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The impact of the common agricultural policy on agricultural productivity

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By

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Abstract

In 2004 10 new countries, primarily Eastern European countries, joined the European Union(EU) with much media speculation concerning how this would affect their economies. This paper will look at how the Common Agricultural Program(CAP) affects agricultural productivity by measuring four independent variables and by using the 2004 entry as a natural experiment. The paper will estimate how the CAP affects the average farm size, fallow land area, proportion of farming dedicated to organic farming, and GDP growth. This is expected to impact agricultural productivity through increasing returns to scale, input availability, efficiency of land use and the Environmental Kuznets Curve respectively. The findings indicate an overall increase in agricultural productivity as a result of joining the EU from higher average farm size, lower levels of fallow land and higher proportions of organic farming. The estimation technique used was an ordinary least squares regression with fixed effects for each country.

I – Introduction

This project will look at the impact of subsidies on agricultural productivity. Specifically my analysis will look at the CAP in the EU and how it affects the productivity of the agricultural sector EU15 (the original EU member states) and EU8 (The 8 Central and Eastern European countries that joined in 2004). Specifically the variables examined will be GDP per capita (as the countries converge with the "old" EU countries' GDP level, pollution and pesticide levels may change and thus affect productivity), land use (how will mandatory fallow land policies affect productivity), proportion of organic farming (how will agricultural subsidies incentivizing organic farming affect productivity), and increasing returns to scale (how will the Euro per hectare policy affect the average farm size).

Investigating the impact of subsidies on agricultural productivity in Central and Eastern Europe provides a very interesting case study of agricultural subsidies. One of the reasons for this is that all the Central and Eastern European countries joined simultaneously in 2004 and received economic assistance via the CAP from day one. This natural experiment presents a unique opportunity to investigate whether or not the CAP has had a negative or positive impact on agricultural productivity. This is also a very important issue as the CAP is engulfed in controversy and contention. This is both from within the EU as net contributors demand a reduction in the program as well as from international organizations such as the World Trade Organization charging that the CAP is an instance of unfair protectionism. This topic is also worth investigating because of the sheer financial magnitude of the program, in 2005 a total of € 43 bn was spent maintaining the program (BBC News 2005). Findings indicating an increased level of productivity due to inclusion in the EU and access to the CAP would help justify the program's continued existence. Conversely, findings indicating that the CAP lowers productivity would lend credence to the critics of the program advocating reducing the subsidies or restructuring the program. Finally, the CAP itself became one of the main problems in the negotiation process of accepting the new members of the EU because they did not receive the full euro per hectare support from day one. The CAP is thus a very significant policy possibly affecting the future of EU expansion.

The CAP itself is also an interesting example of an agricultural subsidy as it has different characteristics, some of which would be expected to reduce productivity while others would be expected to increase productivity. This will be discussed in further detail in the theory section.

Brief History of the Common Agricultural Program in the EU

The EU (previously known as the European Coal and Steel Union) formed a uniform agricultural program for all member states in the late 1950's with the objective of providing farmers with a decent income, consumers with quality products at low prices, and preserving the rural heritage of Europe. The CAP later adopted has become a key component of the pan-European agricultural policy, and was destined to secure food supply for the European Continent. This program was seen as critical in the aftermath of the Second World War when food security was still a concern. While the main part of the CAP was a subsidy scheme to support agricultural prices, an important component of the program was also incentives to encourage free trade among the member countries. In time, the CAP became the main part of the EU budget (until 1992 it took up 62% of the EU budget). The regional (national) differences between net beneficiaries and net payers of this program made the CAP quite contentious. As a result there has been both internal as well as external pressure (e.g. the World Trade Organization) to change the policy. However, since a relatively large majority of votes (and in some cases outright consensus) is needed, structurally changing the CAP has proven time consuming and challenging.

The initial process of negotiating a CAP was difficult, it was first proposed at the Treaty of Rome in 1957, but not ratified until 1962. The problematic part was to have a common market while at the same time offering the same level of protection to the farmers which was enjoyed under the national level subsidy programs. Specifically, the compromise was reported to be between Germany and France; Germany's industry gained access to France, but Germany was to help finance the subsidies paid to French farmers. The accuracy of these reports is hard to verify as the negotiations were behind closed doors. It is, however, beyond any doubt that Germany was and still is the main contributor to the CAP and France is the biggest beneficiary with its large agricultural sector. Today with the accession of the 12 new countries, France will for the first time in history become a net contributor.

There have been several stages of development within the CAP. The year 1992 marked a breakthrough year as the MacSharry reforms were introduced. The main impact of these reforms was to bring prices closer to equilibrium levels and minimize overproduction. Instead of paying for overproduction of goods which led to the infamous sugar mountains and wine lakes which were expensive to maintain, the MacSharry reforms paid to create reforestation, more fallow land and direct payments to farmers to ensure retirement. One of the main forces behind this change was the World Trade Organization's Uruguay Negotiation Round forcing EU countries to have a more reasonable agricultural policy which would not adversely affect agricultural sectors in other countries. Previous EU policies of floor prices created a glut of food products which was dumped on primarily developing countries labeled as "emergency food relief" but ended up destroying farmers' livelihood.

Between May 2004 and January 2007 the EU included 12 new member states, most of which come from Eastern Europe and are currently in transition economies. This was a very controversial move in many different circles. There was much skepticism within "old" EU member states as there was a fear it would be expensive to subsidize the new member states' agricultural sectors. The media also paid close attention to the economic impact of this enlargement. The negotiated consensus was a step-wise integration of the Eastern European countries in the CAP. However, in the negotiations it became clear that large Eastern European agricultural countries (in particular Poland) were unsatisfied with the slow full implementation of the CAP toward the new member states. After long negotiations the 10 Eastern European countries have been admitted into the EU and correspondingly as beneficiaries of CAP.

The next section of this paper will outline the research question and some of the literature and theoretical work already done on this topic, followed by a discussion of the theoretical background, the model used, and the data used for this assignment before results are presented and some concluding remarks are made about the findings.

II – Literature Review

A large number of both books and published articles have examined the issue of agricultural productivity in a variety of subtopics such as geographic locations or specific commodities (listed below). Even though most of these articles focus on a very specific subsidy within a given economy there are some universal characteristics. There is also a consistent subset of literature concerning the EU expansion of the CAP itself and how this affects the level of productivity within the old as well as new economies in general and whether there is a convergence of growth rates. A third set of literature is specific to the use of pesticides and how this affects both short run and long run productivity.

Subsidies in general are thought to create inefficiencies in economic systems as the price signals they send can distort markets and their optimum conditions. With regards to agricultural subsidies in particular Hu and Antle (1993) find that there is an optimum level of productivity which can be significantly affected by agricultural subsidies. In moderate levels government policies can positively affect agricultural productivity due to innovations in crop yields, specialization and economies of scale. However, very high levels of subsidies have a negative affect due to the inherent high tax rates, resource and technology constraints as well as the massive distortions to the incentives of farmers due to irrational resource allocation. This study was based on global World Bank data collected in the 1960's to the 1980's. Agricultural subsidies also incentivizes a certain type of agricultural structures, Breustedt and Glauben (2007) examine how higher levels of subsidies results in lower levels of exits, thereby indicating that stagnant high levels of subsidies would slow down the naturally changing composition of agricultural sectors, while it maintains that this is the case to a lesser extent with smaller farms. Relating specifically to the EU, the 2004 and 2007 enlargements have long been expected and a wide range of predictions have been made on the effect on the EU economies. Baldwin et al. (1997) assess the impact as exclusively positive for both entering countries as well as old countries from bigger markets, although entering countries would benefit the most. Petrakos et al (2005) look at the distribution of benefits among the countries, and conclude that there will be a core/periphery gap where the countries geographically closer to the West will benefit disproportionately. Leguen de la Croix (2004) in an official paper of the European Commission indicates the productivity of the entering Eastern European countries are lower as they add 30% of total hectare of agricultural land, but only add in between 10-20% agricultural production, though this does not control for input costs.

In terms of environmental aspects of the CAP, Van der Grijp and den Hond (2000) and Serra et. al (2005) outline the significant reductions made in the 1990's of pesticides (kg/ha) used by EU member countries due at least in part to tougher EU regulations. How this affects agricultural productivity remains a contentious point. Grossman and Krueger (1991) wrote the seminal work on the Environmental Kuznets Curve outlining how higher levels of GDP would lead to lower levels of pollution. Managi (2006) applies this specifically to pesticides showing tighter regulations abating the environment also removes decreasing returns to scale as many farmers overuse pesticides and are thus forced to reduce their input costs and are forced closer to the point of optimum use. Huang et al (2002) and Dasgupta et. al (2007) highlight cases in China and Bangladesh respectively where lower levels of pesticides increased productivity as the price of inputs were significantly reduced while the crop yields were not impacted significantly. However, Shankar and Thirtle (2005) and Lansik and Silva (2004) determine that pesticides are under-utilized in South Africa and the Netherlands respectively. The optimum use of pesticides is very different according to the specific plant as well as climate, thus deviating findings do not necessarily contradict.

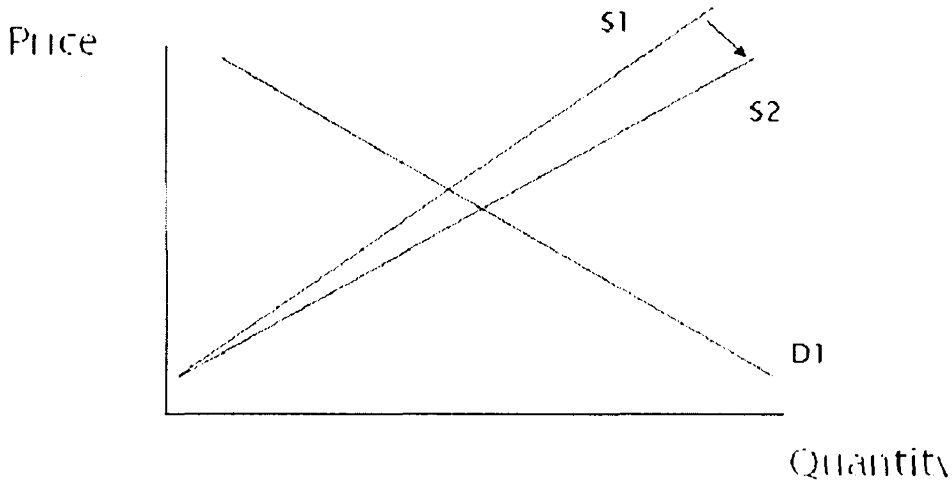
Finally, another regulation of the CAP is that land needs to be fallow within a certain timeframe and subsidies in the EU depend on the extent of diversification, Pascual (2003) finds that diversification and leaving land fallow actually increases agricultural productivity in the long run based off data in the Yucatan in Mexico.

This paper will take a look at these variables within the context of one specific agricultural policy. The entry date is the same for all countries examined, so 2004 presents a precise and uniform change in policy for EU8 while there should be no change in the agricultural policies for the EU15 countries. This paper thus presents a unique perspective to test the applicability of findings of previous studies on EU member states.

III – Research Design and Theoretical Model

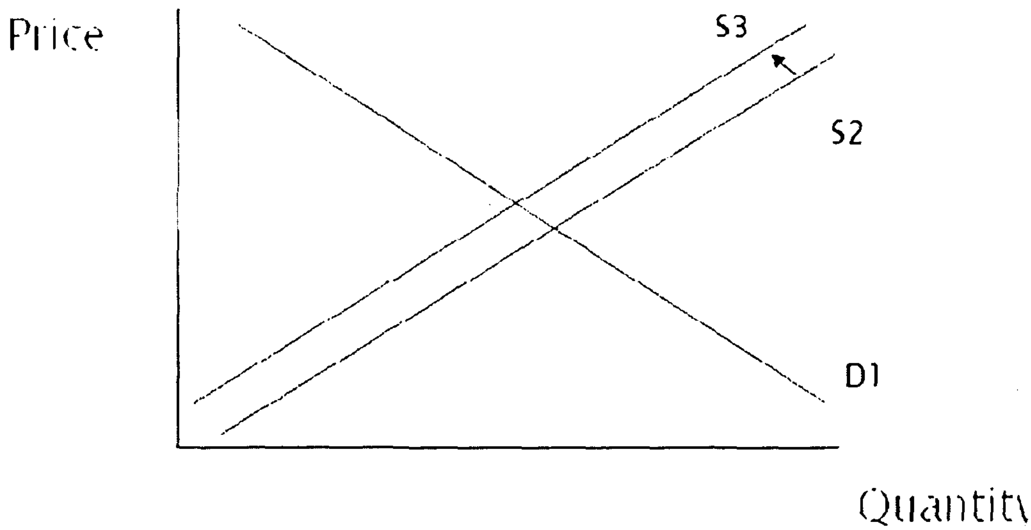
The CAP has a complex set of rules and regulations, but there are three components which each have different impacts. The first of which is the grant to farmers in the EU for arable land in good condition. In order to meet the condition of "good arable land" farmers must lay the land fallow after a number of years dictated by the EU. Since this condition favours larger farmers (Breustedt and Glauben 2007) due to increasing returns to scale, larger farmers can get larger grants while keeping all other costs fixed. The increasing returns to scale could come from bulk buying e.g. tractors and harvesters or from labour specialization on the farm. Thus the first type of grant for having land in good arable condition is a function of its incentive to promote increasing returns to scale. We would thus expect that inclusion into the EU would increase the number of big farms and decrease the number of small farms because these larger farms, ceteris paribus, have a competitive advantage. Because we would expect the average farm size to increase we would simultaneously expect this to increase productivity and pivot the supply curve to the right.

Figure 1



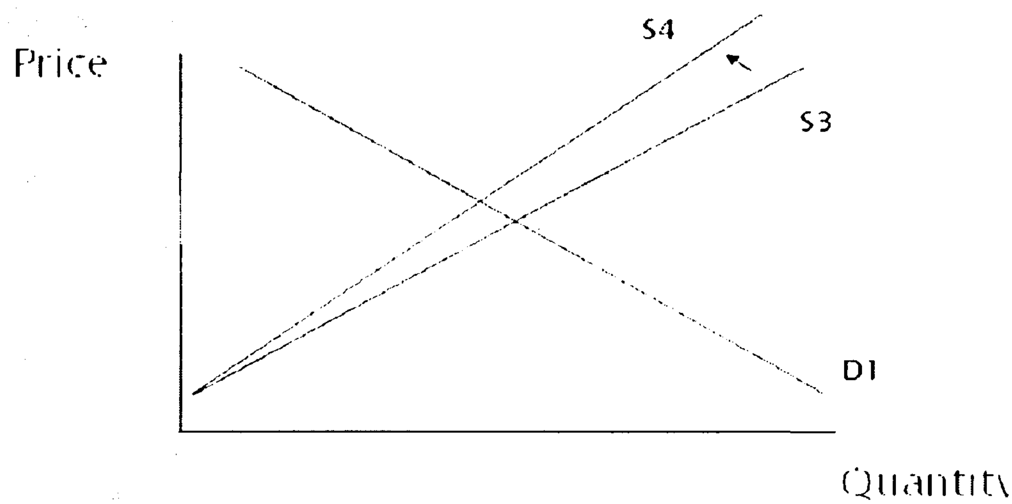
Moreover, farmers are mandated to, but also financially supported for, leaving part of their land fallow every cropping season. The reasoning behind this is that in order to have good soil the land should be left aside with no crops grown or animals grassing on it. This way the soil will recover its nutrients and long term productivity is increased. However, because output from this area is completely eliminated we would expect this in the short run to shift the supply curve left and quantity supplied would decrease. At each and every price level producers would be able to supply less output. The effect on productivity, in terms of income to farmers holding inputs constant is somewhat more ambiguous. The reason for this is that elasticity of demand might be inelastic. Food is generally considered a rather inelastic good as a whole, since there are no substitutes. Of course American produced potatoes are substitutes to European potatoes, but other protectionist components of the CAP (discussed later) effectively eliminate this as a viable option for the consumer. Thus, if the demand indeed is inelastic then a leftwards shift of the supply curve would reduce output, but increase income to farmers.

Figure 2



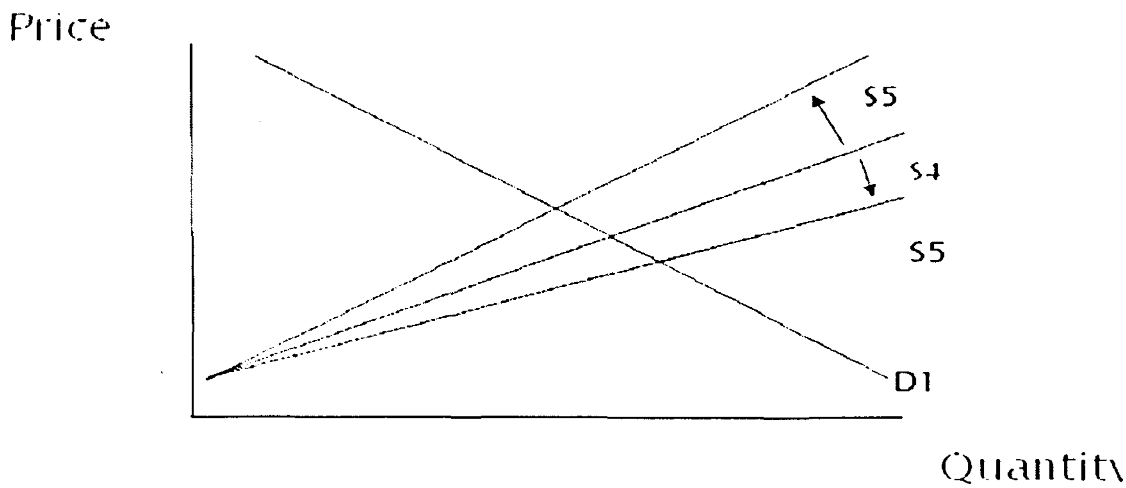
The second component of the CAP is the promotion of ethical farming as organic farming is specifically rewarded with EU subsidies. Organic farming and ethical farming put further restrictions on farmers as they are not allowed to use pesticides, synthetic fertilizers or plant growth regulators. We would predict the CAP incentives for organic farming would increase the proportion of organic farming. This in turn would reduce total output as a series of inputs are now unavailable and the substitutes such as natural fertilizer are less efficient and/or more expensive. However, the effects on productivity remain unclear. The reason for this is that while the total output decreases, as in the number of potatoes harvested per hectare, the organic food is typically more expensive and sold in a different market. Thus total output can go down and total revenue and profits to the farmer go up because the price differential outweighs the reduced output. However, in the absence of a subsidy program we would expect farmers to be profit maximizing agents and grow either organic or non-organic crops on their land according to which is more profitable. This would in the long run make each individual farmer indifferent to the organic market and non-organic market because the price fluctuations in each commodity would be equalized by the price adjustment mechanism. Thus, if the individual farmer is indifferent to organic and non-organic farming in a world with no subsidies, a world in which the CAP exists there is an extra incentive to do organic farming, there would be a shift the proportion of farming dedicated organic farming away from the optimum point of allocative efficiency. We would thus expect a leftwards rotation of the Supply curve due to higher costs of production, even considering the higher price for organic foods.

Figure 3



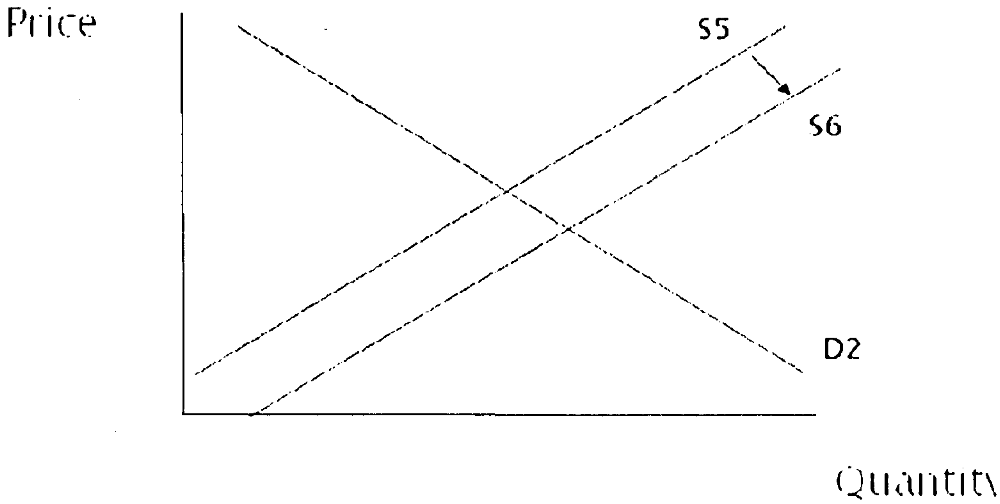
As Managi (2006), Huang et. al (2002) and Dasgupta et. al (2007) point out pesticides are often overused so even if there is a reduction in total output, the larger reduction in costly inputs actually increases productivity. If, however, pesticides are used close to its optimum point or beneath it as Shankar and Thirtle (2005) and Lansik and Silva (2004) argue, further restrictions on pesticides would lower productivity. As Central and Eastern European countries join the EU a GDP convergence is expected, while some predict this taking longer than others, there is widespread consensus it would take place. According to the theory of the Environmental Kuznets Curve, lower levels of GDP are associated with higher levels of pollution and chemical use in agriculture, while higher levels of GDP are associated with lower levels of pollution and pesticide use because of increased regulations as people value environmental protection higher. The relationship, however, is not linear but quadratic as higher levels of GDP are associated with higher levels of pollution at first, but then higher levels of GDP are associated with lower levels of pollution. Depending on where the countries are on the Environmental Kuznets Curve, increases in GDP could both cause higher and lower levels of pollution. As previously noted some types of pollution restrict productivity while others do not so it is difficult to predict the outcome of the direction of the rotation of the supply curve. It should also be noted that this variable is most clearly identified in the long run, and thus the effects may not be visible in the timeframe of this study.

Figure 4



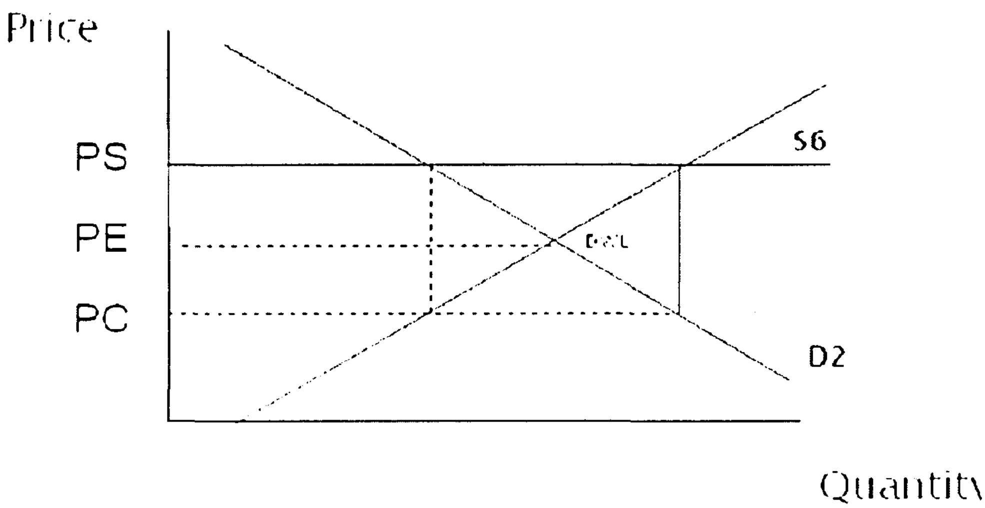
In this model it is expected that farmers are profit maximizers and would seek to maximize productivity under the constraints of the CAP regulations. This means farmers would thus exploit certain regulations that would lead to less productivity, if it would lead to higher profits via grants, but would, ceteris paribus, seek to maximize productivity. With regards to the direct payments, this would function as an outwards shift of the supply curve as a higher amount of money is rewarded for each good produced:

Figure 5



The reason why it is not certain the price would decrease is because the EU has guaranteed to uphold a minimum price (PS) through the price maintenance policies which seek to maintain a certain price level by buying excess production. While the influence of this subsidy has been decreasing it is still in effect today. This functions as a minimum price creating a surplus (PS-D – PC-S) which the government buys up. If the direct payment subsidies would push prices down beneath the floor price, price would not decrease, regardless of how much the supply curve shifts to the right. It should also be noted that this subsidy is only costly when in fact the EU has to intervene and buy up excess surplus, and the price of the subsidy would be amplified by the direct payments subsidy as farmers are not only paid to produce more, but the extra production is purchased by the EU. Thus we would expect both the direct payments and the price stabilization component of the CAP to increase quantity supplied, but there would also be a corresponding increase in inputs used. Increased inputs used may be accompanied by economies of scale from lower per unit costs from bulk buying, but it could also be the case that there would be diseconomies of scale. Certainly there would be a dead weight loss to consumers as graphically demonstrated, since the marginal cost curve is the supply curve and the marginal benefit curve is the demand curve. The triangle DWL makes up this portion of the subsidy measured amount of marginal cost excess of marginal benefit.

Figure 6



Some of the independent variables can be expected to counteract, we would expect larger average farm sizes to increase productivity, but we would also anticipate a possible decrease in productivity from increased proportions of organic farming. These factors pivot the supply curve right and left respectfully. With regards to quantity supplied we would expect the direct payments and minimum price effects to increase quantity supplied, but the overall quantity supplied might decrease if the supply curve pivots left enough to outweigh the rightwards shift in the supply curve and possible disequilibrium effect. Because there is this ambiguity the test for this study will be two tailed:

H0: The CAP does not impact agricultural productivity
H1: The CAP does impact agricultural productivity

The model used for this is a classical Cobb-Douglas production function:

$Y_{it} = A_{it}F(L^{\alpha}_{it}\ K^{\beta}_{it})$ *(Eq.1)*

Where Y_{it} is the agricultural output produced by country i at time t, A_{it} is the Total Factor Productivity which represents the residual impact on output not caused by labour or capital inputs, L^{α}_{it} is the labour input, K^{β}_{it} is the capital input, and e_{it} is the random unobserved error not captured by the variables in the model. In order to run this equation in a regression and estimate the exponents the equation has to be transformed into a Log-Linear form:

$Ln(Y_{it}) = ln\ (A_{it})\ F\ (\alpha\ ln\ (L_{it})\ \beta\ ln\ (K_{it})) + e_{it}$ *(Eq.2)*

In this form the model can check for constant returns to scale and estimate the relative impacts labour and capital have on output. More importantly, having isolated labour and capital we would think of the different components of the CAP affecting Total Factor Productivity in the following way:

$Ln\ (A_{it}) = \lambda_0 + \lambda_1\ ln\ amount\ of\ fallow\ land_{it} + \lambda_2\ ln\ proportion\ of\ organic\ farming_{it} + \lambda_3\ ln\ average\ farm\ size_{it} + \lambda_4\ ln\ GDP\ per\ capita_{it} + \lambda_5\ EU\ variable_{it} + e_{it}$ *(Eq.3)*

We can then estimate the effect of these variables on output in the final equation:

$Ln\ (Y_{it}) = \lambda_0 + \lambda_1\ ln\ amount\ of\ fallow\ land_{it} + \lambda_2\ ln\ proportion\ of\ organic\ farming_{it} + \lambda_3\ ln\ average\ farm\ size_{it} + \lambda_4\ ln\ GDP\ per\ capita_{it} + \lambda_5\ EU\ variable_{it} + \alpha\ ln\ L_{it}\ \beta\ ln\ K_{it} + \delta_i + e_{it}$ *(Eq.4)*

The only differences in this equation are the addition of labour and capital as independent variables and the inclusion of δ_i which represents the fixed effects.

IV – Data and Summary Statistics

The data available for this paper range from 2002 to 2005, the first two years of which the Central and Eastern European countries were not member states of the EU. The data for irrigation area, total farm labour force, number of holdings, and organic crop area had to be interpolated. This was done by taking the arithmetic mean of the surrounding years to fill the data gap, except for the labour force data, here the geometric mean was taken because intuitively we would expect population and labour force growth to grow more rapidly than arithmetically. There were also four countries eliminated from the sample: Estonia, Germany, Ireland and Luxembourg which was due to excessive gaps in the dataset which could not be salvaged by interpolation. This leaves the seven Central and Eastern European countries in the population examined: the Czech Republic, Hungary, Latvia, Lithuania, Poland, Slovakia, and Slovenia, as well as 11 Western European states: Belgium, Denmark, Greece Finland, France, Holland, Italy, Portugal, Spain, Sweden, and the United Kingdom.

The agricultural production data is measured in terms of millions of Euros at basic prices which EuroStat defines as "the price received by the producer, after deduction of all taxes on products but including all subsidies on products. Output of the agricultural industry is made up of the sum of the output of agricultural products, agricultural services and of the goods and services produced in inseparable non-agricultural secondary activities." (EuroStat – Basic Price Definition).

The amount of fallow land is measured in hectares (ha) and is the amount of arable land in the crop rotation on which there is no crop growth and no animal grazing. The proportion of organic farming is calculated by dividing the total area of organic crop production in ha by the total area of crop production in ha. In order for crop area to be defined as organic the area has to fulfill all criteria of EEC regulation No 2092/91 which includes not using any synthetic fertilizer or pesticide.

In order to find the average farm size the total crop area is divided by the total number of holdings. The number of holdings is defined by EuroStat as "a single unit both technically and economically, which has single management and which produces agricultural products. Other supplementary (non-agricultural) products and services may also be provided by the holding" (EuroStat – Holding Definition). The average farm size is thus measured in terms of ha.

When controlling for the relative income of the country the data used in this study is using the Gross Domestic Product per capita at market prices. It reflects the total value of all goods and services produced less the value of goods and services used for intermediate consumption in their production. It is also controlling for different price levels in different countries by using the PPS (Purchasing Power Standards). The income is measured in Euros per capita.

Irrigable area is chosen as a proxy for capital because it is closely correlated with other proxies for capital such as tractors, harvesters and threshers. EuroStat defines irrigable area in ha as "the maximum area which could be irrigated in the reference year using the equipment and the quantity of water normally available on the holding" (EuroStat – Irrigable Area Definition).

The data available for labour is measured in terms of 1000 AWU (Annual Work Units), where an AWU is the work of a full time employee. Finally the EU variable is a dummy variable where a 0 value is given to non-member countries and a 1 to member-countries.

Table 1 presents some summary statistics outlining the arithmetic mean and standard deviation for both the treatment group (EU8 – The newer members of the EU) and the control group (EU15 – the older members of the group). The most important things to note are that the proportion of organic farming approximately doubled in the Central and Eastern European countries after joining while in EU15 it increased from 15% to 18%, that the proportion of fallow land decreased dramatically upon entering for the EU8 members, and that the average farm size increased marginally after the EU8 countries entered the EU, while it stayed static for the EU15 countries. Seeing a decrease in the amount of fallow land upon entering the EU and receiving benefits for leaving land fallow seems curious. However, it must be noted in this context that all countries prior to 2004 had their own national subsidies which could have had a higher incentive to leave land fallow. Moreover, there is also the possibility that the general national subsidies were not high enough to cover the variable cost of harvesting certain fields, and land was thus laid fallow out of economic necessity.

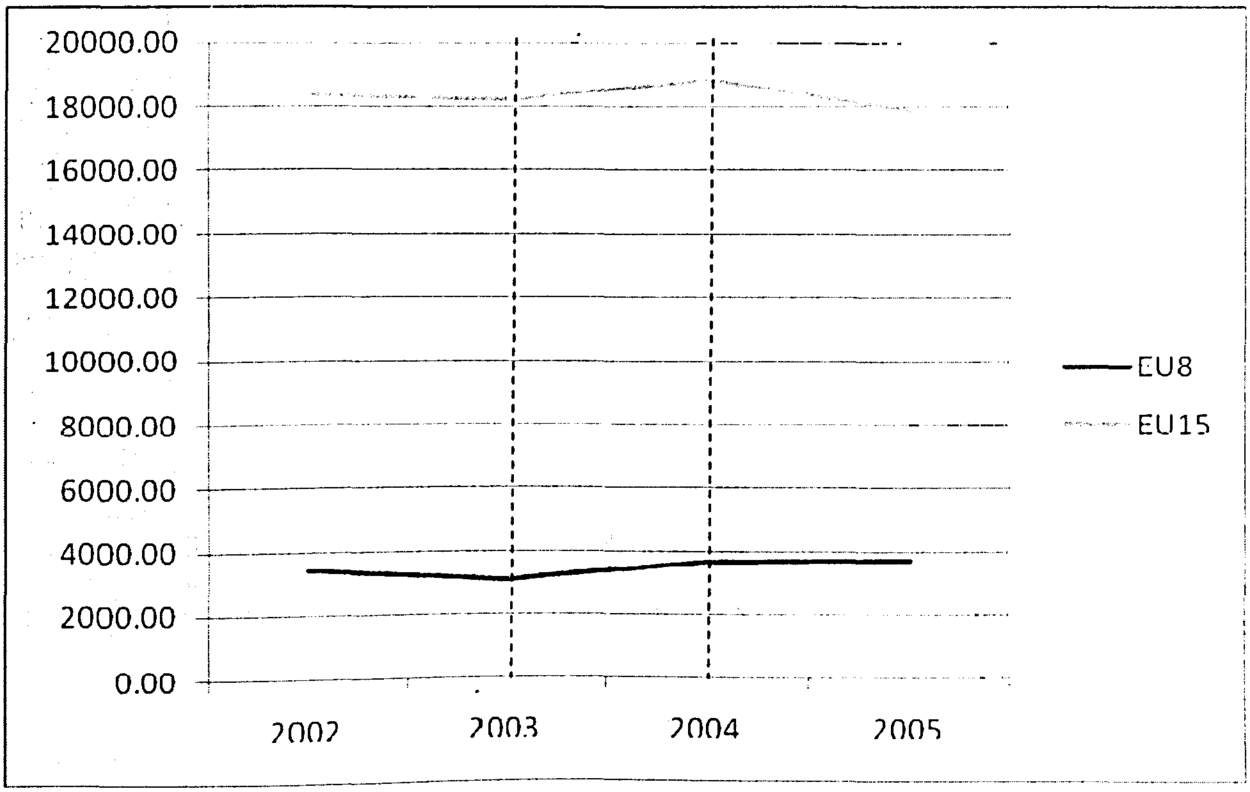
Table 1- Summary Statistics

	EU8				EU15			
	2002-03		2004-05		2002-03		2004-05	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Agricultural Production (mio €)	3713	4142	4230	4799	19320	19089	19281	19173
Fallow Land (ha)	391	718	253	436	472	729	461	714
Organic Crop (% of total)	5.88	7.96	10.82	8.54	15.21	6.87	18.82	12.82%
Irrigable Area (ha)	89332	105551	76564	79889	1057399	1378236	1052457	1375446

Labour (1000 AWU)	464	741	461	773	437	450	413	424
Average Farm Size (ha)	60	129	62	133	9	9	9	9
GDP Per Capita	12000	2874	13707	3849	23045	3279	24564	3535

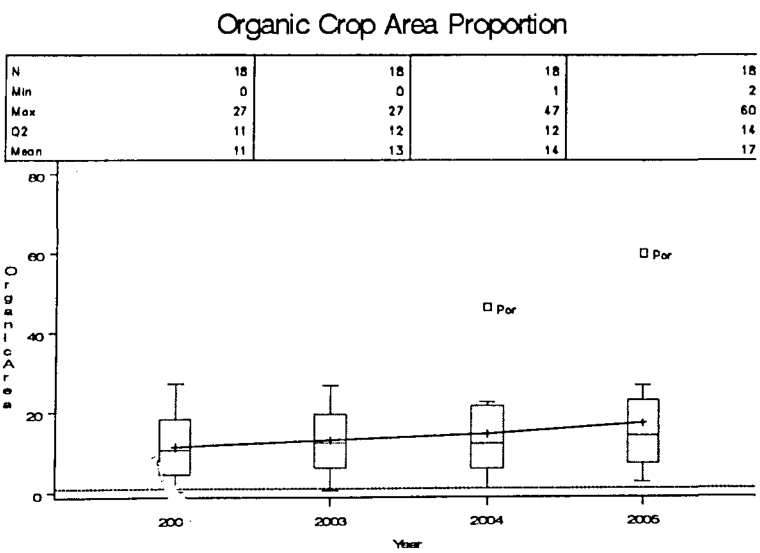
The following graph depicts the agricultural production measured in mio. of Euros received by all farmers in the countries divided into the EU8 group and the EU15 group. As can be seen from the graph, both the treatment and control group have an increase in output following the EU expansion in the range from the year 2003 to the year 2004. While both groups have a similar increase in production in absolute terms – around 600 mio. Euros, the EU8 group has an average of 19% increase while the EU15 group has a 3% increase over the same time span.

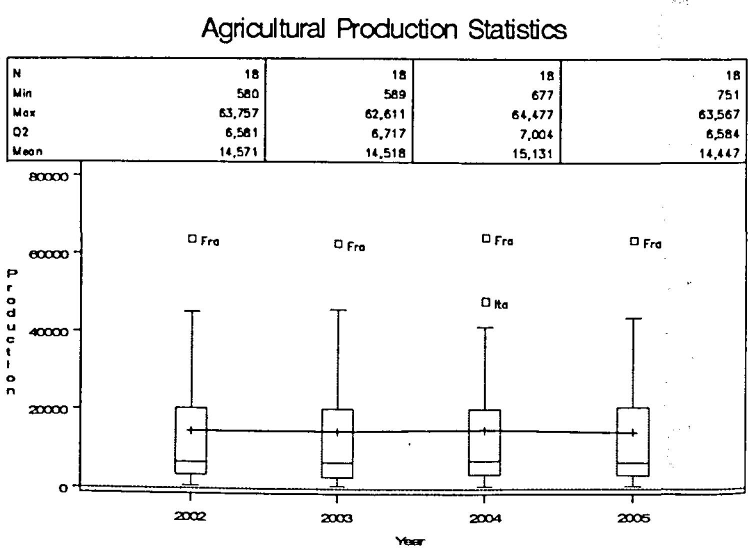
Figure 7



When looking at the variation of data in the different variables box-plots provide a useful way of graphically illustrating the relative concentration of data. We can here see two box plots that for two important variables, agricultural production proportion of organic farming (box-plots for all variables can be found in the Appendix). When looking at the box-plot for agricultural production we can see that the interquartile range from q1-q2 is a lot less pronounced than the other two interquartile ranges. Despite there being outliers for both agricultural production and organic crop area proportion, the data is reasonably varied. When looking at organic crop area proportion specifically we see the opposite, namely that the interquartile range from q3-q4 is truncated, even so looking at the ranges and dataset as a whole there is no reason to reject the results or data because of lack of data dispersion. One variable did not show a lot of variation, namely average farm size which was mostly because there are low numbers associated with the 11 Western European countries and high numbers associated with the EU8 population.

<u>**Figures 8 and 9**</u>





V – Findings

The first regression run was $Ln\ (Y_{it}) = \lambda_0 + \lambda_1\ ln\ amount\ of\ fallow\ land_{it} + \lambda_2 ln\ proportion\ of\ organic\ farming_{it} + \lambda_3 ln\ average\ farm\ size_{it} + \lambda_4\ ln\ GDP\ per\ capita_{it} + \lambda_5\ EU\ variable_{it} + \alpha\ ln\ L_{it}\ \beta\ ln\ K_{it} + \delta_i + e_{it}$ testing the significance magnitude of each independent variable on agricultural production – holding labour and capital constant.

Table 2: Regression Results

Variable	Degrees of Freedom	Parameter Estimate	Standard Error	T Value	P Value
Intercept	1	7.221181	2.3374	3.09	0.0034
Irrigable Area (ha)	1	0.019842	0.0146	1.36	0.1811
Labour (1000 AWU)	1	0.270108	0.1522	1.77	0.0824
Proportion of Organic farming (%)	1	0.036507	0.0129	2.82	0.007
Fallow land (ha)	1	-0.03991	0.0165	-2.42	0.0193
Av. Farm Size (ha)	1	0.389279	0.1054	3.69	0.0006
GDP Per Capita (€)	1	0.00226	0.1703	0.01	0.9895
EU Dummy	1	0.090498	0.0225	4.02	0.0002

As can be seen from the results of the first regression, most of the independent variables were statistically significant. The R squared score was very high, above 99%, but there are two reasons to heed caution in assessing this model based on that statistic. The first of which is that it is a time series analysis, and as such it is not uncommon to have very high r squared scores. The second is that the output included 17 cross sections which were all statistically significant at the 0.01 level. These cross sections capture country specific effects, such as weather, which is not included in any of the independent variables.

Looking specifically at the inputs of Labour and Capital we can see that the parameter estimates have a positive sign like we would expect, but especially Capital measured by Irrigable Area does not seem to be particularly statistically significant. Because we would expect the coefficient to be positive, the p-value should be halved and the variable is thus just significant at the 10% level. However, since Capital is such an important factor in production it is still surprising to see such a relatively high p-value. This raises some concern of the accuracy of the proxy of Irrigable Area to represent Capital as a whole. It also causes some concern of multicollinearity as this could affect the T-stats and thus also the p-values.

The next variable is proportion of organic farming. As can be seen readily from the summary statistics table, the proportion of farming meeting the criteria for organic farming increased in both EU8 and EU15, though it doubled in the EU8 while only marginally increasing in the EU15 group. This variable is statistically significant at the 1% level and interestingly enough has a positive parameter estimate, indicating that higher levels of percentage of farming being organic, holding inputs constant, will result in higher levels of agricultural production. This is very curious, as we would expect this to be a negative coefficient as outlined in the theoretical section. Possible explanation accounting for this statistically significant reverse result could be because the organic farming output market is still relatively new and the incentives made by the CAP is necessary for farmers to enter the market since there are significant barriers to entry and risk associated with price variation in the agricultural output market. However, from these results, it seems clear that that the higher levels of organic farming resulting from entering the EU actually positively affects agricultural production holding inputs constant.

Looking at the fallow land policy variable, the amount of fallow land decreased in both the EU8 area as well as the EU15 area, but it decreased much more drastically in the EU8 area as can be summarized from the summary statistics table. The theoretical section outlined why an increase in fallow land would lower output produced as well as agricultural production (measured in mio. €) if the elasticity of demand is greater than 1. Looking at the regression output the variable is statistically significant at the 5% level and has a negative coefficient. This would mean lower levels of fallow land positively affects agricultural production and by extension that the elasticity of demand for food is perhaps greater than one. Another possible explanation as to why it has a negative coefficient is that there are still significant expenses associated with having the land such as property taxes, maintenances expenses etc. which are not outweighed by the subsidy received by farmers for leaving the land fallow. Regardless of the relative importance of variables explaining the reasoning behind the negative coefficient, since entering the EU countries have reduced the amount of fallow land which increased the (short run) productivity of the agricultural sector of the EU.

The next variable in the regression is the Average Farm Size variable. Upon entering the EU the EU8 group's average farm size increased by 3%, while the average farm size for the EU15 group stayed constant. In theory, we would expect to see an increase in productivity from increased returns to scale since big farms have lower average fixed costs as well as lower average variable costs from bulk buying and specialization. The results seem to substantiate the theoretical work as the variable is statistically significant at the 1% level and has a pretty high magnitude in the positive coefficient. The relative large magnitude reflects in partial the low average farm size in ha for most EU15 countries (the average being 9), so in increase of one hectare on average is relatively large increase.

The GDP per capita variable was anticipated to have a negative coefficient since higher levels of GDP per capita are associated with more stringent regulations on pesticides, water use, fertilizers, plant growth regulators etc. which would reduce productivity. However, it is also possible these same regulations would increase productivity if pesticides are in fact overused and regulations would bring the use of pesticides closer to the optimum use point. The results however indicate that neither of these theories is supported by the data available. The p-value is 99% indicating that there is a 99% chance that the parameter estimate is caused by random variation in the data and not a relationship between GDP per capita and agricultural production.

The last variable examined is the EU dummy variable controlling for whether or not the country is a member of the EU. What this variable captures which is not expressed in any of the other independent variables is the amount of subsidies received by farmers in terms of both direct subsidies, price stabilization subsidies as well as additional mobility of labour etc. This variable is statistically significant at the 1% level and has a positive coefficient indicating that being a member of the EU increases agricultural productivity as production increases while labour and capital are constant.

Included in this regression was a test for constant returns to scale, which demonstrated that there is decreasing returns to scale since the output elasticities do not add up to one. This means that a 20% increase in inputs will result in less than a 20% increase agricultural production, ceteris paribus.

The lack of statistical significance for especially capital does seem to be problematic when looking at the reliability of the results. There is also some concern for multicollinearity, and a test measuring the Variance Inflation Factor for each variable shows how all variables except capital has a VIF under 5 except for capital. Normally VIF scores above 5 should cause some concern with regards to the reliability of t-values while VIF scores above 10 indicate serious danger of unreliable t-values. In an attempt to mitigate some of these potential problems the capital and labour variables were substituted with a variable measuring the capital/labour ratio.

$$Ln\ (Y_{it}) = \lambda_0 + \lambda_1 \ln \text{amount of fallow land}_{it} + \lambda_2 \ln \text{ proportion of organic farming}_{it} + \lambda_3 \ln \text{average farm size}_{it} + \lambda_4 \ln \text{GDP per capita}_{it} + \lambda_5 \text{ EU variable}_{it} + (\alpha \ln L / \beta \ln K) + \delta_i + e_{it}$$

Table 3: Regression Results

Variable	Degrees of Freedom	Parameter Estimate	Standard Error	T Value	P Value
Intercept	1	10.99063	1.4145	7.77	<.0001
Capital/Labour Ratio	1	0.031984	0.0137	2.34	0.0237
Proportion of Organic farming (%)	1	0.043218	0.0129	3.35	0.0016
Fallow land (ha)	1	-0.04521	0.0168	-2.7	0.0096
Av. Farm Size (ha)	1	0.3091	0.1004	3.08	0.0034
GDP Per Capita (€)	1	-0.19099	0.1443	-1.32	0.1918
EU Dummy	1	0.092099	0.0232	3.97	0.0002

Overall these results verify the findings from the first regression, all the variables which were found statistically significant were also statistically significant in this model with the same signs for the parameter estimates. Similarly, GDP per capita is also statistically insignificant even though the p-value is significantly lower. In this model all variables had VIF scores below 5 indicating the significance levels of the previous model were not too disturbed by multicollinearity. Of course, it should be noted that the capital-labour ratio is an imperfect substitute in this context since this ratio can stay constant while both inputs increase as long as they increase at the same rate. Thus, when looking at these variables it is not certain that the levels of input are held constant, but since both models give very similar results it seems reasonable to conclude both that the multicollinearity in the first model is not an issue and that the capital-labour ratio is a decent substitute for the variables individually. Additionally, both models were tested for heteroskedasticity and the null hypothesis of homoskedasticity was accepted.

VI – Conclusion

In conclusion it can be determined that the population of Central and Eastern European countries joining the EU in 2004 benefitted not only in terms of market access and political security, but also in terms a higher level of agricultural productivity combined with a higher level of subsidies. There are three major components to the indirect effects of the Common Agricultural Policy which all caused this: the fallow land policy, the incentive to do organic farming, and the increased farm size. When discussing the benefit of the fallow land policy it should be noted this would reduce agricultural productivity for any country joining the EU which doesn't already have fallow land subsidy greater than that of the CAP. With regards to organic farming, higher proportions of organic farming cause higher levels of agricultural productivity because the prices in the organic output market are still so high that the higher revenues received by suppliers still outweighs the reduction in absolute crop yield. One of the potential reasons why the transition into the organic farming market has not equilibrated in the short run is because of relatively high barriers to entry and price vagaries in the organic output market. The third variable is the Euro per ha policy which favours larger farmers who are more efficient than small scale farmers because of lower average fixed costs as well as lower average variable costs. Outside of these direct effects, being a member of the EU also increases agricultural production while controlling for labour and capital inputs, primarily because of the direct subsidies promoting increasing returns to scale. In terms of GDP per capita this variable was not discovered to have a great impact, but as indicated earlier the proposed relationship of the Environmental Kuznets Curve would be easier to spot over a long term time series dataset. It should also be noted here that while the CAP does seem to increase productivity through the mechanisms elaborated, this comes at a hefty price tag of over € 40 bn. Whether the CAP itself is justified is a question which lies outside the realm of this study, but some of the findings here may give clues to how such a question can be answered in looking at some of the specific components of the CAP.

Future investigation of the relationship between the CAP and agricultural productivity could with benefit include organic beef and pork production in addition to just organic crop production. Moreover, a longer time range than the four years used in this study could establish some of the patterns exhibited here more clearly. Furthermore, a future study would also be able to include Bulgaria, Romania, and perhaps other countries joining the EU as separate treatment groups. Perhaps this study would then also be able to effectively support or reject the validity of the application of the Environmental Kuznets Curve to pesticide use and environmental regulations in the agricultural sector. Further studies could also include climatic variables such as temperature, precipitation, wind etc. However, methodological obstacles such as the non-linear relationship of many climate variables as well as the geographic size and climatic distributions in countries remain.

Finally, some cautionary notes should be given regarding the findings in this study. First of all the data used was, as described in section IV, interpolated. This always involves dangers for the validity of the results due to data inaccuracy. The dataset was also rather small in terms of years covered, which means overarching patterns may not be clearly deciphered in this study. Moreover, the capital proxy was imperfect; perhaps a weighted capital variable combining all farm instruments with irrigation materials could depict the capital used more accurately.

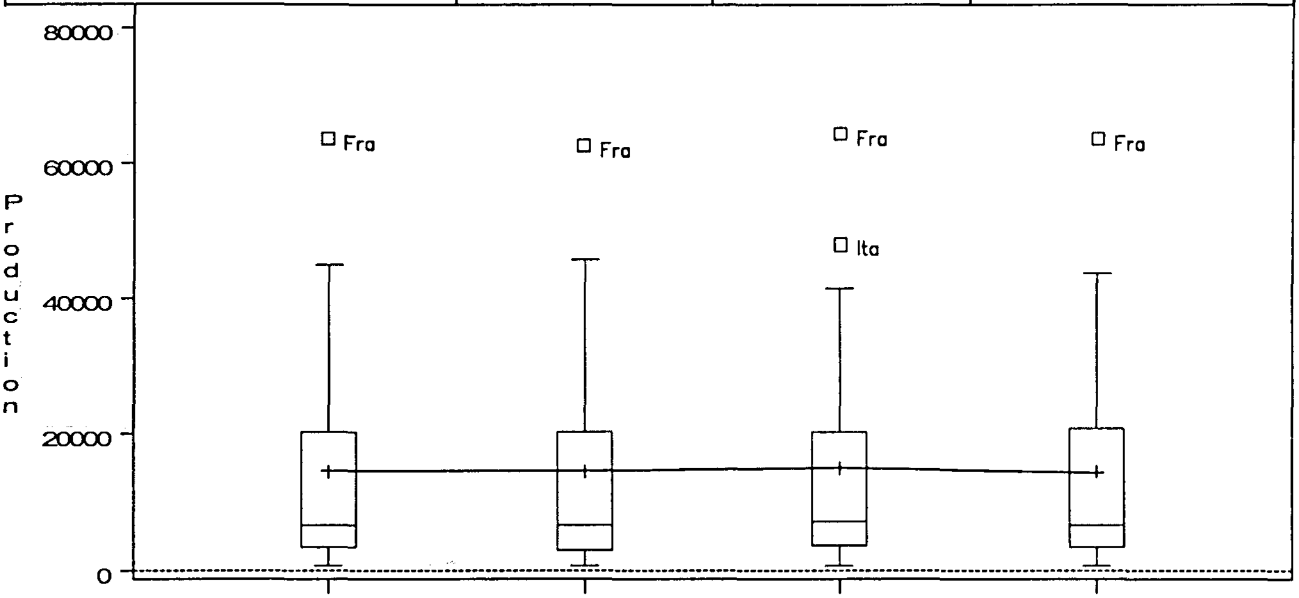
I pledge to have neither given nor received unauthorized assistance during the completion of this work:

Flemming Schneider Rhode

Appendix

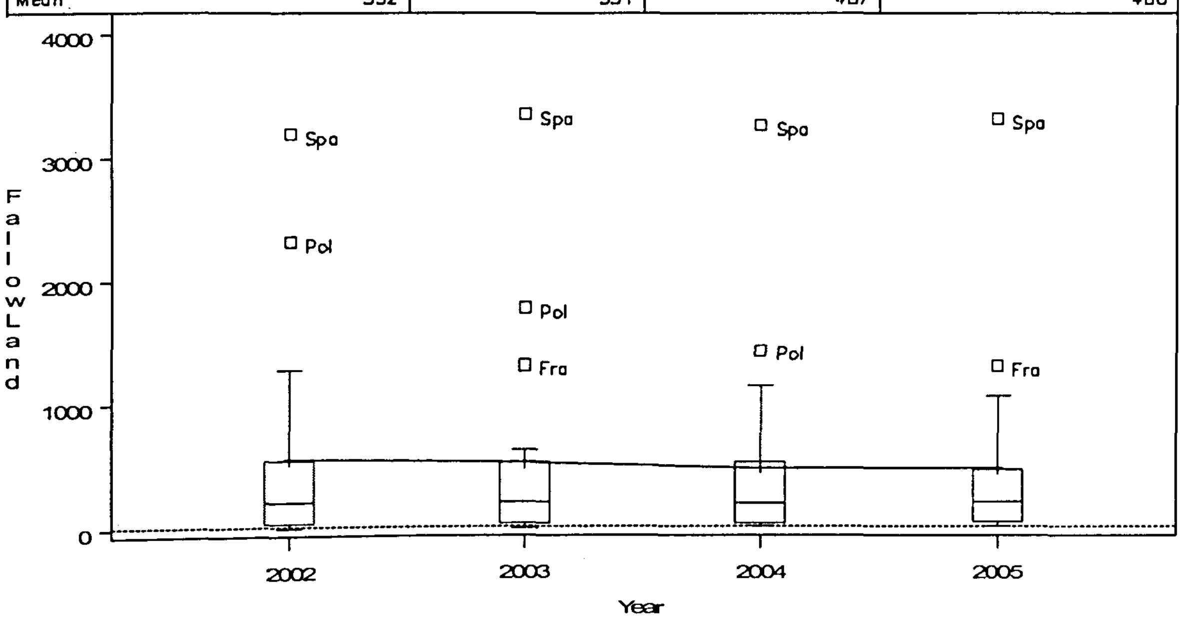
Agricultural Production Statistics

N	18	18	18	18
Min	580	589	677	751
Max	63,757	62,611	64,477	63,567
Q2	6,581	6,717	7,004	6,584
Mean	14,571	14,518	15,131	14,447



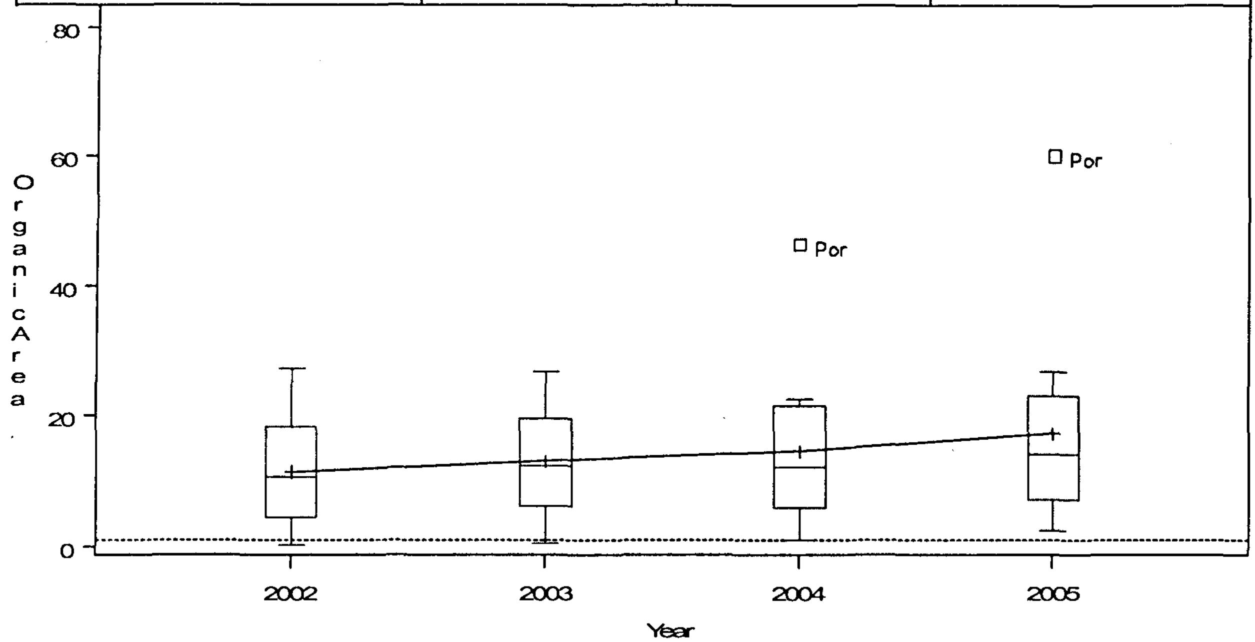
Fallow Land Summary Statistics

N	18	18	18	18
Min	1	1	1	2
Max	3,195	3,353	3,273	3,319
Q2	207	213	191	205
Mean	552	531	487	480



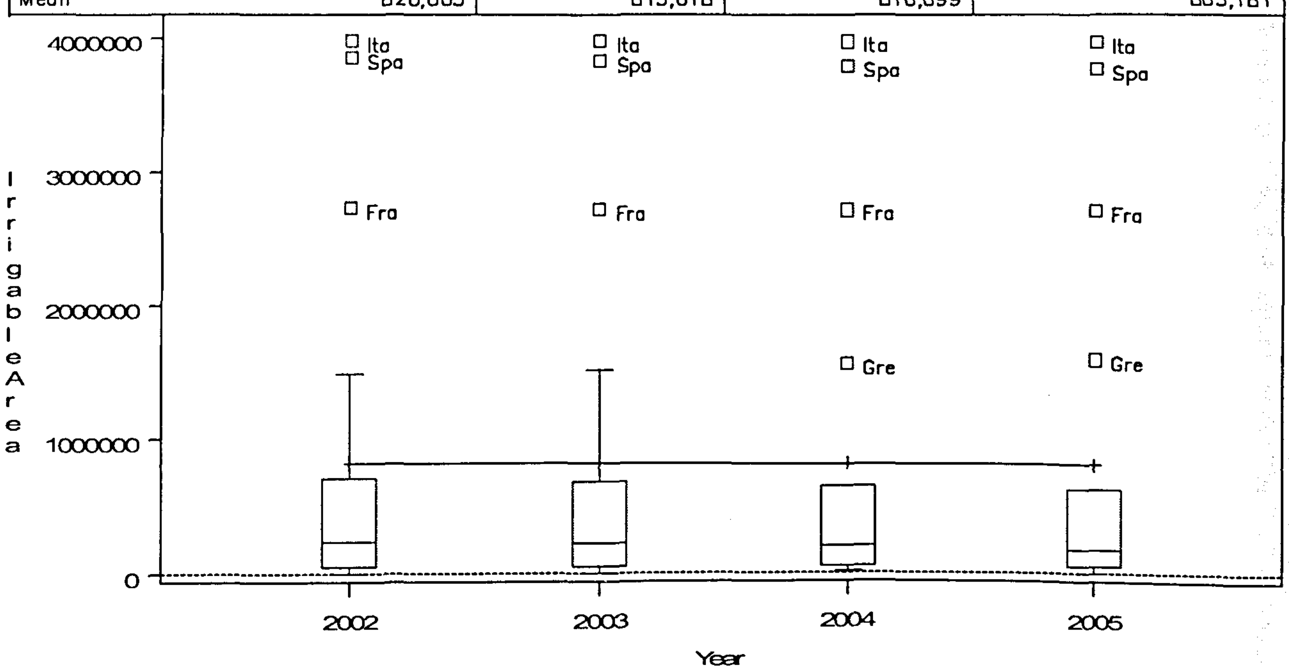
Organic Crop Area Proportion

	2002	2003	2004	2005
N	18	18	18	18
Min	0	0	1	2
Max	27	27	47	60
Q2	11	12	12	14
Mean	11	13	14	17



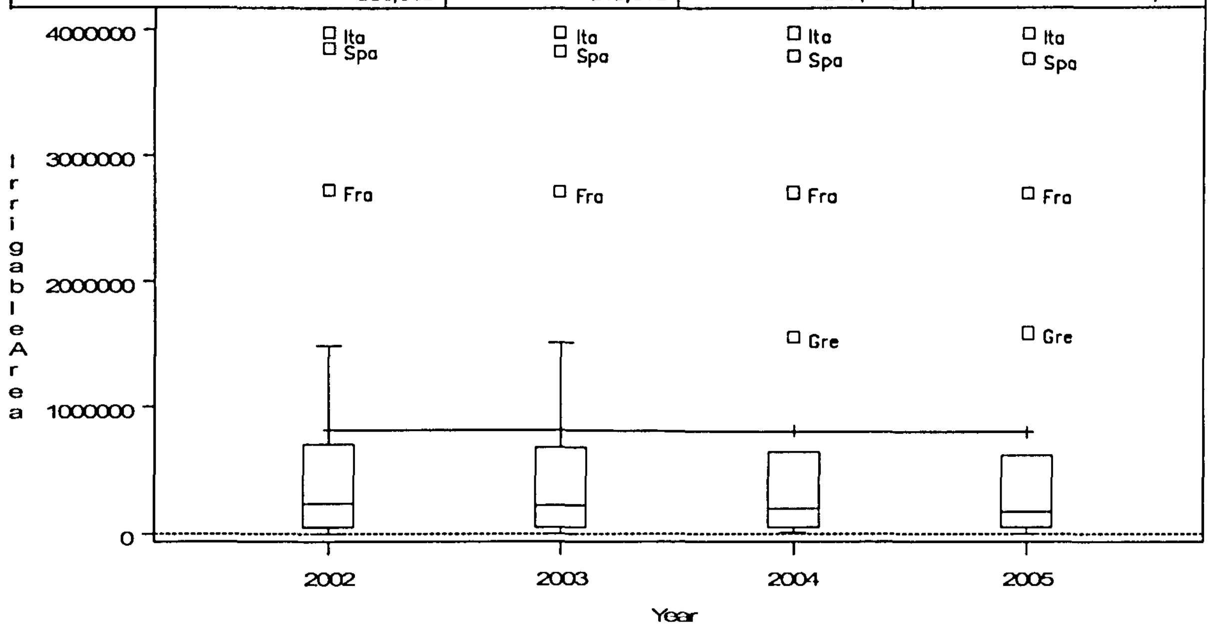
Irrigable Area Statistics

	2002	2003	2004	2005
N	18	18	18	18
Min	124	740	970	790
Max	3,979,480	3,977,210	3,974,940	3,972,670
Q2	231,370	219,000	196,033	173,570
Mean	820,005	815,018	810,099	805,181



Labor Force Statistics

	2002	2003	2004	2005
N	18	18	18	18
Min	124	740	970	790
Max	3,979,480	3,977,210	3,974,940	3,972,670
Q2	231,370	219,000	196,033	173,570
Mean	820,005	815,018	810,099	805,181



Farm Size Statistics

	2002	2003	2004	2005
N	18	18	18	18
Min	1	1	1	1
Max	375	353	359	390
Q2	6	6	6	6
Mean	30	29	29	31