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Master Essay

**“The Internal Market of Mineral Fertilizers and the Law of
One Price”**

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Abstract

The present master essay discusses the law of one price in relation to the EU mineral fertilizer market. The emphasis of the present essay is on mineral fertilizers prices since these make up a large share of the total farm production costs. The homogeneous nature of the analyzed commodity, according to trade theory, implies same price in different markets. However, we find that the law of one price does not hold for the EU mineral fertilizer market and distance plays a significant role in explaining price variations across different locations. Moreover, the impact of distance on price dispersions across the countries was found to be similar for different types of mineral fertilizers. Among other factors, that we considered, the oligopolistic situation proved to be also responsible for the price fluctuations. However, due to the lack of available data and the limited capacity of our analysis, we believe that further studies on this issue will be essential for deeper understanding of emphasized dependences.

Key words: agricultural sector, mineral fertilizers, trade costs, law of one price, price variances, distance, market power.

I. Introduction

1.1 Background of the study

World agricultural sector has passed through significant changes over the past century. Vast structural transformations have been driven by technological changes, which affected production possibilities, labor, prices, and demand for food products. Changes have occurred in the role of the government, policies, and producers as well as in the behavior of consumers and society. Given increasing urbanization and rapid growth of the world's population, modern agriculture should be able to solve one of the 21st century's greatest challenges: feeding a growing world. Agricultural sector is responding to these challenges by increasing specialization, changing vision of agricultural policy and increasing integration of food markets in developed countries (Hendrickson et.al, 2008).

The food chain starts at agricultural inputs sector. The linkages between farm input markets and other markets have recently strengthened (FAO, 2008). Thus, variations in farm inputs prices affect all food and feed commodities. Producers of agricultural inputs, such as fertilizers and machinery, exert the market power of price setting for their products, while farmers take the prices for inputs as given (McCorrison, 1993). So, analysis of input prices is important for understanding the cost structure of food production and explaining differences in food prices across countries.

The emphasis of the present essay is on mineral fertilizers prices because these make up a significant share of the total farm production costs (up to 6 per cent)¹. Hence, the function of the fertilizer market is of great importance for farmers as well as for the downstream agents. The homogeneous and tradable nature of fertilizers gives, according to trade theory, rise for an expectation of a perfect competition. Therefore, any price deviations across the regions will reflect a presence of market segmentation and non-perfect integration between those regions.

¹ Fertilizer & Commodity Chemicals Company, 2009

In this paper we study price variations for different kinds of mineral fertilizers across the European Union during the recent period (2000 – 2009). We chose the Law of One Price as a benchmark model for our analysis of price dispersions, and then we make an attempt to explain deviations from the law using economic and trade theories.

1.2 Objective

The objective of our study is dual. First, to analyze the prices of farmer input – mineral fertilizers – across Europe. For testing the hypothesis of segmentation in the EU market of mineral fertilizers, we use descriptive statistics, graphical and econometric analyses. The existence of market segmentation creates various obstacles to perfect arbitrage. This partly explains the failure of the law of one price. Obviously, deviations from the law of one price across Europe for certain goods have to be considered for any productive efficiency analysis and for agricultural policy making. The second purpose is to explain the reasons for actual price variations which shouldn't occur under the assumptions made in our analysis, according to economic models. We make an attempt to highlight some certain aspects, which, from our point of view, are key factors for determining the cross-countries price differences.

1.3 Motivation

The law of one price is frequently used as a corner stone in international agricultural trade models. But although numerous papers have analyzed the validity of law of one price for food products, less attention in literature has been paid to farm inputs. The lack of previous studies on this topic motivated us to carry out our research. A research on the inputs prices, from our point of view, is an important step in understanding the agricultural economics. Among all farm inputs we decided to focus on mineral fertilizers. They are highly homogeneous goods, for which one can expect the law of one price to hold. If the law of one price is not valid for such traded and standardized commodities, as mineral fertilizers, it can be a sign of imperfect integration of the EU market and an alarm for agricultural policy makers.

1.4 Method

The analysis is based on the method employed in the previous study on the law of one price by Engel and Rogers (1996) combined with available data on the EU mineral fertilizer market. Furthermore, we use regression analysis to confirm robustness of our conclusions. However, the studied area is complex and involves large spectra of various factors. Since it is extremely difficult to account for all the existing dependencies in one study, we narrow it down to aspects considered to be the most essential. So, the conclusions drawn cannot be treated as exhaustive.

1.5 Limitations

The main limitations of our work are due to the quality of the data we are using. The data we obtained are collected from most of the European countries. However, data from some European countries (Germany and Ireland) were not available and thus, were not included in the sample. Germany, as the biggest producer and exporter of mineral fertilizers in the EU, would have been particularly interesting to include in the analysis. But due to the extremely closed and oligopolistic nature of the industry, the publicly available data is limited. Thus, we tried to draw robust conclusions on existing dataset. Moreover, the significant critics of cross-countries analysis of price variations arise from dissimilarities in statistical data collection methods used in different countries.

1.6 Main findings

The key message of our empirical results is that distance matter and market segmentation is likely to be present in the EU mineral fertilizer market. Moreover, the impact of distance on price dispersions across the countries was found to be similar for different types of mineral fertilizers. Recently increased freight rates, which are above all important in mineral fertilizer market, high fuel costs, limited shipping capacity and high port loading, have pushed up shipping costs. All these factors have an impact on geographical trade patterns since countries tend to choose sources of their import from the nearest suppliers to save on transportation costs. Among other factors, that we considered, the oligopolistic situation proved to be also responsible for the price fluctuations.

However, due to the lack of available data and the limited capacity of our analysis, we believe that further studies on this issue will be essential for deeper understanding of emphasized dependences.

1.7 Outline of the paper

The structure of the paper is organized as follows:

Chapter 1 is an introductory chapter. In this first chapter the reader is introduced to the background of the study. We state the objective of the paper, limitations, target group and main findings together with offering an outline of the rest of the paper.

Chapter 2. In the present chapter we introduce to the reader the theory of the law of one price. We discuss the absolute and relative forms of the law, and reasons why it might not hold in practice.

In *Chapter 3* we give a brief overview of previous empirical studies on price differences across countries and regions. We also present theoretical issues that are relevant for our study and previous researches on the law of one price. We summarize the most important articles that have contributed to the understanding of the issues treated in this paper.

Chapter 4 is the empirical section. In this chapter we present the data and the methodology for calculating price differences over time. We also perform a regression analysis for testing the hypothesis of fertilizer market segmentation with physical distance.

Chapter 5. In this chapter we discuss further theoretical considerations on possible reasons for cross-countries fertilizer price differences and test them on empirical data.

Chapter 6. In this chapter we present to the reader main conclusions and findings of the present paper. We will also make some further research suggestions and discuss policy implications of our findings.

II. The Law of One Price

In the present chapter we introduce to the reader the theory of the law of one price. We discuss the absolute and relative forms of the law, and reasons why it might not hold in practice.

The natural way to start analyzing price differences across the countries is the law of one price. It is an economic rule commonly used as a measure of international market integration. It states that after prices are converted to a common currency, the same good should be sold for the same price in different markets (free of transport costs, barriers to trade, and other frictions). The law is particularly used in agriculture and food markets, where goods are highly traded, generally homogenous and expected to conform to price parity (Xu and Orden, 2002).

Therefore, the law of one price is expected to hold for close to near-perfect substitutes agricultural products sold in different locations. For products to be priced identically firms must maximize profits and transport costs, tariff and non-tariff barriers and other related market frictions must be absent. Price equality is ensured as a result of frictionless consumer arbitrage, which requires products to be perfectly substitutable (Mathä, 2006).

In its *absolute form* the law of one price can be written as

$$P_{dt}^k = E_{df} \times P_{ft}^k,$$

where P_{dt}^k is the domestic price of the good k ; P_{ft}^k is foreign price of good k and E_{df} denotes the exchange rate in period t .

The law of one price in absolute form is very restrictive. Due to imperfect competition, transportations costs and trade barriers the law of one price in its pure form almost never holds. But if transportations costs and trade barriers are constant over time and goods are absolutely identical, the prices in trading countries are expected to move in the same direction. Thus, many of the empirical studies employ the *relative form* of the law of one price for analyzing the price differences.

The relative version of the law of one price states that a rise in price level over a period for a certain good in a country should be proportional to the raise in price for the same good in a corresponding country. It can be expressed as:

$$\text{Ln} \left(\frac{P_{i,t}^d}{P_{i,t-1}^d} \right) - \text{Ln} \left(\frac{P_{i,t}^f}{P_{i,t-1}^f} \right) = 0$$

Where $P_{i,t}^d$ is price for commodity i in country D at time t and $P_{i,t}^f$ is price for commodity i in country F at time t . (Xu and Orden, 2002)

For a domestic economy trading with foreign economy the relative law of one price in logarithmic form for any good i in period t can be simplified as

$$p_{dit} = p_{fit} + e_t,$$

where p_{dit} is the logarithm of domestic price; p_{fit} is the logarithm of foreign price and e_t is domestic currency price of the foreign exchange rate.

This equation relaxes the assumption that the prices across the countries must be at the same level and tests if differences in prices remain the same over time.

In reality, however, the relative law of one price in international trade might not hold as well. There are still high barriers to trade and market segmentation continues to exist, although the situation is recently changing. Differences in price are present even for highly tradable goods and the consideration of these deviations are important for understanding the effects of economic integration. Various possible factors have been highlighted by economist as causing these deviations such as, pricing to market, price responses to exchange rate changes, exchange rate risk, costs of distribution, choice of currency denomination of export prices and effects of geographical separation of markets.

While studying the price differences, it is important to be aware of the context in which the law of one price is applied. If the goods traded between different countries are identical or nearly perfect substitutes, then any price inconsistency tend to be swiftly removed by the arbitrage. The prices of primary goods, such as mineral fertilizer, are commonly considered to be equal across the countries, unless there is an imperfect competition between the sellers in the market or the sellers enter long-term contracts with their customers. On the other hand, many manufactured goods do not have near-perfect substitutes produced abroad, and in such a case the law of one price is not supported by the empirical data, even on highly disaggregated level. Furthermore, it implies that highly aggregated data *a priori* cannot be expected to obey the law of one price (perhaps, “with the exception of primarily commodities”, as it is argued by Isard (1977)).

III. Previous Studies on the Law of One Price

This chapter deals with theoretical problems that are relevant for our study and previous researches on the law of one price, so the reader can compare findings on price variations for different types of goods at different markets. We also summarize the most important articles that have contributed to the understanding of the issues treated in this paper.

The empirical studies on international price differences generally find that the law of one price in reality is constantly violated by the observed data. The researchers have arrived to some common stylized facts. First of all, exchange rate affects the law of one price. Secondly, the law of one price does not hold as borders are crossed, and distance between the locations plays an important role in explaining the price deviations. Thirdly, deeper integration in the market dampens the price deviations. And finally, other factors, such as costs and differences in market structure, can also be reasons for failures in the law of one price. Most of the papers argue that convergence rates predicted by the purchasing power parity (PPP) theory are contradictory to the evidence of micro studies on nominal price stickiness (Broda and Weinstein, 2008). For convenience, we summarize the most important articles and main empirical findings in the Table 1 in the end of the chapter.

3.1 Exchange rates

Exchange rates fluctuations are commonly believed to be a corner stone factor in explaining the price deviations across the markets. Isard (1977) tests the law of one price by analyzing the impact of nominal exchange rates on price differences across the countries. The author finds that exchange rates considerably change the relative prices of most narrowly-defined manufactured goods for which prices theoretically should match. Moreover, these price distortions are found to be persistent for long period of time and cannot be treated as transitory conditions (Isard, 1977). Richardson (1978) arrives to a similar conclusion of rejection of the law of one price for the near-perfect substitutes.

3.2 Distance and border

Numerous recent studies examine prices within and between countries, and find that distance and the presence of national borders separating locations are important for determining the degree of the failure of the law of one price. Engel and Rogers (1996) use consumer prices of different good categories for the US and Canadian cities to model the nature of the deviations from the law of one price. The authors assume that distance, changes of the nominal exchange rates, disparity in labor costs, and city specific effects are the main sources of price difference volatility. They find that the distance between cities is the main reason for the variation in the prices of identical goods in different regions; moreover the price variation is higher if the cities are located in different countries. Although some part of the border effect can be explained by sticky nominal prices, large share of cross-border price differences still remains unexplained.

In a similar study for the West European market, Engle and Rogers (2001) find a significant border effect arising from two sources embedded in relative price differences. The first source is the “real barriers” effect due to various barriers to trade; the second source is sticky consumer prices expressed in local currency.

A study by Mathä (2006) is focused on the consequences of monetary integration for price differences. The research shows that even for the relatively small and highly integrated geographical area, absolute deviations from the law of one price for identical goods rise as distance increases and borders are present.

Analyzing differences in the retail prices of commodities traded between US and Japan, Parsley and Wei (2001b) found that a border effect still matters a lot for explaining the price deviations, even after accounting for shipping unit-costs.

3.3 Integration

In order to assess the effect of market integration on price differences between countries, Haskel and Wolf (2001) examine IKEA prices in 25 countries in Europe, Australia, Asia and the South and North Americas using prices of 119 products. They use two major properties of prices: the difference of prices for a given product expressed in common currency and the divergence in

relative prices of similar products for a given country pair. The authors find large price differences that cannot be explained by variation in local costs, tariffs or taxes; however there is a weak evidence of price convergence over time. So, considerable violations of the law of one price are found to be a persistent characteristic of individual goods prices.

Supporting the results of Haskel and Wolf (2001) about the weak price convergence, Rogers (2007) finds that there was a remarkable decline in differences of prices of tradable goods in Europe over the period preceding the launch of euro. However, for non-tradable commodities decline in dispersion was found to be far lower than for tradable goods. Generally speaking, expensive countries in Europe are getting cheaper, while prices in less expensive countries tend to rise. The possible reasons for this phenomenon are unification of tax rates, liberalization of trade and production factors markets, and convergence in incomes caused by the deeper integration.

Parsley and Wei (2007) investigated how the launch of common currency in Europe affects the price levels and the degree of cross-countries arbitrage by using panel data on prices of Big Mac Meals in 25 European countries since 1993. Two questions are addressed in the paper: if price increases followed the adoption of the common currency and if euro helped to deepened market integration by lowering cross border transaction costs and enhancing arbitrage. The researchers conclude that there is no evidence of the price increase caused by the euro adoption. Neither is there any significant evidence of closer market integration due to the introduction of euro. The price dispersion of Big Macs across the European regions can be mainly explained by the price differences in non-traded ingredients of the product.

3.4 Specific market features

Studies have also been made examining other reasons for the deviations from the law of one price. Baba (2008) estimates a structural empirical model using panel data on retail prices, local costs (wages and land prices) and household expenditure allocations for about 200 goods in 47 Japanese cities from 2000 to 2005 in order to study deviations in law of one price. Baba uses an empirical model that allows for location specific costs and price, discrimination, connecting consumer behavior retailer behavior, and market structure to calculate how much each explanation can account for the law of one price violations. The intensity of competition for each

good is estimated, as well as each factors contribution for actual law of one price deviations. Both local distribution costs and demand elasticity are found to be significant and considerably related to the observed retail price level. However, the quantitative effects of those factors are also found to be quite modest hence the results emphasize the importance of other possible factors that determine deviations for a complete understanding.

3.5 Criticisms of previous empirical studies

The most recent research made by Gorodnichenko and Tesar (2009) criticizes the previous studies (e.g. Engel and Rogers (1996)) for overestimating the magnitude of border effects and finding them to be significant where it is implausible. The authors state that these misleading conclusions may be caused by invalid empirical methodology used to isolate the border effect. Gorodnichenko and Tesar (2009) argue that most of the previous studies capture the border effects by the difference between the within-country dispersion and the cross-country dispersion of the price of some particular commodity. Although this measure is convenient for the analysis, it is generally contaminated by the factors unrelated to the border. Thus, the results of a simple comparison of within-and cross-country statistics cannot plausibly identify the impact of the border, being extremely subjective. The paper does not offer an alternative method of evaluating the true cross-border effect, but rather provides a motivated explanation of potential bias in estimations of border effect without accounting for country heterogeneity in prices.

The criticism is further supported in the work by Broda and Weistein (2008). The authors argue that the data limitations do not let the researchers to compare the prices of identical goods systematically within and across borders, forcing to draw the conclusions upon the behavior of price indexes and aggregated prices of goods. Such aggregations may be the main reason for the violation of the law of one price which is found by the most of the empirical studies. Using the prices of wide enough range of identical commodities (barcode data) for the US and Canada, Broda and Weistein (2008) show that the law of one price and PPP theories hold in their absolute forms both across and within the borders. The importance of the distance for explaining the price differences is found to be five to ten times lower for the barcode data than it has been commonly found for the aggregated data. Finally, the authors conclude that rates of price convergence are fast, both within and across borders, which goes in line with microeconomic studies.

Table 1. Summary of the Previous Findings on the Law of One Price

Authors	Year	Method	Data	Results
Isard	1977	regression analysis of the impact of nominal exchange rates on price differences across the countries	good-by-good deviations from the Law-of-One-Price (LOP) for over 1,800 retail goods and services between all the EU countries	exchange rates change the relative prices of most goods and these distortions are long-lasting
Engel and Rogers	1996	regression analysis of the impact of nominal exchange rates on price differences across the countries	CPI data for US and Canadian cities for 14 categories of consumer prices	distance is the main reason for price variations of identical goods in different regions
Engel and Rogers	2001	regression analysis to explore purchasing power parity across cities	consumer price data from 55 european cities in 11 countries over the period 1981-97	boarder effects arise from barriers to trade and sticky consumer prices expressed in local currency
Parsley and Wei	2001	panel data regression analysis	three-dimensional panel data set of prices on 27 traded goods over 88 quarters across 96 cities in the US and Japan.	boarder effect partly explains price deviations, even after accounting for shipping unit-costs
Haskel and Wolf	2001	cross-sectional analysis of differences in relative price divergences	absolute prices for more than 100 identical goods sold in 25 countries in Europe, the Americas, Asia and Australia by IKEA.	violations of the LOOP are not explained by variation in local costs, tariffs or taxes
Xu and Orden	2002	unit root tests and co-integration tests of prices	prices for five traded farm output and four traded non farm produced inputs for Canada and USA	short run adjustments toward the LOOP and price converges to long-run equilibrium for the
Parsley and Wei	2003	regression analysis to examine the law of one price for the big mac real exchange rate and comparison of it with those of its ingredients	big mac prices, prices on ingredients and data on tariffs, sales and value added tax rates for western Europe, Western hemispere and chosen countries in Asia Pacific and Africa	the convergence to the LOOP for the big mac real exchange rate is slower than for its ingredients and the results of Engel (2001) does not hold generally
Mathä	2006	regression analysis of price deviations	individual supermarket prices from Luxembourg and the surrounding regions	absolute deviations from the LOOP for identical goods raise as distance increases
Parsley and Wei	2007	regression analysis of prices on Big Mac meals and its inputs	panel data on prices of big mac meals in 25 european countries	no evidence of price increase or closer market integration caused by the euro adoption
Rogers	2007	regression analysis	local prices of tightly specified items in 50 cities worldwide	price differences declined in Europe in the period before the launch of euro
Broda and Weinstein	2008	use barcode level data to replicate prior work and explain what assumptions caused researchers to find different results from those obtained in the paper	the US and Canadian data that share a common barcode classification	LOOP and PPP theories holds in their absolute form
Chikako Baba	2008	regression analysis	panel data on retail prices, local costs and household expenditure allocations for about 200 goods in 47 Japanese cities	local distribution costs and demand elasticities are related to the observed price
Gorodnichenko and Tesar	2009	re-estimation of previous study by Engel and Rogers (1996)		critisize the previous studies for overestimating the magnitude of border effects and finding them to be significant where it is implausible

Notes: The table presents the summary of main empirical studies discussed in the present chapter

IV. Testing the Law of One Price in the EU Mineral Fertilizer Market

In this chapter, we present the data and methodology for calculating price differences in mineral fertilizer over time. We also perform a regression analysis in testing the hypothesis of fertilizer market segmentation based upon physical distance.

From the brief review of previous empirical studies, one can observe that the failure of the law of one price in international trade is widely documented. It is evident, that similar goods sold in different countries often have different prices. In the present chapter, we test the validity of the law of one price for the mineral fertilizer sector within the EU.

Therefore, we examine the price variations across the EU countries, as well as the importance of distance between the locations, where mineral fertilizers are sold, for determining the degree of the failure of the law of one price. The central hypothesis is that in a highly integrated market, primary traded goods, such as mineral fertilizers, should be sold at similar prices across countries. An alternative hypothesis is that the volatility of price of similar goods between countries should be positively related to the distance between those countries. This implies the presence of market segmentation within the EU market of mineral fertilizers. The disparity of prices of similar goods across regions is always a sign that the markets are not perfectly integrated.

In our analysis, we closely follow the approach used in Engel and Rogers (1996). This method has been chosen as the most suitable for the purposes of the present study. First, the authors use consumer price indices disaggregated into several categories of goods. This data is similar to the data on fertilizer price indices employed in our thesis. Whilst Engel and Rogers use CPI data for US and Canadian cities for 14 categories of consumer prices, we analyze price indices for 9 types of mineral fertilizers in 25 EU countries to examine the nature of the deviations from the law of one price. Secondly, our targets are similar to those of Engel and Rogers in that, we examine the importance of distance between locations in determining the degree of failure of the law of one price.

4.1. Data Description

Three general types of fertilizers are available in the market. They are straight fertilizers, compound fertilizers, and mixed fertilizers. Straight fertilizers supply single plant nutrient: either nitrogen (N), or phosphorus (P), or potassium (K). Compound fertilizers supply more than one plant nutrient (i.e. PK, NP and NPK fertilizers). Finally, mixed fertilizers are a physical mixture of two or more straight and/or compound fertilizers to supply a particular combination of plant nutrients (as defined by ICRISAT).

For the purposes of the present study, we use quarterly data on disaggregated price indices for 6 specific types of mineral fertilizers (N, P, K, PK, NP and NPK) which are mutually exclusive, and 3 aggregated price indices for straight, compound and mixed fertilizers in general. The data is available in Eurostat database and covers the period from 1st quarter 2000 to 4th quarter 2009. The price indices are given in Euro and deflated. The data stream is available for 25 members of the EU. The countries included in the sample are Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Greece, Hungary, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and the United Kingdom.

The main limitation of the data is the absence of some European countries in the sample (Germany and Ireland), as well as some missing observations for particular products in particular countries. Data of higher quality was unfortunately impossible to obtain, due to particular closed and oligopolistic nature of the industry. For this reason the database has been manually adjusted and cleaned from the missing observations.

4.2. Price differences over time

Following the methodological approach of Engel and Rogers (1996), which is also used by many other previous studies, we use the natural logarithm of price quotient as the measure of relative price between two countries.

Thus, for each good k and each country pair $(i ; j)$, by $P_{i,j}^k$ we denote a natural logarithm of the price of good k in location i relative to the price of good k in location j . We take the differences in the logarithms of the relative price between time t and $t-1$ as our measure of relative price changes.

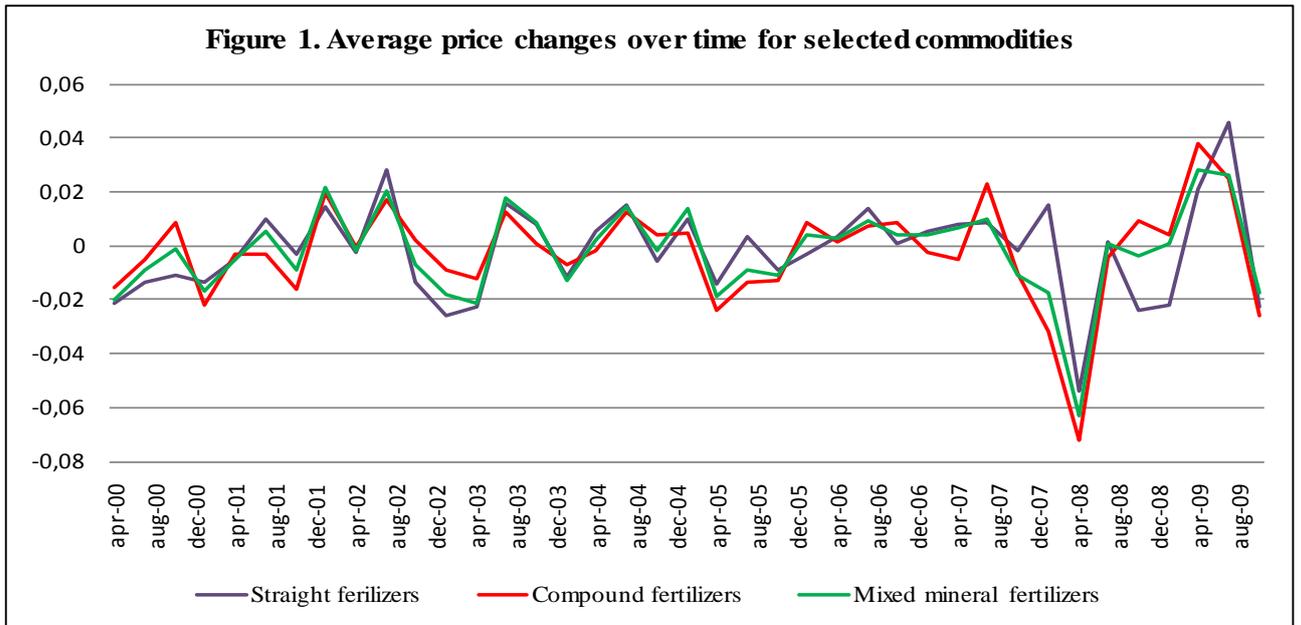
The relative price change is thus defined as:

$$\text{Relative price change } (R_{i,j}^k) = P_{i,j}^k(t) - P_{i,j}^k(t - 1),$$

where $P_{i,j}^k = \ln\left(\frac{p_i^k}{p_j^k}\right)$ and p_i^k is the price for good k in country i at time t . If the law of one price in its relative form holds (i.e. there are no price differences over time), then *Relative price change* should equal to zero.

As the next step, for each country pair we calculate volatility of relative price changes as the standard deviation, using time series on relative prices. Thus, we obtain cross-sectional observations for each product. However, due to data limitations and absence of data for some countries and for some products, we have different numbers of resulting cross-sectional observations on price volatilities for each good.

After performing the calculations, we found significant relative price disparities across the EU countries, as our resulting price volatilities are considerably different from zero. Figure 1 presents the average price changes across the European countries for straight, compound and mixed mineral fertilizers. As is shown in Figure 1, price fluctuations for different types of fertilizers seem to be correlated. The fluctuations have similar patterns and spikes over time match between fertilizers. Also, there is a clear trend of increasing relative price volatility after 2006.



Note: the figure shows the development over time of the average of relative price changes (as defined on p. 18) across the European countries for straight, compound and mixed mineral fertilizers.

Table 2, below, reports summary of descriptive statistics. For each product, we report the average standard deviation for all available pairs of countries, as well as the number of cross-sectional observations, and average distance between the sample countries. The table reveals that, on average, the volatility of prices is slightly lower for the aggregate price indices than for the individual types of fertilizers. However, for each type of good, the variance of prices across the EU is substantial.

Table 2. Average Price Volatility

Good	Type of fertilizer	Average Price Volatility	Number of Country Pairs	Average distance (km)
1	Nitrogenous (N)	0,1285	250	1445,39
2	Phosphatic (P)	0,1715	168	1362,53
3	Potassic (K)	0,1528	150	1402,68
4	All straight fertilizers	0,1207	250	1445,39
5	NP	0,1435	117	1447,39
6	PK	0,1345	90	1262,98
7	NPK	0,1404	208	1455,66
8	All compound fertilizers	0,1223	228	1447,86
9	Mixed mineral fertilizers	0,1103	250	1445,39

Notes: The table gives the mean value of price volatility across all available intercountry combinations within the EU, as well as number of observations and average distance for each good. The measure of volatility is standard deviation of the relative price series. Prices are measured as quarterly differences. The sample period is 1st quarter 2000 - 4th quarter 2009.

Both descriptive statistics and the graphical analysis, performed above, support a hypothesis of the failure of the law of one price in fertilizer inputs market in the EU.

4.3. Regression analysis

To make our conclusions more robust and to confirm that the EU market of mineral fertilizers is indeed segmented by physical distance, we now perform a regression analysis in attempting to explain the volatility of relative price changes by distance between the locations. We start from the simplest specification, regressing volatilities of relative price on a constant and the natural log of distance. The model is given by equation 1:

$$V(R_{i,j}^k) = \beta_1^k + \beta_2^k s_{i,j} + \varepsilon_{i,j}, \quad (1)$$

where $V(R_{i,j}^k)$ is the volatility of relative price between countries i and j for good k , calculated as standard deviation of relative price changes; $s_{i,j}$ is natural *log* of distance between countries i and j ; and $\varepsilon_{i,j}$ is the regression error. Note that, this is a cross-sectional regression. According to our hypothesis that the volatility of prices of similar goods sold in different locations is positively related to the distance between the locations, we expect the coefficients for distance to be positive. We also assume a concave relationship between price volatility and distance, as it is given by the gravity model of trade.

Table 3. Regressions Relating Price Volatility to Distance

Good	Specification 1			Specification 2		Specification 3		
	Constant	Ln distance	Adjusted R ²	Ln distance	Adjusted R ²	Distance	Distance squared	Adjusted R ²
1	-0.038 (0.054)	0.023* (0.008)	0.592	0.017* (0.006)	0.653	1.28* (0.110)	-2.47* (0.565)	0.721
2	-0.076 (0.070)	0.035* (0.011)	0.879	0.032* (0.009)	0.625	1.82* (0.134)	-3.63* (0.645)	0.504
3	0.021 (0.083)	0.019 (0.012)	0.716	0.014 (0.012)	0.597	1.93* (0.180)	-4.97* (0.812)	0.537
4	-0.053 (0.052)	0.024* (0.008)	0.706	0.018* (0.005)	0.784	1.16* (0.104)	-2.05* (0.543)	0.449
5	-0.103 (0.066)	0.035* (0.010)	0.605	0.030* (0.009)	0.411	1.36* (0.120)	-2.35* (0.577)	0.537
6	0.040 (0.072)	0.014 (0.010)	0.568	0.015 (0.011)	0.293	1.86* (0.150)	-5.27* (0.681)	0.350
7	-0.076 (0.058)	0.031* (0.008)	0.473	0.025* (0.008)	0.774	1.53* (0.163)	-3.3* (0.663)	0.559
8	-0.075 (0.053)	0.028* (0.008)	0.815	0.021* (0.006)	0.681	1.18* (0.101)	-2.12* (0.503)	0.678
9	-0.044 (0.046)	0.022* (0.007)	0.856	0.016* (0.005)	0.894	1.10* (0.093)	-2.09* (0.478)	0.774

Notes

1 - (*)denotes statistical significance of the coefficient at 1% level. All the other coefficients are insignificant.

2 - All regressions contain the average price volatility (calculated as standard deviation) as dependent variable. Heteroscedasticity and Autocorrelation consistent standard errors (Newey & West, 1987) are reported in parentheses.

3 - In specification 1, the standard deviation is regressed on ln of distance and constant.

4 - In specification 2, the standard deviation is regressed on ln of distance and specific dummies for each country.

5 - In specification 3, the standard deviation is regressed on distance and distance squared. The coefficients and standard errors of distance and distance squared are multiplied by 10^4 and 10^8 , respectively

6 - It is important to note that there are different numbers of observations for each good (the precise number is provided in table 2)

The resulting coefficients for each type of product, as well as R-squared and Newey-West HAC standard errors for *Specification 1* are reported in the second column of Table 3 above. We find strong evidence that distance is helpful in explaining price dispersion across the EU countries. The coefficient on \ln distance is positive in all cases, and it is significant at the 1-percent level in seven out of nine cases. Resulting R-squared statistics are reasonably large, so the quality of the linear approximation is high. The two regressions (3 and 6), where the coefficient on distance is not significant have the smallest number of cross-sectional observations (150 and 90 respectively). It is interesting, that the values of the distance coefficient for different goods are similar, and on average are equal to 0,026. We will use this fact later in our analysis.

We tried several other specifications as tests of robustness of our results. In order to preserve space, we only report on two other specifications which were found to be reasonable in terms of overall explanatory power, coefficient's values and statistical significance.

First of all, we allow the level of the standard deviation to vary from country to country by including a dummy variable in the equation for each particular country in our sample, D_m . That is, for country pair (i, j) the dummy variables for country i and country j take on values of 1. There are few reasons why we allow the volatility to vary across the countries. First, there may be idiosyncratic measurement error in time series for some countries that make their prices more volatile on average. Second, markets of some sample country pairs may be less integrated than the others, and it can cause greater discrepancies in prices between these two locations. Finally, there can be significant structural differences in agricultural sectors across the EU countries, as well as other country's specific features (e.g. market power of sellers of mineral fertilizers), which can affect the fluctuations of prices for farm inputs. Thus, we estimate

$$V(R_{i,j}^k) = \beta_1^k s_{i,j} + \sum_{m=1}^n \gamma_m^i D_m + \varepsilon_{i,j} , \quad (2)$$

where $V(R_{i,j}^k)$ is the volatility of relative price between countries i and j for good k ; $s_{i,j}$ is natural \log of distance between countries i and j ; D_m are m specific country dummies; and $\varepsilon_{i,j}$ is the regression error. Again, we expect distance coefficients to be positive.

The third column of Table 3 reports the regression results for *Specification 2* for each of 9 types of goods. Outcome goes in line with the results from previous specification. Coefficients on

distance are positive in all the regressions, and statistically significant in seven cases (except regressions 3 and 6). The actual values of the coefficients are also very similar to the ones in specification 1, but slightly smaller due to introduction of dummies as country specific explanatory variables. The values of the distance coefficient for different goods are on average equal to 0,021.

The last model we estimate under the assumption that the distance function is quadratic, rather than logarithmic. The model is given by:

$$V(R_{i,j}^k) = \beta_1^k S_{i,j} + \beta_2^k S_{i,j}^2 + \varepsilon_{i,j} , \quad (3)$$

where $V(R_{i,j}^k)$ is the volatility of relative price between countries i and j for good k ; $S_{i,j}$ is the distance between countries i and j in kilometers; and $\varepsilon_{i,j}$ is the regression error. This specification allows testing for a concave distance relationship. Indeed, as it is shown in the last column of Table 3 above, we find that distance has a positive effect on price variability in all the regressions, whilst the coefficient of the square of distance is always negative. We get significant results for all types of good. That is what we would expect if the distance relationship were concave.

Finally, we test for the restrictions that the coefficients on distance are the same in all the regressions and equal to some average values. For this purpose we employ the Wald test, available in Eviews. The Wald statistic measures how close the unrestricted estimates come to satisfying the restrictions under the null hypothesis. If the restrictions are in fact true, then the unrestricted estimates should come close to satisfying the restrictions. So, we calculate the average value of distance coefficients across all 9 regressions for each specification. The mean value for the first model is 0.026, for the second model 0.021 and for the last specification, average distance coefficient is equal to $1.47 \cdot 10^{-4}$. After, we test if each regression coefficient is close enough to the calculated average value. Table 4 below shows the outcome of coefficient restriction tests.

Table 4. Wald Test for The Restrictions on Coefficients

	Specification 1		Specification 2		Specification 3	
	<i>Null hypothesis: $\beta_2 = 0.026$</i>		<i>Null hypothesis: $\beta_1 = 0.021$</i>		<i>Null hypothesis: $\beta_1 = 1.47 \cdot 10^{-4}$</i>	
Good	F-statistic	Probability	F-statistic	Probability	F-statistic	Probability
1	0.075	0.7837	0.410	0.5226	2.804	0.0953
	Non rejection		Non rejection		Non rejection	
2	1.265	0.2624	1.772	0.1852	6.996	0.0090
	Non rejection		Non rejection		Rejection at 1%	
3	0.348	0.5559	0.328	0.5679	6.669	0.0108
	Non rejection		Non rejection		Rejection at 5%	
4	0.024	0.8774	0.330	0.5662	9.114	0.0028
	Non rejection		Non rejection		Rejection at 1%	
5	0.863	0.3548	0.986	0.3230	0.788	0.3767
	Non rejection		Non rejection		Non rejection	
6	1.415	0.2374	0.240	0.6255	6.772	0.0109
	Non rejection		Non rejection		Rejection at 5%	
7	0.328	0.5673	0.238	0.6265	0.148	0.7010
	Non rejection		Non rejection		Non rejection	
8	0.076	0.7831	0.0001	0.9938	8.003	0.0051
	Non rejection		Non rejection		Rejection at 1%	
9	0.323	0.5704	1.000	0.3184	15.668	0.0001
	Non rejection		Non rejection		Rejection at 1%	

*Notes:*The table presents the results of Wald test performed for testing the restrictions that the coefficients on distance are the same for all types of the goods. It is easy to notice that, for model specifications 1 and 2, test statistics are small, and the restrictions on coefficients of ln distance are accepted for all the regressions. For specification 3, however, the restriction is very strongly rejected in 6 out of 9 cases, which can be attributed to the very specific (quadratic) shape of the distance function.

The tests statistics are small for specifications 1 and 2, and the restriction is accepted in all the equations. So, we found that the coefficient for ln distance is between 0.021 and 0.026, depending on the model specification. For the specification 3, the test statistics are found to be large and the restriction is strongly rejected in 6 out of 9 cases. However, this model is interesting only for testing the concave relationship between price variance and distance, and using actual distance instead of ln distance can explain the results.

Nonetheless, for the first and the second specifications, we are now allowed to make regressions pooling the data across all products. We report the results in table 5. Since we included specific dummy variables to allow for a separate intercept term for each good and all countries, the resulting coefficients are nothing else but the average of the coefficients across the 7 products. Indeed, our expectations based on the results of Wald test are fulfilled. The values of the pooled

regression coefficients are very close to the mean values across 7 individual models, calculated above (0.026 for the first specification, 0.021 for the second specification). We also find that the coefficients on distance are significant and of the expected sign. Hence, the pooled regression gives a versatile summary of the relationship between price variances and distance, and strongly supports the conclusions drawn on individual regressions for each good.

Table 5. Regressions of pooled data

Specification 1			Specification 2	
Constant	Ln distance	Adjusted R ²	Ln distance	Adjusted R ²
-0.044**	0.025*	0.499	0.020*	0.508
(0.021)	(0.003)		(0.003)	

Notes

- 1 - (*) and (**) denote statistical significance of the coefficient at 1% and 5% levels, respectively
- 2 - The table presents the results of regressing pooled data for all the products. Number of observations is 1711. Standard errors, given in parentheses, are HAC (Newey & West, 1987).
- 3 - The two specifications used are the same as above

In the future analysis we will continue to use the pooled OLS regression approach instead of running individual regressions for the each type of mineral fertilizers. It is acceptable to do so, when the groups to be pooled are relatively homogenous. Since we have found small standard errors on the coefficients (large t-statistics) and relatively high R-squared, there are no warning signals that the pooled groups are heterogeneous and pooling may not be appropriate. Moreover, pooling gives us significant increase in the number of available observations, which relaxes the limitations imposed by insufficient data.

Summarizing our findings, we can argue that prices for fertilizers do vary across different locations. Moreover, distance plays a significant role in explaining price disparities in the EU fertilizer market. Recently increased freight rates, which are particularly important in mineral fertilizer market, high fuel costs, limited shipping capacity and high port loading, have pushed up shipping costs. All these factors have an impact on geographical trade patterns since countries tend to choose sources of their import from the nearest suppliers to save on transportation costs. Furthermore, the impact of distance on price dispersions across the countries was found to be similar for different types of mineral fertilizers. But can physical distance alone explain the variability in prices of such homogeneous traded goods, as fertilizers, or are there other factors contributing to the price variances? This question will be addressed in the next chapter.

V. Further Attempt to Explain Price Differences

This chapter is aimed to answer the question, whether distance is the only factor responsible for price volatility within the EU countries. Here we present some theoretical considerations on possible reasons for cross-countries fertilizer price differences and test them on empirical data.

The natural issues to consider while analyzing price deviations are distortions which may arise from the demand and supply sides.

The demand for fertilizers is tightly linked to the food market. And there is no secret that today the world is facing a high food demand. The factors that contribute to the high demand are complex and numerous, including population growth and higher global prices for energy (see Appendix 1). Food production today is simply not large enough to keep up with the demand, and fertilizers play an important role in solving the problem and in further increasing the efficiency of the food production. Currently fertilizers are responsible for 40 to 60 percent of the world's food supply. Given the need to grow more on less land, the amount of crop that can be grown per acre of land is very important to producers and therefore proper fertilization is one of the key factors for determining yield. Mineral nutrients are constantly removed from the soil by cereals and crops. Different crops require different doses of fertilizers, some of them cannot grow without certain minerals. To ensure that each year's yield gains a high nutritious supply, the farmers need to fertilize the soil, to add regularly nitrogen, phosphorus and potassium. Thus, the global demand for fertilizers remains high and increasing (The Fertilizer Institute, 2002). World fertilizer consumption is expected to grow annually at about 1.7% from 2008 to 2012 (FAO, 2008).

Moreover, from the supply side, the fertilizer industry is characterized by imperfect competition, as there is relatively small number of global producers and exporters, which possess significant market power. Given raised prices for energy and supplementary inputs needed to produce various kinds of mixed fertilizers, there is no surprise that production costs are increasing. All these factors are pushing up the global prices for mineral fertilizers, which importing countries are obliged to take as given.

But which of the demand and supply factors might be relevant for the case of the EU countries?
 We now go deeper into details, trying to access the overall situation in our sample countries.

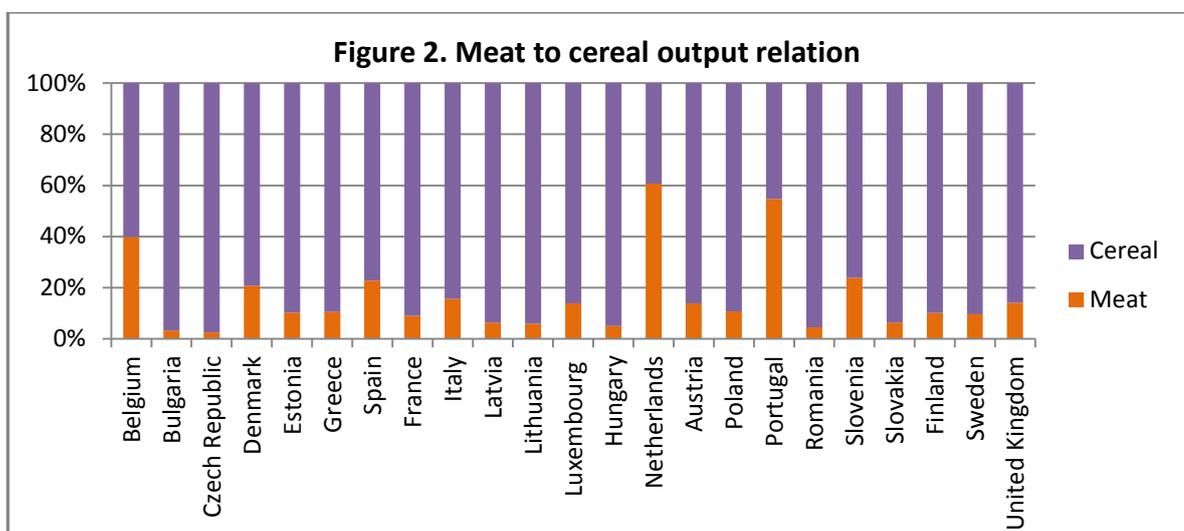
5.1 Demand Generated Price Differences in the EU

5.1.1 Structure of Agricultural Production

From theory recall that demand generated price differentials can be explained by structural differences in agricultural sector, demand for products that require fertilizers for their production, countries' agricultural policies and regulations.

When it comes to the structure of agricultural sector, there is a noticeable heterogeneity across the EU countries. This relates to the fact that some countries are mainly specialized in animal production, while others have relatively bigger crop production sector.

Figure 2 shows the cereal production in relation to meat production in each of the studied countries. Cereal grains are providing more food energy worldwide than any other crops, and are therefore grown in greater quantities, and with the high cereal growth comes a higher demand for fertilizers. Fertilizers are also a necessary input for the meat production, although not to the same extent. Thus, the agricultural structure in the studied countries affects the demand for fertilizers. Countries more specialized in the production of cereals and crops have a higher demand for mineral fertilizers. Moreover, the consumption of fertilizers depends on which crops are traditionally cultivated.



Source: own calculations based on data from Eurostat

For instance, France is one of the most dominant actors in the agricultural industry in Europe. France is the leading producer of cereals in the EU. Moreover, France also holds a leading position in oilseeds and sugar beets in the EU, crops that require significant inputs of mineral fertilizers. The agriculture sector in United Kingdom also has a relatively smaller meat production sector in comparison to their cereal production. The agricultural sector in UK is very efficient and large, with one of the highest level of soil improver's consumption in the EU. This makes France and UK major consumers of mineral fertilizers, since their cereal production is large and the demand for fertilizers is high (FAO country profiles).

The demand for fertilizers is also quite high in Spain. First of all, because food industry is the biggest sector of the economy in Spain accounting for 20 per cent of the country's total industrial output. Secondly, Spanish agriculture became mainly specialized in cereal production, after livestock and dairy sector suffered from increased competition from other EU countries and outbreaks of "mad cow" disease. Traditionally cultivated field crops are cereals, in particular wheat and barley, as well as grapes, fruits and vegetables. However, it is worth to mention that Spanish cereal production has suffered from competition from the EU, and agriculture is handicapped in many places by lack of mechanization, by insufficient irrigation, and by soil exhaustion and erosion (Spain's Ministry of Agriculture).

From Figure 2 it is also notable that Netherlands, Denmark, Belgium and Portugal have a relatively bigger meat production, and thus animal sector. Therefore we can expect the need and demand for fertilizers to be lower in comparison to the countries with high share of cereal production. Livestock production dominates Belgian agriculture, and also is extremely important in Netherlands (FAO country profiles). Dutch farmers have some of the highest yields of beef and milk in the world. Extensive grasslands provide grazing for dairy cows and beef, creating demand for soil improvers.

Swedish agricultural sector contributes 2 percent of GDP. However, being very efficient and highly technological, it makes the country almost self-sufficient in many agricultural products. High yields are possible due to fertilization and mechanization, although soils are generally poor and the cold climate renders the growing season much shorter than elsewhere in Europe. The dairy sector is traditionally very important, although it has recently declined in comparison to grain and vegetable production. Nevertheless share of animal production is still high.

Traditionally cultivated crops are wheat, barley, oats, rye, potatoes, and sugar beets (FAO country profiles).

Differences in fertilizer consumption across countries depend not only on agricultural structure, but also on policies, regulations and laws. For example, there is a growing global concern regarding environmental problems, which has resulted in regulations on water, air and soil quality. This will probably have an increasing impact on farming practices. Farmers in the EU-15 have been requested to improve their nitrogen use efficiency. Environmental regulations and directives also impose greater recycling of organic nutrient sources and performance of nutrient budgeting. This will most likely lower the use of all nutrients. These environmental actions taken by countries are predicted to affect the fertilizer prices and constrain the fertilizer demand. Such trends can become stronger in the future. However, in Central European countries the environmental regulations are not as tight and the demand for fertilizers is growing fast (Bamiere et. al, 2007)

5.1.2 Demand for Biofuels vs. Demand for Fertilizers

Governments in many countries have also taken actions to ensure increasing production of bio-diesel which means that areas devoted to the growth of oilseeds are likely to expand, mainly in Western Europe. The growing interest for biofuels also has a significant effect on fertilizer demand.

Both first-generation biofuels (mainly ethanol made from corn and sugar cane, or biodiesel from vegetable oil) and the second generation biofuels that are still under development (made from crops grown on land not suitable for food production) require huge doses of mainly nitrogen-based fertilizers. Corn, for example, has very shallow roots compared to other crops and can only take up nitrogen during a short time of the year. Wood or woody grasses that are the base of the second generation biofuels are also in need of fertilizers but in less quantity (PotashCorp). The impact of biofuel development on N, P and K fertilizer consumption is particularly significant in the EU, one of the largest biofuel producers (Integer Financial Insight, 2007).

The increase in production of biofuels is partly a consequence of governments encouraging and subsidizing renewable fuels. The demand and supply in the biggest consuming countries are influenced by actions taken by the governments. Biofuels production in the EU is the result of a

voluntary European policy. Member states have individual's targets due to different ambition in the area.

In practice 14 countries had national indicative targets set to 5.75% for 2010; France was even more ambitious with a target of 7 %. Biofuels should account for 5.45% of the EU transport fuel market in 2010. Some countries, like for example Sweden, have a biofuel policy more oriented towards biofuels use, rather than production and they have an open attitude regarding using imported biofuels (Commission of the European Communities, 2007).

However ambitious European goals have proved to be difficult to reach with local production, unless significant resources are devoted to the production. One reason for this is that the production in the EU is oriented towards biodiesel rather than ethanol. Approximately 80% of the biofuels domestically produced are biodiesel. While the EU is a very minor supplier of bio-ethanol, it is by far the world's leader of biodiesel producing approximately 90% of the world production (Bamiere et. al, 2007). However the production of biodiesel is concentrated in roughly 3 member states, Germany, Italy and France. The production in the EU continues to rapidly increase not only in the three major suppliers but also in other countries like UK, Spain and Portugal (see Appendix 2 for details). However, the development of biofuels is distributed uneven in Europe, and some countries are just starting policy implementation in this area.

The production of crops intended for biofuels has become more economically attractive for farmers worldwide, and to meet this increasing demand, farmers will have to replace their crops, look for new arable land which certainly will boost the demand for fertilizers (Integer Financial Insight, 2007).

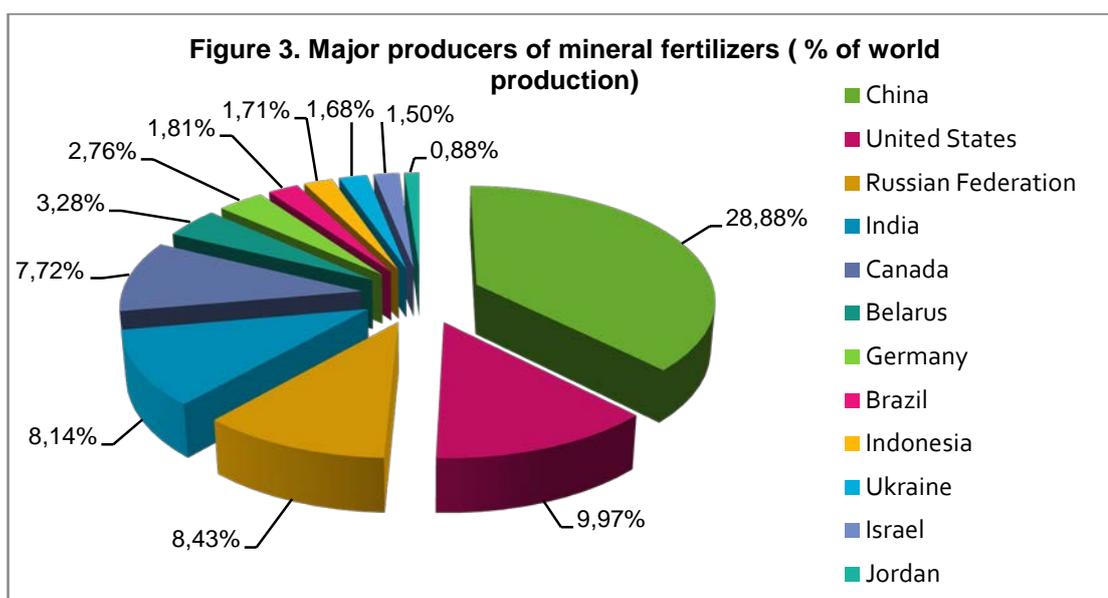
It is worth to mention that there is some difficulty in the prediction of what impact biofuels feedstock production will have on fertilizer demand. It is likely that the former is more dependent on sometimes contradictory policy objectives, rather than on market factors such as oil and feedstock prices. The variables involved in the relation between biofuel production and fertilizers are numerous and complex. For example, even if there is more land usage for feedstock production of biofuels, it is not easy to predict the raise in demand for fertilizers since it will partly offset by less land being used for other crops. In the development of the second generation of biofuels the enabling of other feedstock's such as grass and wood can also affect

the demand of fertilizers since they require less amount of mineral nutrients, this is however not likely to happen in the nearest future (FAO, 2008).

5.2 Competitive Situation in the Mineral Fertilizer Market

The growth in world fertilizer consumption has been impressive since the beginning of the 1960s. However, the fertilizer industry is no stranger to the ups and downs that characterize other commodity industries such as grains, metals, or minerals. The fertilizer industry is of an oligopolistic nature and accounts only a few major actors. As oligopoly combines different aspects of both competitive and monopolistic behavior, it is very difficult to give a unique answer on how it would affect horizontal price transmission. The total effect depends on numerous factors, and first of all, the degree of market concentration.

Fertilizers mainly consist of mined materials, such as phosphate and potash, or manufactured fertilizers, such as nitrogen. The major capacities of these resources are situated in a few countries, and the production is always close to the sources of the natural resources. Consequently, fertilizer supply is in the hands of monopolistic producers and exporters that are mainly the same companies. Specifics of the industry imply that it is extremely difficult for any new players to enter the market due to high entrance barriers and high fixed and variable costs of production. Thus, oligopolistic nature of the industry will continue to prevail in future. Figure 3 shows the biggest producers of mineral fertilizers. As can be seen 12 countries provide in total 76% of world fertilizer supply.



Source: own calculations based on the data from International Fertilizer Association

Since there are not many producers of fertilizers, the existing suppliers possess significant power in the market. The demand of fertilizers is high and increasing which means that that suppliers control the market and in some way the price. However mineral fertilizer producers are also in the hands of raw material producers, who dominate the market. The price of fertilizers reflects the prices of raw materials, and the price for these has increased.

Contracts between buyers and seller in the fertilizer market are notable to mention since they are rather unique in comparison to contracts on other commodities. Buyers and sellers agree to long-term, set price contracts rather than using a spot market. Long term contracts at current price are a guarantee of cash for the producer and it also binds the buyer to the seller (Potash Investing News). High concentration of long term contracts in the fertilizer industry makes it less vulnerable to economic shocks. For example, the global financial crisis led to decline in prices for most commodities but for potash fertilizer market it hardly had any effect (Silvinit).

5.3 Regression Analysis

We now use regression analysis in order to test our considerations on factors discussed above (i.e. differences in demand for fertilizers across the countries and competitive situation in the market) that may generate the price differences for mineral fertilizers across the countries.

The dependent variable in our regression is the same as in the previous sections – volatility of relative price differences across the countries. Apart for *Distance* which has been shown in our prior analysis to increase the price volatility between countries, we include in the regression three proxies for the demand-driven price changes (*Structure*, *Consumption* and *Biofuels*) and one variable for capturing the competitive situation at the world's fertilizer market (*Herfindahl*). All the explanatory variables in the regression are taken in natural logarithms.

The variable *Structure* is aimed to indicate the cross-countries structural differences in agricultural sector. For constructing this variable we simply calculated the average ratio between total crop output and total animal output over the period 2000-2009 for each country, and then bilateral relation between each pair of sample countries. We expect to find a positive dependence between this variable and price volatility. It means that the bigger the structural differences in countries' agricultural sector are, the greater price differences are.

The obvious reason for including a variable *Consumption* is to control for the differences in traditionally cultivated crops and agricultural policies across the EU countries, which may cause deviations in the demand for fertilizers. The variable is just bilateral ratio of average fertilizer consumption per Ha of arable land in two countries over the period 2000-2009. Our hypothesis is based on the basic law of the economic theory – the bigger the differences in the demand are, the greater price differences are.

A variable *Biofuel* is used as a proxy for differences in the demand for fertilizers arising from the current biofuel policies in the sample countries. As biofuels in the EU are mainly produced from the oilseeds, we assume that average share of oilseeds in the total output during 2000 – 2009, reflects the demand for fertilizers used in the biofuel production. Again, to construct the series we take bilateral ratio for each pair of countries. We assume that the bigger the differences in oilseeds shares between countries are, the bigger price dispersion for fertilizers will be, and therefore we expect the coefficient to be positive.

In order to account for the oligopolistic nature of the world market of mineral fertilizers, we constructed a specific *Herfindahl* index for each country in our sample using the formula:

$$H = \sum_{j=1}^{12} s_{ij} ,$$

where s_{ij} is the share of fertilizers imported to country i from one of twelve main world producers j in country i 's total import. The closer index H is to one, the higher the market power of the suppliers in particular importing European country is. Again, for constructing the series we took bilateral ratios of average Herfindahl indices over the period 2000-2009.

We recognize that one variable is not enough to capture the competitive situation in the market, and the data on prices, terms of trade, and contracts would greatly contribute to the robustness of results. However this information is restricted for industry members only.

A brief description of the employed initial data and constructed variables is given in Table 6.

Table 6. Description of Data and Explanatory Variables

<i>Raw data</i>		
Data	Unit	Source
Crop output	Usable production (1000 t)	Eurostat
Animal output	Gross indigenous production (1000 t)	Eurostat
Oilseeds production	Usable production (1000 t)	Eurostat
Total consumption of mineral fertilizers	Tonnes of active ingredient (1000 t)	Eurostat
Total import of mineral fertilizers	Net weight (kg)	UN comtrade
Import from countries-main producers	Net weight (kg)	UN comtrade
Arable land	Area (1000 Ha)	Faostat

Note: for all the indicators we use yearly data from 2000 to 2009

<i>Explanatory variables</i>	
Variable	Definition
<i>Distance</i>	Distance in the natural log of kilometers
<i>Structure</i>	Proxy for the structural differences in agriculture: Crop output/Animal output
<i>Consumption</i>	Proxy for the differences in demand for fertilizers: Total consumption/Arable land
<i>Biofuel</i>	Proxy for demand driven by biofuel production: Oilseeds production/Crop output
<i>Herfindahl</i>	Proxy for differences in competitive situation, sum of market shares of main importers

Relatively small dataset and heterogeneity of data across different types of fertilizers makes it convenient to employ the pooled cross-sectional regression approach. We use a fixed effects model and include grouping variables for all nine groups of fertilizers. It means that all regression coefficients are restricted to be the same across all cross-sections. Table 7 displays the output from this regression, both the estimates of the coefficients and the fixed effect.

Table 7. Multiple Regression Analysis

Variable	Coefficient	Std. Error	t-Statistics	Probability
<i>C</i>	-0.030263	0.019271	-1.570395	0.1165
<i>Distance</i>	0.018735*	0.002791	6.711669	0.0000
<i>Structure</i>	0.000094*	0.000026	3.562747	0.0004
<i>Consumption</i>	0.006399*	0.002175	2.941884	0.0033
<i>Biofuels</i>	0.000038*	0.000011	3.746488	0.0002
<i>Herfindahl</i>	0.015086*	0.001822	8.278067	0.0000

Fixed Effects (Cross-Section)	
N	-0.005366
P	0.038817
K	0.018877
Straight	-0.013129
NP	0.007637
PK	0.014339
NPK	0.008974
All compound	-0.012756
Mixed mineral	-0.023572

Adjusted R-squared: 0.314	Total pool observations: 1711
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Notes: The table presents the output of pooled regression. The dependent variable is price volatility (calculated as standard deviation) across the in-sample EU countries. Robust White cross-section standard errors are used in the estimation.

The constant term is included automatically due to the shape of the model, so that the fixed effects can be interpreted as deviations from the overall mean. The reported adjusted R-squared describes the explanatory power of the entire specification, including the estimated fixed effects. The obtained value of 0,314 is fairly high for the pooled regression.

Additionally, it should be mentioned that we estimate our model using White cross-section standard errors, to allow for general contemporaneous correlation between the residuals. This method of computing the standard errors gives robust estimates of standard errors, *t*-statistic values and probabilities. All the coefficients are statistically significant at 1% - level. However coefficients on some variables are almost zero (*Structure* and *Biofuels*). The results for the *Structure* variable is surprising, although it might be the case that animal production demands more fertilizers than we assumed, and therefore demand differences between crop- oriented and animal oriented agricultural sectors are evened. Low coefficient for *Biofuel* might be due to the fact that it is difficult to determine net effect of biofuel policies on fertilizer market. From one side increased area of biofuel crops (oilseeds) leads to higher demand for fertilizers, but on the other side this positive impact is largely offset by decreased area devoted to the production of traditional crops.

The coefficient for consumption is also relatively small. Thus, the differences in consumption levels across countries do not explain much of the price variations.

It is notable, that the coefficient for Distance became lower after including other explanatory variables compared to individual regression estimates obtained earlier (0.018 vs. 0.025). But distance still remains very important for explaining the price volatility.

There is another factor found to contribute largely to price disparity, namely differences in competitive situation in the fertilizer market. The coefficient 0.015 is very close to the Distance coefficient value, which implies that the price deviations arise from two almost equally important sources. So, oligopolistic nature of suppliers is by far the most important feature of mineral fertilizers market.

VI. Conclusions

Interest in international price variability across different locations has recently gained significant momentum and the amount of studies on this topic is increasing. Under the assumptions of full horizontal price transmission and market integration, which follow from standard perfect competition model, the law of one price should govern spatial price relations and dampen the cross-countries price differences. In practice, such situation can indicate the presence of well functioning and highly integrated market. On contrary, remarkable price differences make the existence of integration in the market rather questionable.

The present essay was focused on the analysis of the prices for mineral fertilizers across selected European states. The most important message of our empirical results is that distance matter and spatial market segmentation is likely to be present in the EU mineral fertilizer market. A reason underlying this finding is that countries are likely to import from the geographically nearest suppliers in order to minimize trade costs. Freight rates, such as shipping costs and fuel costs, are among the most important determinants of price in the fertilizer market. Thus, countries which are located closer to raw mineral deposits have advantage in terms of lower costs and are expected to have lower price on average.

Another important implication of our empirical study is that the market structure in mineral fertilizer market is a key determinant of price. The major capacities of raw phosphate, potash and nitrogen are situated in a few countries, and the production is always located close to the sources of the natural deposits. Consequently, fertilizer supply is in the hands of monopolistic producers and exporters that are mainly the same companies.

Specific features of the industry suggest that it is extremely difficult for any new players to enter the market due to scale effects, high entrance barriers, high fixed and variable costs of production. Therefore, horizontal price transmission is affected by the imperfect competitive situation of the market. The existing suppliers possess significant power in the market. The demand of fertilizers is high, which means that that suppliers control the market and to a great extent the price.

Moreover, specifics of the contract terms are also worth to mention, since they are different from the terms of contracts on other commodities. Buyers and sellers usually enter long-term agreements and set price contracts, rather than using a spot market. High concentration of long term contracts in the fertilizer industry makes it less vulnerable to economic shocks, which are not fully transmitted to the final consumers (farmers). For example, the global financial crisis led to decline in prices for most commodities but for mineral fertilizer market it hardly had any effect.

Since the linkages between farm input markets and other markets have recently strengthened, the conditions in the farm input market is of great importance for farmers as well as for the downstream agents of the food chain. Analysis of input prices is important for understanding the cost structure of food production and the topic should gain more attention from agricultural economists. We believe that our findings are interesting, although not exhaustive. So, the topic will continue to be a fruitful area of discussion in the future.

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Eurostat Statistics Database <http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/>

FAO statistics <http://www.fao.org/corp/statistics/en/>

FAO: country profiles <http://www.fao.org/countryprofiles/default.asp?lang=en>

FERTECON: Fertilizer Economic Market Analysis & Consultancy <http://www.fertecon.com/>

IFA: International Fertilizer Industry Association <http://www.fertilizer.org/ifa/Home-Page/STATISTICS>

Potash Investing News http://www.silvinit.ru/press/news/details_180.html

PotashCorp <http://www.potashcorp.com/customers/products/fertilizer/>

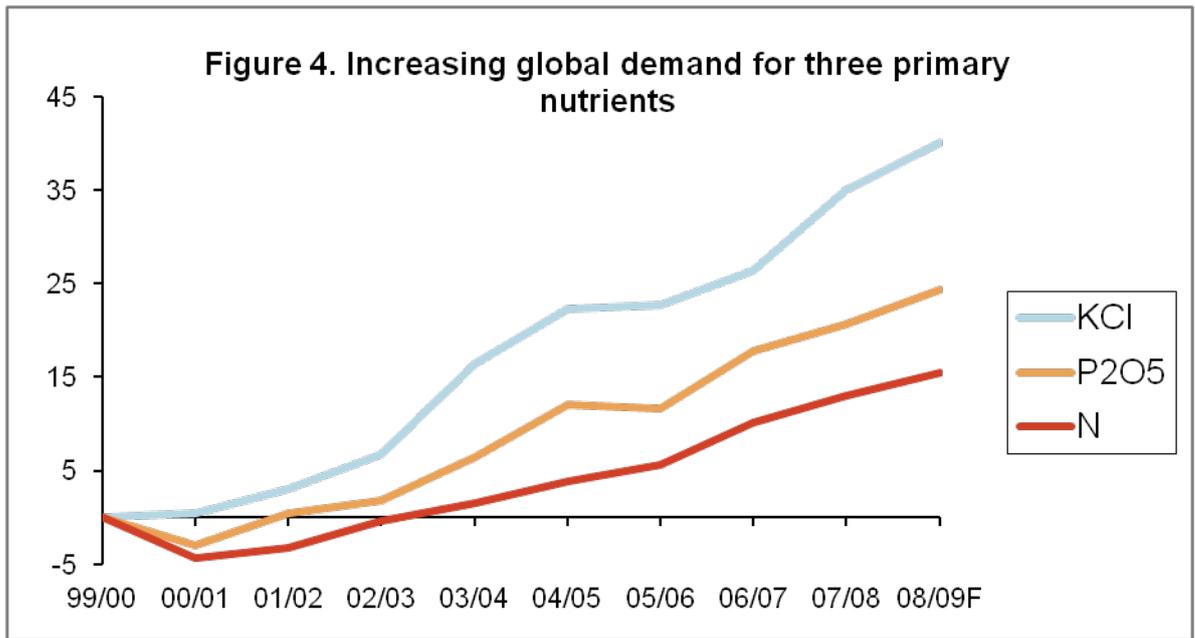
Silvinit http://www.silvinit.ru/press/news/details_180.html

Spain’s Ministry of Agriculture <http://www.foodanddrinkeurope.com/Consumer-Trends/>

The International Crops Research Institute (ICRISAT) <http://www.icrisat.org/>

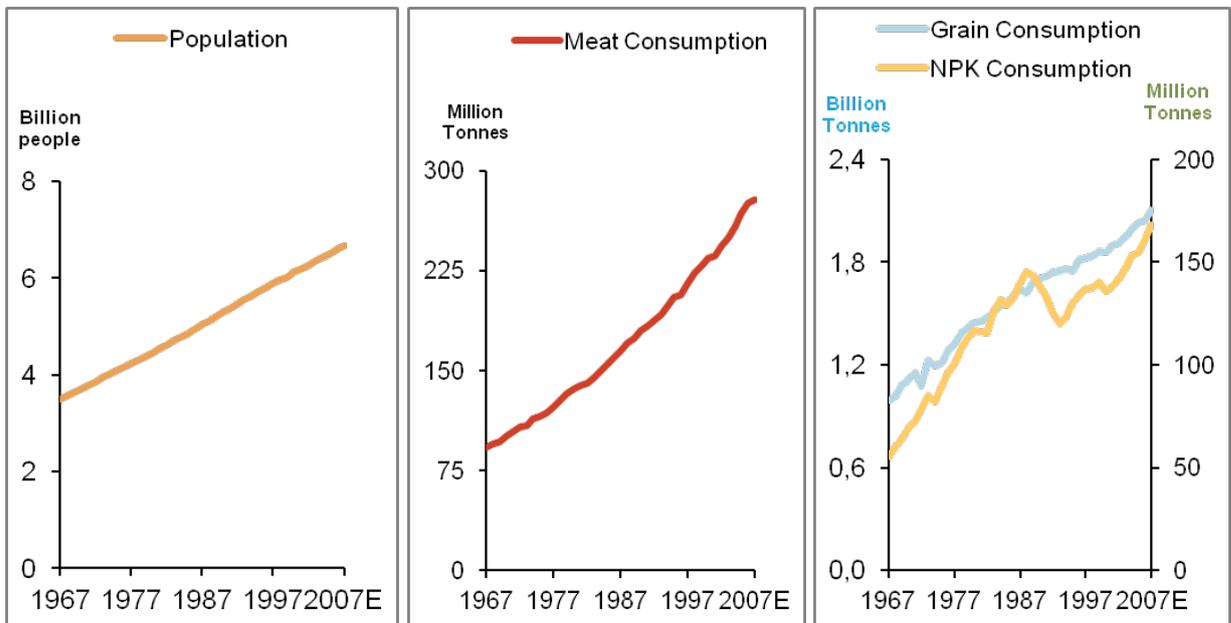
UN Comtrade <http://comtrade.un.org/>

Appendix 1. Global Trends in Mineral Fertilizer Market

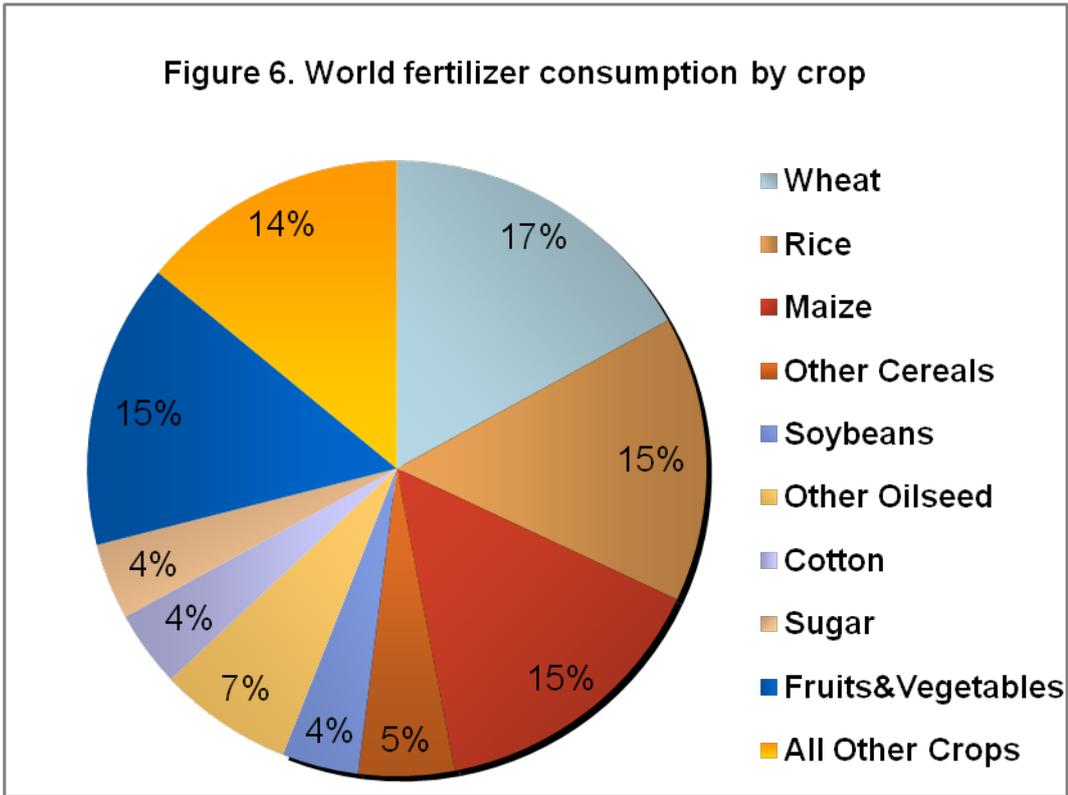


Source: Fertecon and PotashCorp

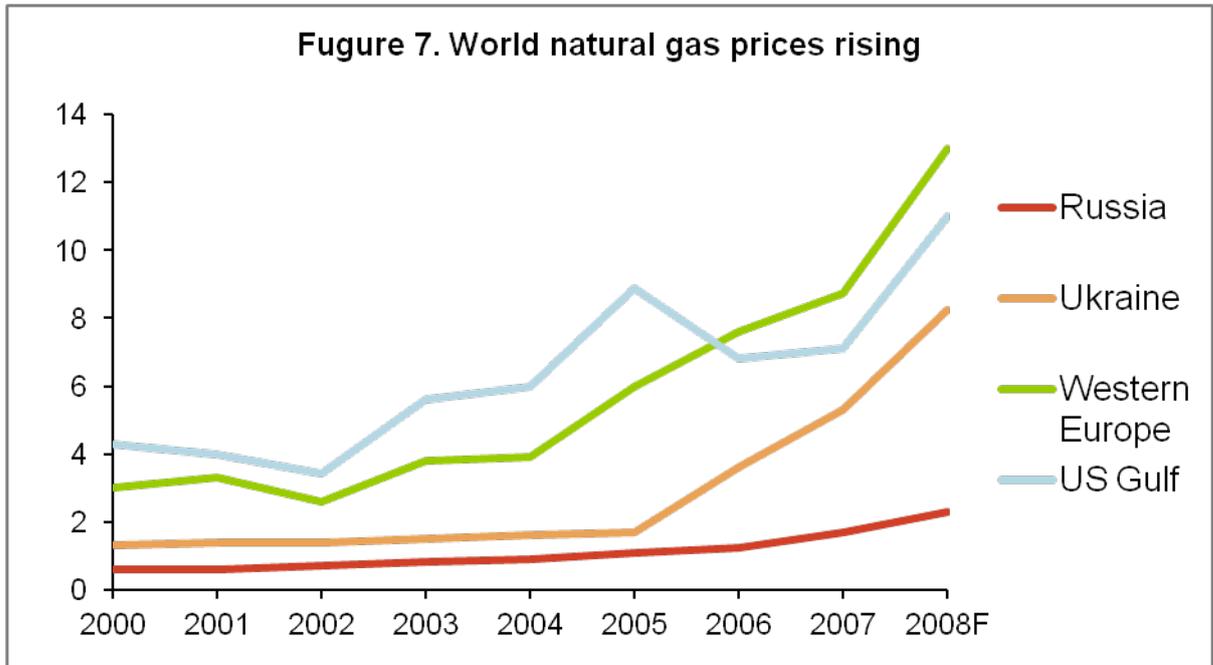
Figure 5. Fertilizer industry demand drivers



Source: United Nations, FAO, IFA, Fertecon, PotashCorp



Source: IFA



Source: Fertecon, PotashCorp

Appendix 2. Biodiesel Production in the EU

Table 8. Biodiesel Production in the EU (1000 metric tons)

	2002	2003	2004	2005	2006	2007	2008
Italy	210	271	320	396	447	363	595
France	366	357	348	492	743	872	1815
UK	3	9	9	51	192	150	192
Check Rep.	69	70	60	133	107	61	104
Austria	25	32	57	85	123	267	213
Denmark	1	41	70	71	80	85	131
Sweden	1	1	1.4	1	13	63	
Spain		6	13	73	99	168	207
Lithuania			5	7	10	26	268
Slovakia			15	78	82	46	146
Poland				100	116	80	275
Portugal				1	91	175	268
Estonia				7	1	0	0
Slovenia				8	11	11	9
Greece				3	42	100	107
Belgium				1	25	166	277
Netherlands					18	85	101
Romania					10	36	65
Bulgaria					4	9	11
Latvia					7	9	30
Hungary					0	7	105
Cyprus					1	1	9
Malta					2	1	1
Finland					0	39	85
Luxemburg					0	0	0
Total EU-25	1134	1504	1933	3184	4890	5713	7755
Production yearly growth		35%	35%	65%	54%	16.8%	35.7%

Source: European Biodiesel Board