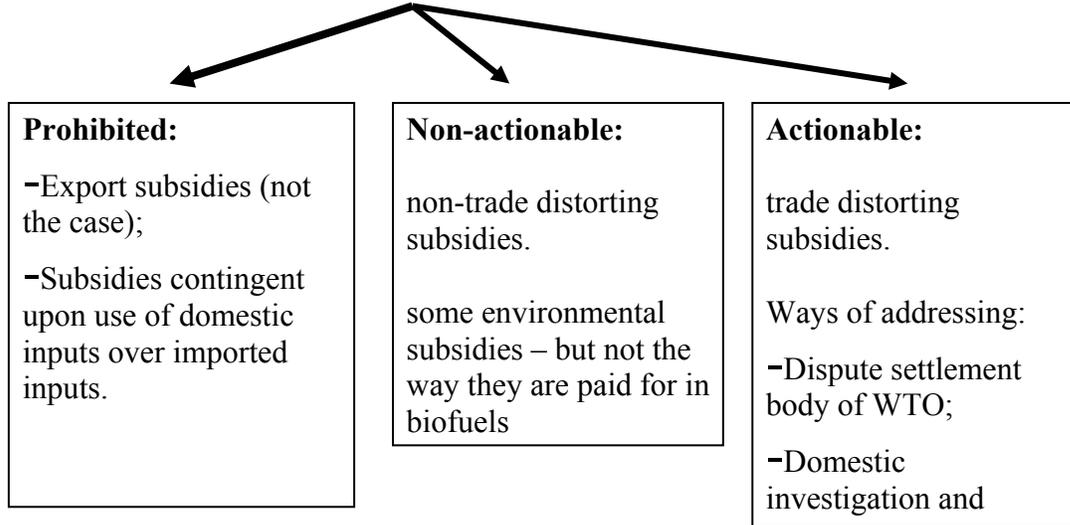
Next question is how does the WTO treat biofuels? There are many potential policy issues that can arise when countries start trading biofuels. These are related to the level of subsidies, market access and tariff classification, different technical barriers to trade that can occur based on the product standards and technologies used in the production of biofuels and, as well, issues related to trade in biotechnological produced biofuels (Kerr and Loppacher, 2005). However, this research concentrates only on the potential trade problems that can arise as a result of large levels of governmental support (subsidies) for the development of the biofuels market.

The primary problem regarding trade in biofuels is their definition and classification under the WTO. Most WTO members are also members of the World Customs Organization (WCO) and they use the system of classifications developed by WCO, known as Harmonized Commodity Description and Coding System (HS). Under the WTO, tariff levels and the allowable subsidies are negotiated based on this system. Ethanol is considered an agricultural product (HS Cap. 22), being classified based on its chemical composition as undenatured (220710) and denatured (220720), but is not separately classified as fuel ethanol as opposed to ethanol used for other purposes. Conversely, biodiesel is considered an industrial product, being classified in HS Cap. 38. The definition of these products is a central question. Rules for industrial products specified under the WTO Subsidy and Countervailing Measures (SCM) agreement set greater constraints on the subsidy levels. Rules for agricultural products specified under the WTO Agreement on Agriculture (AoA) place fewer constraints on subsidies. Agricultural tariffs are, typically, considerably larger than non agricultural tariffs. The

classification problem becomes more complicated when considering the possibility that some biofuels might be considered environmental goods and thus be subject to negotiations related to “Environmental Goods and Services”. However, during the Doha Round, little progress was made in these negotiations, including agreement on the definition of what would be considered an “environmental good” (IPC and REIL, 2006). If the latter are considered “energy goods”, the WTO does not have specific disciplines for trade in energy as until recently, major players in energy market, such as Saudi Arabia, were not part of the agreement (Selivanova, 2006). Thus, it is commonly accepted that with some exceptions, including national security and scarce and potentially scarce commodities, energy policies are exempted from discipline (IPC and REIL, 2006). Other complications would arise if the US were to attempt to use the “primary” exemption in the WTO, claiming that their subsidies for biofuels have been put in place for reasons of “national security”. However, this reason would not be claimed by other countries, such as Canada, that do not have an energy security problem.

If biofuels were to be categorized as industrial goods, the subsidies would be disciplined by the rules of the SCM agreement. SCM agreement divides the subsidies in three categories: prohibited, actionable and non-actionable (Figure 2.10).

Figure 2.10 Subsidies and Countervailing Measures  
Industrial Products



As Figure 2.10 shows, a subsidy is considered prohibited if it is contingent on export performance or on the use of domestic over imported inputs. They are known as export subsidies and local content subsidies. The non-actionable subsidies are represented by general subsidies, which are not related to a specific firm or industry and do not distort trade, such as subsidies for research activities, for adaptation to new environmental requirements and for development of industries in disadvantaged areas (WTO, 1994a). The third category, the actionable subsidies are the ones that distort trade in the sense that they cause adverse effects to the interests of other countries that are WTO members. One basis for actionability is represented by the existence of serious prejudice to the interests of other members, meaning that the subsidized product displaces the complainant's exports from the domestic market or from a third market. One criteria for deciding whether a subsidy provoked serious prejudice to the interests of another country is the size of the subsidy, considering that when the total ad valorem subsidization of a product exceeds 5%, serious prejudice has occurred. Other criteria for actionability are

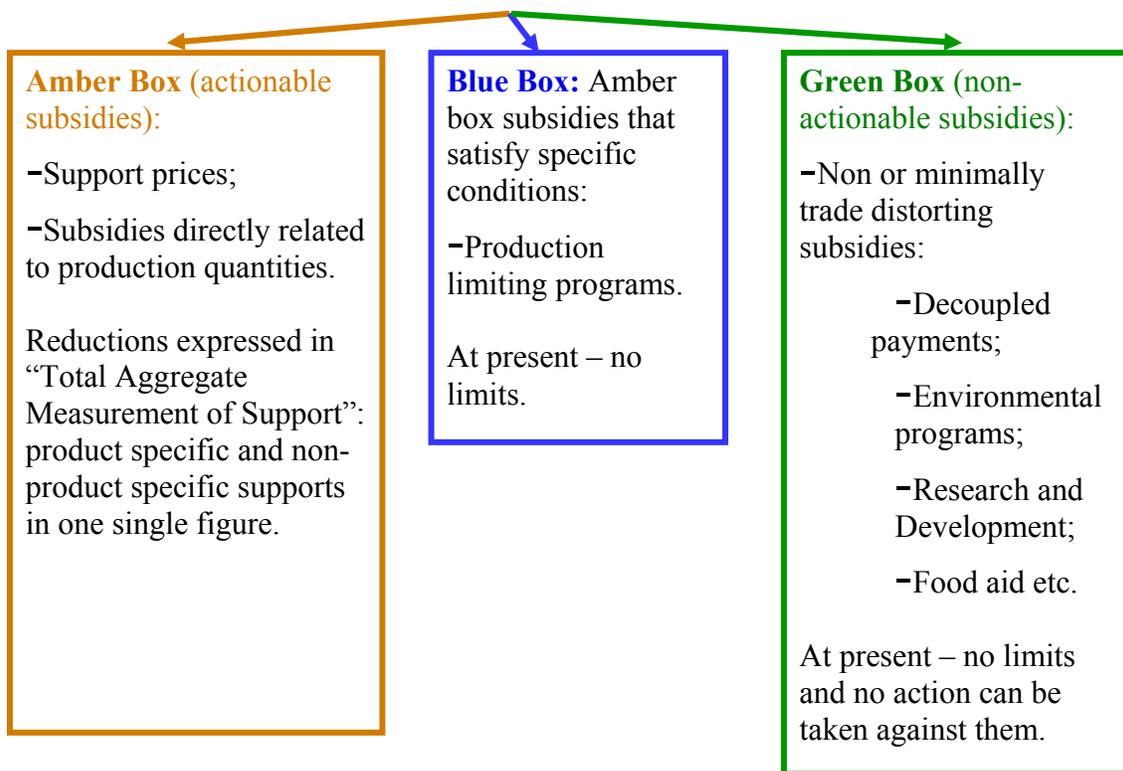
represented by material injury and nullification and impairment of the benefits of bound tariff rates (WTO, 1994a). The WTO members can address an actionable subsidy in two ways: by either using the Dispute Settlement of the WTO to have the subsidy withdrawn, or by opening a domestic investigation and charging a countervailing duty on imports from the specific country. Based on these definitions, the subsidies given for the biofuel industry in the US and Canada would fit the category of actionable subsidies, as they are clearly larger than 5% of the product value (Kerr and Loppacher, 2005). Thus, if biofuels were to be categorized as industrial products at the WTO and the current levels of subsidies continue to be given to the industry and are administered in the same way, there is a considerable potential for trade disputes in the future.

If biofuels were to be categorized as agricultural goods, they would be governed by the WTO Agreement on Agriculture (AoA). Under AoA, the subsidies are classified in a similar fashion to industrial subsidies, but they face lower constraints and they have different definitions (Kerr and Loppacher, 2005) (Figure 2.11).

The subsidies included in the Green box (non-actionable) are the ones that do not or only minimally distort trade. They are not targeted at specific products and they are decoupled from current output or prices. The box includes government-funded programs like environmental protection and regional development programs. The Green box subsidies are allowed without limits and no action can be taken against them. The Amber box (actionable) includes all the subsidies that are not in the Green box. These subsidies are allowed if they are lower than “de minimis” level (5% for developed countries and 10%

for developing countries) and the reduction commitment of each country is expressed in terms of the “Total Aggregate Measure of Support” (AMS), which is calculated based on the specific and non-specific product support. The final box, the Blue box, includes Amber box subsidies that satisfy specific conditions; for example farmers who would limit their production would get the support. Currently, there are no limits on these subsidies (although some countries want to change this). The subsidies included in the Blue box are not taken into account when the AMS is calculated (WTO, 2004a).

Figure 2.11 WTO Agreement on Agriculture  
Domestic support



Taking into account the definition of each type of subsidy, we could conclude that biofuel subsidies can be included in Amber box, being considered actionable subsidies. If

governments consider biofuel subsidies to be very important, they will face few constraints, as the level of the other Amber subsidies could be cut in order to make room for biofuel subsidies within the capped level (Kerr and Loppacher, 2005).

Another issue that can arise is if the governments try to fit biofuel subsidies in the Green box, under an environmental program. Thus, they will not be limited or actionable.

However, in order to be considered payments under an environmental program, certain conditions need to hold. In summary, they have to be payments under a clearly-defined government environmental or conservation program, they have to be dependent on conforming to certain pre-specified activity norms and the payment should be limited to the extra cost or loss of income involved in complying with the government program (WTO, 1994a). If biofuel subsidies are categorized in the Green box, two main issues could arise in a trade dispute. First, there should be enough scientific evidence that environmental benefits are provided and they fit within an environmental program and, second, there is a question of how the extra costs are measured (Kerr and Loppacher, 2005). In a trade dispute, each country will likely have a different way of considering how much is “enough” scientific evidence and how the extra costs are calculated.

Therefore, disputes are almost sure to arise in the near future at the WTO.

## 2.7 Summary and conclusions

Issues regarding climate change and energy security have led to the continued development of alternative fuels. In addition, the agricultural sector views biofuels as a future growth area that could help save a declining industry. Thus, development of a large

market for biofuel is judged to have two main benefits for North America. The first is a reduction of Greenhouse Gas Emissions (GHG) for Canada, while we believe the U.S. will likely pursue subsidy to reduce dependence on imported oil from economically and politically volatile areas. Secondary advantages associated with using biofuels are rural development and the creation of new markets for agricultural commodities, leading to new jobs in the rural sector. The main disadvantage of using biofuels at the moment is its high cost relative to petroleum. Even at current petroleum prices, a biofuel market will not grow without being highly subsidized by governments.

This research begins with the biofuel subsidy issue facing the US. Simply put, increased use of biofuels will help the US increase energy security. Next, we examine the Canadian perspective on biofuels, where we argue that the key factor encouraging subsidy is Kyoto commitments. By investing today in a biofuel market, these two governments effectively purchase an option for future consumption to meet either Kyoto commitments or demands of energy security.

A theoretical real options model is developed to examine how the same governmental policy (subsidization) towards this issue under different motivation leads to various levels of optimal subsidies. Optimal biofuel subsidy in Canada is a function of price and quantity of biofuel consumed, and the quantity of oil that is replaced by biofuel. In contrast, the US optimal biofuel subsidy is a function of the same parameters plus the price of oil. Interpreting and solving the stochastic differential equations for each country

is analytically difficult and needs to be done using numerical methods. The two levels of optimal subsidies per capita solved here will be precisely quantified in future research.

Note that if the level of subsidies for the development of biofuels industry in the two countries differs considerably, the likeliness of a trade dispute arising increases. Disputes will be a function of whether the subsidies are included in the so-called “green box” or not. If they are included in the green box being used for environmental reasons, they will not be actionable or limited, so there will be no trade problems. In this case, there should be scientific evidence that environmental benefits are provided and, second, the industry is subsidized because the biofuels are not priced competitively. However, the lack of clarity in current trade law in these areas means that future trade disputes are likely to arise (Kerr and Loppacher, 2004).

Based on our theoretical model, we conclude that the levels of optimal subsidies in the two countries would be different in general, with the exception of two situations: when there is no demand for biofuels, in which case we concluded that optimal subsidies would be zero, and when the price of oil internalizes the externality which is produced by the consumption of oil. In all the other situations, the optimal subsidies would be different, increasing the potential for trade problems between the two countries.

APPENDIX A – DERIVATION OF MEAN AND VARIANCE FOR  $\tilde{S}$  (Pindyck, 1993)

We know that  $S(t)$  follows the following controlled diffusion process:

$$dS = -I dt + \sigma_S (IS)^{1/2} dz \quad (2.A.1)$$

Following Pindyck (1993), we define the function  $M(S)$ :

$$M(S) = E_t \left[ \int_t^T I d\tau | S(t) \right] \quad (2.A.2)$$

where  $T$  is the first time interval for  $S=0$ . We show that the expected value of  $S$ , which is expressed by  $M(S)$  would equal  $S$ .

In order to derive the mean of  $S$ , we solve the Kolmogorov backward equation:

$$\frac{1}{2} \sigma_S^2 IS M_{SS} - IM_S + I = 0 \quad (2.A.3)$$

subject to the following boundary conditions:

$$\begin{aligned} M(0) &= 0 \\ M(\infty) &= \infty \end{aligned} \quad (2.A.4)$$

One clear solution of Eq. (2.A.3) subject to boundary conditions (2.A.4) is  $M(S)=S$ .

The variance of  $S$  would equal:

$$\text{Var}(S) = E_t \left[ \int_t^T Id\tau | S \right]^2 - S^2(t) \quad (2.A.5)$$

We consider  $G(S) = E_t \left[ \int_t^T Id\tau | S \right]^2$  and solve Kolmogorov backward equation (Karlin and

Taylor, 1981):

$$\frac{1}{2} \sigma_S^2 ISG_{SS} - IG_S + 2IS = 0 \quad (2.A.6)$$

subject to the following boundary conditions:

$$\begin{aligned} G(0) &= 0 \\ G(\infty) &= \infty \end{aligned} \quad (2.A.7)$$

The solution of this equation is:

$$G(S) = \frac{2S^2}{2 - \sigma_S^2} \quad (2.A.8)$$

From Eq. (2.A.5) and (2.A.8), we obtain the variance of S:

$$\text{Var}(S) = \left( \frac{\sigma_S^2}{2 - \sigma_S^2} \right) S^2 \quad (2.A.9)$$

## APPENDIX B - CONTINGENT CLAIM ANALYSIS

### The US

Given that the opportunity to invest is worth  $F(P, Q, O, y, S)$ ,  $n$  units of the asset with price  $P$ ,  $m$  units of the asset with price  $Q$ ,  $a$  units of the asset with price  $O$ ,  $b$  units of the asset with price  $y$  and  $c$  units of the asset with price  $S$  are sold short.

The value of the portfolio is:

$$\Phi = F - n * P - m * Q - a * O - b * y - c * S \quad (2.B.1)$$

As  $P, Q, O, y$  and  $S$  change, also the  $n, m, a, b$  and  $c$  will change from one short time interval to the next. Thus, the composition of the portfolio will continuously be changed. For each short time interval  $dt$ , we keep  $n, m, a, b$  and  $c$  fixed.

As no rational investor would hold a long-run position in the project without a dividend payment, the short position in this portfolio requires payments of

$\delta_p nP, \delta_q mQ, \delta_o aO, \delta_y by$  and  $\delta_s cS$ .  $\delta$  represents an opportunity cost of delaying the project and keeping the option to invest alive (Dixit and Pindick, 1994). In addition, as the investment is taking place a payment stream of  $I(t)$  should be paid to hold the investment opportunity. Thus, the total value of the portfolio is:

$$\begin{aligned} \Phi = F - n * P - m * Q - a * O - b * y - c * S - \delta_p nP - \delta_q mQ - \delta_o aO - \\ - \delta_y by - \delta_s cS - I(t) \end{aligned} \quad (2.B.2)$$

As a result, the instantaneous change in the value of the portfolio is:

$$d\Phi = dF - n\delta_p Pdt - m\delta_q Qdt - a\delta_o Odt - b\delta_y ydt - c\delta_s Sdt - I(t)dt \quad (2.B.3)$$

Using Ito's Lemma, we obtain:

$$dF = F_p dP + F_Q dQ + F_o dO + F_y dy + F_s dS + \frac{1}{2} F_{pp} dP^2 + \frac{1}{2} F_{QQ} dQ^2 + \frac{1}{2} F_{oo} dO^2 + \frac{1}{2} F_{ss} dS^2 + F_{pQ} dP dQ + \frac{1}{2} F_{yo} dy dO + \frac{1}{2} F_{oQ} dO dQ \quad (2.B.4)$$

where:

$$\begin{aligned} dP &= \alpha_p Pdt + \sigma_p Pdz_p \Rightarrow dP^2 = \sigma_p^2 P^2 dt \\ dQ &= \alpha_Q Qdt + \sigma_Q Qdz_Q \Rightarrow dQ^2 = \sigma_Q^2 Q^2 dt \\ dPdQ &= \sigma_p \sigma_Q \rho_{pQ} dt \\ dO &= \eta(\bar{O} - O)dt + \sigma_o Odz_o \Rightarrow dO^2 = \sigma_o^2 O^2 dt \\ dy &= \alpha_y ydt + \sigma_y ydz_y \Rightarrow dy^2 = \sigma_y^2 y^2 dt \\ dydO &= \sigma_y \sigma_o \rho_{yo} dt \\ dOdQ &= \sigma_o \sigma_Q \rho_{oQ} dt \\ dS &= -Idt + \sigma_s (IS)^{1/2} dz_s \Rightarrow dS^2 = \sigma_s^2 ISdt \end{aligned} \quad (2.B.5)$$

To make the portfolio riskless, we choose  $n = F_p, m = F_Q, a = F_o, b = F_y, c = F_s$ .

Thus, the change in the value of the portfolio becomes:

$$\begin{aligned}
d\Phi = & F_P dP + F_Q dQ + F_o dO + F_y dy + F_S dS + \frac{1}{2} F_{PP} \sigma_P^2 P^2 dt + \frac{1}{2} F_{QQ} \sigma_Q^2 Q^2 dt + \\
& + \frac{1}{2} F_{oo} \sigma_o^2 O^2 dt + \frac{1}{2} F_{yy} \sigma_y^2 y^2 dt + \frac{1}{2} F_{SS} \sigma_S^2 S^2 dt + F_{PQ} \sigma_P \sigma_Q PQ \rho_{PQ} dt + F_{yO} \sigma_y \sigma_o yO \rho_{yo} dt + \\
& + F_{oQ} \sigma_o \sigma_Q OQ \rho_{oQ} dt - F_P \delta_P P dt - F_Q \delta_Q Q dt - F_o \delta_o O dt - F_o \delta_o O dt - \\
& - F_y \delta_y y dt - F_S \delta_S S dt - I(t) dt
\end{aligned} \tag{2.B.6}$$

$$\begin{aligned}
d\Phi = & \frac{1}{2} F_{PP} \sigma_P^2 P^2 dt + \frac{1}{2} F_{QQ} \sigma_Q^2 Q^2 dt + \frac{1}{2} F_{oo} \sigma_o^2 O^2 dt + \frac{1}{2} F_{yy} \sigma_y^2 y^2 dt + \\
& + \frac{1}{2} F_{SS} \sigma_S^2 S^2 dt + F_{PQ} \sigma_P \sigma_Q PQ \rho_{PQ} dt + F_{yO} \sigma_y \sigma_o yO \rho_{yo} dt + \\
& + F_{oQ} \sigma_o \sigma_Q OQ \rho_{oQ} dt - F_P \delta_P P dt - F_Q \delta_Q Q dt - F_o \delta_o O dt - F_y \delta_y y dt - \\
& - F_S \delta_S S dt - I(t) dt
\end{aligned} \tag{2.B.7}$$

Over the time interval (t, t+dt), the holder of the portfolio will have the capital gain:

$$\begin{aligned}
& \frac{1}{2} F_{PP} \sigma_P^2 P^2 dt + \frac{1}{2} F_{QQ} \sigma_Q^2 Q^2 dt + \frac{1}{2} F_{oo} \sigma_o^2 O^2 dt + \frac{1}{2} F_{yy} \sigma_y^2 y^2 dt + \frac{1}{2} F_{SS} \sigma_S^2 S^2 dt + \\
& + F_{PQ} \sigma_P \sigma_Q PQ \rho_{PQ} dt + F_{yO} \sigma_y \sigma_o yO \rho_{yo} dt + F_{oQ} \sigma_o \sigma_Q OQ \rho_{oQ} dt
\end{aligned} \tag{2.B.8}$$

In the same time interval, the cost of the portfolio is:

$$F_P \delta_P P dt + F_Q \delta_Q Q dt + F_o \delta_o O dt + F_y \delta_y y dt + F_S \delta_S S dt + I(t) dt \tag{2.B.9}$$

The next step is to equate the value of the portfolio over the time interval (t, t+dt) to the riskless return:

$$r(F - nP - mQ - aO - by - cS) \quad (2.B.10)$$

After collecting the terms, we get the basic equation:

$$\begin{aligned} & \frac{1}{2} F_{PP} \sigma_P^2 P^2 + \frac{1}{2} F_{QQ} \sigma_Q^2 Q^2 + \frac{1}{2} F_{OO} \sigma_O^2 O^2 + \frac{1}{2} F_{yy} \sigma_y^2 y^2 + \frac{1}{2} F_{SS} \sigma_S^2 S^2 + \\ & + F_{PQ} \sigma_P \sigma_Q PQ \rho_{PQ} + F_{yO} \sigma_y \sigma_O yO \rho_{yO} + F_{oQ} \sigma_o \sigma_Q OQ \rho_{oQ} + \\ & + F_P P(r - \delta_p) + F_Q Q(r - \delta_q) + F_o O(r - \delta_o) + F_y y(r - \delta_y) + F_S S(r - \delta_S) - I = rF \end{aligned} \quad (2.B.11)$$

where,

$$S(r - \delta_S) = -I \quad (2.B.12)$$

### Canada

Given that the opportunity to invest is worth  $F(P, Q, D(y), S)$ ,  $n$  units of the asset with price  $P$ ,  $m$  units of the asset with price  $Q$ ,  $a$  units of the asset with price  $D(y)$  and  $b$  units of the asset with price  $S$  are sold short.

The value of the portfolio is:

$$\Phi = F - n * P - m * Q - a * D(y) - b * S \quad (2.B.13)$$

As  $P$ ,  $Q$ ,  $D(y)$  and  $S$  change, also the  $n$ ,  $m$ ,  $a$  and  $b$  will change from one short time interval to the next. Thus, the composition of the portfolio will continuously be changed. For each short time interval  $dt$ , we keep  $n$ ,  $m$ ,  $a$  and  $b$  fixed.

As no rational investor would hold a long-run position in the project without a dividend payment, the short position in this portfolio requires payments of  $\delta_p nP$ ,  $\delta_q mQ$ ,  $\delta_d a y \gamma_i \tau$  and  $\delta_s bS$ .  $\delta$  represents in fact an opportunity cost of delaying the project and keeping the option to invest alive (Dixit and Pindick, 1994). In addition, as the investment is taking place a payment stream of  $I(t)$  should be paid to hold the investment opportunity. Thus, the total value of the portfolio is:

$$\Phi = F - n * P - m * Q - a * y \gamma_i \tau - b * S - \delta_p nP - \delta_q mQ - \delta_d a y \gamma_i \tau - \delta_s bS - I(t) \quad (2.B.14)$$

As a result, the instantaneous change in the value of the portfolio is:

$$d\Phi = dF - ndP - n\delta_p Pdt - mdQ - m\delta_q Qdt - adD - a\delta_d y \gamma_i \tau dt - bdS - b\delta_s Sdt - I(t)dt \quad (2.B.15)$$

Using Ito's Lemma, we obtain:

$$\begin{aligned}
dF = & F_P dP + F_Q dQ + F_D dD + F_S dS + \frac{1}{2} F_{PP} dP^2 + \frac{1}{2} F_{QQ} dQ^2 + \\
& + \frac{1}{2} F_{DD} dD^2 + \frac{1}{2} F_{SS} dS^2 + F_{PQ} dP dQ
\end{aligned} \tag{2.B.16}$$

where:

$$\begin{aligned}
dP &= \alpha_P P dt + \sigma_P P dz_P \Rightarrow dP^2 = \sigma_P^2 P^2 dt \\
dQ &= \alpha_Q Q dt + \sigma_Q Q dz_Q \Rightarrow dQ^2 = \sigma_Q^2 Q^2 dt \\
dP dQ &= \sigma_P \sigma_Q PQ \rho_{PQ} dt \\
dD &= \gamma_i \tau (\alpha_y y dt + \sigma_y y dz_y) \Rightarrow dD^2 = \sigma_y^2 y^2 \gamma_i^2 \tau^2 dt \\
dS &= -I dt + \sigma_S (IS)^{1/2} dz_S \Rightarrow dS^2 = \sigma_S^2 IS dt
\end{aligned} \tag{2.B.17}$$

To make the portfolio riskless, we choose  $n = F_P, m = F_Q, a = F_D, b = F_S$ .

Thus, the change in the value of the portfolio becomes:

$$\begin{aligned}
d\Phi = & F_P dP + F_Q dQ + F_D dD + F_S dS + \frac{1}{2} F_{PP} \sigma_P^2 P^2 dt + \frac{1}{2} F_{QQ} \sigma_Q^2 Q^2 dt + \\
& + \frac{1}{2} F_{DD} \sigma_y^2 y^2 \gamma_i^2 \tau^2 dt + \frac{1}{2} F_{SS} \sigma_S^2 IS dt + F_{PQ} \sigma_P \sigma_Q PQ \rho_{PQ} dt - F_P dP - F_P \delta_P P dt - \\
& - F_Q dQ - F_Q \delta_Q Q dt - F_D dD - F_D \delta_D y \gamma_i \tau dt - F_S dS - F_S \delta_S S dt - I(t) dt
\end{aligned} \tag{2.B.18}$$

$$\begin{aligned}
d\Phi = & \frac{1}{2} F_{PP} \sigma_P^2 P^2 dt + \frac{1}{2} F_{QQ} \sigma_Q^2 Q^2 dt + \frac{1}{2} F_{DD} \sigma_y^2 y^2 \gamma_i^2 \tau^2 dt + \frac{1}{2} F_{SS} \sigma_S^2 IS dt + \\
& + F_{PQ} \sigma_P \sigma_Q PQ \rho_{PQ} dt - F_P \delta_P P dt - F_Q \delta_Q Q dt - F_D \delta_D y \gamma_i \tau dt - F_S \delta_S S dt - I(t) dt
\end{aligned} \tag{2.B.19}$$

Over the time interval (t, t+dt), the holder of the portfolio will have the capital gain:

$$\begin{aligned} & \frac{1}{2} F_{PP} \sigma_P^2 P^2 dt + \frac{1}{2} F_{QQ} \sigma_Q^2 Q^2 dt + \frac{1}{2} F_{DD} \sigma_y^2 y^2 \gamma_i^2 dt + \frac{1}{2} F_{SS} \sigma_S^2 IS dt + \\ & + F_{PQ} \sigma_P \sigma_Q PQ \rho_{PQ} dt \end{aligned} \quad (2.B.20)$$

In the same time interval, the cost of the portfolio is:

$$F_P \delta_p P dt + F_Q \delta_q Q dt + F_D \delta_d y \gamma_i \tau dt + F_S \delta_S S dt + I(t) dt \quad (2.B.21)$$

The next step is to equate the value of the portfolio over the time interval (t, t+dt) to the riskless return:

$$r(F - nP - mQ - aD - bS) \quad (2.B.22)$$

After collecting the terms, we get the basic equation:

$$\begin{aligned} & \frac{1}{2} F_{PP} \sigma_P^2 P^2 + \frac{1}{2} F_{QQ} \sigma_Q^2 Q^2 + \frac{1}{2} F_{dd} \sigma_y^2 y^2 \gamma_i^2 \tau^2 + \frac{1}{2} F_{SS} \sigma_S^2 IS + \\ & + F_{PQ} \sigma_P \sigma_Q PQ \rho_{PQ} + F_P P(r - \delta_p) + F_Q Q(r - \delta_q) + F_d y \gamma_i \tau (r - \delta_d) + \\ & + F_S S(r - \delta_S) - I = rF \end{aligned} \quad (2.B.23)$$

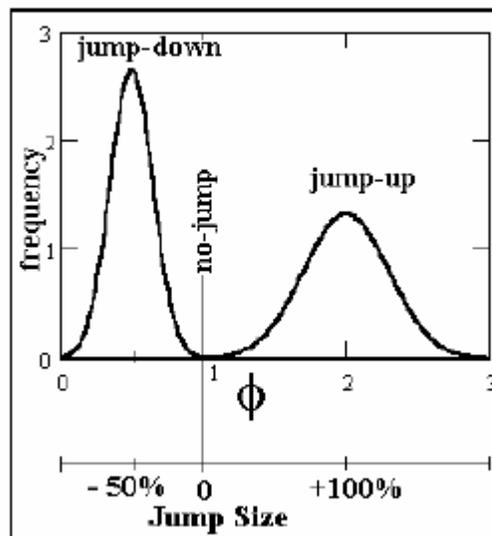
where,

$$S(r - \delta_S) = -I \quad (2.B.24)$$

## APPENDIX C – JUMP-DIFFUSION MODEL

The jump-diffusion model links changes in price and the arrival of information. This type of model combines two types of information: the smooth variation in oil prices due to normal information, and the jump in prices caused by abnormal news or information. Smooth variation is modeled using a mean-reversion process (a continuous process), while jumps are captured with a Poisson process (a discrete time process). In turn, the Poisson-jump for petroleum prices can be either positive or negative, depending on the specific economic/political conditions. This means price can suffer a sudden increase or decrease. Note that the inter-arrival times of successive jumps must be independently and identically distributed (i.i.d.) random variables. Figure 2.C.1 shows how the jump sizes for both cases, jump-up and jump-down, are random.

Figure 2.C.1 Random Jumps Distribution



Source: Dias and Rocha (1999)

The rate of change in oil price can be written in the following manner:

$$\begin{aligned}
\frac{dO}{O} &= \eta \left( \bar{O} - O \right) dt + \sigma_O dz_O + dq \\
dq &= \begin{cases} 0, & \text{with probability } 1 - \lambda dt \\ \phi - 1, & \text{with probability } \lambda dt \end{cases} \\
k &= E(\phi - 1)
\end{aligned} \tag{2.C.1}$$

The first term of Eq. (2.C.1) is a mean-reverting drift, where  $\bar{O}$  is the long-run equilibrium mean and  $\eta$  is the speed of reversion. The second term represents continuous time uncertainty, where  $\sigma$  is the volatility and  $dz_O$  is a Wiener increment. The last term,  $dq$ , is the jump term, appearing with a probability  $\lambda dt$  ( $\lambda$  is a Poisson arrival parameter). Finally,  $\phi$  is the jump size probability distribution, while the expected jump size is represented here by  $k$ .

Using contingent claim analysis and following the same steps specified in Appendix B, the investment opportunity should satisfy the following partial differential equation:

$$\begin{aligned}
\max_{I(t)} & \frac{1}{2} F_{PP} \sigma_P^2 P^2 + \frac{1}{2} F_{QQ} \sigma_Q^2 Q^2 + \frac{1}{2} F_{OO} \sigma_O^2 O^2 + \frac{1}{2} F_{yy} \sigma_y^2 y^2 + \\
& + \frac{1}{2} F_{SS} \sigma_S^2 S^2 + F_{PQ} \sigma_P \sigma_Q PQ \rho_{PQ} + F_{yO} \sigma_y \sigma_O yO \rho_{yO} + F_{OQ} \sigma_O \sigma_Q OQ \rho_{OQ} + \\
& + F_P P(r - \delta_p) + F_Q Q(r - \delta_q) + F_O O(r - \delta_o) - \lambda KOF_O + \lambda F(O\Phi) - \\
& - (r + \lambda)F(O) + F_y y(r - \delta_y) + F_S S(r - \delta_s) - I = 0
\end{aligned} \tag{2.C.2}$$

Eq. (2.C.2) is linear in  $I$ , the rate of investment, and, thus, the maximization problem will have a bang-bang solution:

$$I(t) = \begin{cases} I_m, & \frac{1}{2} F_{SS} \sigma_S^2 S^2 - F_S - 1 \geq 0 \\ 0, & \text{otherwise} \end{cases} \tag{2.C.3}$$

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# ESSAY 3: ANTIDUMPING ACTIONS AND FREE RIDING

## 3.1 Introduction

Anti-dumping (AD) actions are legal measures permitted under Article VI of General Agreement on Tariffs and Trade (GATT). While AD was little used in the past, its prominence as a trade policy instrument has been increasing rapidly in recent years. Historically, traditional users of anti-dumping actions were the United States (US), European Union (EU), Canada and Australia, who accounted for more than two-thirds of the AD cases between 1990 and 1995. Developing countries became more active in AD actions after the adoption of the Antidumping Agreement within the World Trade Organization (WTO) framework in 1995 (Das, 2003). AD use has increased dramatically over the last two decades due to the reduction and even the elimination of most other trade policy instruments (tariffs, quotas, variable levies, voluntary export restraints, etc.).

In theory, AD actions should be used only in the case of “unfair” trade practices, but in practice, due to the way that AD is defined in trade law, they are used for different motives – primarily to provide economic protection. Prusa and Skeath (2001) found evidence that two types of motives characterize an increase in the number of AD actions, for both traditional and new users: economic and strategic motives. Economic motives are related to the traditional view of AD as a reaction to “unfair” trade and to the new view of AD being a mechanism for providing economic protection. The strategic motives are centred on retaliation<sup>16</sup> and club<sup>17</sup> motives.

The guidelines provided by GATT/WTO anti-dumping code are implemented by each member state. The WTO guidelines provide both requirements that must be fulfilled in order to impose an AD measure and detailed procedural requirements. The latter governs the conduct of AD investigations and the imposition and maintenance of AD measures. As the WTO guidelines are somewhat vague, each country interprets them in different ways, leading to substantial variation among AD statutes. A failure to respect any of the requirements can be taken to the WTO’s Dispute Settlement Body and the offending country may be required to bring the measure into conformity with the Agreement or face retaliation if it fails to do so. In the US, two governmental agencies are authorized to handle an AD case: the International Trade Administration (ITA), which has the role of determining whether there are sales at less than fair value and the International Trade Commission (ITC), which determines whether a US industry is or might be materially injured.

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<sup>16</sup> AD is used as a tool to retaliate/punish those countries which have used it in the past.

<sup>17</sup> The traditional users of AD law form a “club” and tend to use the law against each other rather than against the non-club members.

The cost of conducting an AD case in the US is high, including the administrative costs and the cost of hiring a legal counsel, which has the role of proving to the International Trade Commission (ITC) that the domestic US industry has been injured by the imports. A firm will contribute to AD expenditures as long as the probability of winning the case is high and the expected benefits of winning an AD action are higher than the costs. Clearly, if a firm realizes that its participation in an AD petition does not increase the probability of winning, it will choose not to participate. There is some empirical evidence suggesting that when firms form broad coalitions in an AD case, the chances of winning are higher and, as result, the individual costs are smaller.

In this research, the indirect benefits of an AD case are considered to be a public good. The exporting firm that dumped goods in the importer's (home) market would reduce its exports to the specific country and all producers in the industry will benefit from the increase in price. Only the firms that lobby for protection have to bear the costs, while the benefits are shared by all the firms in the industry, leading to the possibility of free riding. In this light, Herander and Pupp (1991) define free riding as "a situation where firms abstain from contributing to a collectively profitable action" (pp. 136).

Secondly, anti-dumping benefits will be considered a joint product having both public and private characteristics. This situation can be applied for US only because of the so-called Byrd Amendment. This Amendment stipulates that any duties assessed from an antidumping case will be shared among the firms that supported the original petitions.

The outcome of the Byrd Amendment is expected to be that free riding decreases and, in addition, that the number of petitions will increase.

Consequently, this chapter will address the following question: Can it be shown analytically that an AD petition opens the possibility of free riding when the benefits of an AD case are considered a public good or a joint product?

In order to be able to analyze the behaviour of a firm faced with the decision of whether or not to participate in an AD action, it is important to understand how dumping is defined and how to open an AD case, what the main procedures are and the timetables followed in an AD investigation, specifically in the US, and finally, how the Byrd Amendment creates an incentive for firms to participate in an AD case.

Given the increased use of AD actions and debate among trade policy analysts, economists and politicians regarding the fairness of AD as a trade policy instrument, this chapter starts by analyzing definitions of dumping and the tests used in AD investigations. This first section is important in understanding why AD actions are used as a trade protection instrument. As the chapter concentrates on the US AD investigations, the next section reports general statistical information pertaining to AD and, specifically, the procedures and timetables for US AD investigations. By outlining the main steps of an AD investigation, the reader will get a feeling about the risks and the delays that the firms face when operate internationally. The main characteristics of the Byrd Amendment are outlined, as well as the effects of the Byrd Amendment on firms'

decisions regarding filing an AD petition. The chapter continues with an AD case-study, which highlights the steps in the US investigation procedure and shows which economic facts are taken into account when judging whether dumping takes place. After understanding how an AD investigation is handled, the research focuses on firms' behavior concerning the decision whether or not to participate in an AD investigation. In the next section, the literature on AD, lobbying and free riding is reviewed, followed by a discussion of the methodology and results obtained in this research. The study ends with a section outlining a potential empirical analysis that would explore the firm's decision regarding participation in an AD case along with a summary and conclusions.

### 3.2 Dumping

In theory, AD actions are intended to be used only against exporters suspected of "unfair" pricing practices. "Unfair" pricing practices are considered situations in which the products are exported at less than normal or fair value, and the domestic industry is injured or likely to be injured by the unfairly priced imports. Normal value is defined as the price of like goods in the exporter's country or, alternatively, the average cost of the exporting firm.

The GATT Antidumping Agreement defines dumping in three ways:

**Article 2.1:** For the purpose of this Agreement, a product is to be considered as being dumped, i.e. introduced into the commerce of another country at less than its normal value, if the export price of the product exported from one country to another is less than the comparable price, in the ordinary course of trade, for like product when destined for consumption in the exporting country.

**Article 2.2:** When there are no sales of the like product in the ordinary course of trade in the domestic market of the exporting country or when, because of the particular market

situation or the low volume of sales in the domestic market of the exporting country, such sales do not permit a proper comparison, the margin of dumping shall be determined by comparison with a comparable price of like product when exported to an appropriate third country, provided that this price is representative, or with the cost of production in the country of origin plus a reasonable amount for administrative, selling and general costs and for profits.

Thus, AD actions should combat international price discrimination or selling below cost.

Both price discrimination and selling below cost are, however, normal business practices domestically: legal profit maximizing/loss minimizing strategies of firms.

The first definition, according to Article 2.1, can be called the “price discrimination” definition<sup>18</sup>. A firm can be accused of dumping if it sells a product in a foreign market at a price lower than the price in the home market. Price discrimination is a normal business practice that a profit-maximizing firm follows when it faces different demand curves in different markets. Therefore, selling at different prices in different markets might be evidence of market power, but not necessarily of unfair pricing being practiced against domestic firms.

The second definition in Article 2.2, the so called “selling below cost” definition, allows proof of dumping if the price charged by the firm in the importer’s market is less than the exporting firm’s cost of production plus “administrative, selling and general costs”. Firms often sell below cost in the short-run either because markets are depressed or because they want to dispose of inventory. Selling below cost domestically is not an “unfair” business practice, as firms continue to operate while minimizing their losses.

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<sup>18</sup> The second definition – the “third market test” is simply a variation of the price discrimination definition and will not be considered further.

However, selling at different prices in different markets and selling below cost are characteristics of predatory pricing, which is an “unfair” business practice in domestic competition laws in a number of countries. Price discrimination and selling below cost represent necessary conditions for predatory pricing to occur, but they are not sufficient conditions. It can be shown that in the short-run, a price-discriminating monopolist could lose money in both markets<sup>19</sup>. While waiting for markets to recover, the firm will price to minimize its losses and not to drive out the competitors in the lower-priced market. It is also possible that a firm can cover a cost in the high-priced market, but not in the low-priced market. In addition, when judging if a firm is predatory pricing, it is important to know that firms do not maximize profits in the short-run. Thus, the short-run profit maximizing models that predict a firm’s pricing strategy are not applicable because, in the case of predatory pricing, the firm must endure a long period of losses in forcing competitors out of business. Finally, it might be impossible for these firms to avoid the competitors’ re-entry when price is raised after monopolizing the market (Kerr, 2001; McGee, 1958).

Graphically, situations where activities defined as dumping are instead simple profit maximizing activities are illustrated in Figures 3.1, 3.2 and 3.3 (Kerr, 2006). In the figures below,  $D_H$  represents the domestic demand,  $D_F$  is the foreign demand and both demand functions are downward sloping suggesting that the firm has some degree of market power in both markets. The profit maximizing output ( $Q_T$ ) is determined by setting total marginal revenue ( $MR_T = MR_H + MR_F$ ) equal to marginal cost (MC). The quantities that the firm provides in each market ( $Q_H$  and  $Q_F$ ) lie at the intersection

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<sup>19</sup> Of course, if adverse market conditions persist, then the firm will have to exit both markets.

between marginal cost for which the total quantity is produced and the marginal revenue curves in each market. The firm will charge price  $P_H$  in the home market and  $P_F$  in the foreign market, prices being found at the intersection of quantity provided in the market and the respective demand curves<sup>20</sup>. Figure 3.1 shows the situation where the firm price discriminates and makes profit in both markets. In this case, as the price in the foreign market is lower than the price in the home market, the firm could be accused of dumping even while simply following a profit maximization strategy.

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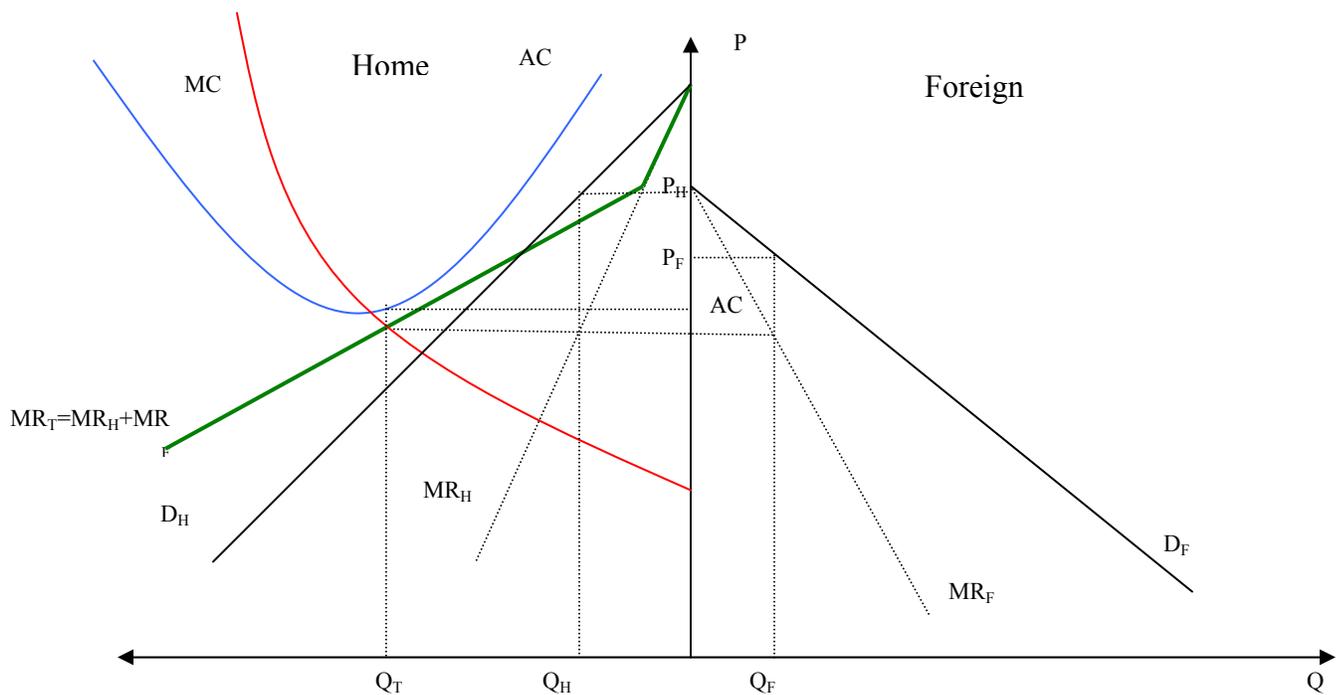
<sup>20</sup> Consider the monopolist's problem of selecting the output level in the two markets: home and foreign. In each market  $k$ , the firm's revenue is given by:  $R_k(q_k) = p_k(q_k) * q_k$ , where  $p_k$  is the price charged in market  $k$  and  $q_k$  is the output produced in market  $k$ . Thus, the firm's profit maximization problem is:  $\max \Pi = \sum_{q_H, q_F} R_k(q_k) - c(\sum q_k)$ , where  $c$  is the total cost. The first order condition gives the

following solution:  $\frac{\partial \Pi}{\partial q_k} = MR_k - MC = 0 \Rightarrow MR_H = MR_F = MC$ , where  $MR$  is the marginal

revenue and  $MC$  is the marginal cost. As the  $MR$  equals  $p \left( 1 + \frac{1}{\varepsilon} \right)$ , where  $p$  is the price per unit and  $\varepsilon$  is the price elasticity of demand, the maximization condition becomes:

$p_H \left( 1 + \frac{1}{\varepsilon_H} \right) = p_F \left( 1 + \frac{1}{\varepsilon_F} \right) = MC$ . Thus, the monopolist will charge the same price in the two countries only when the price elasticities of the demand curves in the two countries are the same. The total revenue is increased when the higher price is charged in the country that has the least-elastic demand (Friedman, 2002).

Figure 3.1 International price discrimination



In Figure 3.2, the firm makes profit in the home market and losses in the foreign market, but there is no “unfair” pricing strategy, as the firm is maximizing profit/minimizing losses in the short-run. According to the situation depicted in Figure 3.2, this firm could be accused of dumping both on the price-discrimination and selling below cost definitions, as there are profits available in the home market that could potentially be used to cross-subsidize the losses in foreign market. Finally, figure 3.3 shows the case in which the firm incurs losses in both markets, but, again, this firm can be accused of dumping according to both definitions. From the firm’s perspective, this situation might represent a best short-run strategy in cases when markets become depressed after the firm has made fixed investments in plant and equipment, but output cannot be sustained in the long-run. Clearly, in the long-run this firm will be obliged to exit.

Figure 3.2 Price discrimination and selling below cost: profit in home market and losses in foreign market

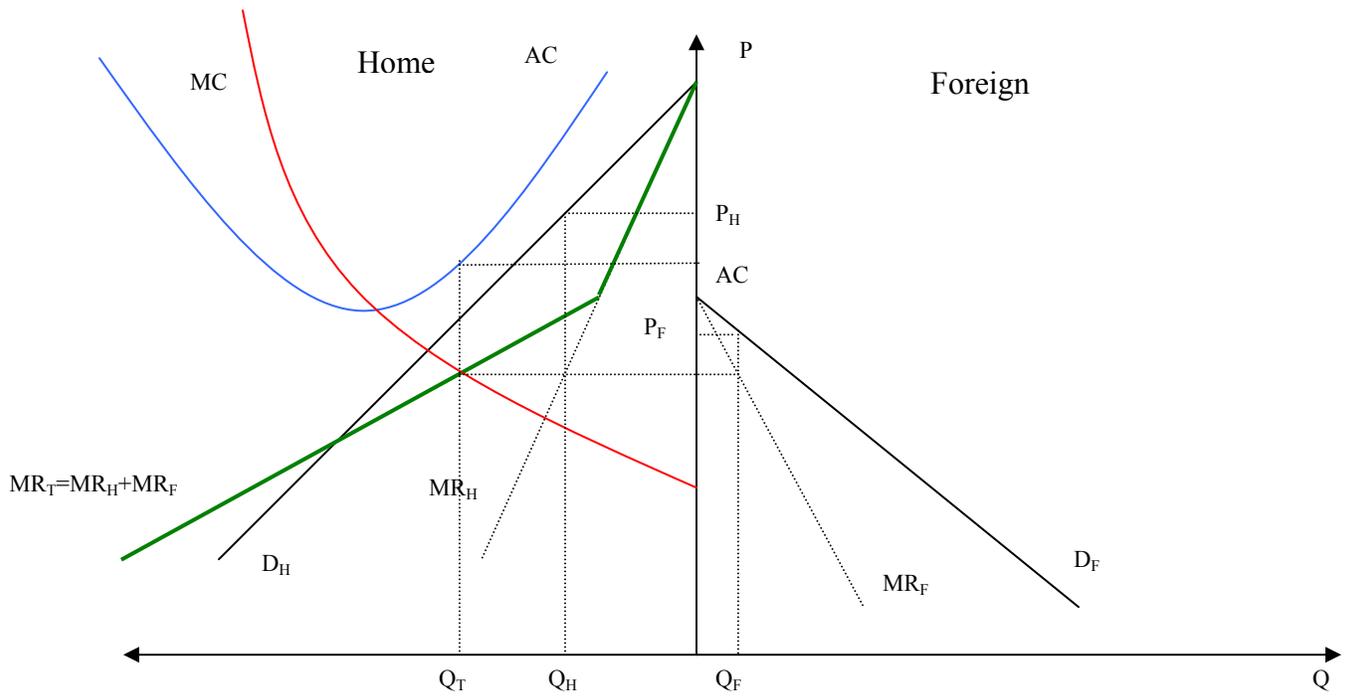
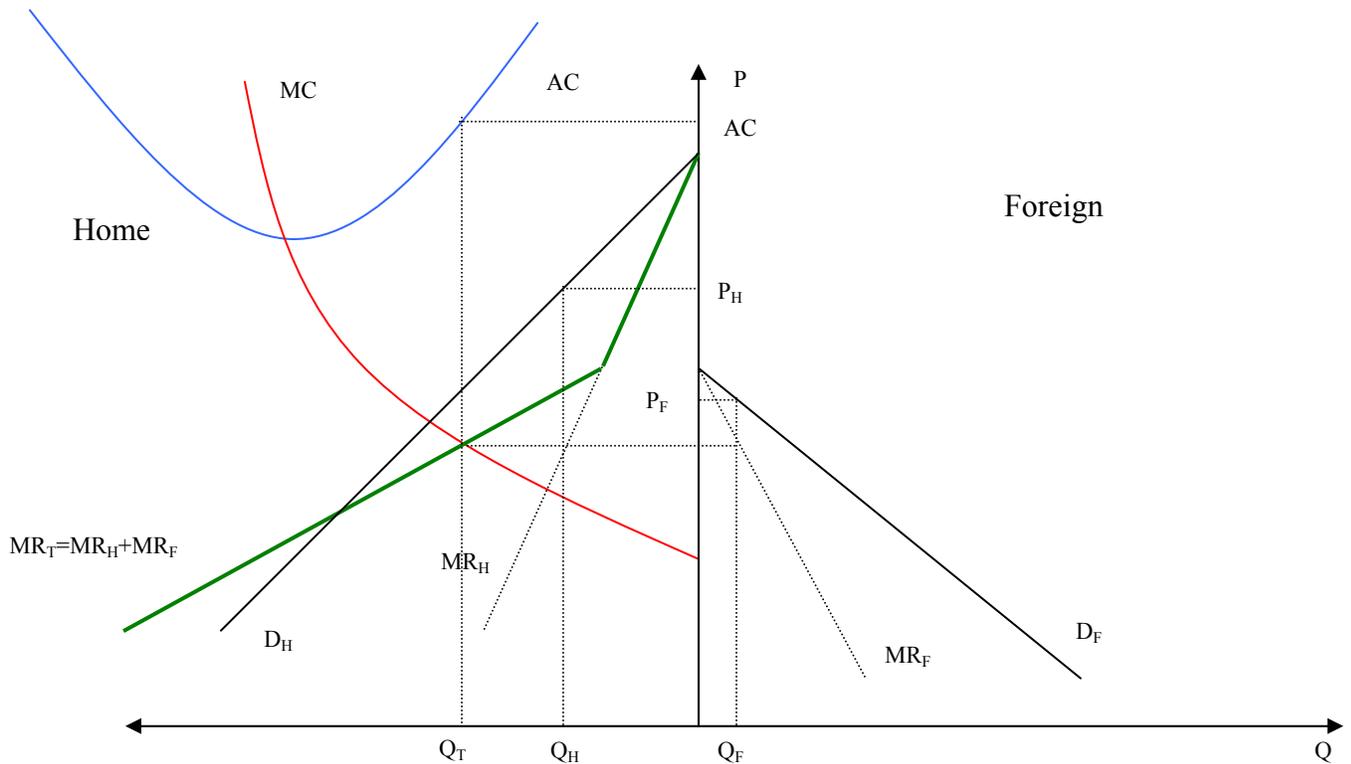


Figure 3.3 Price discrimination and selling below cost: losses in both markets



In most of the trade literature AD is considered as an instrument of protection – simply a means of restricting imports. The poor economic rationale behind dumping allows protectionist interests to threaten foreign competitors and to use existing domestic mechanisms for harassment, through the costs required to prepare legal defences as well as a loss of revenues from temporary reductions in market access. There is substantial evidence that AD is used even in the absence of any actual dumping. As a result, the decision to file an AD petition can be viewed as purely a rent-seeking activity. For instance, AD actions can be used to reduce imports when international markets decline. Considering that if the importing market is depressed, prices would decrease and many firms would sell below cost. Politicians would be pressed by industry for trade protection and, at the same time, domestic firms would complain that they are being injured by the imports. In the US, for example, politicians can deflect requests for protection by sending the complainants to ITC to open an AD case. The ITC can undertake a quick preliminary investigation that can conclude there is a possibility that the US firms are experiencing substantial damage caused by imports at unfairly low prices. If a positive preliminary determination of dumping is reached, a temporary AD duty will be imposed on imports from the offending firm or firms. Further, a full investigation would follow in order to assess if dumping actually occurred. In the case where it is found that no dumping took place, the foreign firms get back money paid as AD duty, but until the full investigation is over, the foreign firms access to the importer's market is inhibited. Hence, even if dumping is not occurring, the domestic firm gets short-term protection.

We cannot conclude that the substantial increase in AD activity can be explained just by the growth of “unfair” trade. Information on AD actions and the main motives for the increase in the number of AD cases will be outlined in the next section.

### 3.3 The use of antidumping actions and AD investigation procedure

#### 3.3.1 AD statistics

The first antidumping legislation was put in place in Canada in 1904 and the 1947 GATT also included antidumping provisions (Kerr, 2001). Dumping was defined as price discrimination in the original GATT and that definition has remained unchanged. For the pre-1980 period, there was no exact accounting of AD activity as under GATT regulations, countries were not obliged to report AD actions – which were carried out by domestic institutions in importing countries. However, during this time, AD disputes were very rare because the GATT rules for imposing duties were difficult to satisfy. Further, tariffs in general were higher and, as a result, industries were less exposed to import competition. The major users of AD at the time were the US, EU, Australia, Canada, South Africa and New Zealand. On average, two or three dozen cases were filed each year. Existing information shows that only 5% of AD cases resulted in duties being imposed until the early 1970s (Blonigen and Prusa, 2001).

The Tokyo Round, which concluded in 1979, brought many changes to AD law, two of which were very important. First, the definition of dumping was expanded to include sales below cost and not only price discrimination. The second change was the removal of one important piece of evidence that was required before duties were imposed – to

demonstrate that the dumped imports are the main cause for material injury. The latter provision was also part of the Kennedy Round Antidumping Code. As a result, during 1980s alone, there were more than 1600 AD cases filed worldwide, with 99% being filed by US, EU, Australia and Canada (Finger, 1993). Starting with the early 1990s, developing countries (i.e., new users) started to file more and more cases - over half of AD petitions were filed by developing countries by the mid-1990s. Finger et al. (2000) have found that between 1995, when the WTO came into effect, and 2000, developing countries initiated 559 cases compared to 463 cases by developed countries (Table 3.1). And between 1995 and 2003, there were 2416 antidumping cases initiated worldwide (Young and Wainio, 2005). As Blonigen and Prusa (2001) suggest, the increase in AD activity cannot be explained by an increase in “unfair” trade, rather it is simply a result of weakening the AD requirements. Other researchers found two additional reasons to explain the growth in AD disputes. Ongoing tariff liberalization, which leads to more trade, in turn led to increased stress for import competing industries. The second reason is that safeguards are considered unsatisfactory by firms facing declining international competitiveness (Hansen and Prusa, 1995; Miranda, Torres and Ruiz, 1998; Finger, Ng and Wangchuk, 2000). Prusa (1992) argues that the increase in AD activity takes place because of the *in terrorem* effect, which means that by harassing the foreign rivals through antidumping, the domestic industry receives benefits.

Table 3.1 Numbers and percentages of antidumping initiations  
by country group, 1995-1999

<b>By/Against</b>	<b>Industrial Economies<sup>a</sup></b>	<b>Developing Economies<sup>b</sup></b>	<b>China, PRC<sup>c</sup></b>	<b>Transition Economies<sup>d</sup></b>	<b>All Economies</b>
Numbers of Antidumping Initiations					
Industrial Economies	127	274	54	62	463
Developing Economies	178	282	82	99	559
Transition Economies	3	1	1	3	7
All Economies	308	557	137	164	1029
Percentages of Antidumping Initiations					
Industrial Economies	27	59	12	13	100
Developing Economies	32	50	15	18	100
Transition Economies	43	14	14	43	100
All Economies	30	54	13	16	100

<sup>a</sup> Include USA, Canada, Australia, Japan, New Zealand, Iceland, Norway, Switzerland, and 15 European Union members.

<sup>b</sup> All other economies excluding industrial economies and transition economies.

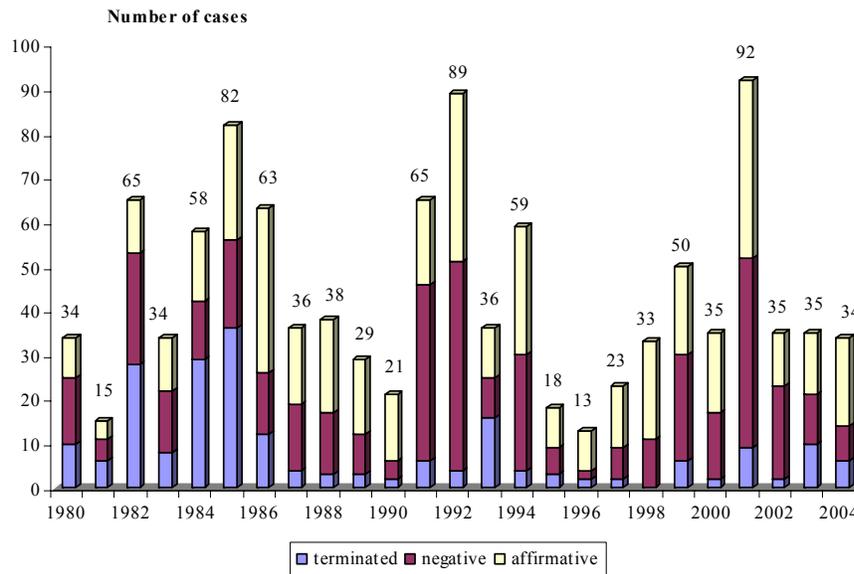
<sup>c</sup> Exclude Hong Kong, China; Macau, China; and Chinese Taipei.

<sup>d</sup> Include 27 transition economies in Eastern Europe and Central Asia

Source: Finger et. al. (2000)

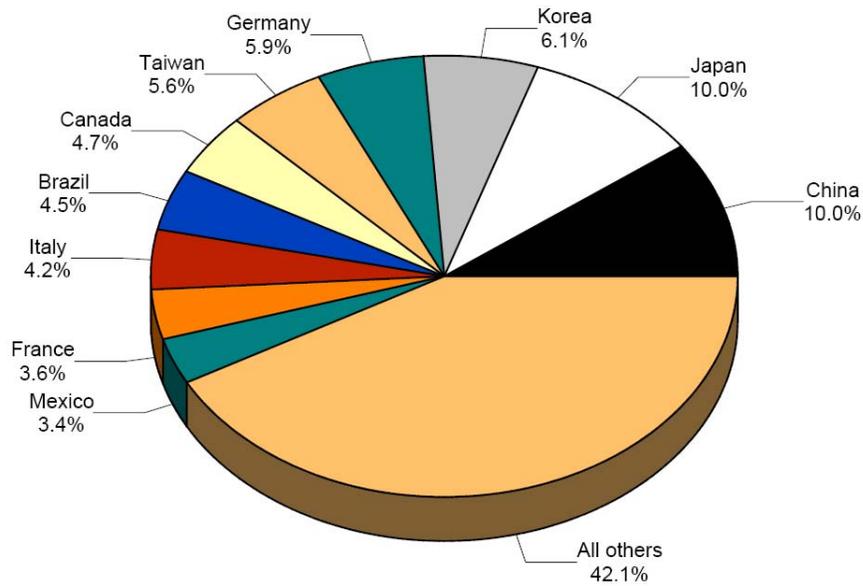
In the case of the US, the number of AD cases grew from 223 in the pre-1980 period (starting with 1955) to 1024 in the post-1980 period. From the total number of petitions filed, an affirmative decision was reached in 45% of cases in the pre-1980 era, compared to 67% in the post-1980 period. Figure 3.4 shows the total number of US AD cases for the period 1980-2004 and the final decision for each of them. In the same period of time, the top two countries that were cited in US AD cases were China and Japan, followed by Korea, Germany and Taiwan. Canada is in sixth place (Figure 3.5).

Figure 3.4 Antidumping case summary, by number of cases, fiscal years 1980-2004



Source: US International Trade Commission (USITC) (2005b)

Figure 3.5 Top ten countries cited in antidumping cases, by number of cases, fiscal years 1980-2004, cumulative



Source: US International Trade Commission (USITC) (2005b)

The trend in AD during the 1990s shows that the US became from the worlds' most prolific user of AD law the second most investigated country after China (Prusa and Skeath, 2001).

In the US, one agency handles dumping determination (ITA) and another handles injury determination (ITC), while other countries such as the EU and Australia have a single agency that makes both determinations. This bifurcated approach has the advantage that the outcome is more objective as the two different agencies should reach the same conclusion. For example, in the US, ITA has issued only three negative less than fair value (LTFV) determinations in the past decade (out of almost 400 determinations). The advantage of the unified approach is that it reduces the resources required and avoids conflicting results (Blonigen and Prusa, 2001). The next section will describe the main steps of an AD investigation process in the US, including a description of the statutory timetable.

### 3.3.2 US investigation procedure

If domestic producers believe that foreign competitors are dumping merchandise in their market, a home firm or a coalition of firms can initiate an AD case. Each country has its own procedures regarding AD cases. The WTO guidelines leave room for considerable latitude in the design of domestic AD institutions and procedures and member states apply the guidelines in their own way. There are some key similarities and differences among the members' arrangements for dealing with dumping (Blonigen and Prusa, 2001). The US investigation procedure is the focus of this section.

The two US governmental organizations responsible for carrying out AD cases are the US Department of Commerce's International Trade Administration (ITA) and US International Trade Commission (ITC). ITA determines whether there are sales at less than fair value, while ITC determines whether a US industry is or might be materially injured. Fair value is expressed by the foreign firm's domestic price after adjustments for differences in the products, purchased quantities or the sale circumstances that are taken into account. When there is no domestic market for the exported good, the price of the product in a third market would be considered and, finally, in absence of domestic and third market sales, a constructed value is used, which is calculated as the cost plus profit – an approximation of average total cost. Injury can take the form of depressed prices; lost sales; decline in sales, reduced market share, lower profits, reduced productivity, lower than expected return on investment; decreased production capacity; increased imports from the specific exporter; decreased employment, falling wages, mounting inventories and constraints in the ability to raise capital (ITA).

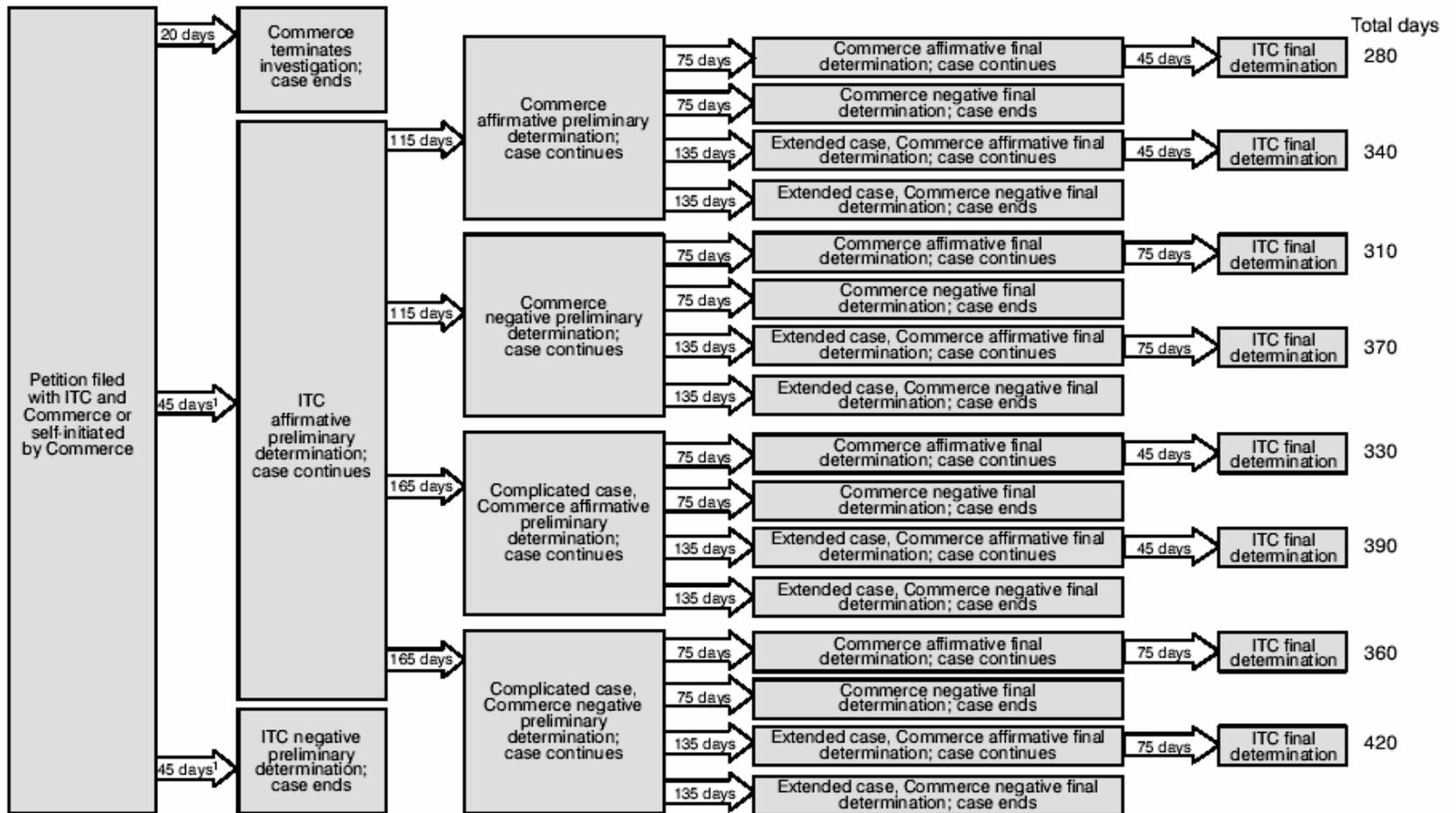
In the US, a petition can be filed on behalf of the industry if “(i) the domestic producers or workers who support the petition account for at least 25 percent of the total production of the domestic like product, and (ii) the domestic producers or workers who support the petition account for more than 50 percent of the production of the domestic like product produced by that portion of the industry expressing support for or opposition to the petition.” (US International Trade Commission, “Antidumping and Countervailing Duty Handbook”, 2005a, pp.16). Thus, the number of firms that participate in a petition plays

an important role in reaching a conclusion, (i.e. that the domestic industry is harmed) and ultimately whether to impose an AD duty against foreign exporters or not.

According to ITC, the investigation process has five steps: (1) initiation of the investigation by ITA; (2) the preliminary phase of the ITC's investigation; (3) the preliminary phase of the ITA's investigation; (4) the final phase of the ITA's investigation; and (5) the final phase of the ITC's investigation. Except for stage 3, a negative determination by either organization leads to termination of the proceedings. The interested party should file a petition with both the ITA and the ITC. In stage 1, the ITA should determine in 20 days if the case contains the elements and information necessary for the imposition of a duty. In stage 2, within 45 days, the ITC should make a material injury determination. The preliminary phase of ITC determination can be broken into six stages: (1) institution of the investigation and scheduling of the preliminary phase; (2) questionnaires; (3) staff conference and briefs; (4) staff report and memoranda; (5) briefing and vote; and (6) determination and views of the Commission. In stage 3, within 160 days after the petition was submitted, the ITA makes a preliminary determination whether there is reasonable information to believe that imports are being sold at less than fair value. If the evaluation of the ITA is affirmative, after publishing the notice of determination in *Federal Register*, all the subjected imports are liquidated and the importers are required to post a cash deposit or a bond on the estimated weighted dumping margin. Within 235 days after the date the petition was filed, in Stage 4, the ITA is required to make a final determination whether or not the imports are sold at less than fair value. In stage 5, within 280 days after the date of filing the petition, the ITC

should determine whether or not the US industry is materially injured by the respective imports. The final phase of the Commission's investigation may be broken down into eight stages: (1) scheduling of the final phase; (2) questionnaires; (3) pre-hearing staff report; (4) hearing and briefs; (5) final staff report and memoranda; (6) closing of the record and final comments by parties; (7) briefing and vote; and (8) determination and views of the Commission. The statutory timetable for an AD investigation is presented in Figure 3.6.

Figure 3.6: Statutory timetable for antidumping investigations (in days)



Source: US International Trade Commission (USITC)[a]

After a maximum of five years from the publication of a decision regarding an antidumping investigation, the two commissions, ITA and ITC, conduct a review, called a “sunset review”, to determine whether the annulment of an AD order would lead to the continuation or repetition of dumping and of material injury. Again, the ITA determines if the dumping will continue or recur and the ITC would determine if the material injury would continue or recur. If both agencies reach affirmative answers, the order is continued for another five years, otherwise the order is revoked. The timetable for the sunset review is presented in Table 3.2.

Table 3.2 Timetable for five-year reviews

<b>ACTION/EVENT</b>	<b>DAY</b>
Notice of institution published in the <i>Federal Register</i>	0
Entries of appearance/APO applications	21
Responses to notice of institution	50
Comments on appropriateness of expedited review	75
Notice of expedited or full review	95

Source: US International Trade Commission (USITC) (1998)

In case the interested parties do not respond or they give inadequate responses to the notice of initiation, the ITA and ITC take a final decision in a short time. These reviews are named “expedited” reviews (Table 3.3).

Table 3.3 Expedited Review

<b>ACTION/EVENT</b>	<b>DAY</b>
Commerce expedited determination (if issued)	120
Staff report to Commission and parties	122
Written submission on merits by parties	127
Commission vote	140
Commission determination and views transmitted to Commerce	150

Source: US International Trade Commission (USITC) (1998)

In cases where the interested parties respond adequately to the notice of initiation, both commissions will conduct reviews that are called “full” reviews (Table 3.4).

Table 3.4 Full Review

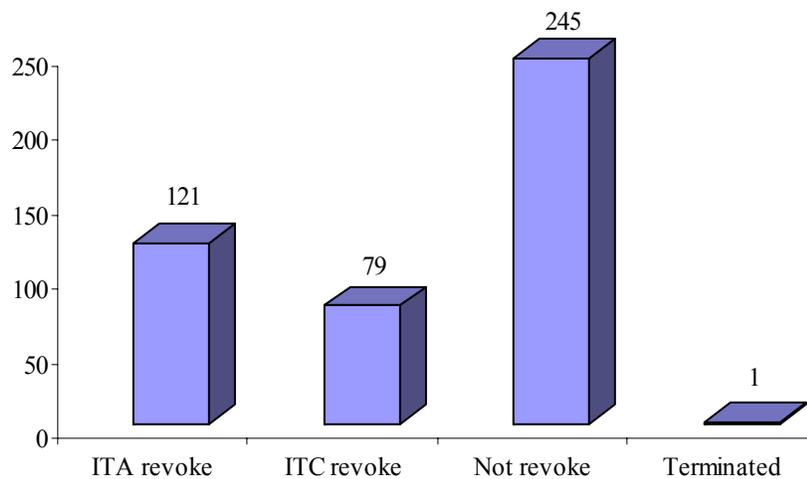
<b>ACTION/EVENT</b>	<b>DAY</b>
New entries of appearance/APO applications	180
Draft questionnaires to parties for comment	190
Party comments on draft questionnaires	205
Questionnaires mail date	225
Commerce subsidy/dumping determination	240
Questionnaires return date	255
Prehearing report to Commission and parties	285
Prehearing briefs	295
Hearing	305
Posthearing briefs	315
Staff report to Commission and parties	330
Final party comments	340
Commission vote	348
Commission determination and views transmitted to Commerce	360

Source: US International Trade Commission (USITC)(1998)

Sunset reviews were introduced in the antidumping and countervailing duty laws in the Uruguay Round Agreements Act approved in late 1994. All the antidumping and countervailing duty orders issued after January 1, 1995 are reviewed five years after they became effective. All antidumping and countervailing duties orders issued before 1995 were reviewed starting in July 1998 and completed in February 2001. The five-year

reviews for the pre-1995 orders are known as “transition” reviews. Out of 309 cases of transition reviews, 53% were not revoked, while 47% of cases were cancelled by either one of the commissions. Regarding the non-transition reviews, there are a total number of 114 cases, with 71% not being revoked, 28% cancelled by either commission and 1% terminated (Figure 3.7).

Figure 3.7 Five-year review investigations, outcomes by number of cases, fiscal years 1998-2004



Source: US International Trade Commission (2005b)

In the US, any AD duties collected are deposited in the General Fund of the US Treasury. However, according to a new bill titled “The Continued Dumping and Subsidy Offset Act” (CDSOA), which was enacted in 2000, the AD duties are shared among the AD petitioners. This bill, which is also known as “Byrd Amendment”, is outlined in the next section.

### 3.4 Byrd Amendment

In January 1999, Senator Mike DeWine of Ohio introduced a bill titled “The Continued Dumping and Subsidy Offset Act” (CDSOA). The bill stipulated that any duties assessed from an AD case should be distributed on an annual basis to “the affected domestic producers for qualifying expenditures” (USITC [b]), which means that the duties will be shared among the companies that supported the original petitions. Senator Byrd sponsored the bill in the senate, which was enacted on October 28, 2000 as part of the Agriculture, Rural Development, Food and Drug Administration, and Related Agencies Appropriations Act of 2001. This is why the law is called Byrd amendment.

The Byrd amendment is applied in cases where foreign products continues to be subsidized or dumped in the US market after an AD or CV duty has already been assessed. According to this law, the revenues collected from an AD or CVD case are distributed to the producers hurt by unfair trade, represented by petitioners and interested parties, and they are not deposited in the General Fund of the US Treasury as had previously been the case. The affected producers are represented by any “manufacturer, producer, farmer, rancher or worker representative (including associations of these individuals)” that was a petitioner or interested party in support of an AD or CVD petition and remains in operation<sup>21</sup>. Thus, the CDSOA does not consider eligible for duties distribution those companies that did not agree with the opening of a petition, those that ended the production of a product covered by an order and those that were acquired by companies who were against a petition. The expenses that are incurred by the affected producers between the issuing of an AD or CVD order and its termination and

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<sup>21</sup> 19 U.S.C. 1675 c(b)(1)

that are offset by the duties include “manufacturing facilities, equipment, research and development, personnel training, acquisition of technology, health care benefits for employees paid by the employer, pension benefits for employees paid by the employer, environmental equipment, training, or technology, acquisition of raw materials and other inputs and working capital or other funds needed to maintain production”<sup>22</sup>.

There are two agencies that implement CDSOA: the US International Trade Commission (ITC), which has the responsibility of developing a list with all eligible producers and US Customs and Border Protection (CBP), which has the responsibility of annually distributing the collected duties to the eligible producers. Also CBP has the responsibility for establishing the procedures for the distribution of payments and to publish in the *Federal Register* a notice of intent to distribute payments and a list with all the eligible domestic producers (US Government Accountability Office (GAO), 2005). A “Clearing Account” is established for each individual AD and CVD order under which the CBP places all estimated AD and CVD that are deposited with the CBP. When the duties are paid, the funds are distributed in “Special Accounts” opened for each individual case, from which the disbursements are made to the individual claimants. As the offset payments that will be distributed are limited by the funds available in the Special Accounts, the actual payment can cover only a small proportion compared to what is claimed (Grimmett and Jones, 2005). If the amount collected for a specific order is insufficient to pay everything that it was claimed, a *pro rata* share would be given to each claimant (Table 3.5). According to the *pro rata* formula, the individual disbursement percentage is determined based on the qualifying expenditures submitted. Thus, this

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<sup>22</sup> 19 U.S.C. 1675 c(b)(4)

creates an incentive for producers to claim as many expenses as possible compared with the other producers, potentially giving them a larger share of funds (GAO, 2005).

As can be seen in Table 3.5, the total amounts disbursed represented maximum of 0.02 percentage from the total amount claimed over the years, while the claims increased from almost 1.2 trillion dollars in 2001 to more than 3 trillion dollars in 2006, suggesting an incentive exists for producers to claim more. Most of the total disbursement in 2004, 93%, was given to producers of ball bearings, steel, petroleum wax candles, cement, food products, computer chips, polyester fiber, pencils, softwood lumber and industrial belts (Grimmett and Jones, 2005).

The CBP distributes the payments within 60 days of the first day of the next fiscal year and, also, a final annual report with all claims and disbursements has to be completed after all the payments have been made for the fiscal year.

Table 3.5 Key distributions under the Byrd Amendment 2001-2006  
(dollars)

Case no.	Commodity/origin	2001	2002	2003*	2004	2005	2006
A-122-838	Softwood lumber/Canada		-	24,016	5,306,436	3,229,963	-
A-201-802	Gray portland cement and clinker/Mexico	3,253,895	3,564	2,112	21,293,059	2,185,990	-
A-201-822	Stainless steel sheet and strip/Mexico	34,034	5,240,895	3,376,035	5,805,231	5,369,130	-
A-421-805	Aramid fiber/Netherlands	-	7,121,070	(153,560)	(7,943)	1,027,367	-
A-428-201	Ball bearings/Germany	7,506,014	23,499,893	6,394,952	4,613,618	7,583,602	20,850,712
A-428-203	Cylindrical roller bearings/Germany	7,225,640	9,951,095	3,567,701	4,592,228	6,378,469	26,451,117
A-475-818	Pasta/Italy	17,533,483	4,674,035	1,792,345	1,549,947	6,124,402	5,748,606
A-549-813	Canned pineapple/Thailand	1,792,483	530,693	5,394,993	1,658,695	3,065,874	1,409,609
A-559-201	Ball bearings/Singapore	6,871,336	50,988	61,580	-	-	-
A-570-504	Petroleum wax candles/China	18,317,982	69,536,244	3,325,043	51,391,920	21,523,740	1,609,741
A-570-840	Manganese metal/China	-	6,274,365	-	-	-	-
A-570-848	Crawfish tail meat/China	-	7,468,892	9,763,987	8,183,566	2,198,146	4,545,131
A-580-809	Circular welded nonalloy steel pipe/Korea	2,730,659	2,269,488	464,129	5,982,092	646,956	525,094
A-580-812	DRAMs of 1 megabit and above/Korea	5,117,438	14,413,121	1,823,572	11,946,020	176,194	1,032,265
A-588-015	Television receivers/Japan	24,311,452	9,016,052	(111,534)	197,019	264,943	-
A-588-054	Tapered roller bearings <= 4 inches/Japan	731,926	7,894,347	18,188,461	1,874,270	2,177,014	1,612,061
A-588-201	Ball bearings/Japan	51,447,879	55,266,544	39,419,202	35,358,173	47,810,802	40,090,301
A-588-604	Tapered roller bearings over 4 inches/Japan	5,176,911	14,378,990	33,740,298	15,695,328	14,552,104	2,366,033
A-588-807	Industrial belts/Japan	7,525,799	2,710,171	601,579	5,118,547	1,420,261	4,021,479
A-588-835	Oil country tubular goods/Japan	-	7,130,662	1,699,066	1,167,223	76,454	1,707,963
A-588-845	Stainless steel sheet and strip/Japan	6,636,053	19,694	4,697,297	3,945,532	3,598,564	5,616,517
	<b>Total amount disbursed</b>	<b>231,201,891</b>	<b>329,871,464</b>	<b>190,247,425</b>	<b>284,044,599</b>	<b>226,051,863</b>	<b>379,981,933</b>
	<b>Total certified claims</b>	<b>1,189,592,904,866</b>	<b>1,416,828,122,356</b>	<b>1,187,504,594,797</b>	<b>1,948,769,519,521</b>	<b>3,217,704,150,597</b>	<b>3,248,848,697,167</b>
	<b>% Disbursed</b>	<b>0.02</b>	<b>0.02</b>	<b>0.02</b>	<b>0.02</b>	<b>0.001</b>	<b>0.01</b>

\*An additional US\$50 million pending distribution as of 1 March 2004.

Parentheses indicate refunds to importers.

Sources: Harris and Devadoss, 2005; Grimmett and Jones, 2005, US Customs and Border Protection.

In December 2000, nine WTO members, the EU, Australia, Brazil, Chile, India, Indonesia, Japan, Korea and Thailand, brought complaints about CDSOA to the WTO, being followed in May 2001 by Canada and Mexico. These countries claimed that CDSOA is inconsistent with following WTO elements: Antidumping Agreement, Agreement on Subsidies and Countervailing Measures and other WTO obligations. The WTO reached the conclusion that CDSOA is not consistent with the US WTO obligations as it creates a “specific action against” dumping and subsidization and it gives an incentive for domestic producers to file or participate in antidumping and countervail petitions. The US agreed to comply with the WTO ruling. The compliance period expired on December 27, 2003, but US did not change or repeal the law. Thus, in January 2004, eight complainants, Brazil, Chile, EU, India, Japan, Korea, Canada and Mexico, asked the WTO Dispute Settlement for the right to retaliate. The rest of the complainants, Australia, Indonesia and Thailand, extended the compliance period for US until December 27, 2004.

WTO gave authorization to the eight members to impose additional import duties on US exports in an amount equal to 72% of the CDSOA disbursement for the preceding year based on the amount of AD or CV duties collected on that member’s products each year. Thus, on May 1, 2005 the EU and Canada started to apply an additional 15% customs duty on certain products from US. In particular, the EU imposed retaliatory duties on certain apparel, binders and notebooks, crane trucks, sweet corn and wire spectacle frames, while Canada imposed its duties on live swine, ornamental fish, oysters, as well as certain cigarettes and fish items. On August 18, 2005, Mexico decided to start

applying additional duties of 30% on some prepared milk products, 20% on wine and 9% on chewing gum, while on September 1, 2005, Japan began imposing 15% additional duty on 15 categories of US goods: seven types of ball bearings, three types of flat-rolled steel products, navigational instruments, machinery accessories, printing machines, forklift trucks and industrial belts. The remaining four members might suspend the concessions, while the three members that did not request the right to retaliate have entered into agreements with US, for which they will not ask for the suspension of concessions, but will keep the right to retaliate at any point in the future (Grimmett and Jones, 2005).

There are many supporters of CDSOA in the US Congress. Even more provisions to the law were introduced to ensure the full liquidation of the collected duties. At the same time, there are many members of Congress who are opposed to CDSOA and want to repeal the law. In response to their efforts to repeal the law in 2004 and 2005, more than half of the Senate Appropriations Committee members were against the repealing the law. As a result, on April 26, 2004, US negotiators partially complied with the demands of the CDSOA supporters by proposing to the WTO that negotiators should consider “the right of WTO members to distribute monies collected from antidumping and countervailing duties” as part of Doha Round (Grimmett and Jones, 2005). However, on February 1, 2006, the Congress passed the Deficit Reduction Omnibus Reconciliation Act, which includes a provision that repeals the CDSOA starting October 2007.

There are contradictory opinions regarding the CDSOA among economists and policy makers. Some believe that CDSOA increases economic efficiency, while others think it is worth a small amount of inefficiency to preserve US industries and jobs affected by “unfair” trade.

The first criticism brought against CDSOA is that there will be a greater incentive for domestic industries to petition for an AD investigation. This might occur for two reasons. First, the tariff revenue distributed to firms would increase the total benefit of filing a petition and, thus, it is more likely that a set of firms will have positive net benefits from funding the AD petition. The second reason is related to the way the funds are distributed. As the duties are distributed only among the firms that actively supported the petition, Byrd would likely diminish the free rider problem when petitions are launched. The data suggest that the number of AD cases did not increase (2000 – 35 cases, 2001 – 92 cases, 2002 – 35 cases, 2003 – 35 cases, 2004 – 34 cases)<sup>23</sup>, but the average proportion of firms participating in a petition increased from 40.4 % between 1980 and 2000 to 46.3 percent following passage of Byrd Amendment (2001-2003) (Olson, 2005).

CDSOA can also encourage inefficient production. As the distribution of benefits is unequal within an industry, some firms have an advantage over the other domestic, as well as global, competitors. Usually an AD petition is filed by less efficient firms in the industry, and, thus, the duties are distributed among these specific firms, which would normally increase their production. This increase in production might also lower the

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<sup>23</sup> Of course, there are many reasons why petitions are launched. Hence, the role of the Byrd Amendment cannot be determined, *ceteris paribus*.

market price and, as result, output of other firms in the industry would decrease. Thus, the more efficient firms in the industry would be adversely affected, while the inefficient ones receive a benefit and increase production (CBO, 2004). Another argument explaining possible inefficient production is that since a firm is qualified for disbursement only if it manufactures the same particular product, the firm might produce the specific good longer than it is efficient to do so instead of allocating resources for the production of alternative products (Grimmett and Jones, 2005).

CDSOA also increases transaction costs. By increasing the incentive for firms to file AD cases and by adding the costs associated with the distribution of duties, the total social cost increases.

Another negative aspect pertaining to Byrd is retaliation by other countries, which affect the interests of US exporters. Finally, Byrd discourages the settling of cases by private negotiation because, with an investigation, they would get protection as well as the duty revenues, while with suspension agreements they only get protection. If the effect is either good or bad for the US economy is unclear. In any case, a positive effect is represented by the fact that AD duties are sometimes so high that they can force the foreign firms out of the US market, while with a settlement agreement the foreign firms usually remain in the market. Further, with a settlement agreement, the rent obtained from the price increase remains with the foreign producer, while in case of an investigation, the rent goes to the US government as duty revenue.

A secondary effect of implementing Byrd Amendment is represented by an increased incentive of the trade lawyers to follow up the cases in favour of the domestic producers. In the US, it is common for law firms to undertake cases where their fees are entirely determined by a pre-specified share of the settlement (i.e. their income is determined solely by their ability to obtain a monetary settlement for their clients). The trade lawyers may, hence, be directly interested in their financial reward when presenting the case in front of ITC. Further, the trade lawyers might encourage domestic producers to file petitions.

Based on the general discussion in this section, the purpose of the next section is to give an overview of what is happening in one AD case and to see whether this specific case is in some way legitimate or whether it is an expression of protectionist actions.

### 3.5 Case study – the US case against Durum wheat and Hard Red Spring wheat from Canada

Since the early 1990s, imports of Canadian durum and spring wheat have been a concern to wheat producers in the northern US. They claim that the Canadian wheat imports are highly subsidized and this affects the prices of the local grains in a negative way. The complains of the US producers are aggravated by the Canadian Wheat Board (CWB), which they consider it has special market powers and financial guarantees by the Canadian government, and by certain Canadian import rules and regulations that discriminate against imports to the benefit of Canadian wheat producers. On the other hand, Canada maintains that its grain import practices and CWB export practices comply with WTO obligations and international trade rules. These disputes led to various

investigations initiated by US trade officials pertaining to Canadian wheat trading practices and the CWB (Schnepf, 2004).

### 3.5.1 Industry characteristics

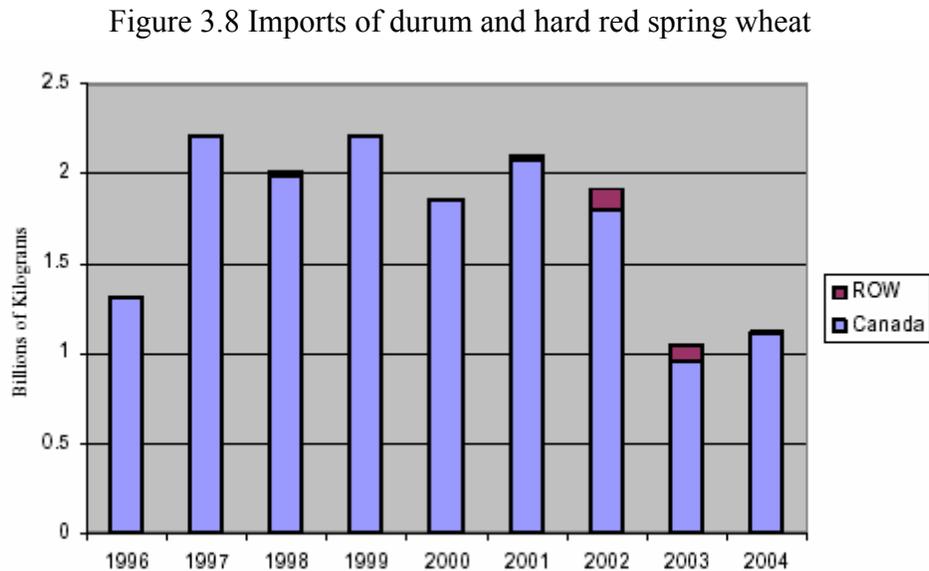
Hard Red Spring Wheat (HRS) is one of the three classes of hard wheat, having the highest content of protein and gluten relative to the other two classes, Hard Red Winter (HRW) and Hard White (HW). HRS is valued as it can be blended with lower-protein wheat to be milled into premium bread flour. Durum wheat, on the other hand, is also a type of hard, high-protein wheat, but it is valued because it is the only wheat class that can be milled into semolina and can be processed into various pasta products. Therefore, the two classes of wheat have a significant premium price over the other wheat types.

Most of the Canadian production of HRS and durum wheat occurs in the Prairie Provinces (Manitoba, Saskatchewan and Alberta), while US production takes place in the northern states (Minnesota, Montana, North and South Dakota and Washington).

The big difference between the HRS and durum industries in the US and Canada is represented by the way in which the products are marketed: in the US, grain is marketed through producer cooperatives and trading companies, while in Canada, the Canadian Wheat Board (CWB) has the exclusive right to buy and sell western Canadian wheat and barley (Schnepf, 2004).

The US is the world's biggest exporter of wheat, while Canada is the world's leading exporter of HRS and durum wheat. Imports of wheat into the US are, in general, small, approximately 3% of total US supplies each year, and most of the imports are represented

by HRS and durum from Canada. As Figure 3.8 indicates, almost all US imports of HRS and durum wheat are from Canada (Olson<sup>24</sup>).



Source: Olson, K., “Dumping in agriculture. Case studies in antidumping. Case study: wheat”

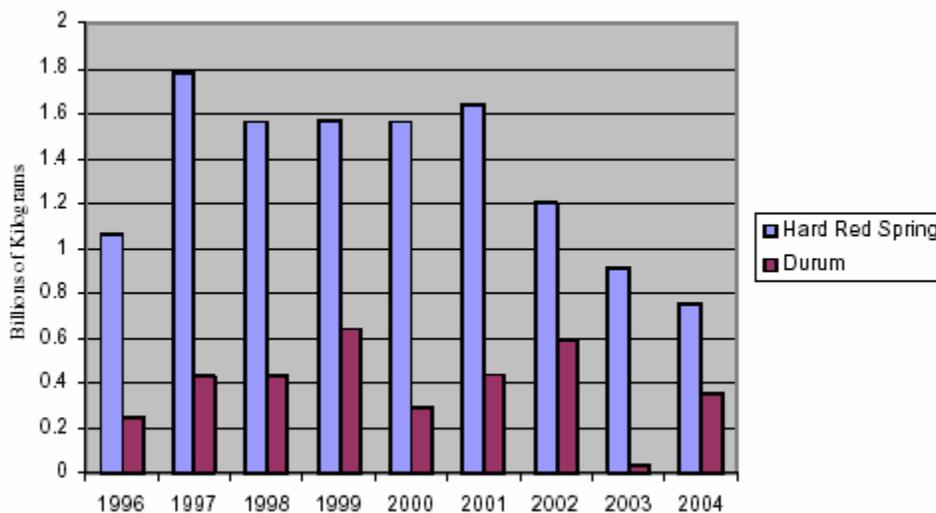
The increasing trend of imports of HRS and durum wheat from Canada, starting in the early 1990s: from 330,000 metric tons in 1989 to over 2.4 million metric tons (mmt) in 1994/1995 and having an average of over 1.8 mmt since then, has been considered very disruptive by the US border states’ producers, especially in periods of low prices. The growth in agricultural trade between the two countries can be explained by many factors such as the 1989 Free Trade Agreement between US and Canada, policy changes and different macroeconomic factors (e.g. exchange rate).

Production of durum wheat in the US has decreased in the period prior to the antidumping petition from 110 million bushels in 2000/2001 to 79 million bushels in

<sup>24</sup> <http://nw08.american.edu/~reynolds/>

2002/2003. The same situation could be observed in case of HRS, domestic production in the US has decreased from 502 million bushels in 2000/2001 to 357 million bushels in 2002/2003. At the same time imports of Canadian durum and HRS have increased. The imports of HRS wheat rose from 41 million bushels in 2000/2001 to 46 million bushels in 2001/2002, afterwards falling to 11 million bushels in 2002/2003, while durum imports increased from 12 million bushels in 2000/2001 to 18 million bushels in 2001/2002, afterwards decreasing to 13 million bushels in 2002/2003 (Figure 3.9).

Figure 3.9 US Imports of Durum and Hard Red Spring Wheat from Canada



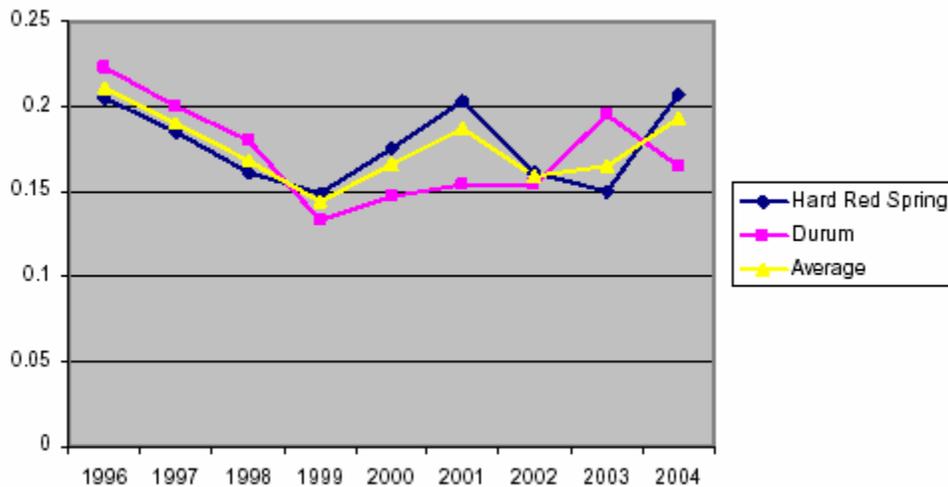
Source: Olson, K., "Dumping in agriculture. Case studies in antidumping. Case study: wheat"

The market share of Canadian HRS in the US rose from 12.8% in 2000/2001 to 15.9% in 2001/2002, dropping sharply to 5.8% in 2002/2003. A similar trend could be observed for Canada's share of the US market for durum wheat, it increased from 18% in 2000/2001 to 29.3% in 2001/2002, falling back to 20.8% in 2002/2003 (Olson<sup>25</sup>).

<sup>25</sup> <http://nw08.american.edu/~reynolds/>

As can be seen in Figure 3.10, the average import price of HRS wheat from Canada fell in the period prior to the antidumping petition. As a result, the price received by the US producers decreased from \$2.94 per bushel in 2000/2001 to \$2.89 per bushel in 2001/2002, which does not seem to be a significant decline. It increased dramatically, however, in 2002/2003 to \$3.84 per bushel.

Figure 3.10 Average import price of durum and HRS wheat from Canada (Calculated unit price per kilogram)



Source: Olson, K., "Dumping in agriculture. Case studies in antidumping. Case study: wheat"

Durum prices followed an opposite trend, as the average import price has increased in the period prior to the antidumping petition and, as a result, the price received by the US farmers rose from \$2.66 per bushel in 2000/2001 to \$4.04 in 2002/2003 (Olson<sup>26</sup>).

### 3.5.2 The antidumping case against Canadian wheat

On September 13, 2002, the North Dakota Wheat Commission, the Durum Growers Trade Action Committee and US Durum Growers Association filed an AD and a CVD

<sup>26</sup> <http://nw08.american.edu/~reynolds/>

petition with both the ITC and ITA claiming that the US market was materially injured or was threaten to be injured by subsidized and less than fair value (LTFV) imports of Canadian durum and hard red spring wheat. The period under investigation was July 1, 2001 – June 30, 2002. On November 25, 2002, the preliminary decision of the ITC was that wheat producers in the US were being materially injured by the Canadian imports of durum and HRS wheat, thus letting the investigation to move forward (USITC, 2003).

On May 8, 2003, the ITA released its preliminary determination that durum wheat and HRS from Canada were being, or likely to be, sold at less than fair value on the US market. The temporary antidumping duties established by ITA were 8.15% for each exporter, CWB and all others, in the case of durum wheat and 6.12%, again for CWB on one side and all the other exporters on the other side, for HRS wheat. The dumping margin is calculated as the difference between the normal value and the export price. In the case of durum wheat and HRS wheat, the ITA calculated the normal value based on the Canadian home market sales data as the merchandise was sold in sufficient quantities in home market and there is no particular market situation that prevents a proper comparison with the export price. When the normal value is calculated using domestic prices, the ITA compares the domestic prices to the average cost of production in the country under the investigation. As there were more than 56,000 HRS wheat producers in Canada, the ITA developed a methodology to calculate a representative cost of production and constructed value for the merchandise under consideration. The ITA stratified producers of HRS wheat by all relevant soil types within each major producing province, calculated a simple average of the costs of production within a stratum and,

further, it weight averaged the amounts per stratum based on each stratum's delivered tons. As some of the 27 Canadian producers that were selected for the calculation of the cost of production did not provide the necessary information to calculate the average cost of production, ITA was obliged to use "facts otherwise available" to calculate the cost of production of these specific producers<sup>27</sup>. As CWB was the largest exporter to US of the specific merchandise during the investigated period, the ITA used CWB as a sole respondent in the HRS wheat investigation. More than 20% of the CWB's HRS home market sales were at prices less than the average cost of production and, thus, these sales were excluded from the calculation of the normal value.

The ITC final ruling of October 20, 2003 regarding the AD investigation was that the US market is materially injured by the Canadian imports of hard red spring wheat, but not by durum wheat. The reasoning of ITC behind the decision not to impose dumping duties on durum wheat was that as the import price of durum wheat from Canada was, generally, higher than the price charged by the domestic producers, the volume of durum wheat imports from Canada could not depress the domestic price. The ITC established that the lower net returns of the US domestic industry in 2001/2002 was caused by decreases in governmental payments and increases in total expenses (Olson<sup>28</sup>). The final determination of ITA was that the imports of hard red spring and durum wheat are sold in the US at less than fair value (LTFV), injuring domestic producers. Thus, the final weighted-average dumping margin calculated and imposed on durum wheat was 8.26%

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<sup>27</sup> WTO Standard: In cases in which any interested Member or interested party refuses access to, or otherwise does not provide necessary information within a reasonable period or significantly impedes the investigation, preliminary and final determinations, affirmative or negative, may be made on the basis of the facts available. (AD Agreement, Art. 6.8; SCM Agreement 12.7)

<sup>28</sup> <http://nw08.american.edu/~reynolds/>

and on HRS was 8.87%. However, AD duties were imposed only on Canadian imports of HRS wheat, as ITC did not find that durum wheat was materially injuring the US market (USITC, 2003).

On November 24, 2003, the CWB filed a request for panel review with the US Section of the North American Free Trade Agreement (NAFTA) Secretariat. On June 7, 2005, a NAFTA dispute settlement panel directed the ITC to reconsider the affirmative material injury determination regarding the Canadian exports of HRS wheat to US. There were different reasons why the panel asked for a reconsideration: 1) they considered that ITC made a mistake in finding that the volume of subjects imports was significant; 2) there was not enough evidence regarding price underselling and price suppression; 3) there was not enough evidence for finding that Canadian imports led to the price drop in the period 2000/2001 and 2001/2002; 4), they believed that the ITC did not compare the prices at the same level of trade; 5) the ITC did not consider other factors that could be causing injury to US producers.

In the review the ITC used as purchase prices of domestically produced and imports of HRS wheat, the prices reported by US millers. The ITC has determined that the Canadian HRS is not significantly underpriced. Thus, on October 2005, the ITC determined that the domestic industry was not materially injured or threaten to be injured by the Canadian imports of HRS wheat. As a result, the US removed the antidumping duties on Canadian imports of HRS wheat.

Each step of an AD case (pre-investigation, investigation, post-investigation) affects the behaviour of the domestic and foreign firms in different ways. Further, the costs and benefits of an AD case play an important role in deciding whether or not to participate in a petition. Consequently, the AD literature will be reviewed in the next section.

### 3.6 Literature review

The literature on AD is extensive because of the widespread use of AD protection. Blonigen and Prusa (2001) review the growing literature on AD. They divide the literature on AD into three broad categories related to different phases of the trade policy: pre-investigation, investigation and post-investigation.

Prusa and Skeath (2001) found in an empirical study that the increasing trend that is observed in AD petitions can be explained by both economic and strategic motivations. The economic motives pertain to “unfair” trade and “special protection”. The “special protection” is defined by Bagwell and Staiger (1990) as a tool utilized by countries to limit the expansion of imports or exports for the sensitive industries that would occur as a result of tariff-reduction obligations imposed by trade negotiations. The set of strategic reasons considered in their study can be classified as “club” and “retaliation” motives. The traditional users of AD protection are considered club members, while “retaliation” refers to AD petitions that are filed against countries that had previously investigated them. The empirical results showed that both, the economic and strategic motives, are important for traditional users of AD, while for the new users the strategic reasons are the most important.

Blonigen and Prusa (2003a) argue that the cost of AD protection is much higher than that suggested by standard tariff analysis for two reasons: first, the administrative reviews that adjust the AD duties and, second, the altering of profit maximizing behaviour by domestic and foreign firms in order to influence the AD outcome. They argue that in addition to the loss in welfare arising from the administrative reviews, which is outlined in Gallaway et al. (1999), there are other costs of AD duties that are difficult to observe and estimate: the possibility of retaliation, the way in which an AD protection in the upstream industry affects the downstream industries and the domestic industry's rent-seeking cost. They review the literature on how AD distorts the non-cooperative outcomes<sup>29</sup>. Their review concentrates mostly on how firms can manipulate the dumping margin and the injury determination, which provide almost diametrically opposite incentives to alter strategic behaviour. Regarding the manipulation of the dumping margin that is calculated based on a price method, the domestic firm can increase the output in a Cournot game, driving down the domestic common price and, as a result, the foreign firm's exports. On the other hand, if the foreign firm determines the export price which is used in the calculation of the dumping margin, it can have incentive to raise prices and, as a result, the domestic firm can raise the price as well, hurting the domestic welfare (Ethier and Fischer, 1987; Fischer, 1992 and Reitzes, 1993). As to injury manipulation, Hillman et al. (1987) considered employment as strategic variable, firms hiring an excessive number of workers in period 0 and firing them in period 1.

Vandenbussche and Wauthy (2001) show that firm's product quality choice may be

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<sup>29</sup> The non-cooperative outcome literature is concentrated on "the link between decisions and the prospect of AD protection as internal to the firm" (Blonigen and Prusa, 2003a, pp. 239), while the cooperative outcome literature is focused on different ways in which AD law can lead to collusions among firms (Blonigen and Prusa, 2003b).

affected. Several papers looked at the relationship between the threat of AD protection and voluntary export restraints (VER). Anderson (1992, 1993) examined the case when the causality runs from VERs to AD duties, which leads to an outcome called “domino dumping”, meaning that the foreign firms are encouraged to dump in order to start an AD case that will lead to a VER. The motive is the capture of the quota rents that are available in the VER. Kolev and Prusa (2002) examined the case when the causality runs from AD to VERs and found that the efficient and inefficient foreign firms form a pool and voluntarily restrain their exports in period 1, which leads the AD authorities to impose a very low AD duty for efficient firms and very high ones for the inefficient firms.

In terms of the question of how a cooperative outcome would be influenced by AD, there are several theoretical papers showing how the AD law can lead to the collusion among domestic and foreign firms. Prusa (1992) answered the question of why there are so many antidumping petitions withdrawn in the US. He outlined the fact that the firms that are participating in an AD case are exempt from antitrust actions according to a US legal principle called *Noerr-Pennington*, thus opening the door for private settlements between the domestic and foreign firms once an AD case has been initiated. Using a bargaining model, he showed that the firms would prefer settlements rather than AD duties and, hence, to withdraw cases.

Another body of literature looks at how the AD process and the imposition of an AD duty affect domestic and foreign country welfare, trade volume and the prices. The effect of

AD duty on welfare, given that most of the studies use computable partial and general equilibrium models, are the ones obtained in case of an *ad-valorem* tariff. Some features of AD law, however, are complex. The administrative review is one example. As in the administrative review, the ITA recalculates dumping margins, DeVault (1996) has shown that many foreign firms raise prices, the dumping margins are lower in the administrative reviews and AD duties can be avoided. Gallaway et al. (1999) found that while the welfare loss on the US economy from AD and CVD duties was \$209 million annually, the real welfare loss ranges from \$2 to \$4 billion annually because of how much the AD duties declined over time as a result of the administrative reviews.

Lee and Jun (2002) review the five effects that AD petitions and duties have on trade that are outlined by the literature: the first degree of *in terrorem* (the first order of investigation) effect or trade destruction effect, which represents the direct impact of raising the tariff on imports into the subject country; the trade diversion effect, which is a side-effect of the AD protection, representing the rising in the value of exports from non-petitioned competitors to the country that initiated the AD petition; the second degree of *in terrorem* (the second order of investigation) effect which is also a side-effect of AD protection and means the reduction of the value of exports by the non-petitioned to the country that initiates the AD petitions; the trade deflection effect, which is another side-effect of AD protection, arising because the petitioned country shifts exports to other markets to make up for the market lost in the original importing country; and the trade depression effect, again a side effect that means that the non-petitioned firms will decrease their exports to the petitioned country. Another effect of AD investigation and

duty imposition is tariff-jumping by foreign firms. Haaland and Wooten (1998) and Vandebussche, Veuglers and Belderbos (1999) show that domestic producers can be worse off because of increased domestic competition if the foreign firms locate in the protectionist country to avoid AD protection.

The effects of AD duties and investigations on prices is that the price paid by the consumers in the protectionist country increases. Boltuck (1987) derived the market conditions that would determine how much the foreign firm raises its export price and/or lowers its home price to decrease the AD duty when the dumping margin is calculated as the difference between the foreign firm's export price and the domestic price.

The area of trade policy with oligopolistic industries has been widely researched. Most of the literature on strategic trade policy under oligopoly has assumed that the firms within a country are symmetric such that either they have the same marginal cost of production or they are of the same size. However, Helpman and Krugman (1989) have outlined that there is a need for models of strategic trade that would consider heterogeneous firms. Thus, Collie (1993) has shown that under asymmetric oligopoly, trade policy has a rationalization effect that does not occur in a symmetric oligopoly. The rationalization effect depends on the convexity of demand and the variation of the industry's output. The author is analysing the effect of an export subsidy. In a later paper, Collie (2006) showed that the *ad valorem* and specific trade policy instruments such as import tariffs and production subsidies have similar rationalization effects as an export subsidy. An *ad valorem* production subsidy has an additional negative rationalization effect compared to

a specific production subsidy. On the other hand, Van Long and Soubeyran (1997) have shown that in case of an asymmetric oligopoly such that the firms have different marginal costs, in the determination of the optimal trade policy a major importance is played by the Herfindahl index of concentration and the elasticity of the slope of demand. One of their results is that in case of a convex demand curve, an export subsidy shifts the domestic concentration in favour of lower cost firms and if the concentration index is high, the efficiency gain will be higher than the loss resulting from a fall in price. In case of a concave demand, an export tax would be optimal.

A number of authors have discussed the collective action problems. Rodrik (1986) had shown in a Nash lobbying game that the well-established proposition that subsidies are superior to tariffs for achieving any economic or non-economic objective can be reversed as long as the endogeneity of the distortion or non-economic objective is allowed. Van Long and Soubeyran (1996) analyzed the relationship between the degree of heterogeneity of a pressure group, demand conditions and the total lobbying expenditures for tariff protection, in non-cooperative and cooperative games. They concluded that in a non-cooperative setting, an increase in the degree of heterogeneity of domestic firms increases the total lobbying expenditures under specific sufficient conditions, while in a cooperative game, there is a positive correlation between heterogeneity and lobbying expenditures if the elasticity of the slope of the demand curve is negative. Hillman, Van Long and Soubeyran (2001) looked at an oligopolistic industry in non-cooperative and cooperative settings where firms allocate resources between lobbying for quantitative import restrictions and internal cost-reducing activities. They showed that under non-

cooperative lobbying, the ranking of firms' profitability is reversed when lobbying opportunities are available as long as either the monitoring technology exhibits increasing returns or the demand curve is locally convex. They explained this result by the evidence of free riding in a non-cooperative lobbying. As in cooperative lobbying there is no free riding, the reverse situation does not appear. Bandyopadhyay, Park and Wall (2004) have concentrated on lobbying for domestic export subsidies and have concluded that greater domestic cost heterogeneity leads to a higher subsidy level and a larger domestic market share. Regarding the effect of cost heterogeneity on the welfare, the results are ambiguous, showing that for a near symmetric situation, the increased heterogeneity reduces domestic welfare if the number of domestic firms exceeds a critical number, while for a farther from symmetric situation, the relationship is reversed.

Conlon and Pecorino (2004) outlined that lobbying is characterized by activities that are aimed to influence different policies (e.g. tariffs, quotas, tax policy etc.), while rent seeking is represented by a set of activities that would lead to obtaining rents for particular agents, given existing policies (e.g. competing for import licenses etc.). Thus, free riding is an important problem in case of lobbying as all the firms in the industry would benefit from a tariff or a quota, for example, and not just the firm that lobbied for it. On the other hand, in case of rent seeking, only one agent gets an import licence, for example, the licence being denied to the others. Thus the benefits of rent seeking are rival and excludable and free riding does not occur.

Some authors have studied the relationship between lobbying and free-riding. The general conclusion that they found is that lobbying for non-excludable goods suffers from free-riding mainly when the firms play non-cooperative games. Grossman and Helpman (1996) showed that the sunset industries are better at overcoming the free rider problem associated with interest group politics than the sunrise industries. They explained their result on the observation that firms in a sunset industry are not new entrants who can free ride on the efforts of those with the sunk investments, which is the opposite in case of sunrise industries.

Pecorino (1998) analyzed the relationship between industry concentration and free riding in a repeated tariff lobbying game where cooperation is maintained through a trigger strategy. His results contrast with the previous findings such that there is no presumption that it is becoming more difficult to maintain cooperation as the number of firms in the industry rises. In a subsequent paper, Pecorino (2001) studied again the relationship between industry concentration and free riding. In a non-cooperative lobbying game, his results showed that only the largest firm lobbies for protection and that only the size of the largest firm influences the equilibrium tariff. However, the effect of an increase in the market share of the dominant firm on the cooperation is ambiguous. On the other hand, in a repeated game, the size distribution among the fringe firms affects the ability to maintain cooperation, such that cooperation is easier to be maintained when there are only few fringe firms than when there are many small fringe firms.

Sandler and Hartley (2001) looked at problems of collective action, developing expenditure reaction functions. They considered the case of national defence, considered as a pure public good, and showed that small and poor allies free ride on the large and rich allies in NATO (exploitation hypothesis). The free riding is a consequence of the defence spilling, which replaces the need for the ally's self-provision of defence. In the case of a standard pure public good model, they showed that the exploitation hypothesis might arise, indicating that the defence burdens are shared in a disproportionate fashion. They also considered a joint product model of alliances, where there are private benefits among allies, but public within an ally. In this case, they showed that the exploitation hypothesis loses its relevancy and the disproportionality between allies' defence burdens dissipates.

Mao and Zaleski (2001) showed that free riding is a function of industry concentration and the rate of return on lobbying. They developed a cooperative game theory model in which the firms lobby the government for tariff protection. In case of low rate of return on lobbying, free riding will decrease as industry concentration increases. When the lobbying expenditures have high rates of return, free riding is decreasing even in the less concentrated industries.

In Magee (2002), the tariffs are determined endogenously through a Nash bargaining model between an industry lobby and the government. He showed that the free rider problem becomes more severe when industry concentration decreases. He also considered another three situations: the rent obtained from the lobbying game is received

by the industry, case in which an increase in the number of firms makes cooperation easier to maintain; a large part of the rent goes to the industry, which leads initially to easier cooperation in case the number of firms increases below a critical value, but afterwards the free rider problem becomes more stringent; and a large fraction of the lobbying rents is captured by the policy maker, case in which an increase in the number of firms makes cooperation more difficult.

Baylis and Furtan (2003) looked at the link between federalism, rent-seeking and free-riding behaviour. They considered the case of the dairy industry in Canada, which is regulated through production quotas, administered pricing schemes and import tariffs. They showed that the federalist framework for Canadian agriculture creates the potential for underinvestment in rent seeking. Further, they estimated reaction functions for provincial rent seeking expenditures, testing whether the provinces cooperate, act independently or free ride on each other. They showed that the Canadian provinces that have less to lose from a change to the supply management system in the dairy industry free ride on the expenditure of the larger provinces. Provinces free ride when lobbying the federal government for supply management rents.

The relationship between anti-dumping/countervailing duties and the free-riding in lobbying activities is not well studied. The paper by Herarder and Pupp (1991) is based on the microeconomic factors that might affect the decision of a representative firm in the steel industry and not on the macroeconomic situation. Macroeconomic factors cannot accurately reflect the economic performance of some industries. The authors take into

account the fact that the benefits of antidumping and countervailing duties have the characteristics of a public good. The results show that an increasing relationship between the expenditure on anti-dumping and countervailing duty cases and the potential benefits of the trade action does not exist, indicating that firms have the potential to free ride. They also show that the sectors that can control the free riding problem the best will get the highest protection; and not the sectors that are most injured by imports.

Olson (2004) estimates a structural model of rent-seeking by firms and her focus is on the free riding phenomenon. She used data on 157 countries and 447 four-digit 1987 Standard Industrial Code (SIC) industries in the manufacturing sector for the period 1980-1996. She also empirically studied the possibility of an industry reaching a settlement agreement with the foreign competitors. The empirical results obtained in this study are that the industries with more firms and more concentrated industries are having greater problems in overcoming the free riding problem. The author found that there is a directly proportional relation between the trade protection level and political factors, including the number of firms that chose to lobby the government for protection. Olson (2005) conducts an empirical analysis to see whether the introduction of the Byrd Amendment increased the level of rent seeking in the US. The study concentrates on two questions: whether the introduction of Byrd Amendment led to an increase in the number of AD cases and in the average proportion of the industry filing a petition. She used data at the four-digit SIC level on AD filings by over 350 US manufacturing industries between 1980 and 2003. A Zero Inflated Poisson model was used to estimate the determinants of number of antidumping petitions and the results confirm that more

petitions are filed under Byrd by traditional AD users. An Ordinary Least Square (OLS) regression was used to estimate the proportion of the industry that files a petition and the results confirmed that the Byrd Amendment gives firms an incentive to contribute to the filing of a petition, thus mitigating the free rider problem.

Chang and Gayle (2006) developed a non-cooperative game with homogenous firms to examine the economic effects of Byrd Amendment. They concluded that if Byrd disbursements are related to the volume of imports, for more competitive markets than Cournot equilibrium, Byrd may increase the foreign imports, while if the market is less competitive than a Cournot, Byrd acts as an instrument of trade protectionism.

On the other hand, Ichino and Wong (2001) considered that there is a difference between political lobbying and a petition for administered protection. According to them, in administered protection, the level of protection is not related to the resources spent on filing a petition, thus the agents cannot influence directly the decision in an AD case and the size of the AD duty. They studied the decision to file a petition for administered protection considering that the protection that the agents get is a public binary good. The authors concluded that as long as the probability of protection is independent of the number of petitioners, there will be no free riding only if the individual benefit from protection is fairly small, such that no firm is willing to file a petition by itself. Otherwise, when the benefits-costs ratio increases, there will be free riding.

The focus of the rest of this chapter is on the relationship between the firms' participation in an AD case and the characteristics of the AD benefits. The main issue that is analyzed whether there is free riding in an AD case and whether the free riding decreases as a result of Byrd amendment.

### 3.7 Research methodology

This part of the chapter discusses the research method utilized to study the behaviour of a firm in case of an AD petition. It will show that for AD cases, there is a possibility of free riding. Following the seminal paper of Olson and Zeckhauser (1966), who analyzed the economics of alliances, this chapter will show that in AD petitions as well, the "exploitation hypothesis" will occur. The "exploitation hypothesis" is defined by Olson and Zeckhauser (1966) as the disproportionate sharing of burdens in an alliance, dependent on a pure public good, which leads to the possibility of free riding by the small allies on the large allies. Firstly, AD petitions will be considered a pure public good with non-rival and non-excludable benefits. The AD benefits are non-rival when one firm's consumption of a unit of benefits does not subtract from the consumption opportunities available to the other firms in the industry from the same unit. The AD benefits are non-excludable as they are accessible to all firms in the industry and they cannot be provided just to the petitioners. In this case, it is expected that the free riding will be high. Secondly, the AD petitions are considered a joint product, with public and private features. This situation can be applied only in case of US because of the Byrd Amendment. Thus, when firms lobby for AD protection, except the benefits that all firms in the industry get from the imposition of a tariff, the petitioners or the supporters of a

petition will share the AD duty collected under certain circumstances. Therefore, the firm-specific benefits represent an incentive for firms to participate in the lobbying process, and, thus, the free rider problem would diminish.

However, the AD statistics (Table 3.6) show that before year 2000 when Byrd was amended, free riding was taking place.

Table 3.6 The number of firms in the industry and the number of petitioning firms: 1990-2000

<b>Number home firms in the industry</b>	<b>The number of petitioning firms</b>		
	1 firm	All firms	Some firms
1 firm (19 cases)	19 cases	-	-
2 firms (16 cases)	11 cases	5 cases	-
3 firms (17 cases)	14 cases	2 cases	1 case
4 firms (11 cases)	8 cases	1 case	2 cases
5 firms (12 cases)	6 cases	1 case	5 cases
6 to 10 firms (31 cases)	9 cases	0 cases	22 cases
More than 10 firms (40 cases)	4 cases	0 cases	36 cases

Source: Yasu Ichino and Kar-yiu Wong, 2001

As it can be observed in Table 3.6, when the number of firms in the industry is small, the petition is typically filed by 1 firm, while when the number of firms in the industry is large, more firms would join the petition, but not all of them. This situation can be explained by the fact that in industries with a small number of firms, the gains from protection that one firm receives are large enough to cover the petitioning cost. On the other hand, for industries with a large number of firms, the firms jointly file petitions as

the individual gain from protection is not large enough to cover the petitioning cost. As Table 3.6 shows, in all situations there is evidence of free riding.

According to Olson (2005), the average proportions of firms participating in a petition increased from 40.4 % between 1980 and 2000 to 46.3 percent following the passage of Byrd Amendment (2001-2003) (Table 3.7).

Table 3.7 Proportion of firms filing Antidumping petitions

	Share of petitions filed Between 1980 – 2000	Share of petitions filed Between 2001-2003
$0.00 < Proportion < 0.25$	36.7	17.0
$0.25 < Proportion < 0.50$	35.7	51.9
$0.50 < Proportion < 0.75$	12.3	18.5
$0.75 < Proportion < 1.00$	15.6	12.6

Source: Olson, K.M., 2005

In this theoretical model, it is assumed that the firms in the industry play a non-cooperative (Cournot-Nash) game. According to Shy (1995), “an outcome is said to be a Nash equilibrium (NE) if no player would find it beneficial to deviate provided that all other players do not deviate from their strategies played at the Nash outcome.”<sup>30</sup> As the Cournot-Nash game is characterized by simultaneous moves, the conjectural variation is zero, meaning that each firm assumes that the other firms would continue producing the same level of output no matter how it behaves.

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<sup>30</sup> Shy, O. (1995), *Industrial Organization: Theory and Applications*, Published by Cambridge, Mass. MIT Press, pp. 18.

It is a two-stage lobbying game of protection with heterogeneous firms, which is solved using backward induction. Thus, in the second stage, given the AD duty, the domestic and foreign firms set their output levels by playing a Cournot-Nash game. In the first stage, the domestic firms play the non-cooperative lobbying game that determines the AD duty rate. Hence, in each stage, a Nash equilibrium is obtained for the specific sub-game.

It is assumed that there is a market for a homogenous product in the home country with the following demand function

$$P = P(Q) \tag{3.1}$$

where P represents the price, while Q is the total output supplied on the home country market. The usual assumption is that the demand is downward sloping, thus

$$P'(Q) < 0 \tag{3.2}$$

The home country (domestic) market is supplied by m domestic firms and m\* foreign firms. Considering that the individual output for a firm i is q<sub>i</sub>, the total quantity supplied on the domestic market is:

$$Q = \sum_{i=1}^{m+m^*} q_i \tag{3.3}$$

It is considered that the unit cost of production for a firm  $i$  is constant and it is denoted by  $\Theta_i$ . By assuming a constant marginal cost of production, the output decisions in the domestic market are independent of the output decisions in the foreign markets.

Thus, following Van Long and Soubeyran (1996), in the second stage of the game, each firm, domestic and foreign, maximizes its profit taking into account that the exports to the domestic market are subject to a specific AD duty, which is denoted by  $t$ . The objective function for a domestic firm is represented by:

$$\max_{q_i} \Pi_i = [P(Q) - \Theta_i] * q_i, \quad i = 1, 2, \dots, m \quad (3.4)$$

while the objective function for an exporter is:

$$\max_{q_j} \Pi_j = [P(Q) - \Theta_j - t] * q_j, \quad j = m + 1, \dots, m + m^* \quad (3.5)$$

These are unconstrained maximization problems. The Cournot equilibrium is represented by  $m+m^*$  equations, which are the first order conditions (FOC) for the maximization problems:

$$q_i P'(Q) + P(Q) = \Theta_i, \quad i = 1, 2, \dots, m \quad (3.6)$$

$$q_j P'(Q) + P(Q) = \Theta_j + t, \quad j = m + 1, \dots, m + m^* \quad (3.7)$$

The profit functions are maximized if the second order conditions (SOC) hold:

$$q_k P''(Q) + 2P'(Q) < 0, \quad k = 1, 2, \dots, m + m^* \quad (3.8)$$

By adding up all the FOC, Eq. (3.6) and (3.7), for the domestic and foreign firms, the total quantity supplied on the domestic market can be found:

$$QP'(Q) + (m + m^*)P(Q) = \Theta_s + m^* t \quad (3.9)$$

where:

$$\Theta_s = \sum_{k=1}^{m+m^*} \Theta_k \quad (3.10)$$

Eq. (3.9) shows that the equilibrium quantity supplied on the domestic market is a function of the sum of the unit costs and the total AD duty that is collected from the exporting firms. Hence, the total quantity supplied can be written as:

$$Q = Q(\Theta_s + m^* t) \quad (3.11)$$

This result is in agreement with the theorem of Bergstrom and Varian (1985), which states that the equilibrium quantity in Nash equilibrium is independent of the distribution of the unit costs, being a function only of the sum of the unit costs.

Based on the FOC, some comparative statistics can be carried out. By totally differentiating Eq. (3.9), the relationship between the Cournot equilibrium output and the AD duty rate is obtained. Hence,

$$\frac{\partial Q}{\partial t} = \frac{m^*}{(m + m^* + 1)P' + QP''} \quad (3.12)$$

The denominator of expression (3.12) is negative, due to Hahn stability condition (Hahn, 1962). According to Hahn, a sufficient condition for stability of a Cournot equilibrium with respect to a natural adjustment process is that the marginal revenue of each firm should decrease as the output of any other firm increases. Thus, it is assumed that the outputs are strategic substitutes, meaning that the reaction functions are downward sloping. Hence, a well known result is obtained, as the AD duty increases, the equilibrium total output decreases.

Based on the effect of the AD duty on the total equilibrium output supplied on the domestic market, the relationship between the profit of the domestic firms and the AD duty can be found. From Eq. (3.6), the output of a domestic firm is:

$$q_i = \frac{P(Q) - \Theta_i}{-P'} \quad (3.13)$$

Thus, the equilibrium profit for a domestic firm  $i$  is equal to:

$$\Pi_i = [P(Q) - \Theta_i]q_i = \frac{[P(Q) - \Theta_i]^2}{-P'} \quad (3.14)$$

Knowing that the total quantity  $Q$  is a function of the AD duty rate  $t$ , the change in the individual domestic firm profit for a unit change in the AD duty rate is:

$$\frac{\partial \Pi_i}{\partial t} = \frac{\partial \Pi_i}{\partial Q} * \frac{\partial Q}{\partial t} \quad (3.15)$$

where

$$\frac{\partial \Pi_i}{\partial Q} = \frac{[(P - \Theta_i)P'' - 2(P')^2][P - \Theta_i]}{(-P')^2} = q_i(q_i P'' + 2P') \quad (3.16)$$

According to SOC, expression (3.16) has a negative sign. Thus, from Eq. (3.12), (3.15) and (3.16), it follows that any domestic firm would gain from an increase in the AD duty.

Based on the profit function found in stage II, stage I of the game can be solved. In stage I lobbying is introduced, meaning that the domestic firms can lobby the governmental organizations (e.g. ITC) that are responsible for resolving the AD cases, to put in place and to raise the AD duty. As Herander and Pupp (1991) have shown, the ITC's injury decision is not dependent only on the prescribed injury criteria, but also on the effectiveness of the industry coalition. Hence, lobbying plays an important role in the decision of protecting a market against foreign producers.

Stage I of the game will be analyzed in two situations. Firstly, the benefits of the AD petition are purely public. Thus, all the firms in the industry will benefit from the imposition of an AD duty and not only the domestic firms that are paying the lobbying cost. It is expected that this situation will be characterized by a high level of free riding. Secondly, the benefits of an AD petition are considered a joint product. Hence, all the firms in the industry will benefit from the imposition of the trade restriction, but only the firms that will actively participate in the lobbying process would share the AD duties collected. It follows that the domestic firms would have an additional incentive to participate in the AD cases. Thus, it is expected that in this situation the free riding will decrease.

Stage I of the game is played only among the domestic firms. As was outlined in the previous part of this chapter, to obtain a favourable decision, the AD case must be first initiated. According to the antidumping and countervailing legislation, a petition can be initiated only if a number of firms with a total specific market share sign the petition. Thus,  $m_1$  represents the domestic firms that are necessary to sign the petition in order for the case to be accepted. In this model, it is considered that there always will be  $m_1$  firms that are initiating the petition and, therefore, they participate in the lobbying action. The rest of the domestic firms,  $m_2$  ( $m - m_1$ ), called fringe firms, will decide according to the petitioning benefit-cost ratio and the probability of winning the case if they will participate or not in the lobbying action. It is assumed that the firms are normally distributed with respect their marginal cost of production. As the firms with the highest market share or the most efficient firms are gaining the most from restricting trade, it is

assumed that the  $m_1$  firms that are initiating the petition are the most efficient ones, thus they always have lower marginal costs than the fringe firms.

By having two domestic firms, one with a low cost of production and the other one with high cost of production, it can be shown that the low cost firm will always produce more than a high cost firm. Let  $i$  be the low cost firm, with  $\Theta_i$  the marginal cost of production, and  $j$  be the high cost firm, with  $\Theta_j$  marginal cost of production. Using Eq. (3.13), it follows that:

$$q_i - q_j = \frac{\Theta_j - \Theta_i}{-P'} \quad (3.17)$$

As  $\Theta_j$  is greater than  $\Theta_i$  and  $P'$  is negative, the sign of the expression (3.17) is always positive, thus a petitioner will always produce more than a fringe firm.

In Stage I of the game, the firms decide simultaneously how much to pay for lobbying. Let's consider that an initiating (petitioner) firm would incur  $s_{li}$  lobbying costs, while a fringe firm would have  $s_{fj}$  lobbying costs in case he participates. The AD duty,  $t$ , is an increasing function of the total lobbying cost  $s$ , where

$$s = \sum_{i=1}^{m_1} s_{li} + \sum_{j=m_1+1}^m s_{fj} \quad (3.18)$$

Hence, it is postulated that:

$$t = t(s), t'(s) > 0, t''(s) < 0 \quad (3.19)$$

Expressions (3.19) show the normal assumptions that the marginal effectiveness of lobbying expenditure is positive, but diminishing. When there are no private benefits, the objective function of a petitioner is:

$$\max_{s_{li}} N_i = \Pi_i(Q(t, \Theta_i)) - s_{li} \quad (3.20)$$

where  $N_i$  is the net profit,  $\Pi_i(Q(t), \Theta_i)$  is the firm's Cournot equilibrium profit from

Stage II and  $t$  stands for  $t(\sum_{i=1}^{m_i} s_{li} + \sum_{j=m_1+1}^m s_{ff})$ . This is an unconstrained maximization

problem. In maximizing the net profit, a firm takes into account only its own lobbying expenditures as in a Cournot equilibrium there is no conjectural variation, meaning that the firm conjectures that the other firms will not change their output in response to a change in its own output level. The necessary condition for maximizing  $N_i$  is:

$$\frac{\partial N_i}{\partial s_{li}} = \frac{\partial \Pi_i}{\partial Q} * \frac{\partial Q}{\partial t} * t'(\cdot) - 1 = 0, \quad i = \overline{1, m_1} \quad (3.21)$$

For maximization of net profit, expression (3.21) always equals 0 as it is assumed that the petitioners certainly are participating in the lobbying action, thus  $s_{li} > 0$ . The necessary condition for maximizing  $N_i$  can be rewritten as:

$$q_i [q_i P'' + 2P'] * \frac{\partial Q}{\partial t} * t'(\cdot) = 1 \quad (3.22)$$

It is assumed that SOC holds

$$\frac{\partial^2 N_i}{\partial s_{li}^2} < 0, \quad i = \overline{1, m_1} \quad (3.23)$$

and thus, there is an unique positive solution,  $s_{li}$ , that maximizes the net profit of firm  $i$ .

On the other hand, a fringe firm will maximize, with respect its own lobbying expenditures,  $s_{fj}$ , the following net profit function, taking into account the non-negativity constraint:

$$\max_{s_{fj}} N_j = \Pi_j(Q(t), \Theta_j) - s_{fj}, \quad j = \overline{m_1 + 1, m} \quad (3.24)$$

where again,  $\Pi_j(Q(t), \Theta_j)$  is the Cournot equilibrium profit found in Stage II.

The necessary condition for maximization is:

$$\frac{\partial N_j}{\partial s_{ff}} = \frac{\partial \Pi_j}{\partial Q} * \frac{\partial Q}{\partial t} * t'(\cdot) - 1 \leq 0 \quad \text{and} \quad s_{ff} \geq 0 \quad \text{with complementary slackness.} \quad (3.25)$$

The complementary slackness condition says that for  $s_{ff} > 0$ , the equality for the maximization necessary condition holds, meaning that in case a fringe firm participates in the petition, there is an equilibrium lobbying cost that would maximize its net profit function. If  $s_{ff} = 0$ , the first condition in expression (3.25) will always be less than 0, meaning that when a fringe firm does not participate in a petition, 0 is the equilibrium lobbying cost that would maximize its net profit function and, as a consequence, the firm free rides. Considering only the situation where  $s_{ff} > 0$ , the necessary condition for maximization can be rewritten as:

$$q_j [q_j P'' + 2P'] * \frac{\partial Q}{\partial t} * t'(\cdot) = 1 \quad (3.26)$$

It is assumed that the SOC holds and, hence, there is a unique Nash equilibrium lobbying cost. As Eq. (3.22), the FOC for a petitioner, always holds, the question is in which situations Eq. (3.26), the FOC for a fringe firm, would hold. The circumstances under which the necessary condition for maximization of net profit for a fringe firm would hold can be found by equalizing the two FOCs. Thus, it is obtained that:

$$(q_i - q_j) [P''(q_i + q_j) + 2P'] = 0 \quad (3.27)$$

As it was shown before, the quantity produced by a low cost firm,  $q_i$ , is always higher than the quantity produced by a high cost firm,  $q_j$ . Therefore,  $q_i - q_j$  is always positive. Expression (3.27) equals 0 only when  $P''(q_i + q_j) + 2P'$  is 0. According to the stability condition for a Cournot equilibrium,

$$P' + q_i P'' < 0 \tag{3.28}$$

$$P' + q_j P'' < 0 \tag{3.29}$$

By adding up the two stability conditions, the following inequality is obtained:

$$2P' + (q_i + q_j)P'' < 0 \tag{3.30}$$

Based on the heterogeneity of firms and the stability condition, the equality expressed in Eq. (3.27) can never hold, showing that there is no lobbying cost for a fringe firm that would maximize its net profit. It can be concluded that in case of having only public benefits, all the fringe firms will free ride and the petition will be supported financially only by the minimum number of firms necessary to initiate a petition.

Considering the situation under Byrd Amendment, the analysis would include the private benefits expressed as a function  $B_i$ . The private benefits are dependent on the individual lobbying cost. Thus,

$$B_i = B_i(s_{li}), B_i' > 0, B_i'' < 0 \quad (3.31)$$

The assumption about the private benefit function is that it is increasing in the firm's lobbying cost, but diminishing. The private benefit would be different for each firm depending on their market share, the losses that they suffer as a result of dumping and the size of the imports. However, all these factors are represented by the individual lobbying cost assuming that the firms with the higher losses or larger market share would have more interest in winning the AD case than the smaller firms.

Thus, the objective function of a petitioner is the maximization of the net profit function including the private benefits:

$$\max_{s_{li}} N_i = \Pi_i(Q(t), \Theta_i) + B_i(s_{li}) - s_{li} \quad (3.32)$$

where,  $N_i$  is the net profit function for firm  $i$ ,  $\Pi_i(Q(t), \Theta_i)$  is the Cournot's equilibrium

profit found in Stage II,  $t$  stands for  $t(\sum_{i=1}^{m_1} s_{li} + \sum_{j=m_1+1}^m s_{lj})$  and  $B_i$  is the individual private

benefit. This is an unconstrained maximization problem as well. The necessary condition for a petitioner to maximize its net profit is:

$$\frac{\partial N_i}{\partial s_{li}} = \frac{\partial \Pi_i}{\partial Q} * \frac{\partial Q}{\partial t} * t'(\cdot) + \frac{\partial B_i}{\partial s_{li}} - 1 = 0, \quad i = \overline{1, m_1} \quad (3.33)$$

As the  $m_1$  firms will initiate the AD petition, the FOC will always be binding, meaning that there is always an equilibrium individual lobbying cost,  $s_{li}$ , that maximizes the net profit function for firm  $i$ . Assuming again that SOC holds, meaning that

$$\frac{\partial^2 N_i}{\partial s_{li}^2} < 0, \quad i = \overline{1, m_1} \quad (3.34)$$

there will be an unique positive lobbying cost that maximizes the net profit function of firm  $i$ .

Also, a fringe firm will maximize its net profit function taking into account the non-negativity constraint, which can be written as:

$$\max_{s_{ff}} N_j = \Pi_j(Q(t), \Theta_j) + B_j(s_{ff}) - s_{ff}, \quad j = \overline{m_1 + 1, m} \quad (3.35)$$

where  $N_j$  is the net profit function for a fringe firm,  $\Pi_j(Q(t), \Theta_j)$  is the equilibrium

profit found in Stage II,  $t$  stands for  $t(\sum_{i=1}^{m_1} s_{li} + \sum_{j=m_1+1}^m s_{ff})$  and  $B_j$  represents the private benefit

for the fringe firm  $j$ , which is a function of the individual lobbying cost.

The necessary condition for profit maximization for a fringe firm is:

$$\frac{\partial N_j}{\partial s_{ff}} = \frac{\partial \Pi_j}{\partial Q} * \frac{\partial Q}{\partial t} * t'(\cdot) + \frac{\partial B_j}{\partial s_{ff}} - 1 \leq 0 \text{ and } s_{ff} \geq 0 \text{ with complementary slackness.} \quad (3.36)$$

Therefore, if  $s_{ff}=0$  is the lobbying cost that maximizes the net profit for a fringe firm, the necessary condition for maximization will never be binding and all the fringe firms will free ride. In case  $s_{ff}>0$ , the FOC will be binding and there will be an equilibrium lobbying cost for the fringe firm that would maximize the net profit function. By assuming that the second order condition holds, the equilibrium will be unique. Knowing that equation (3.33), FOC for a petitioner, will always hold, as the initiators of the petition will at all times pay for lobbying, the conditions under which Eq. (3.36), FOC for a fringe firm, will hold can be found. The specific conditions are obtained by equating the two FOCs. Thus, it can be concluded that the fringe firms for which the condition:

$$\left( \frac{\partial \Pi_i}{\partial Q} - \frac{\partial \Pi_j}{\partial Q} \right) * \frac{\partial Q}{\partial t} * t'(\cdot) + \left( \frac{\partial B_i}{\partial s_{li}} - \frac{\partial B_j}{\partial s_{ff}} \right) = 0 \quad (3.37)$$

holds will not free ride. Having a closer look at the non-free riding condition, it can be rewritten as:

$$(q_i - q_j) * [P''(q_i + q_j) + 2P'] * \frac{\partial Q}{\partial t} * t'(\cdot) + \left( \frac{\partial B_i}{\partial s_{li}} - \frac{\partial B_j}{\partial s_{ff}} \right) = 0 \quad (3.38)$$

As it was shown before, the firm with the low cost of production will produce more than a firm with high cost of production and, thus, knowing that firm  $i$ , one of the petitioners, has a lower cost of production than firm  $j$ , one of the fringe firms,  $q_i - q_j$  will always be positive. The expression  $[P''(q_i + q_j) + 2P']$  is negative due to stability condition,  $\frac{\partial Q}{\partial t}$  was shown as being less than 0, while  $t'(\cdot)$  is positive according to the assumptions of the model. Thus, the first term of expression (3.37), which represents the additional marginal public benefit of lobbying that a petitioner receives compared to a fringe firm, is always positive. By assumption, the private marginal benefits of lobbying for a petitioner and a fringe firm,  $\frac{\partial B_i}{\partial s_{ii}}$  and  $\frac{\partial B_j}{\partial s_{jj}}$ , are positive.

The fringe firms for which the private marginal benefit equals the sum between the marginal private benefit of a petitioner and the additional public benefit of a petitioner compared to the fringe firm, will not free ride. Hence, it can be concluded that there will be some fringe firms for which the marginal private benefit would be high enough to represent an incentive for them to participate in the lobbying action. Thus, the free riding will be reduced in comparison with the situation where the AD duty has only public benefits.

Based on the non-free riding condition, some conclusions can be drawn regarding the relationship between the heterogeneity among firms and the possibility of free riding. Thus, the non-free riding equality can be expressed as:

$$\frac{\Theta_j - \Theta_i}{-P'} * [P''(q_i + q_j) + 2P'] * \frac{\partial Q}{\partial t} * t'(\cdot) + \frac{\partial B_i}{\partial s_{ii}} = \frac{\partial B_j}{\partial s_{jj}} \quad (3.39)$$

Hence,

$$\frac{\frac{\partial B_j}{\partial s_{jj}}}{\partial(\Theta_j - \Theta_i)} = \frac{P''(q_i + q_j) + 2P'}{-P'} * \frac{\partial Q}{\partial t} * t'(\cdot) \quad (3.40)$$

which has a positive sign, meaning that if the heterogeneity of firms increases, the marginal private benefits for a fringe firm should be higher in order for the firm not to free ride. Thus, an increase in the degree of heterogeneity of domestic firms would lead to more free riding among the fringe firms. It can be concluded that only the fringe firms with marginal cost of production close to the petitioners' marginal cost of production will find it beneficial not to free ride.

Since our concern is more on Stage I problem, the second stage can be simplified by considering, as special case, a linear inverse demand function. Thus, the price can be written as:

$$P(Q) = a - b * Q; \quad a, b > 0 \quad (3.41)$$

For a linear inverse demand function, the Cournot equilibrium quantity that would be supplied on the domestic market becomes:

$$Q = \frac{(m + m^*)a - \Theta_s - m^* t}{(m + m^* + 1)b} \quad (3.42)$$

where  $m$  represents the number of domestic firms,  $m^*$  is the number of exporters,  $t$  is the

AD duty rate and  $\Theta_s = \sum_{k=1}^{m+m^*} \Theta_k$ . As was shown in the general case,  $Q = Q(\Theta_s + m^* t)$

and the relationship between the total quantity supplied and the AD duty rate is negative being equal to:

$$\frac{\partial Q}{\partial t} = -\frac{m^*}{b(m + m^* + 1)} < 0 \quad (3.43)$$

The individual profit for a domestic firm equals:

$$\Pi_i = \frac{(a - bQ - \Theta_i)^2}{b} \quad (3.44)$$

and the change in the individual profit for a change in the AD duty rate is positive being equal to:

$$\frac{\partial \Pi_i}{\partial t} = \frac{2(a - bQ - \Theta_i)m^*}{b(m + m^* + 1)} > 0 \quad (3.45)$$

Moving further into the first stage of the game, in case where the AD duty has only public benefits, it is found that the fringe firms for which the condition

$$\Theta_i = \Theta_j, \quad i = \overline{1, m_1}; \quad j = \overline{m_1 + 1, m} \quad (3.46)$$

holds, will not free ride. As it is assumed that the firms are normally distributed with respect their marginal cost of production and a petitioner will always have a lower marginal cost of production than a fringe firm ( $\Theta_i < \Theta_j$ ), the non-free riding condition never holds, the conclusion that was expected as the general case has led to the same result.

In case where the benefits of an AD petition have the characteristics of a joint product, the non-free riding condition becomes

$$-2(\Theta_j - \Theta_i) \frac{\partial Q}{\partial t} t'(\cdot) + \frac{\partial B_i}{\partial s_{li}} = \frac{\partial B_j}{\partial s_{ff}} \quad (3.47)$$

where  $\Theta_i$  and  $\Theta_j$  are the marginal costs of production for a petitioner and, respectively, a fringe firm with  $\Theta_i < \Theta_j$ ,  $t'(\cdot)$  represents the marginal AD duty rate with respect to the lobbying expenses, while  $\frac{\partial B_i}{\partial s_{li}}$  and  $\frac{\partial B_j}{\partial s_{ff}}$  are the marginal private benefits of lobbying a petitioning and, respectively, a fringe firm.

By substituting the first derivative of the total quantity supplied with respect the AD duty rate by expression (3.43), the non-free riding condition can be re-written as

$$2(\Theta_j - \Theta_i) \frac{m^*}{b(m_1 + m_2 + m^* + 1)} + \frac{\partial B_i}{\partial s_{li}} = \frac{\partial B_j}{\partial s_{ff}} \quad (3.48)$$

where  $m_1$  is the number of firms that initiate the AD petition, while  $m_2$  is the number of fringe firms, with  $m_1 + m_2 = m$  being the total number of domestic firms. Being a specific case of the general analysis carried out before, the same conclusion is obtained, meaning that a fringe firm will not free ride, as long as its marginal private benefits of lobbying equals the sum between the marginal private benefits of a petitioner and the additional marginal public benefits gained by a petitioner compared with a fringe firm.

Regarding the relationship between free riding and heterogeneity of firms, the main conclusion is that as firms become more heterogeneous, the incentive to free ride grows, thus the fringe firms that are close in terms of marginal cost of production with the petitioning firms will have more incentive not free ride.

Based on the non-free riding condition obtained in case of a linear inverse demand function, some conclusions about how a change in the number of firms will affect the possibility of free riding can be drawn.

Thus, if the market is less competitive than Cournot, by considering just two domestic firms, one petitioner and one fringe firm, and one exporter, the fringe firm will not free ride on the lobbying expenses of the petitioner if

$$\frac{\Theta_j - \Theta_i}{2b} + \frac{\partial B_i}{\partial s_{li}} = \frac{\partial B_j}{\partial s_{fj}} \quad (3.49)$$

If the fringe firm has a much higher marginal cost of production compared to the petitioning firm, it will require a large market share and, thus, a sufficient level of private benefits to compensate for the additional marginal public benefits and the marginal private benefits of the petitioner in order not to free ride. Alternatively if its marginal private benefits are low, which makes an investment in lobbying unprofitable, the result is a decision to free ride.

If the fringe firm has a low marginal cost of production in comparison with that of the petitioning firm, the chances of getting sufficiently high private benefits for the firm to decide to participate in the lobbying process are much higher than in the first situation where the difference in the marginal costs of the two domestic firms is large.

As the market becomes more competitive than is the case under a Cournot situation, the individual private benefits would decrease as according to Byrd Amendment, the disbursements are divided among the petitioning firms. Thus, for less concentrated industries, the incentive to participate in an AD case would decrease.

Moving further to a situation of a perfectly competitive market characterized by an infinite number of domestic suppliers, any of the firms will be too small to influence the price or to have any market power. In this case, either all firms will participate in the lobbying process or none of them will as their costs and public or private benefits from lobbying would be the same.

To summarize, the results obtained in this chapter, first, when an AD petition is considered to have only the characteristics of a public good, only the set of the most efficient firms necessary to initiate the petition will participate in the lobbying process, while all the others will free ride and, second, in the case that the AD petition has both, public and private characteristics, some other firms, in addition to the ones necessary to initiate the petition, will pay for lobbying. The non-free riders are represented by domestic firms with a marginal cost of production close to the petitioner's marginal cost of production.

As outlined in the previous section, the literature on AD is quite extensive, but the decisions taken at the firm level regarding the possibility of participating in an AD investigation is not much studied. The research that addresses this issue is, for the most part, concentrated on empirical findings (Herander and Pupp, 1991; Olson, 2004) or on simple theoretical models based on different strong assumptions, as for example considering that all firms in the industry are homogenous (Chang and Gayle, 2006). Some of the literature does not consider the AD petition as a lobbying activity, while other authors believe the opposite. The model developed in this chapter is novel, in the

sense that, to my knowledge, there is no other study that models an AD investigation as a lobbying game of protection with heterogeneous firms. As outlined before, it is a two-stage game, solved using backward induction. In the second stage, the domestic and foreign firms play a Cournot-Nash game and set their output levels given the AD duty, while in the first stage, the domestic firms play a non-cooperative lobbying game determining the AD duty rate. Thus, the model combines the literature on administered protection, lobbying and free riding. Another important feature of the model is that the firms are assumed to be heterogeneous. Heterogeneity among firms is an important determinant of the group's influence on economic policies. Most of the literature considers, for the sake of simplicity, identical agents, but the cost of this assumption is not small when taking into account endogenous policies. The model can also be used when analyzing the effects of other trade policies such as tariffs, countervailing duties, export taxes, etc. It can also be easily applied when studying different domestic policies, by considering only domestic firms. Thus, by bringing together knowledge related to different economic and trade policy issues and by being kept simple enough to be used in analyzing the effects of different other policy instruments, the theoretical model developed in this chapter represents an important contribution to the literature on trade policy.

### 3.8 Data and possible empirical methodology

A possible empirical analysis would use firm level data on antidumping filings by US manufacturing industries between 1980 and 2003. From all the manufacturing industries, the steel industry would represent the best selection for empirical investigation for two

reasons. The first motive is that the steel industry has seen the largest number of AD petitions and, second, most of the micro level data are available. The database from Olson provides a list of all petitions filed by industries, the proportion of firms filing the petitions, including the four-digit Standard Industrial Code (SIC) for the period 1980-1997 and the six-digit North American Industry Classification System (NAICS) for the period 1998-2003 and the disbursements for each petitioner. This database can be supplemented using information from the Global Antidumping database for the period 1980-2003 with the firms that participated in each petition. Using the Standard & Poor Compustat for North America database, the yearly employees' number and sales for each individual firm can be partially identified. The database contains a total of 1031 AD cases for the period 1980-2003 in the entire manufacturing sector, 430 cases being filed only in the steel industry. Out of the total 430 cases filed in the steel industry, 66 petitions took place in the period 2001-2003, after Byrd was passed into law.

The firm specific data that should be considered in the study are the individual firm AD costs and individual firm AD benefits. The expected costs of filing a petition per firm include payments to lawyers, economists and other consultants that prepare the petition, the presentation for the ITC and the responses to comments of opponents of the petition. The task of each firm's group that deals with a petition – hereafter termed counsel team – depends on the number of contributing firms. The collective cost of preparing and dealing with a petition – hereafter counsel costs – depends in general on the complexity of the case. In addition usually one counsel team will be hired by several firms which will share the counsel costs. As a result, the counsel costs of an individual firm decline with the

number of contributing firms. The privacy of information, however, does not allow any direct calculation of the costs associated with an AD case. Herander and Pupp (1991) reported that per firm costs can range between \$50,000 and \$150,000 per case – but this was 20 years ago. Olson (2005) suggested that the expected cost consists of two terms: the average cost of participating in a petition, which decreases with the number of firms and another term that allows contributions to vary with the size of the firm. Thus, the average cost is the same for each participating firm while the individual firm costs are a function of the size of the firm. As a result, a proxy can be used for the individual cost of participating in a petition (for example the size of the firm expressed by the number of employees).

The expected benefits per firm can be calculated as the summation of three factors: the profits accruing to a firm when the government imposes a duty as, for example, the greater the share of product production, the greater the benefits, which will be a function of the number of firms participating in a petition (more firms can provide more political pressure for higher protection); the disbursements that the firm gets after the Byrd amendment came into force; and, as in Olson 2005, expected benefits that are known only by the domestic industry; i.e. factors that contain private information about potential growth in the market or future cost changes. As there are no firm level data available on the benefits accruing to individual firms except for the disbursements under Byrd, the variable can be approximated by constructions based on different industry characteristics such as: growth in industry's imports, total size of the US market, the size of the individual firm and the number of firms participating in a petition.

Except for the firm level factors that influence the cost of antidumping, among the exogenous variables included in the reaction function, are different industry and macroeconomic factors: annual real import levels, growth in capacity utilization, political influence (the four firm concentration ration ), real exchange rate, real GDP growth etc.

In order to test whether the free riding has decreased after the introduction of the Byrd Amendment, a dummy variable can be used for petitions filed between 2001 and 2003.

An OLS estimation would be used. It is a cross section regression and not in panel form as we do not consider yearly values, but the individual cases' values (each year there are several antidumping cases initiated and the same firm can participate in all of them). In order to test whether firm  $i$  free rides on the petitioning expenses of firm  $j$ , the estimated coefficient on the expenses should be negative: as the petitioning costs of firm  $j$  increases, the petitioning cost of firm  $i$  decreases.

There are several issues with the firm level data that have to be solved before estimating the model. First, regarding the proxy used for the individual firm costs (number of employees or sales), there are many missing values. Second, per firm expected benefits should be simulated based on the industry and firm characteristics.

The individual firm data collected allow an examination of whether the theoretical results hold in reality. One of the main conclusions of theoretical model is that before the Byrd Amendment was implemented, a petition was supported financially only by the minimum

number of firms necessary to initiate a petition, while all the others would free ride.

These firms are the most efficient producers in the industry, meaning that they have the highest levels of sales. As the firm's sales are a function of the marginal cost of production and by assuming that the individual marginal cost of production is constant, the firm that is producing the highest level of sales will have the lowest production cost. After the coming into force of the Byrd Agreement, free riding is reduced and for some of the fringe firms, the marginal private benefit would be high enough to represent an incentive to participate in the lobbying action.

The data that are considered for this exercise are related to the AD cases open in the steel industry, specifically for steel works, blast furnaces (including coke ovens) and rolling mills (SIC 3312) for the period 1980-1997, and for iron and steel mills (NAICS 331111) for the period 1998-2003. By looking at the data, the main question that should be answered is whether or not the petitioners are the most efficient firms in the industry. During the period 1980 – 2003, there were 351 AD cases open in the steel industry's sectors outlined above, with a total number of 126 petitioners. Among the 126 petitioners, 9 firms went bankrupt, 16 were purchased or merged with other firms, while for 28 firms no information is available. As the individual data are only partially available, it is not possible to give a definitive answer.

However, one main characteristic of the data that is available is that the firms that most often participated in the AD petitions are either closed or purchased by other firms, including Bethlehem Steel Corp., which was once the second largest producer in the US

after the US Steel. Is this an indication that the least efficient firms in fact petitioned for protection? Firstly, the US Steel, which is the largest integrated producer of steel in the US and the seventh largest in the world, participated as a petitioner in most of the AD cases opened during the time period 1980-2003. Secondly, while the US steel industry prospered during World War II, later on, as a result of non-investment in newer technology plus the high benefit concessions given to US steelworkers, the American steel producers started to decline in efficiency relative to foreign steel firms. Thus, a high percentage of firms went bankrupt and trade barriers were requested to fight competition from countries such as Kazakhstan and South Korea. The collapse of Soviet Union produced six major steel producing countries – Russia, Ukraine, Kazakhstan, Moldova, Belarus and Uzbekistan – that have as main goal to produce and export as much steel as possible. On the other hand, the emerging economies of Asia, especially China which is the world largest producer of steel, have also expanded their exports. The increase in the amount of exports pushed the world price of steel down during 1990s. The former Soviet Union and the other emerging economies would still find it beneficial to produce steel as their production costs were much lower. On top of cost efficiency, the currency devaluation in emerging markets gave another boost to exports to dollar economies. Another interesting characteristic of the individual data is related to the companies that were purchased or merged with other steel producers. Most of the steel producers were purchased by firms that were participating as petitioners in AD cases. Being able to acquire other firms in such an instable environment might represent an indication of efficiency.

Thus, it is hard to conclude whether or not the main petitioners are the most efficient firms even if they are the largest steel producers in the US. It can be concluded, however, that the US steel producers are much less efficient than the foreign competitors from different emerging economies. An econometric analysis will be needed to see whether the theoretical results hold but sufficient data does not exist to undertake a formal empirical investigation.

### 3.9 Summary and conclusions

Anti-dumping (AD) actions are legitimate measures permitted under Article VI of General Agreement on Tariffs and Trade (GATT). Even if AD was little used in the past, its importance has been increasing rapidly. The traditional users of AD measures, the US, the EU, Canada and Australia, accounted for more than two thirds of the AD cases opened before 1995. After 1995, when the AD Agreement was adopted by the WTO, developing countries became more active, filing over half of the AD petitions. The main explanation for the increase in the number of AD cases is related to trade liberalization: the reduction and even the elimination of trade policy instruments lead to an increase in trade volume, and thus, to more trade tensions. Therefore, AD actions, for the most part, became an answer to requests for economic protection, and they are not being used only in cases of “unfair” trade practices.

The WTO AD Agreement specifies different guidelines that have to be taken into account by each member state when imposing AD measures. However, each country interprets the specific guidelines in different ways, leading to considerable variations among AD

statutes. In the US, two governmental agencies handle an AD case. These are the ITA and ITC. Each of them has a different role to undertake in an AD case, but only if both agencies arrive at a positive conclusion will a decision to impose anti-dumping duties be taken.

Following the seminal paper of Olson and Zeckhauser (1966), who analyzed the economics of alliances, this research proves theoretically that even in AD petitions, the “exploitation hypothesis” can occur. The “exploitation hypothesis” is defined by Olson and Zeckhauser (1966) as the disproportionate sharing of burdens in an alliance dependent on a pure public good, which leads to the possibility of free riding by the small allies on the large allies. AD petitions are considered a pure public good with non-rival and non-excludable benefits meaning that considerable free riding can be expected. The indirect benefits of an AD case can be considered a public good because as an AD duty increases the price of imports, all the domestic producers will benefit. However, only the firms that lobby for protection have to bear the costs, leading to the possibility of free riding: a firm will contribute to the AD expenditures as long as the benefits of winning the case are higher than the incurred costs taking into account the probability of winning the case.

In the second situation considered in this chapter, the indirect benefits of an AD case are a joint product, with public and private features. This situation can be applied only in case of US because of the so called Byrd Amendment: when firms lobby for AD protection, in addition to the benefits that all firms in the industry receive from the

imposition of a tariff, the petitioners or the supporters of a petition will share the AD duty collected. Therefore, the firm-specific benefits represent an incentive for firms to participate in the lobbying process, and, thus, the free rider problem would diminish.

The theoretical model developed in this chapter assumes that the firms in the industry play a non-cooperative (Cournot-Nash) game. It is a two-stage lobbying game of protection with heterogeneous firms, which is solved using backward induction. Thus, in the second stage, given the AD duty, the domestic and foreign firms set their output levels by playing a Cournot-Nash game. In the first stage, the domestic firms play the non-cooperative lobbying game that determines the AD duty rate. Hence, in each stage, a Nash equilibrium is obtained for the specific sub-game. Some of the assumptions of the model are that there is a market for a homogenous product in the home country and the unit cost of production for each firm is constant. The result obtained for the second stage is the same for both cases studied: the equilibrium quantity that is provided on the domestic market by the domestic and foreign producers is independent of the distribution of the unit costs, being a function only of the sum of the unit costs. The results of the Stage I of the game, the lobbying game played only among the domestic producers, are different in the two situations analyzed.

In case of an AD petition with only public benefits, all the fringe firms will free ride and the petition will be supported financially only by the minimum number of firms necessary to initiate a petition. When considering AD benefits as a joint product, it could be concluded that there will be some fringe firms for which the marginal private benefit

would be high enough to represent an incentive to participate in the lobbying action. As well, an increase in the degree of heterogeneity of domestic firms would lead to more free riding among the fringe firms. Thus, the fringe firms with marginal cost of production close to the petitioners' marginal cost of production will find it beneficial not to free ride.

The theoretical model developed in this chapter is new and it represents an important contribution to trade policy literature. It combines the literature on administered protection, lobbying and free riding and it considers heterogeneous firms, which is an important determinant of the group's influence on endogenous economic policies. The model can be easily applied when examining the effects of other trade or domestic policies.

The theoretical results could not be verified by analyzing the firm level data on AD cases opened in the US steel industry – where the best industry level data exists. An empirical test of whether the relationship between the free riding and the characteristics of AD indirect benefits' explained by the findings of this theoretical research will have to await the collection of better data.

APPENDIX A – VARIABLES IDENTIFICATION

Table 3.A.1 Variables identification

Variable name	Description variable
P	Price of product
Q	Total output supplied on home country market
m	Number domestic firms
m*	Number foreign firms
q	Individual output
$\theta$	Individual unit cost of production
t	AD duty
$\Pi$	Profit function
s	Total lobbying cost
$s_l$	Individual lobbying cost for a petitioner
$s_f$	Individual lobbying cost for a fringe firm
N	Net profit function
$m_1$	Number of petitioners (initiators)
$m_2 = m - m_1$	Number of fringe firms
$B_i$	Private benefits
a, b	Intercept and slope of a linear inverse demand function

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