Analysing the Effects of Subsidies on Eastern European Agriculture

by

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I certify that the work in this thesis entitled "Analysing the effects of subsidies on Eastern European Agriculture" has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree to any other university or institution other than Macquarie University.

I also certify that this thesis is an original piece of research and it has been written by me. Any help and assistance that I have received in my research work and the preparation of the thesis itself have been appropriately acknowledged.

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Abstract

In light of recent reforms to the European Unions (EU) Common Agricultural Policy (CAP), this study investigates the effect agricultural subsidies have had on seven Eastern European nations total factor productivity (TFP).[1] In particular, the effect decoupling reform has had on the TFP of these nations. This reform meant farmers would receive an income support payment, which would be based on particular environmental, animal welfare and food safety standards, rather than receiving subsidies based on the type of agricultural product they produced.

This thesis utilises the Rizov et al. (2013) methodology, which was modified from Olley and Pakes (1996) to model unobserved TFP and to directly consider the effects of subsidies in the estimation equation. Using panel data from the Farm Accountancy Data Network (FADN), the effect decoupled subsidies have had on Eastern European agricultural is observed. The results are consistent with previous literature (Goodwin and Mishra, 2006; Rizov et al., 2013; Mary, 2013) that decoupling reform has more positive effects on TFP, when compared to the full sample, which includes coupled subsidies.

A spearman rank correlation coefficient is used to determine whether subsidies

[1]Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland and Slovenia.

and TFP can be described as a monotonic function. The spearman correlation results indicate that decoupling reform has had positive, statistically significant effects (to the 10% level) on four of the seven nations respective TFP index, and on two nations TFP growth.[2] This is consistent with the results from Čechura (2012), Rizov et al. (2013), Mary (2013), and indicates that decoupling reform may have less distortionary impacts on farm behaviour, leading to increased productivity.

[2] For TFP index these nations were Estonia, Hungary, Poland, and Slovenia. For TFP growth these nations were Estonia and Hungary.

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Chapter 1

Introduction

European Union (EU) economics can be described as an intricate financial, political and social structure, which utilises an annual budget of approximately 150 billion euros. Of this total budget around 60 billion euros (40%) is given to the EU Common Agricultural Policy (CAP) (European Commission, 2013c). This study analyses the effects of CAP subsidies on the TFP of Eastern European nations. In particular, the impact decoupling reform had on these nations. A brief historical background of the CAP will be provided to give context to this research question.

The CAP was developed during the early years of the European Economic Community (EEC). Its main goal was to create a mutual policy amongst the members of the EEC, which sought to provide affordable food for European citizens, as well as maintaining a fair standard of living for farmers (European Commission, 2010b). Ruano (2003) explains that the CAP was created in the wake of post-war fears of food shortage and Europe wanting to avoid a reliance of food supply outside of the continent. On the other hand, the CAP specifically targeted the European agricultural sector, as it was seen as backward compared to other nations around the world, in particular the United States, and that an injection of funds would spur modernisation within this sector of Europes economy (European Commission, 2010b; European Commission, 2013b).

Jovanović (2005) outlines at the creation of the CAP in 1962 the five primary objectives of the policy were:

1. To increase agricultural productivity by promoting technical progress and by ensuring the reasonable development of agricultural production;
2. To ensure a fair standard of living for those in the agricultural community, with a focus on the growth of farmers income;
3. To stabilise agricultural markets;
4. To guarantee the availability of agricultural goods;
5. And that these agricultural goods were available at reasonable prices.

The CAP proved to be successful, as production amongst EEC members flourished. This eventually led to large surpluses of grains by EEC farmers in the 1970s and 1980s, resulting in world prices plummeting, negatively affecting the CAP and European farmers. In the 1990s the CAP was reworked, which led to the creation of a two pillar system.[3] The 'first pillar' referred to direct payments and market measures to support EU farmers, whereas the 'second pillar' involved rural development policy,

[3] In 1993 the EEC officially became the EU.

which aimed to provide a fair standard of living for the EU agricultural community as well preserving the environment (European Commission, 2010b). Until the 1990s farmers were mainly receiving payments based on the type of agricultural good they produced. From the early 2000s the CAP began to shift towards the second pillar. This meant that funds began to target the economic, social and cultural development of rural Europe. Farmers were encouraged to become entrepreneurs, which aimed to spur the creation of jobs, as well as the renovation of villages and rural infrastructure (Jovanović, 2005).

In 2003 the CAP underwent a significant change, as payments to farmers were decoupled. This meant that farmers no longer received subsidies based on the type of agricultural product they produced. Rather they would receive an income support payment, which would be based off particular environmental, animal welfare and food safety standards (European Commission, 2010b).

The period from 2004 became known as the Eastern enlargement. From this period, thirteen European nations have joined the EU.[4] This has resulted in an additional seven million farmers, which more than doubled the total amount of people employed in the agricultural sector in the EU prior to this enlargement. Jovanović (2005) explains that this expansion and the resulting CAP funds given to Eastern nations had the potential to give a strong boost to EU agricultural production. However, there remained large imbalances in the distribution of these funds between nations.

A combination of the EU expansion, and escalating political tensions regard-

[4]Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia joined in 2004, Bulgaria and Romania joined in 2007 and Croatia joined in 2013.

ing the distribution of funds spurred further CAP policy changes, resulting in the European Commission prompting an inquiry for a 'new' CAP, which would focus on the budgetary framework from the years 2014 to 2020 (European Commission, 2013a; European Commission, 2013b). This new CAP places a greater focus on the redistribution of funds across all EU member nations, as well as increased food security, supporting farming communities so that they maintain (or increase) the quality, value and diversity of the agricultural products they produce, as well as creating more rural employment opportunities.[5]

1.1 Motivation and Contribution

This study is motivated by the fact that subsidy payments are integral to farms in Europe. The European Commission (2010b) claims that without subsidy payments up to 75% of EU farms would not be able to cover their on-site costs, and that the share of profitable farms would fall to below 20%. It is clear that EU farmers have a large dependence on CAP subsidy payments. Furthermore the 2014 CAP reforms mean that current subsidy payments being made to EU farmers will also change. Some literature suggests that subsidies have had mixed effects on TFP.[6] However, the studies with account for decoupling reform imply that they have had positive effects on a nations productivity (Čechura, 2012; Rizov et al., 2013; Mary, 2013). It would be interesting to see the impact subsidies have had on Eastern

[5]The EU claims that analyses by the FAO show that global food demand may increase as much as 70% by 2050 (European Commission, 2010a).

[6]Lagerkvist (2005), Ciaian et al. (2012), Tocco et al. (2013), Pechrová and Vlašicová (2013) showed negative effects of subsidies, whereas Goodwin and Mishra (2006), Brümmer et al. (2002), Latruffe et al. (2011) showed positive effects of subsidies.

European nations, before the new CAP reforms begin to be phased in over the coming years. This study is also motivated by Rizov et al. (2013) who analysed TFP on fifteen Western European nations. The contribution of this study to the agriculture literature is that the Rizov et al. (2013) methodology will be applied to seven Eastern European nations using panel market level data from the years 2004 to 2011. This methodology has not yet been applied to Eastern European agriculture. This study will also analyse the effects the 2003 decoupling reform has had on the TFP of these nations.[7]

The structure of the thesis will now be outlined. Chapter 2 provides a review of how subsidies affect agricultural productivity, developments in production function estimation, as well empirical papers relating to subsidies and TFP. Chapter 3 outlines the Rizov et al. (2013) behavioural framework and production function estimation equation. Following this, robustness checks will be explained, followed by a description of the data, variables, and how TFP is calculated. Chapter 4 provides the results of the production function and TFP estimation, followed by a discussion of the results. Finally, Chapter 5 provides some concluding comments on the study.

[7]According to the European Union (2003) and Agripolicy (2010), the implementation of decoupling reform was gradual. Hence decoupled subsidies were in full effect by 2006 for Czech Republic, Estonia, Hungary, Latvia, Lithuania and Poland, and 2007 for Slovenia.

Chapter 2

Literature Review

It is unmistakable that global food production has increased significantly over the past century. What is even more impressive is that this production has not only kept up, but surpassed the global population surge in the latter half of the twentieth century (Food and Agricultural Organisation, 2013). It is these types of phenomena that incite a curiosity in researchers to ask questions why this is the case? More so, what particular factors lead to such an increase in agricultural productivity? Evenson et al. (1975) points to the intensification of agricultural production practices, ranging from investment in more efficient irrigation systems, to the increased use of more effective inputs such as fertilisers, and advances in farming machinery, which led to the harvesting of crops in a more sufficient period of time. Such increases in productivity have led researchers to develop a variety of models to try and explain these economic happenings.

This chapter will be organised as follows. Section 2.1 identifies that subsidies can affect agricultural productivity in one of four ways: by changing relative input/output prices and impacting input usage; through farm growth and exit; by means of income effects and changes in investment decisions; and through subsidies being used as a means of risk mitigation. Section 2.2 will discuss more complex production function estimations and how they accounted for biases and inconsistencies of previous analyses. Section 2.3 presents various empirical papers concerning subsidies and their effects on TFP (Section 2.3.1). Finally, sections 2.3.2 and 2.3.3 will discuss specific studies relating to technical efficiency, and farmers credit constraints.

2.1 Impacts of Subsidies on Agriculture

One ways in which subsidies can affect agricultural productivity is explained by Huffman (1977), who claims that changes in relative input/output prices can significantly impact input usage. The study found that with large decreases in the prices of nitrogen fertilizer from 1950 to 1964 in US agriculture, and developments of new hybrid corn varieties during this same period of time, created disequilibrium in the usage of nitrogen.[8] The author estimated optimal nitrogen application, and found that nitrogen use during this period increased by more than 2.5 times. An 'adjustment function' was established to see how the overuse of this input could be mitigated. It discovered that through investment in education and farming practices, the human capital variables could help increase the allocative efficiency of farmers, and consequently help increase yearly yield. This paper highlights the distortionary impacts

[8] This decrease in price was due to farmers shifting to fertilisers with a higher concentration of nitrogen, as well as technical change in the fertiliser industry, which could have been due to government subsidisation.

that input prices can have on input usage.

Similarly, the Laha and Kuri (2011) paper found that the limited resources available to West Bengali farmers in India, as well as fluctuating fertiliser prices had significant effects on their input use. Using Data Envelopment Analysis (DEA), the authors found that although farmers allocated their resources quite well, there was a gap of sixteen percent to improve the distribution of these resources. Education (based on years of schooling) was found to have increased positive effects on resource allocation, and that larger farms tend to be more efficient in their input allocation compared to smaller farms. It is argued that if greater financial assistance is provided to smaller farmers, and education and cheaper fertilisers is made more accessible to these farmers, then this could potentially increase allocative efficiency, and have a more positive impact on input usage on the productivity of these farms.

Secondly, subsidies can also affect farm growth and exit, which may impact a nations productivity. Sarris et al. (1999) paper looks at the growth of small scale and corporate farms in Central and Eastern Europe. The authors claim that the increased purchasing level of capital and inputs (such as fertilisers) of corporate farms is unsustainable, and that their future survivability will be largely dependent on subsidies. In fact, the authors argue that small scale farms have a largely unexploited production potential. They put forward that small scale farms can create a commercial ‘middle class, which can increase the size and productivity of these farms. There are many hindrances to this theoretical consideration, non-more so than access to technology, as well as allocative efficiency. In fact, the authors present a compelling argument from the agricultural production literature that family farms are far more efficient in their allocation of resources compared to larger farms (refer to pp.316-219 of Sarris et al., 1999). However, they note that the transition from small scale to medium sized farms has its problems. One such problem are that imperfections in agricultural land markets have led to large amounts of leasing and renting, implying that those renting land would be unwilling to make long term investments on that land. Also access to sufficient amounts of start-up and working capital would be difficult to obtain. The concluding remarks imply that greater access of technology and funds to small farms could potentially significantly increase agricultural productivity in Central and Eastern Europe.

Ciaian and Swinnen (2006) argue the CAP decoupling reform, as well the Eastern enlargement of the EU significantly impacts the EU land market. They claim-large scale corporate farms distort land prices, which is partially due to new reforms implemented by the EU which significantly increase transaction costs, and consequently push small farmers out of business. A theoretical model of land markets with transaction costs and imperfect completion was established and various scenarios were considered such as the impact of CAP payments before and after decoupling, unequal access to subsidies, and farm restructuring. It was found that if there is competition from individual farms, the domination of the land market by corporate farms and transaction costs will not affect the proposition that CAP payments will benefit corporate farms instead of farmers. However, if subsidies are distributed unequally, farmers with small amounts of land will be net losers even if they receive subsidy payments, and large corporate farms will benefit from this. This effectively means that small farms will exit, as it will be unprofitable to stay on their land. The authors conclude that small farmers may ultimately pay a greater price compared to corporate farms, as CAP decoupling reform may likely result in land rents falling, and corporate farms becoming larger, though further analysis will have to be done to see if this claim is true.

Thirdly, changes in policies are a vital factor that can affect a farmers income, and consequently a their investment decisions. Alston and James (2002) create a theoretical model, to observe the welfare effects of the implementation of a subsidy policy in a competitive agricultural market using a surplus transformation curve (STC).[9] In order to reduce the STC to two dimensions, consumers and tax payers were treated as one group, and producers (or farmers) the other group. It was found that the STC for both groups were concave, and that producers can always be made better off at the expense of consumers and tax payers, that is, producer welfare always increases as the subsidy is increased. The authors go on to say that investment decisions based on agricultural policy changes are largely dependent on the amount of risk producers are willing to take. They claim that risk averse producers may respond methodically to policies that change prices variability, the logic being that they are willing to produce at a guaranteed price, hence securely knowing what income they will earn, though no further analysis is done in regards to this claim.

On the other hand, Lagerkvist (2005) analysed the change in investment decisions when farmers income is threatened. He conducted a study of 617 farms in Sweden, which sought to analyse how CAP reform uncertainty may affect agricultural invest-

[9]For further information regarding the STC refer to Alston and James (2002) pp.1695. It essentially evaluates the combinations of producer, consumer, and taxpayer welfare associated with setting different subsidy settings.

ment incentives. The theoretical study suggests that if there is uncertainty within agricultural policy reform, this may potentially inhibit investment, and that potential shifts in agricultural policy may create 'noise' in terms of subsidies given to farmers. The author suggests that in order to alleviate this, policy makers should make information readily available to farmers in regards to proposed reforms, in particular those which concern payment levels, as this could significantly affect the investment decisions of the farmers.

Finally, subsidies can also be used as an insurance effect on risk mitigation, which could impact a farms production. Rizov et al. (2013) refers to this as a soft budget constraint. In the context of agricultural production, it essentially means productive efforts are not vital, as the subsidy provider can act as an insurer taking over moral hazard, whilst the insured (those who receive the subsidies) are less careful in protecting their wealth. Raiser (1994) re-emphasise this by incorporating the idea of contract violations into the concept of soft budget constraints. The author puts forward that a budget constraint can be softened if buyers do not pay for the goods they buy, debtors do not honour their debt contracts, or producers do not cover their costs out of their revenue. Such an example is similar to Petrick (2004a), where Polish banks would only give credit to farmers who were deemed reliable.

Although this study does not specifically relate subsidies to the agricultural sector, Raiser (1994) paper investigates the issues of the costs and sustainability of economic reforms in relation to the economic transformation of Central and Eastern Europe. Such economic reforms relate to economic growth and investment decisions, which could entail the agricultural sector. The author tests for the effects of budget softness on inflation, economic growth, as well as reform sustainability. The cross-country analysis takes into account 32 developing nations, which consist of EECs from the period 1978 to 1988. The results showed that stabilisation of inflation may be difficult if soft budget constraints are present. The author suggests that solving distortions both in financial markets and in foreign trade are crucial to achieving stable inflation. In regards to economic growth, it is reduced if there is budget softness. This is in the case of the short run, hence expansionary fiscal policies hurts growth the most. The author goes on to say that in regards to reform sustainability, instruments that ensure contract enforcement and monitor the economic behaviour of agents are very important in the success of policy. Using the example of Poland, the author puts forward that the reform of increasing the number of private enterprises within the country has led to an increase in production, which has given Poland sustained growth for an extended amount of years.

The following section will explain more complex production function estimations, and how they accounted for biases in previous analyses.

2.2 Developments in Production Functions

A breakthrough study in estimating production functions was by Olley and Pakes (1996). They echoed other authors claims, such as Heady and Dillon (1961), Griliches (1963) and Griliches and Mairesse (1995) that regression analyses such as Ordinary Least Squares (OLS) led to inconsistent and biased results of coefficient estimates. Their analysis of productivity in the telecommunications equipment industry addressed two interrelated problems. The first was the selection problem which was caused by unobserved productivity and a firm shutting down operation. What this problem tried to solve was how to take into account and estimate the entry and exit of firms into the production function estimation. The second interrelated issue was the simultaneity problem, which was caused by endogeneity between productivity and inputs such as capital, k_{jt}, and labour, l_{jt}, where j is a firm at time t. The following will be a brief explanation of how these endogeneity problems were solved.[10] Ackerberg et al. (2006) explain that endogeneity of k_{jt} can be solved by assuming that unobserved productivity, ω_{jt}, evolves according to the first order Markov process $p(\omega_{jt+1}|I_{jt}) = p(\omega_{jt+1}|\omega_{jt})$, where I_{jt} is the firms information at time t. From this equation, current and past realisation of productivity are assumed to be part of I_{jt}. Capital is assumed to be a dynamic input subject to investment. What Olley and Pakes (1996) did is assume that k_{jt} at time t was determined at $t-1$, and thus in I_{jt-1}. This implies that capital must be uncorrelated with unobserved productivity. Intuitively this makes sense, as it may take a full time period, t, for new capital to be ordered, delivered and installed (Ackerberg et al. (2006)).

The endogeneity of labour, l_{jt} is more difficult to solve as it is considered a non-dynamic input. As this will be derived in Chapter 3 only a brief summary will be given here. Essentially, the labour coefficient is estimated through an investment demand function $i_{jt} = i_t(\omega_{jt}, k_{jt})$, which is assumed to be strictly monotonic. As a result, the investment demand function can be inverted to produce $\omega_{jt} = f^{-1}(i_{jt}, k_{jt})$, which is then replaced into the original estimation equation. Ackerberg et al. (2006)

[10] Chapter 3 explains an altered Olley and Pakes (1996) approach, as it incorporates subsidies into the model.

use the following production function equation as an example: $y_{jt} = \beta_k k_{jt} + \beta_l l_{jt} + \omega_{jt} + \varepsilon_{jt}$, where ϵ_{jt} is the error term. From here the 'first stage' equation can be estimated using OLS, which gives the coefficient of the labour term.

Olley and Pakes (1996) (OP) compared their estimation procedure to OLS and Fixed Effects within (FE) regression, and found that estimates of capital for the OP method were less than half compared to OLS and FE, and that the labour coefficient of OLS and FE was 15% larger compared to OP. They claim this demonstrates the large biases when it came to estimating production functions using OLS or FE. Also, their results showed that between the years 1974 to 1987, the telecommunications industry had overall positive growth. This positive growth most likely came from the reallocation of capital to more productive factories, that is, the entry and exit of firms, which would have not been picked up by other estimation methods. However, there was also negative growth for two years. The authors explain this was due to restructuring costs caused by the introduction of reforms in the telecommunications industry.

Levinsohn and Petrin (2003) critiqued the OP approach by claiming that the investment demand function was not ideal in firm level production function estimation. They argue that in microeconomic data sets, many firms have zero investment, which is in direct violation of the OP monotonicity assumption. The OP method can deal with zero investment by discarding that data, which Ackerberg et al. (2006) claim would be an efficiency loss. Levinsohn and Petrin (2003) instead suggest introducing an intermediate input demand function, which is usually represented by the materials variable in many studies (Levinsohn and Petrin, 2003; Ackerberg et al., 2006;

Petrick and Kloss, 2013).[11] The reasoning behind this choice is that the materials variable is far less prone to zeros compared to investment, which will result in the strict monotonicity assumption holding. The authors prove that the intermediate inputs demand function is a reliable proxy for the productivity shock in a production function.

Another new approach to estimating production functions was done by Blundell and Bond (2000). They claimed that standard Generalised Methods of Moment (GMM) estimators produced poor results. Such approaches eliminated unobserved effects on the firm by taking first differences of the dependant variables. This could result in large biases and inconsistencies in the data. Blundell and Bond (2000) addressed this by creating an extended GMM estimator. This method utilised the lagged inputs levels (such as labour and materials) at two periods as instruments for the first-differenced equation. In addition to this, the first lagged differences were used as instruments for the equation in levels. Not only did the authors show that this extended GMM had more accurate results in their analysis of US manufacturing firms, but that the lagged instruments at two periods were useful in addressing endogeneity (for instance, between capital and productivity) at levels, without overestimating the model. Such dynamic production functions allow to control for input endogeneity and for individual-specific unobserved heterogeneity (which is not the case in OP and LP), but assume that the unobserved productivity is time invariant. Another method of solving input endogeneity is presented by Chambers and Just (1989) and Lacroix and Thomas (2011), which involves the simultaneous estimation

[11] More information regarding the derivation of the intermediate inputs demand function will be given in Chapter 3, Section 3.3.1.

of the production function, along with the input demands equation that are derived from a farms profit maximisation equation. In such an setting, input demand is written as a function of prices and the input demand equations are estimated in a system including the production function. Such a method can be seen as an instrumental variables approach where input and output prices are used as instruments, which can help solve the endogeneity problem when estimating agricultural production functions.

Petrick and Kloss (2013) compared the above mentioned methodologies Olley and Pakes (1996), hereafter OP; Blundell and Bond (2000) hereafter BB; as well as Levinsohn and Petrin (2003), hereafter LP; alongside OLS and FE in relation to agricultural data.

The data set covered 2001 to 2008 for Denmark, France, East Germany, West Germany, Italy and the United Kingdom, and 2004 to 2008 for Poland and Slovakia. The results revealed that OLS and FE coefficients were biased. OLS had overestimated coefficients for capital compared to OP, whereas the LP methodology had more plausible statistically significant results. On the other hand the BB estimator proved it could be implemented with sufficiently long panel data, but it did not always produce satisfactory results.

The LP approach was also used to calculate shadow prices on working capital. The output showed that the return on working capital is often above typical market interest rates for capital. Such a result implies that there is a credit rationing problem within agricultural finance markets within the EU. This means that if policy is shifted to improving the availability of working capital, this could potentially increase agricultural productivity. The results appear to be consistent with that of Jorgenson and Griliches (1967), Griliches and Mairesse (1995), Olley and Pakes (1996) in that the OLS estimates are biased. Petrick and Kloss (2013) also note the OP and LP appears to suitable for agricultural data, with both estimations of the production functions producing plausible, statistically significant results, which address issues found in OLS and FE, such as endogeneity between unobserved productivity and inputs.

2.3 Empirical Studies

The following three sections will discuss selected studies to do with agricultural subsidies and the effects they have had on production on productivity. Section 2.3.1 presents various subsidy studies and their effects on productivity. Sections 2.3.2 and 2.3.3 introduce technical efficiency and farmer credit constraint studies, as it was identified by Rizov et al. (2013) that subsidies significantly affects these two factors.

2.3.1 Subsidy and Productivity Studies

Ridier and Jacquet (2002) analysed the impact of Common Agricultural Policy (CAP) decoupled payments of producers decisions. In particular they accounted for price uncertainty and risk aversion. The theoretical model was applied to cattle farms in two French regions. Note the the analysis relied on simulations, though surveys were taken from region specific farms in order to calibrate the model. The results found that decoupled farm subsidies may affect certain areas more than others. Their results indicate that production increases substantially when payments are coupled to production. However, when subsidies are decoupled, the wealth of farmers increases, and their risk aversion decreases. The authors conclude that decoupled subsidies are a weaker incentive to farm enlargement than coupled payments. However, the inclusion of incentives for environmental care and food safety standards could lead to potentially beneficial outcomes on productivity.

Goodwin and Mishra (2006) analysed the extent to which the United States (US) farm subsidy program brought about distortions in production. The study was centred on the Corn Belt, which is a major source of agricultural production in the US. The authors note that the data collected from the years 1998 to 2001 by the National Agricultural Statistics Service (NASS) had one major limitation, which was the lack of repeated sampling on individual farms. This means that it was impossible to observe the same farm from year to year, hence the study relies on cross-sectional variability.

They found that direct payments to farmers could lead to increased production within the Corn Belt. The authors point out that the acreage effects are actually quite small, implying that if direct payments were to increase substantially for these farms, the amount of land used to sow crops would not increase all that much. The authors re-emphasise the limitations of the data, and their inability to observe one farm over time. However, Goodwin and Mishra (2005) revisit this question with an updated data set from the NASS. This allowed the authors to condition recent acreage allocation on a farms historical base acreage. Little evidence to support producers using subsidies to rent or buy additional land was found. Furthermore there was no statistically significant relationship found within the sample of Corn Belt farms, between direct payments and more land being allocated to the production of corn.

This result is in contrast to Rizov et al. (2013) who analysed the effects subsidies had on fifteen Western European nations before and after the CAP decoupling reform. The data was obtained from the Farm Accountancy Data Network (FADN) from the years 1990 to 2008. They utilised a modified OP estimation and found that prior to the reform, eleven nations had negative effects on their TFP, yet after decoupling was implemented, fourteen nations showed positive effects on farm productivity (Greece being the exception). The authors concluded that decoupled payments are less distortive and enhance productivity, yet there is evidence which indicates that improvements in future food security are needed, potentially through a further increase in the productivity of Europes agricultural sector. This outcome is consistent with Mary (2013) who investigates the effects of the CAP on TFP in French farms from the years 1996 to 2003. The author argues that the current state at which subsidies are being distributed is having a detrimental effect on productivity in France and that further reform is needed. He alludes to the 2003 reform, whereby subsidies were decoupled, and suggests that this may potentially reduce the negative impacts of subsidies on TFP. This inference is proven to be true by Rizov et al. (2013). Tocco et al. (2013) analysed the effects of coupled and decoupled payments on labour in four European nations (France, Hungary, Italy and Poland). They found that decoupled payments results in farms reducing their labour input, that is, working less hours, compared to when these farms receive coupled payments. This result is attributed to payments being made independently of the level of production of a particular crop or animal. Interestingly, since decoupled payments increase the unearned incomes of farmers, Tocco et al. (2013) hypothesise that farmers dedicate less time to farm work, and more time off-farm work or leisure, due to this wealth effect.

2.3.2 Technical Efficiency

Rizov et al. (2013) describe technical inefficiency as higher profits leading to slack and the lack of motivation to seek cost improving methods. Pechrová and Vlašicová (2013) on the other hand, describe technical efficiency as the maximum quantity of output that is attainable by given input. Only recent studies of technical efficiency with a focus on Europe shall be mentioned in this literature review.[12]

Brümmer et al. (2002) utilise an output distance function, and creates a TFP growth index, which is decomposed into four components (technical change, technical and allocative efficiency, and scale component). They estimate a translog output distance function for a particular region in each country, as well as a common function for all regions, in order to compare productivity trends between the countries. The study focused on dairy farms from particular regions in three European nations: Germany, the Netherlands, and Poland, from the years 1991 to 1994. Their theoretical ('ratio') model is less susceptible to endogeneity bias, compared to previous models.[13] The analysis found diversified results, German TFP growth increased by 6% and was predominantly due to high rate of technical change, TFP growth in

[12]This is due to there being a word limit for this thesis.

[13]For a more in depth discussion refer to Brümmer et al. (2002) pp.632-633.

the Netherlands increased by 3% and was due to allocative efficiency, whilst TFP decreased in Poland by 5% which was due to the technical change component of the study. The authors suggested that this decrease may have been due to Polands restricted access to modern farming technologies throughout this sample period.

Latruffe et al. (2011) examines the link between agricultural subsidies and farm efficiency in Europe. The data was taken from the FADN from the years 1990 to 2007 and included seven Western European nations. An Input Distance Frontiers (IDF) approach was used, and found that in all seven countries the subsidies variable and hired labour were both positive and significant. The authors explain that this result means that in nations where farmers are more dependent on subsidies, they exhibit lower levels of technical efficiency. The authors claim the CAP payments to European farms reduce technical efficiency, which is consistent with the literature. However, the average of technical efficiency for all farms for each country ranged from a low of 91.8% for Germany to a high of 94.9% for Denmark. This is relatively high compared to other studies, but the authors liken this to different approaches in calculating technical efficiency by other authors such as Brümmer et al. (2002) or Pechrová and Vlašicová (2013). The latter study estimated the efficiency of biodynamic farms compared to organic farms in the Czech Republic. This was analysed through a stochastic frontier production function model. The panel data ranged from the years 2005 to 2012. The results showed that biodynamic farms produce 66% of their potential output, whilst organic farms produce 79% of their potential output. When subsidies were taken into account it was found that inefficiency increased, which was the opposite of what the authors had hypothesized.

This result is interesting as Čechura (2012) found that technical efficiency may be increased by direct payments to particular sectors of the Czech agriculture industry.[14] Pechrová and Vlašicová (2013) explain this inconsistency in their result may be due to direct payments to farms not yet being fully decoupled from production, and suggest that this may change when the new CAP reforms go into effect in 2014.[15]

2.3.3 Farmers Access to Credit

Petrick (2004a) analyse the effects of governmentally promoted credit access on the investment behaviour of Polish farmers. This was done by addressing two questions, the first asked whether there is any significant credit rationing despite government intervention and what are its determinants. The second whether subsidised funds are in fact used for productive investment in the farm sector or are being used for other purposes.

The data used was from a Polish farm survey in 2000, which was conducted in three regions, the sample of which consisted of 464 farms. In regards to previous data on credit access in Poland, the results showed that only 45.2% of all farmers are regarded as exogenously credit-rationed, though the majority of farmers were partially credit rationed, which meant that they received some credit, but not as much as desired.

A probit model analysis was carried out to determine the rationing status of farmers. Based on the parameters of the model, total land owned was not statis-

[14]These sectors consisted of plant production, animal production, combined production and other production.

[15]To see the full list of these reforms refer to European Commission (2013b).

tically significant, which implies that this variable was of less importance to the determination of credit rationing. Petrick (2004a) provides a possible explanation for this result, putting forward that Polish banks may base rationing off different collateral, such as machinery or buildings. In fact in a similar study, where Petrick (2004b) found that farmers with older machinery had greater difficulty in obtained credit from banks. Furthermore, a reputation variable proved to be statically significant, which suggested that banks would extend credit only to reliable clients. This essentially answered the first question previously mentioned. In regards to the second question, through the establishment of an investment equation, it was found that access to credit has a significant role in determining the investment decisions of farmers. However, the results found when it came to investing, the credit which was obtained was used for other purposes other than productive investment. A tobit estimate of the investment equation was equal to 0.53, this result meant that essentially every second borrower invested less in productive assets. The author concludes that policy may need to be restructured to shift the perspective of Polish banks from being conservative and risk averse. Petrick (2004a) suggests that there appears to be a negligent supervision on behalf of banks, which results in an unspecified range of credit uses, which may not necessarily be a beneficial investment to the farmer who has obtained the credit.

Ciaian et al. (2012) analyse how farm production and various inputs such as land, labour and capital were related to Eastern European farmers access to credit. The study was from the years 2004 to 2005 and which contained 37,409 farms, from eight Eastern European countries. The paper proposed two testable hypotheses, the first being that input allocation and farm output are not affected by a farms access to credit, if farms are not credit constrained. The second hypothesis being, in the presence of credit constraint, the alleviation of the constraint will result in an increase in the farm output whereas the impact on the scale of farm inputs use is ambiguous. Using a propensity score matching (PSM) estimator, the study found that there was no statistically significant impact of credit on the value of production.[16] On the other hand, the results suggested if farms had greater access to credit, this would have a positive impact on TFP. This positive impact of TFP appeared to be statistically stronger in countries predominantly comprised of small individual farms, such as in Lithuania and Poland. Another finding was that for the majority of nations in the study, farm access to credit had a negative impact on labour use. This seems to be consistent in the literature, as farms invest in capital equipment, which is usually labour saving (IAMO, 2003; European Commission, 2013a).

In relation to the previously mentioned hypotheses, this implied that farms are asymmetrically credit constrained. In particular, farms tend to be credit constrained with respect to investment, but credit unconstrained with respect to land and labour. The authors propose potential policy changes, suggesting that improved access to credit in the agricultural sector may result in an increase in productivity within individual farms.

Overall, it was explained that subsidies can affect farm production in one of four ways: by changing relative input/output prices and impacting input usage; through farm growth and exit; by means of income effects and changes in investment deci-

[16] Refer to Ciaian et al. (2012), pp. 29-30 for more information regarding matching estimators, and the authors methodological approach.

sions; and through subsidies being used as a means of risk mitigation. The empircal studies presented show mixed results on the effects of subsidies on TFP, however, the majority of studies which examined decoupling reform found that decoupled subsidies had positive effects on productivity within their respective analyses. Chapter 3 will outline a model which incorporates subsidies into the production function estimation, as well as a method of examining the impacts of subsidies on the TFP of the Eastern European nations considered in this study.

Chapter 3

Methodology

Olley and Pakes (1996) developed a methodology to address endogeneity and selection biases in production function estimation, which exist in other estimation techniques, such as OLS. This chapter builds on this work by introducing subsidies into the empirical model. This model is similar to that of Rizov et al. (2013) who incorporate subsidies into the behavioural framework and production function estimation equation. Section 3.1 and 3.2 describe the theoretical framework behind this approach. Section 3.3 outlines a robustness method, which follows that of Petrick and Kloss (2013), who suggest comparing the OP method, to the LP approach, OLS, and FE regression. Section 3.4.1 describes the the Farm Accountancy Data Network (hereafter FADN) database. Sections 3.4.2 will define the variables to be used in the estimation regression, and Section 3.4.3 will explain the Spearman Rank Correlation Coefficient, which is a method to compare the before and after effects of decoupling reform on TFP.

3.1 Behavioural Framework

Rizov et al. (2013) extend Olley and Pakes (1996) by allowing farm decisions and market environment to be affected by CAP subsidies, which they include in the structural model of the farm.[17] The objective is to model unobserved productivity (or TFP), and directly control for the effects of subsidies in the estimation algorithm. This study will similarly follow the behavioural framework of Rizov et al. (2013). A single period profit function of farm j at time t is defined as[18]

$$\pi(k_{jt}, s_{jt}, \omega_{jt}, \vec{e}_{jt}) - c(i_{jt}, s_{jt}, \vec{e}_{jt}), \tag{3.1}$$

where restricted profit is defined $\pi(.)$ and cost is defined $c(.)$. Both are dependent on k_{jt}, which is the log capital; ω_{jt}, which is the log of unobserved productivity; i_{jt} being the log of farms investment; s_{jt}, the farm subsidies and $\vec{e}_{jt}$, which represents the economic environment that farms face at a particular point in time. $\vec{e}_{jt}$ captures the effects of input prices, demand conditions and industry characteristics.[19] Both k_{jt} and ω_{jt} are considered to be the farms state variables. All these factors are assumed to change over time.

Farm j maximises its expected value of current and future profits according to the following Bellman equation:

[17] For further information regarding the Olley-Pakes methedology, refer to Section 2.2

[18] The data in this study is market level data, rather than farm level data

[19] Industry characteristics could include the size of a particular market; whether large or small farms dominate; whether these markets consist of family farms; or large scale corporate farms etc.

$$V(k_{jt}, s_{jt}, \omega_{jt}, \vec{e}_{jt}) = max \left\{ \begin{array}{l} \Phi(k_{jt}, s_{jt}, \omega_{jt}, \vec{e}_{jt}), \\ max_{i_{jt}}\{\pi(k_{jt}, s_{jt}, \omega_{jt}, \vec{e}_{jt}) - c(i_{jt}, s_{jt}, \vec{e}_{jt}) + \\ \beta E[V(k_{jt+1}, s_{jt+1}, \omega_{jt+1}, \vec{e}_{jt_{jt+1}})|(k_{jt}, s_{jt}, \omega_{jt}, \vec{e}_{jt}, i_{jt}]\} \end{array} \right\}. \tag{3.2}$$

From the Bellman equation, $V(k_{jt}, s_{jt}, \omega_{jt}, \vec{e}_{jt})$ represents a vector of $k_{jt}, s_{jt}, \omega_{jt}, \vec{e}_{jt}$, the max before the brackets indicates that a farm compares its sell-off value (Φ) to the expected discounted returns of staying in the business. The β refers to the farms discount factor, whereas βE represents information available at time t to $t + 1$.

As noted by Rizov et al. (2013), the farm has two choices it can make based on the Bellman equation. The first is to decide whether to exit or continue operating. If the farms current state variables indicate that continuation of production is not worthwhile, then the farms exits and receives a sell-off value equal to Φ. If the farms chooses to continue, it selects an optimal investment level i_{jt}. Rizov et al. (2013) assume that equilibrium exists, and that the difference in profits between the farm continuing and exiting is increasing in ω_{jt}. From this an the optimal decision rule of a farm to remain in production (survivability) can be written as

$$X_{jt} = \left\{ \begin{array}{l} 1 \text{ if } \omega_{jt} \geq \overline{\omega}_{jt}(k_{jt}, s_{jt}, \vec{e}_{jt}) \\ 0 \end{array} \right. . \tag{3.3}$$

Additionally the investment demand function is written as

$$i_{jt} = i_t(k_{jt}, s_{jt}, \omega_{jt}, \vec{e}_{jt}). \tag{3.4}$$

Olley and Pakes (1996)show that $i_t(.)$ and $\overline{\omega}(.)$ (the threshold function) is determined as part as a Markov perfect Nash equilibrium,[20] and are also dependant on the state variables (k_{jt}, and ω_{jt}) ,the characteristics of the economic environment ($\vec{e}_{jt}$), as well as subsidies and factor prices. Furthermore a condition of a farm staying in production is that it has to decide its input, labour (l), materials (m) use and investment (i). Rizov et al. (2013) suggest that farms capital stock might be related to the level of subsidies, which could potentially lead to more capital intensive farms. As a result, the inclusion of subsidies into equations (3.3) and (3.4) not only control for differences through capital stock, but also control for differences in market conditions.

It is assumed that investment determines capital stock at the beginning of each period using the law of capital accumulation $k_{jt} = (1-\delta)k_{jt-1} + i_{jt-1}$, where δ is the depreciation rate of capital. It is further assumed that investment is monotonically increasing in productivity, based on the level of subsidies received. Both Olley and Pakes (1996) and Rizov et al. (2013) note that this assumption is broken at zero investment values, though in none of the observations in this study is this the case.[21]

Assuming monotonicity, investment can be inverted to generate the productivity

[20] Ericson and Pakes (1995) provide a formal definition, as well as proving the existence of a Markov perfect Nash equilibrium in investment. That is, they "show an equilibrium where firms perceptions of the distribution of future market structures are consistent with the objective distribution of market structures that the firms choices generate" (Olley and Pakes, 1996, p.1272).

[21] Petrick and Kloss (2013) provide an interesting discussion regarding some assumptions of agricultural production functions. In particular explain that ω_{jt} evolving monotonously with the observed characteristics of the firm is plausible in an agricultural setting, particularly for annual fluctuating shocks, but less so for slowly changing unobservable variables, such as soil or management quality. For further discussion of these assumptions pp.5-6 of Petrick and Kloss (2013).

function

$$\omega_{jt} = h_t(i_{jt}, k_{jt}, s_{jt}, \vec{e}_{jt}). \tag{3.5}$$

From this equation, it is assumed that productivity evolves based on a first-order Markov process with a transition probability $p(\omega_{jt}|\omega_{jt-1})$, and is determined by a set of distributions conditional on information at time t, which takes into account past productivity shocks (Rizov et al., 2013). As a result, Rizov et al. (2013) claim that exit and investment decisions based on what the farm already knows will rely on the farms perception of the future market conditions. In particular, its past productivity.

3.2 Estimation Equation

Following Rizov et al. (2013), the estimation algorithm proceeds in two stages. Firstly, the production function is defined

$$y_{jt} = \beta_0 + \beta_m m_{jt} + \beta_l l_{jt} + \beta_k k_{jt} + \omega_{jt} + v_{jt} \tag{3.6}$$

where y_{jt} is the log of gross real output and v_{jt} is a random error term with a zero mean. All other variables are as previously defined. Equation (3.5), or the inverted investment demand (productivity) equation is then incorporated into equation (3.6) to give

$$y_{jt} = \beta_0 + \beta_m m_{jt} + \beta_l l_{jt} + \beta_k k_{jt} + h_t(i_{jt}, k_{jt}, s_{jt}, \vec{e}_{jt}) + v_{jt} \tag{3.7}$$

where the productivity equation $h_t(.)$ is treated non-parametrically using a polynomial. However, as Rizov et al. (2013) and Ackerberg et al. (2006) note, this treatment results in collinearity. To account for this, $h_t(.)$, k_{jt} and the constant β_0 are combined into a new function $\phi_t(i_{jt}, r_{jt}, \vec{e}_{jt}, k_{jt}, a_{jt})$, such that equation (3.7) becomes

$$y_{jt} = \beta_m m_{jt} + \beta_l l_{jt} + \phi_t(i_{jt}, k_{jt}, s_{jt}, \vec{e}_{jt}) + v_{jt}. \tag{3.8}$$

Equation (3.8) defines the first stage of the estimation equation, and is estimated using OLS. As well as the subsidies variable s_{jt}, a dummy variable for subsidies is also interacted with the polynomials of investment and capital, which captures the effects of decoupling reform.[22]

Only the labour and materials coefficients (β_l and β_m) are identified in this first stage estimation, whereas the capital coefficient (β_k) is identified in the second stage estimation equation. Rizov et al. (2013) assume that farm labour is treated as a non-dynamic input which is a function of the state variables (including subsidies), and that labour decisions are always made during the current period. Furthermore, it is assumed that materials are treated as a non-dynamic input, whereby decisions are always made after labour is chosen and the simultaneous realisation of productivity in that same period of time. Finally, it is also assumed that labour affects demand for materials: $m_{jt} = m_t(\omega_{jt}, k_{jt}, s_{jt}, l_{jt}, \vec{e}_{jt})$, though the timing of decisions on labour and materials demand differs within each period. Rizov et al. (2013) argue that these three assumptions create a partial dependence of materials on labour demand which in turn bring additional variation in equation (3.8), which dispels any possible

[22]This dummy will be referred to as d_{jt}. Although decoupling reform was introduced in 2003, the process was gradual, hence subsidies were decoupled from 2006 onwards for Czech Republic, Estonia, Hungary, Latvia and Lithuania, and 2007 onwards for Slovenia (European Union, 2003; Agripolicy, 2010)

collinearity within the non-parametric aspect of this equation. As equation (3.8) also estimates $\hat{\phi}_t$, ω_{jt} can be expressed in the second stage estimation equation as

$$\hat{\omega}_{jt} = \hat{\phi}_{jt} - \beta_0 - \beta_k k_{jt}. \tag{3.9}$$

However, the second stage estimation is affected by endogenous selection, as the exit rate in period t depends directly on ω_{jt}. To account for this ω_{jt} is decomposed into the following equation

$$\omega_{jt} = E\left[\omega_{jt}|\omega_{jt-1}\right] + \xi_{jt} = g(\omega_{jt-1}) + \xi_{jt}, \tag{3.10}$$

whereby $g(.)$ is a conditional expectation of ω_{jt} given current information as well as past productivity and ξ_{jt} is a residual. ξ_{jt} is uncorrelated with information in $t-1$ and as a result is uncorrelated with k_{jt}, which is chosen prior to time t. Rizov et al. (2013) assume that a farms exit decision in a time period t, depends directly on ω_{jt}, which as a result creates a correlation between the exit decision and ξ_{jt}. This correlation is based on the assumption that farms exit production quickly. That is, exit in the same period that the decision is made. To account for this endogeneity Rizov et al. (2013) propose that if the exit is decided in the period before the actual exit occurs, exit will be uncorrelated with ξ_{jt}. To formally account for this an additional variable is added to equation (3.10):

$$\omega_{jt} = g'(\omega_{jt-1}, \hat{P}_{jt}) + \xi_{jt}, \tag{3.11}$$

where $\hat{P}_{jt}$ is the estimated propensity-to-exit score, which controls for impact of selection on the expectation of ω_{jt}. $\hat{P}_{jt}$ is estimated non-parametrically using a probit model with a polynomial approximation.

It is important to note a significant difference between the approach of this study and that of Rizov et al. (2013). The data set these authors used consisted of individual farm data from the FADN. This study did not have access to such data, instead observations consisted of eight markets from the years 2004 to 2011 (the data set is discussed in greater detail in section 3.4).

As this study will use market level data, in order to get around the entry and exit of firms, a proxy for the exit rate must be established.

From the behavioural framework of Olley and Pakes (1996) and Rizov et al. (2013), the proxy exit rate is constructed as follows. Firstly, the log of capital (k_{jt}) is averaged from each of the eight markets from one year, for each nation. This calculation is repeated for each year and nation in the entire sample. If the average of k_{jt} was below any observation of k_{jt} of the eight markets for one particular year, then that would be deemed as an exit.[23] The justification behind this method is taken from Olley and Pakes (1996), who show in a probit analysis that a firms exit probability is negatively related to its productivity and capital stock. Capital stock is defined by Olley and Pakes (1996) as the level of investment, together with current capital and variable factors (such as labour). From this definition, equation (3.3) shows that a farm will continue operation if $\omega_{jt} \geq \overline{\omega}(.)$. Since capital ($k_{jt}$) is a part

[23] As an example, a simple average of log of capital for the eight markets in 2004 for the Czech Republic was taken, any observation that fell below the average was deemed an exit, this was repeated for the years 2005 to 2011. This process was then repeated for the remaining nations: Estonia, Hungary, Latvia, Lithuania, Poland and Slovenia.

of this equation, the decision to use this variable as a proxy exit rate was made. This proxy exit rate does not replace equation (3.3), this proxy rate is in fact necessary to estimate the survival probability of a farm (in this case market) in the actual estimation equation through a probit analysis, where the exit rate is the dependant variable.[24]

Following the estimation of $\hat{P}_{jt}$, equations (3.9) and (3.11) are combined into equation (3.6) to give

$$y_{jt} - \widehat{\beta}_m m_{jt} - \widehat{\beta}_l l_{jt} = \beta_k k_{jt} + g'(\hat{\phi}_{jt-1} - \beta_k k_{jt-1}, \hat{P}_{jt}) + \varepsilon_{jt}. \tag{3.12}$$

Equation (3.12) is estimated by non-linear least squares, where $g(.)$ is estimated with a polynomial. The two β_0 terms are included in the non-parametric function $g(.)$, and ε_{jt} is defined as a composite error term made up of υ_{jt} and ξ_{jt}. $\hat{\phi}_{jt-1}$ is estimated from the first stage estimation equation at period $t-1$ and is used due the expectation that ω_{jt}, given current information, depends on ω_{jt-1}. The capital coefficient (β_k) is also obtained through this estimation.

Rizov et al. (2013) follow Olley and Pakes (1996) using the estimated production coefficients of capital, labour and materials to obtain a TFP estimate from the

[24] The estimation of the survival probability is just one step in estimating the OP methodology. The exit rate does not enter as a direct regressor in the estimation equation. For further information refer to Yasar et al. (2008). There is only one line of code that you need to use in Stata in order to estimate the OP equation, hence avoiding having to manually calculate the two step estimation equation, pp.229-230 go through a step by step analysis of how the mechanics behind the equation work.

residual of the production function

$$tfp_{jt} = \exp(y_{jt} - \hat{\beta}_m m_{jt} - \hat{\beta}_l l_{jt} - \hat{\beta}_k k_{jt}). \tag{3.13}$$

This system was estimated in Stata 13 using the code developed by Yasar et al. (2008).[25]

3.3 Robustness Check

To check the robustness of the OP production function estimation, this study follows Petrick and Kloss (2013) and considers three other methodologies. These are the LP, OLS and FE estimation.

3.3.1 Levinsohn Petrin Approach

Out of the three alternative estimation methodologies, the LP approach is by far most similar to OP.[26] The state variables are the same, i.e. capital, k_{jt}, and unobserved productivity, ω_{jt}. The key differences are that there is no exit variable, and instead of using an investment demand function (equation (3.4)), an intermediate inputs demand function is adopted. To give a brief outline of this methodology, the following production function is considered:

$$y_{jt} = \beta_0 + \beta_m m_{jt} + \beta_l l_{jt} + \beta_k k_{jt} + \omega_{jt} + v_{jt}, \tag{3.14}$$

[25]The code to estimate the OP production function was "opreg". There was also code to estimate TFP after the opreg command was run, which was "predict tfp".

[26]For further information regarding the LP approach, refer to Section 2.2.

where the inputs demand function is defined as

$$m_{jt} = m_t(k_{jt}, s_{jt}, \omega_{jt}). \tag{3.15}$$

Note that equation (3.15) is similar to equation (3.6), and the definition of variables are the same as in the OP methodology. The LP approach is similarly modified to include subsidies, s_{jt}. The use of m_{jt} is also deliberate, as the materials variable is generally used to represent intermediate inputs, as is the case in this study.

Ackerberg et al. (2006) explain that the LP approach makes sense, as generally investment data fluctuates quite a lot, and one often finds zeros for certain observations. Such data inconsistences violate the monotonicity assumption made by Olley and Pakes (1996). However, there do exist potential collinearity issues in the LP approach, particularly in the identification of the labour coefficient in the first stage of the estimation (equation (3.18) below). Levinsohn and Petrin (2003) argue that using intermediate inputs is far more consistent, as there is generally far more reliable data, and that there is less of a possibility of monotonicity being violated. Assuming monotonicity, equation (3.15) is inverted to generate

$$\omega_{jt} = \omega_t(m_{jt}, k_{jt}, s_{jt}). \tag{3.16}$$

As this is only a robustness check, only a summary of the estimation equation will provided.[27] The LP approach follows a two-step estimation procedure similar to

[27] For more information regarding the derivation of the LP approach refer p.327 onwards in Levinsohn and Petrin (2003) as well as p.7 onwards in Ackerberg et al. (2006)

the OP method. Equation (3.16) is substituted into (3.14) to give

$$y_{jt} = \beta_0 + \beta_m m_{jt} + \beta_l l_{jt} + \beta_k k_{jt} + \omega_t(m_{jt}, k_{jt}, s_{jt}) + v_{jt}. \tag{3.17}$$

Equation (3.17) is estimated using a semi-parametric estimator. In this first stage only the labour, l_{jt} coefficient is identified. The second stage subtracts the labour variable from (3.14) to generate $y{*}_{jt}$. This gives

$$y{*}_{jt} = y_{jt} - l_{jt}\beta_l = \beta_0 + \beta_m m_{jt} + \beta_k k_{jt} + \omega_t(m_{jt}, k_{jt}, s_{jt}) + v_{jt}. \tag{3.18}$$

As in OP, ω_t is decomposed to create a $g(.)$ function similar to OP. This $g(.)$ function is similar to equation (3.11), except that there is no $\hat{P}_{jt}$ in this equation. The $g(.)$ function is substituted into (3.18) which gives

$$y{*}_{jt} = \beta_m m_{jt} + \beta_k k_{jt} + g(\omega_{t-1}) + v{*}_{jt} \tag{3.19}$$

where $v{*}_{jt} = \xi_{jt} + v_{jt}$, and ξ_{jt} is the residual of the $g(.)$ function. From here, the coefficients of k_{jt} and m_{jt} can be identified, which completes the second stage. The final estimation equation can be summarised as follows:

$$y_{jt} = \beta_l l_{jt} + \beta_i i_{jt} + \beta_s s_{jt} + \beta_d d_{jt} + \beta k_{jt} + m_{jt}. \tag{3.20}$$

The final estimation equation is similar to the OP approach; capital, k_{jt} remains the state variable, except materials, m_{jt}, is now considered the proxy variable, representing the intermediate inputs demand function. This estimation was done using the LP stata package with code developed by Petrin et al. (2004).[28]

3.3.2 Ordinary Least Squares and Fixed Effects Model

As a final benchmark of comparison, as simple OLS and FE model will be produced, although of course both suffer from aforementioned problems. The OLS and FE estimation equation will be as follows, the only difference is that for FE z_j is added to the model, which represents an time-invariant for each market:

$$y_{jt} = \beta_0 + \beta_m m_{jt} + \beta_l l_{jt} + \beta_k k_{jt} + \beta_i i_{jt} + \beta_s s_{jt} + \beta_d d_{jt} + v_{jt}. \tag{3.21}$$

All variables are the same as previously described in the OP and LP estimations, and v_{jt} is the error term. As is noted by a wide array of literature including Griliches and Mairesse (1995), Olley and Pakes (1996), Levinsohn and Petrin (2003), Ackerberg et al. (2006), Petrick and Kloss (2013) and Rizov et al. (2013), the OLS approach is subject to the endogeneity problem, which leads to the estimates of the coefficients being biased. Part of this endogeneity is a result of the assumption that the error term, v_{jt}, is uncorrelated with input choices across farms and time (Levinsohn and Petrin, 2003). Furthermore Ackerberg et al. (2006) note that a farms optimal choice of k_{jt} and l_{jt} is generally correlated with productivity ω_{jt}, and since OLS does not account for this, leads to the coefficients of these variables being biased and inconsistent. Olley and Pakes (1996) and Rizov et al. (2013) reinforce this observation by Ackerberg et al. (2006), adding that the OLS coefficients of capital, labour and

[28] The code to estimate the LP production function was "levpet".

materials are biased because of this endogeneity. The FE regression faces similar endogeneity issues, but the main cause of these problems arises from the assumption that unobservable variables are constant over time, which is almost certainly not the case for unobserved productivity. Furthermore it is assumed that $\omega_{jt} = \omega_{jt-1} \forall t$ which is a strong assumption to make, and hence could result in low and inconsistent estimates of k_{jt} (Ackerberg et al., 2006).

3.4 The Data

The following sections describe the Farm Accountancy Data Network (FADN) data used in this study. Section 3.4.1 provides a general overview of the FADN database, while Section 3.4.2 describes the variables used in the regression models. Finally, Section 3.4.3 will explain the Spearman Rank Correlation Coefficient, and why it is a good measure of showing the relation between CAP subsidies and TFP in Eastern European nations.

3.4.1 Farm Accountancy Data Network

The FADN was established in 1965 to primarily evaluate the income of agricultural holdings as well as the potential impacts of the CAP on farms (Farm Accountancy Data Network, 2010). Part of this evaluation involves the FADN collecting data from national agricultural surveys from EU member states. The data collected from these national surveys involves a sample of farms that are deemed to be representative of the sample population of that particular member state. In fact the FADN boasts that out the sample 80 000 commercial farms covered of the current 25 EU member states, the survey covers approximately 90% of total utilised agricultural area (UAA), and accounts for 90% of total agricultural production in the EU.[29] On top of this, the FADN is the only source of agricultural data that is harmonised in the EU, in the sense that the book keeping principles are the same across EU nations. The FADN database has over 150 variables including output, capital, labour, materials, cost, income, subsidies, taxes and other financial variables.

There are a wide variety of data sets which the FADN makes publicly available.[30] This study utilises the TF8 regional data set. The data is in the form of a panel set, and involves seven Eastern European nations, in which there are eight agricultural markets, covering the years 2004 to 2011 for a total of 958 observations. The nations are Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland and Slovenia. Although this data is a regional set, considering the small agricultural sectors of some eastern European nations, the FADN deemed only breaking down Poland into four, and Hungary into seven agricultural regions was necessary. The remaining nations in this study can be viewed as one agricultural region. The markets are fieldcrops, horticulture, wine, other permanent crops, milk, other grazing livestock, granivores,

[29]There are farms in all the EU nations which produce little output, which the FADN deems as not necessary to include in the survey. As a result the FADN defines a commercial farm as being "large enough to provide a main activity for the farmer and a level of income sufficient to support his or her family" (Farm Accountancy Data Network, 2010, p.4). The FADN also stipulates for the purpose of data collection, that a commercial farm must exceed a certain economic size. An 'economic size' calculation takes into consideration the value of a crop or livestock item, the value of output from one hectare or from one animal, and the cost of inputs required to produce that output. A list of the economic size thresholds for all EU member states can be viewed on pp.5-6 in Farm Accountancy Data Network (2010). UAA represents different land classes ranging from <5 hectares, to >50 hectares

[30]These can be found at: œhttp://ec.europa.eu/agriculture/rica/database/consult_std_reports_en.cfm

and mixed farms. For definitions of these markets please refer to Farm Accountancy Data Network (2010). Note that the data is pooled across all eight markets, as there are not enough obervations in estimating each individual market. This implies that the marginal productvity of capital and labour is the same across the eight markets. This study admits that this is a strong assumption to make, which could only be rectified with access to farm level data.

3.4.2 Definition of the Variables

The variables used in the analysis are now discussed. All monetary variables are calculated in Euros. Note the data used in this study is market level, not farm level as in Olley and Pakes (1996) and Rizov et al. (2013).[31]

Output, y_{jt} (FADN variable SE131) is defined as the real value of total annual output.

Labour, l_{jt} (SE011) is defined as the total full-time equivalent output, which is measured in hours worked annually.

The materials variable, m_{jt} (SE281 + SE336) measures variable costs, and adds total annual specific costs to total annual overheads, respectively. The construction of this variable represents current costs that are not linked to specific areas of production, rather they take into account variable costs related to animal and crop production such as fertilizers, as well as overheads such as costs of machinery and buildings, as well as costs of contractors. Rizov et al. (2013) note that it is impossible to separate the contractors labour costs from total annual specific costs (SE336) as it

[31] Market level data was used as farm level data was not publically available.

contains other factors such as cost of machinery, but they include it in the materials variable regardless.

Subsidies, s_{jt} is constructed by adding totals subsidies excluding subsidies on investment (SE605), to subsidies on investment (SEE406). This variable captures all cash flow paid to farms under the CAP.

Subsidy Dummy, d_{jt} captures the effect of when decoupling reform was implemented in each nation. The dummy will equal one from 2006 onwards for Czech Republic, Estonia, Hungary, Latvia, Lithuania and Poland, and 2007 onwards for Slovenia.

The capital variable, k_{jt} is a little more complex to create. Rizov et al. (2013) note that leasing land and buildings is common practice in European farms. So in order to get an accurate capital variable the total fixed capital used in production must be estimated. The construction of this variable follows Rizov et al. (2013) and is done in two stages. The first stage involves establishing the rental value of land and buildings, hence rent paid for farmland and buildings (SE375) is divided by rented UAA (SE030) to give the rental payment per hectare, this will be referred to as p_1. Next the value of land and buildings owned is calculated. This adds the balance sheet value of land, permanent crops and quotas (SE446) to the balance sheet value of buildings (SE450), this will be referred to as v_1. Now total UAA (SE025) is subtracted from UAA rented (SE030); v_1 is then divided by this new calculation to create h_1, which is the value for land and buildings per hectare.

The equations that have so far been calculated lead to the second stage of estimating k_{jt} , which is determining the rate of return on land and buildings. This rate of return is given by dividing p_1 by h_1, which will be denoted r_1. Total rental payments (SE375) are then divided by r_1 which gives the value of land and buildings rented. Summing this to total fixed assets owned (SE441) gives total fixed capital, which creates the capital variable that will be used in the estimation of OP, LP, OLS and FE. Capital, k_{jt} is treated as a state variable in the estimation of both OP and LP.

Investment, i_{jt}, is constructed using the perpetual inventory method: $i_t = k_{t+1}(1-\delta)k_t$. Where t is the time period and δ is the depreciation rate. Rizov et al. (2013) argue this measure captures investment in total fixed capital, both owned and rented.[32]

The depreciation rate is defined as the depreciation of capital assets estimated at replacement value (SE360) divided by total fixed assets (SE441).[33] The average is taken for the entire data set, resulting in an average depreciation rate of 0.0523, or 5.23%.

The exit rate is defined as a binary variable. 1 represents a market staying in the sample, and 0 represents an exit. A coefficient will not be estimated for the exit rate, however it is necessary for the estimation the OP methodology.

Beyond estimation of the production function, one of the main objectives of this study is to analyse TFP. The approach used, again follows Rizov et al. (2013), who create a TFP Index, and TFP Growth variable. First of all the TFP measure is weighted using output, which captures the effects of the market composition. For comparative purposes the TFP Index and TFP Growth variables are defined as,

[32] Since no depreciation rate is defined, this study will calculate its own.

[33] SE360 takes into account plantations of permanent crops, farm buildings and fixed equipment, land improvements, machinery and equipment and forest plantations. The Farm Accountancy Data Network (2010) note that depreciation of land and circulating capital is not included in this variable.

respectively:

$$TFP_{index} = tfp_{jt}/\overline{tfp}_t \tag{3.22}$$

$$\Delta TFP_{growth} = log(tfp_{jt}/tfp_{jt-1}) \tag{3.23}$$

where $\overline{tfp}_t$ is the average productivity of all markets in period t.

3.4.3 Spearman Rank Correlation Coefficient

The final part of the methodology section outlines how the effects of decoupling reform on Eastern European agricultures TFP will be evaluated. To compare the effects of subsidies on TFP, Rizov et al. (2013) use the Spearman Rank Correlation Coefficient (SRCC), otherwise known as Spearmans ρ.

The SRCC assumes that both variables are described as a monotonic function. The sign of the Spearman correlation indicates the direction of the link between the variables and increases in magnitude (gets closer to +1 or -1) as the as strength of the relationship between the two variables increases, meaning they become closer to being perfect monotone functions of each other.

McDonald (2009) notes that this assumption is less restrictive compared to other approaches, such as the Pearson coefficient, which assumes a linear relationship between both variables. Also, as suggested by Weir (2014), scatterplots and box plots are generated to determine if SRCC is more suitable than the Pearson correlation. Figures A.1 and A.2 in Appendix A plot the subsidies variable against the respective TFP Index and TFP Growth scatterplots for each nation. They show some evidence of a positive relationship between these variables, which is stronger for nations such as Czech Republic and weaker for Lithuania. Slovenia shows a slightly negative relationship, particularly between subsidies and the TFP Index. Furthermore, box plots (Figures A.3 to A.9) for all nations show outliers ranging between the three variables, as well as the median lines in many of the variables for each nation being skewed away from the centre of the box, indicating that it may not be a normal distribution (Weir, 2014). Since the Pearson correlation is sensitive to outliers, and the Spearman correlation has no normality assumptions (McDonald, 2009), the SRCC is ideal to test the correlation of subsidies between TFP Index and TFP Growth, respectively.

For the purpose of explaining the construction of the SRCC, the X variable will refer to the subsidies variable, whereas Y will refer to TFP Index and TFP Growth, respectively. First of all, each observation from variables X and Y were ranked from highest to lowest, for each nation.[34] From here the X and Y variables are subtracted from each other:

$$d_i = X - Y \tag{3.24}$$

where i is an observation. The sum of these d should be equal to zero. The correlation coefficient is calculated as follows:

$$\rho = 1 - \frac{6\sum d_i^2}{n(n^2-1)} \tag{3.25}$$

where d_i^2 is the squared difference in the rank observation, and n is the number of

[34]If there were two observations that had the same value you would need to average the two. For instance, if ranks of observations 6 and 7 were the same, the rank for these two observations would be 6.5. This was not the case for any of the observations, for any country, in this study.

observations.

To evaluate the impact of decoupling reform the SRCC is estimated twice. The first estimation will be done for the full sample, that is years 2004 to 2011 for each nation, and will be referred to as 'full sample'.[35] The second estimation will only include the years decoupling reform was implemented in each nation ('post-reform'), as previously mentioned this means only the years 2006 to 2011 will be estimated for Czech Republic, Estonia, Hungary, Latvia, Lithuania and Poland, and the years 2007 to 2011 will be estimated for Slovenia. This will allow comparison of the sign of the coefficient, as well as the magnitude of ρ, to see if decoupling reform had any impact TFP within these Eastern European nations compared to the full sample.

[35] A 'pre-reform' sample was considered, which would only include coupled subsidies, that is, years 2004-2005 for Czech Republic, Estonia, Hungary, Latvia, Lithuania and Poland, and the years 2004 to 2006 for Slovenia. This was avoided due to the small sample of observations. As a result this is not as strong a comparison compared to that of Rizov et al. (2013), but it is still effective in showing the effects decoupling reform has had on TFP. Kendalls rank correlation was also considered, but the SRCC proved to be the superior choice.

Chapter 4

Empirical Results

This chapter presents results of the models developed in Chapter 3. Section 4.1 provides summary statistics from all seven nations, which are accompanied by market specific graphs in Appendix B. Section 4.2 gives estimates of the production function coefficients using the OP methodology. Furthermore a robustness comparison between the OP, LP, OLS and FE approaches is shown, with specific results being available in Appendix C. Section 4.3 analyses the TFP Index and Growth estimates using Spearman Rank Correlation Coefficients (SRCC), to determine the strength of the relationship between subsidies and these two estimates.

4.1 Summary Statistics

Table 4.1 shows that Poland has the most farms, Total UAA (refer to Section 3.4.1 for a definition of this), and subsidies received in total. However, it is the Czech Republic that receives the most subsides per farm, which is most likely due to the Czech agricultural sector predominately comprising of large corporate farms (Čechura, 2012, Pechrová and Vlašicová, 2013). Estonia had the least amount of farms, and received the smallest amount of total subsidies, however, it was second only to the Czech Republic in terms of subsidies reveived per farm.

It interesting to note that prior to these nations entry into the EU, subsidies had a minimal role in agricultural production. Swinnen and Vranken (2010) expands on this claiming that although some subsidies were provided for these nations, the focus was more on market reform, and increasing the competitiveness of these nations not only in Europe, but around the world. Governments in Central and Eastern Europe chose to implement land reform and privatisation policies to spur competition. Swinnen and Vranken (2010) found that nations with a greater percentage of small scale or family farms (such as Hungary and Poland) were quicker to adjust to these reforms, compared to other nations where larger farms were more prevalent such as the Czech Republic. During this time Macours and Swinnen (2000) argue that the implementation of price liberalisation greatly hurt Central and Eastern European nations, claiming that this reform contributed to almost half of the agricultural output decline between the years 1989 to 1995, compared to other land reform or market based policies.[36]

[36] As this analysis is focused on the effect of subsidies after these Eastern European nations joined the EU in 2004, the role of subsidies and the policies in place prior to entry to the EU was only briefly touched upon. For further information to earlier policies refer to Macours and Swinnen (2000) and Swinnen and Vranken (2010).

Table 4.1: Information Regarding the Eastern European Nations Agricultural Sector

Country	Total Number of Farms	Total UAA (ha)	Subsidies Received in Total	Subsidies Received Per Farm
Czech Republic	22 860	3 483 500	1 168 700.9	77.1
Estonia	19 610	940 930	193 730.3	23.6
Hungary	576 810	4 686 340	1 729 107.4	14.7
Latvia	83 390	1 796 290	577 437.3	14.2
Lithuania	199 910	2 742 560	277 608.5	8.9
Poland	1 506 620	14 447 290	4 692 755.7	5.7
Slovenia	74 650	482 650	243 782.3	8.1

Total Number of Farms, Total UAA, and Subsidies Recieved Per Farm was obtained from 2010 data, these statistics were taken from the FADN fact sheet website, which can be found at `http://ec.europa.eu/agriculture/rica//database/factsheets_en.cfm`. Subsidies recieved in total were obtained from 2012 data, and can be found at `http://ec.europa.eu/agriculture/statistics/factsheets/index_en.htm`. Subsidies Received in Total is measured in 000s Euros. Subsidies Received Per Farm is measured in 000s Euros.

Table 4.2 presents summary statistics for the seven Eastern European nations considered in this study. It is well known that the Czech Republic agricultural sector is predominantly comprised of large corporate farms, which explains why the means for each of the variables in Table 4.2 are largest. In fact, based on the European Unions latest survey (European Commission, 2014), for agricultural holdings that were more than 30 hectares; made up 50% of total UAA.

The other six nations are typically comprised of small to medium scale family farms. Estonia and Latvia represent the medium scale family sized farms (European Commission, 2014; Macours and Swinnen, 2000). Based off European Commission (2014) estimates, holdings which are more than 10 hectares make up 46% and 39% of UAA of each nation respectively. Furthermore, Table 4.2 show that Estonia is the second most capital intensive nation, and Latvia is fifth within the study.

Table 4.2: Summary Statistics

Country	Output (s.d)	Capital (s.d)	Investment (s.d)	Labour (s.d)	Materials (s.d)	Subsidies (s.d)	Exits (N)
Czech Republic	267.7	2453.9	203.7	13964.1	207.5	47.3	0.43
	(252.0)	(2617.8)	(684.6)	(9280)	(212.2)	(44.7)	(63)
Estonia	122.4	329.6	49.2	7047.2	91.6	18.6	0.40
	(151.9)	(299.7)	(135.7)	(4301)	(118.1)	(13.9)	(48)
Hungary	81.9	299.7	38.7	4747.9	60.9	14.2	0.52
	(103.1)	(417.3)	(361.1)	(3265)	(86.1)	(11.9)	(264)
Latvia	118.9	204.3	22.1	8451.9	87.6	17.3	0.38
	(186.6)	(270.6)	(124.1)	(8989)	(138.7)	(11.8)	(50)
Lithuania	81.5	167.2	37.6	6081.0	55.4	11.8	0.37
	(187.2)	(257.3)	(183.4)	(6137)	(149.5)	(10.1)	(51)
Poland	34.5	132.8	22.9	4369.7	20.5	4.4	0.51
	(29.0)	(72.4)	(31.0)	(1257)	(20.8)	(3.4)	(219)
Slovenia	29.0	268.1	16.8	3336.3	17.8	8.2	0.44
	(20.3)	(142.5)	(56.7)	(683)	(14.4)	(5.7)	(53)

The mean and standard deviation (s.d) are provided for each variable. N is the number of observations. Note that in the actual estimation equation the logs of output, capital, and investment are used, but Table 4.1 provides the unlogged values. Investment is calculated using the perpetual inventory method as explained in the methodology chapter (Section 3.4.2). The variables output, capital, investment, materials, subsidies and (s.d) are measured in 1000 euros. Labour is measured in total full-time hours worked annually. Exits are measured as a percentage, refer to methodology chapter (Section 3.2) for how the exit rate was calculated.

The remaining nations (Hungary, Lithuania, Poland and Slovenia), primarily consist of small scale family farms, ranging from 79% of holdings for Lithuania, to 91% for Hungary that are 10 hectares or less European Commission (2014). Most of these nations produce relatively less per farm compared to other European nations where medium to large scale corporate farms tend to dominate; for instance Czech republic, Denmark, West Germany, or the United Kingdom (Petrick et al., 2012). Petrick and Kloss (2013) and Macours and Swinnen (2000) explain that these nations tend to be less capital intensive, and more labour intensive. However there are exceptions. In the case of Hungary and Slovenia, the data reveals 91% and 84% of holdings are equal to or less than 10 hectares, respectively. Yet out of the small scale family farming nations, these two appear to be more capital intensive; even more so that the medium scale family farms of Latvia.[37]

Appendix A provides additional perspective in comparing the seven nations TF8 markets, to the six variables in Table 4.2. Some general observations show that Poland consistently dominates horticulture in all but subsidies. With regards to the other markets, although Poland is a close third, the Czech Republic and Hungary tend to dominate the other seven markets in all six variables, with a few exceptions. Also, there is a consistent dip in the milk market from 2005 to 2006, as well as other grazing livestock in 2008 to 2009 for Hungary in all six variables. This is likely due to Hungary being divided into seven agricultural regions, in the case of these graphs the data was aggregated for comparative purposes, so particular regions may have produced different agricultural output each year.

From Figure A.1 it is clear that Czech Republic, Hungary, and Poland dominate output throughout the sample period. While each series displays some changes through time, Hungary in particular has large dips in its field crops, wine, milk, other grazing livestock and granivores sector.

In Figure A.2 the Czech Republic dominates capital in five out of the eight markets, which comes as no surprise, due to its highly corporatized agricultural sector. The Czech Republic also experiences large dips in its horticulture and wine sectors,

[37]Note that the rates for farm exit are quite high. It was suggested that the exit rate in Table 4.1 be compared to national statistics of farm exits. Such statistics are unfortunately unavailable for these Eastern European nations. The exit rate would be more accurate for farm level data, which this study did not have access to.

though it is difficult to interpret why this is the case. Hungary and Poland yet again have large capital input compared to the remaining nations.

Figure A.3 shows investment which is calculated through the law of capital accumulation $k_{jt} = (1-\delta)k_{jt-1} + I_{jt-1}$, when rearranged gives , where t is the time period and δ is the depreciation rate. This explains why there is negative investment, if capital in period $t+1$ is higher by a particular amount of capital in the current period t, then negative investment may ensue. On an annual basis, most of the nations in the sample have positive investment, only in certain years slightly falling into the negative investment threshold. Again Hungary and the Czech Republic fluctuate quite a lot in various markets, most notably in horticulture, wine, other permanent crops and granivores.

The labour variable in Figure A.4 shows similar trends to Figures A.1-3, as Hungary dominates field crops, wine, other permanent crops and mixed farms in total annual hours worked from the sample, Poland dominates horticulture and other grazing livestock. Milk is closely contested by Czech Republic, Hungary and Poland, whereas Granivores see a large surge of hours worked in 2011 by Slovenians. The time series plots remains relatively steady, bar some exceptions, such as the large drop in the annual hours worked in the milk and granivores market by Hungary. Note that the hours worked by Hungarians in the granivores market slowly recovers, whereas Latvias steadily drops.

In regards to materials in Figure A.5, the plots remain relatively constant, with similar fluctuations as in the previous figures for Hungary in the Wine and Milk sector, as well as other grazing livestock.

Figure A.6 shows that subsidies received are dominated by Hungary and the Czech Republic. However, it should be kept in mind that the FADN data is chosen from a representative sample population, but it is interesting to see that Poland is not as prominent, as it receives the highest portion of subsidies in absolute terms, which is roughly 4.7 billion euros, the next closest being Hungary which is approximately 1.7 billion euros (European Commission, 2014). Having said that, the farming population in Poland is nearly triple that of Hungary, which may be one possible explanation, as the subsidy per farm is lower compared to that of the Czech Republic or Hungary. The following section will discuss the estimation results of the OP model.

4.2 Olley and Pakes Estimation

Table 4.3 provides estimation results from the OP model. There is substantial variation amongst the seven European nations. The capital variable is negative only for Estonia, and for the remaining nations ranges between 0.046 for Slovenia up to 0.634 for Lithuania. The labour, materials and subsidies coefficients are extremely small, which implies that they have little to no impact on output for their respective nations. The significance for these variables range from no significance to 10% significance as shown in Appendix C.

Table 4.3: Production Function Coefficients and Productivity Estimates

Country	β_k (s.e)	β_l (s.e)	β_m (s.e)	Adj.R^2 (N)	TFP Index (TFP Growth)
Czech Republic	0.334*	6.68e-06	1.94e-06	0.93	0.989
	(0.174)	(0.000)	(0.000)	(55)	(+0.001)
Estonia	-0.113	0.00001*	5.37e-06*	0.89	0.990
	(0.285)	(0.000)	(0.000)	(42)	(-0.015)
Hungary	0.436**	0.00002	6.01e-06	0.79	0.999
	(0.212)	(0.000)	(0.000)	(191)	(-0.018)
Latvia	0.029	0.0001	4.44e-06***	0.95	0.958
	(0.327)	(0.000)	(0.000)	(50)	(+0.038)
Lithuania	0.634	0.0004***	-0.00001	0.92	0.833
	(0.523)	(0.000)	(0.000)	(50)	(-0.099)
Poland	0.058	0.0002***	0.00002***	0.81	0.996
	(0.087)	(0.000)	(0.000)	(208)	(-0.006)
Slovenia	0.046	0.0003**	0.00007***	0.77	1.035
	(0.410)	(0.000)	(0.000)	(53)	(-0.011)

N is the number of observations. β_k = coefficient of capital, β_l = coefficient of labour, β_m = coefficient of materials. Note that the s.e of variables that is 0.000 are generally far smaller than this, but in order to keep some consistency in the table, the s.e were rounded to three decimal places. This was not done for the coefficients in order to show the how small the magnitudes were. The significance level of these variables can be seen in Appendix C. , *** is 1% significance, ** is 5% significance, and * is 10% significance. A Wald test of joint significance was run for the first stage of the OP estimation, and was the null of no difference was rejected from zero at 1% for all nations. A Breusch-Pagan test for heteroskedasticity was run, and found that Poland had signs of heteroskedasticity, whereas the null of constant variance was not rejected at 1% levels for Czech Republic, Estonia, Hungary, Latvia, Lithuania, and 10% for Slovenia. Also, a BreuschGodfrey test for first and second-order autocorrelation was run, Czech Republic, Estonia, Hungary, Lithuania, Poland and Slovenia showed no signs of autocorrelation at the 1% level, however, Latvia did show signs of autocorrelation.

Few studies have used the OP approach to analyse agricultural subsidies. Rizov et al. (2013), adjust the OP approach to compare the before and after effects of decoupling reform within the EU and find a negative sign of the subsidy coefficient from twelve of the fifteen Western European nations prior to decoupling reform, which is consistent with Brümmer et al. (2002), Luik et al. (2011),Čechura (2012), Mary (2013), who all show in their relevant studies that subsidies (before decoupling) have negative effects on productivity in their respective nations.[38]

The final column in Table 4.3 shows TFP Index and TFP Growth. TFP Index ranges from 0.833 for Lithuania, to 1.035 for Slovenia, Rizov et al. (2013) suggest that a higher index could be representative of more productive farms or dominant farming sectors. This does not appear to be the case for any of the nations in this study. TFP Growth shows some minimal, yet interesting results, where five nations exhibit negative growth, with Lithuania being the largest at -0.099%. The largest agricultural economies, Poland and Hungary, also have negative yet small annual growth. Only the Czech Republic and Latvia have positive annual growth though this is minimal, being 0.001% and 0.038% respectively, more comments shall be made in regards TFP in Section 4.4.

4.3 Checking Robustness of Olley and Pakes

Following Petrick and Kloss (2013), three other models were estimated to check the robustness of the OP approach. These were Levinsohn and Petrin (LP), Ordinary Least Squares (OLS) and Fixed Effects (FE) models. A summary of the robustness of the OP estimation can be seen in Table 4.4, and estimates of all four models are provided in Appendix C.

[38] Note that Brümmer et al. (2002) studied Polish, German and Dutch farms, Luik et al. (2011) Estonian farms, Čechura (2012) analysed Czech farms, and Mary (2013) French agriculture.

Table 4.4: Robustness Comparison

Country	β_k	β_l	β_m
Czech Republic	✓(+)	✓(+)	✓(+)
Estonia	OP (-) LP,OLS,FE (+)	✓(+)	✓(+)
Hungary	✓(+)	OP,LP,FE (+) OLS (-)	✓(+)
Latvia	✓(+)	OP, LP, OLS (+) FE (-)	✓(+)
Lithuania	✓(+)	✓(+)	✓(+)
Poland	✓(+)	✓(+)	✓(+)
Slovenia	✓(+)	✓(+)	✓(+)

β_k = coefficient of capital, β_l = coefficient of labour, β_m = coefficient of materials. A ✓ means that all of the signs for that particular coefficient were the same. A (+) means that the coefficient was positive, a (-) means that the coefficient was negative. For countries where there were different signs, the respective estimation technique has been provided with the sign that the technique estimated for that particular coefficient. OP represents the Olley and Pakes methodology, LP the Levinsohn and Petrin approach, OLS is Ordinary Least Squares, and FE represents Fixed Effects Regression. Investment was not included as a coefficient as is not estimated in the OP approach, and the robustness check is aimed at comparing the flexibility of the OP estimation to other approaches.

The signs of all coefficients are the same in the Czech Republic, Lithuania, Poland and Slovenia, for all four estimation techniques, implying that the estimation equation is robust for these nations. There are mixed results for Estonia, Hungary and Latvia, but otherwise the OP approach appears to be robust with the majority of the estimation techniques, with the exception of a few variables from a few countries.[39] The p-value varies amongst all variables, from no statistical significance to 10% significance (refer to Appendix C for more details).

[39] For instance capital for Estonia, labour for Hungary and Latvia

As shown by OP, OLS estimates can lead to upwardly biased estimates in comparison to the OP approach, this is corroborated in Griliches and Mairesse (1995), Ackerberg et al. (2006), Rizov et al. (2013). The capital coefficient for OLS is consistently higher, which was the case in Olley and Pakes (1996),Rizov et al. (2013), Petrick and Kloss (2013) (refer to Appendix C for more details). The only exception for the OLS capital coefficient being lower was for Czech Republic. The positive signs for capital, labour, materials are consistent with Rizov et al. (2013), Mary (2013), Petrick and Kloss (2013).[40]

4.4 Subsidies and Total Factor Productivity

This methodology uses the Spearman Rank Correlation Coefficient (SRCC) to assess the relationship between two variables, and determines whether they can be described as a monotonic function. The sign of the SRCC indicates the direction of the link between X and Y. The SRCC increases in magnitude as X and Y become closer to being perfect monotone functions of each other. In the case of this analysis, subsidies and TFP Index will be analysed in Table 4.5, and subsidies and TFP growth in Table 4.6.

The 'full sample' column refers to the full data set of each country, which includes coupled and decoupled subsidies; whereas the 'post-reform' column refers to decoupling reform. Post-reform is from 2006 onwards for Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, and 2007 onwards for Slovenia.[41]

[40]There were a few exceptions, to see the summary of the of all four estimation techniques to the model refer to the robustness comparison in Table 4.4.

[41]European Union (2003) and Agripolicy (2010) explain that the implementation of decoupling

Table 4.5: Correlation between Subsidies and TFP Index

Country	Full Sample (p-value) (N)	Post-Reform (p-value) (N)
Czech Republic	0.328 (0.009) (63)	0.403 (0.186) (48)
Estonia	0.583 (0.000) (48)	0.592 (0.000) (36)
Hungary	0.386 (0.000) (264)	0.452 (0.000) (200)
Latvia	0.252 (0.078) (50)	0.248 (0.128) (39)
Lithuania	-0.133 (0.350) (51)	0.025 (0.875) (42)
Poland	0.634 (0.000) (219)	0.653 (0.000) (164)
Slovenia	-0.568 (0.000) (53)	-0.486 (0.000) (41)

Rizov et al. (2013) note that that since subsidies are widely utilised by farms in the EU, it is difficult to identify treatment and control groups, and compare the effects that subsidies have had. This is why the authors deem the Spearman rank correlation coefficient the most effective in showing the strength of the relationship between subsidies and the TFP Index and TFP Growth. Based on Table 4.5, six of the seven nations (Czech Republic, Estonia, Hungary, Latvia, Poland and Slovenia) have statistically significant values at 10% or better at the full sample. Four nations (Estonia, Hungary, Poland and Slovenia) have significance levels at 1% for both the full sample and post-reform, whereas Lithuania is statistically insignificant in both samples. The results are consistent with the literature in the sense that decoupling (post-reform) has a more positive impact than when coupled subsidies were included

reform was gradual, and that this policy was fully in effect in 2006 for Czech Republic, Estonia, Hungary, Latvia, Lithuania and Poland, and from 2007 onwards for Slovenia.

(full sample) (Kazukauskas et al., 2010; Rizov et al., 2013; Mary, 2013; Tocco et al., 2013). The strength of the relationship of subsidies and the TFP Index is also quite strong ranging from -0.568 to 0.653, the way this can be interpreted is that for a positive correlation coefficient, there is a positive monotonic relationship, meaning small increases in subsidies are associated with small increases in the TFP index.

Based on these estimates, out of the statistically significant coefficients, Estonia, Hungary and Poland have a positively monotonic relationship, whereas Slovenia is strongly negatively monotonic, meaning that subsidies and the TFP Index are negatively correlated in this nation.

With regards to Slovenia, both the full sample and post-reform remain negative, although decoupling reform appears to have a slightly more positive effect. The high statistical significance and negative coefficient of both variables warrants some explanation. One possibility is that Slovenia chose to implement the Single Payment System (SPS) compared to other Eastern European nations, which applied the Single Area Payment Scheme (SAPS). SAPS was only available to nations who joined the from EU 2004 onwards, whereas the SPS is the common payment scheme to current members in Western Europe (European Union, 2003). The SAPS simplified subsidy allocation to a payment per hectare of agricultural land, whereas SPS is more complicated, and takes into account animal per head and/or area dedicated to sowing crops (Agripolicy, 2010). Furthermore, Slovenia chose to delay subsidy payments until 2007, this delay to adopt a decoupling policy on top of choosing an alternative payment method may be the reason why there is a negative correlation for Slovenia.

Table 4.6 only shows Estonia and Hungary with statistically significant coeffi-

Table 4.6: Correlation between Subsidies and TFP Growth

Country	Full Sample (p-value) (N)	Post-Reform (p-value) (N)
Czech Republic	0.054 (0.693) (55)	0.099 (0.500) (48)
Estonia	0.381 (0.013) (42)	0.411 (0.015) (36)
Hungary	0.305 (0.000) (216)	0.334 (0.001) (186)
Latvia	-0.097 (0.548) (41)	-0.251 (0.139) (36)
Lithuania	0.181 (0.241) (44)	0.199 (0.216) (40)
Poland	0.012 (0.864) (190)	0.066 (0.399) (163)
Slovenia	0.174 (0.254) (45)	0.061 (0.437) (40)

cients for both the full sample and post-reform TFP growth (to 5% significance). For the statistically significant nations, all exhibit results which show that decoupling has a more positive impact on TFP growth, although it is minimal in both instances.[42] Rizov et al. (2013) and Mary (2013) show that coupled subsidies have a negative impact on growth, although this is not the case with these results (as there are still coupled payments in the full sample), the papers do agree that decoupled subsidies have increased positive effects on TFP growth.

A potential explanation for the increased positive effects of decoupled subsidies compared to coupled payments is provided by Rizov et al. (2013), who explain such a result may be due to allocative and technical inefficiencies together with payment uncertainty. Coupled subsidies may lead to the generation of less credit (from banks

[42]In fact, five of the seven nations show more positive effects, though three of them are statistically insignificant.

or lenders), which could lead to less productive investment compared to decoupled payments. Lagerkvist (2005) also suggest that under potential CAP reform, if there is a lack of information and uncertainty in future prices, farmers may overinvest before the reform date if they expect a reform that is likely to reduce their area payment, which leads to inefficiency of credit distribution. However, if complete information is given in regards to the reform, clearer investment decisions can be made, improving the efficiency use of credit allocation.

Rizov et al. (2013) also point to the possibility that coupled subsidies may be funnelled to other agents, such as through changes in market prices, further reducing the benefits of these payments. The possibility that decoupled payments may alleviate this issue is supported by Petrick (2004a), who argues if distribution of credit (which includes subsidy payments) were regulated, such as investment decisions of farmers, this could benefit farmers by helping them make ideal investment choices on capital or inputs which could consequently increase productivity. This benefit could be through the reduction of investing in machinery, which would be a decreased cost for the farmer, hence improving their welfare. Finally, Ciaian et al. (2012) also suggest that this could also lead to a decrease in risk aversion, as farms may be more willing to expand their capital, or adopt farming technologies which could increase their productivity further.

Chapter 5

Conclusion

Farms in the EU clearly have a large reliance on agricultural subsidies provided by the CAP. This is shown in European Commission (2010b) statistics which suggest that without subsidy payments, up to 75% of EU farms would not be able to cover on-site costs, and that the share of profitable farms would fall below 20%. But how have subsidies affected these farms' productivities? This study followed the Rizov et al. (2013) production function estimation and applied it to seven Eastern European nations. The aim was to analyse the effects decoupling reform had on the TFP of these nations. It was shown that decoupling reform had more positive effects on TFP when compared to the full data sample which included coupled subsidies. This is consistent with previous studies such as Luik et al. (2011); Čechura (2012); Rizov et al. (2013); Mary (2013). It should be noted that Estonia, Hungary, Lithuania, Poland and Slovenia showed very small decrease of overall TFP Growth from 2004 to 2011, whilst Czech Republic and Latvia showed small postive signs of growth (from

Table 4.3).

A Spearman rank correlation coefficient was then used to show the relationship between subsides and TFP. Estonia, Hungary, Poland and Slovenia had statistically significant results for both the full sample and post-reform of their TFP index. These results also showed that post-reform decoupling had more positive effects on these countries TFP index. Slovenia was the only country with significant results to have a negative coefficient for post-reform. A possibility for this negative sign was that Slovenia chose to implement Single Payment System (SPS) subsidies, compared to the other Eastern European states who implemented a Single Area Payment Scheme (SAPS). SAPS simplified subsidy allocation, whereas SPS was more complex in its subsidy distribution.[43] This, combined with Slovenia choosing to implement decoupling reform in 2007 may be factors for the negative sign. Furthermore, Estonia and Hungary were the only nations to show statistically significant results for both the full sample and post-reform TFP growth. The results showed that decoupling reform had increased positive effects on agricultural growth for these nations.

The Spearman correlation also found that decoupling reform has positive, statistically significant effects for Estonia and Hungary, which is consistent with the before mentioned literature.

5.1 Further Research

This study only had access to market level data. This was unfortunate, as farm level data would have been ideal for the model, particularly in establishing the exit

[43] Refer to Section 4.4 for more details regarding SPS and SAPS.

rule.[44] Also it was suggested that each market be estimated individually for the estimation equation, this was not possible as there were not enough obervations in the estimation. As a result the only choice was to pool the data across all eight markets. Note that this is a strong assumption to make as it implies that the marginal productivity of capital and labour is the same across all eight markets.

The assumptions of this model also appear to be quite strigent, such as the strict monotonicity assumption, though it is applicable in this study, as the assumption is not violated. Furthermore, Petrick and Kloss (2013) draw attention to OP assuming ω_{jt} evolves monotonously with the observed characteristics of the firm. They claim that this is a plausible in an agricultural setting, especially when considering annual fluctuating shocks, but note that it is less applicable for slowly changing unobservable variables, such as soil or management quality. Although there are some short comings of this paper, the results obtained are consistent with studies which use farm level data. For instance, decoupling reform has more positive effects on TFP as well as the coefficient of capital being overestimated by OLS compared to OP. Further research could involve implementing farm level data to the estimation equation used in this study to see if the results vary for the respective Eastern European nations.

[44] It was suggested that the OP methedology be estimated without the exit rate, this was not possible as the exit rate is necessary to estimate the survival probability, which is then used to estimtate the coefficients of the production function. If one were to get access to farm level data, then a more accurate exit rate could be estimated, which in turn would lead to more accurate results.

5.2 Future of Common Agricultural Policy

The proposed CAP reforms from 2014 to 2020 will preserve the long standing goals of the EU which are maintaining food security, and increasing environmental conservation and food safety standards. Based on the findings of this paper, it appears that a greater push for increasing productivity should also be put in place for Eastern European nations. Even though it was found that decoupling reform appeared to have positive effects on productivity, five of the seven nations had overall negative TFP Growth from the period of EU entry, and those that had positive TFP Growth (Czech Republic and Latvia), were very small. The 2014 reform has also placed a focus on young farmers, and will provide generous remuneration for those looking to get into agriculture. This is a step in the right direction, as although this study did not analyse age brackets of farmers, and ageing (and decreasing) agricultural population in Eastern Europe may be one factor of these poor TFP outcomes. Also, this new reform aims to redistribute funds more evenly across EU member states (European Commission, 2013a). Perhaps an influx of subsidy payments may spur on further agricultural growth in Eastern Europe. It also seems that the EU will restructure the SPS and SAPS payment system to make it easier to manage and distribute funds, and to make it compatible with EU and domestic policies. Furthermore, the EU aims to structure the payments scheme so that it is stable in the long run, which means that farmers will have long term guarantees that they shall receive a certain amount of funds (European Commission, 2010c).[45] Although the Euro-

[45]For more discussion regarding the restructuring of the SPS and SAPS refer to European Commission (2010c), p. 95 onwards.

pean Commission (2010c) report claims that these proposed reforms are based on recent economic literature, only time will tell of their effectiveness on the agricultural production and productivity of EU farms.

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Appendices

Appendix A

Scatterplots and Box Plots

Figure A.1: Scatterplots for the Seven Eastern European Nations

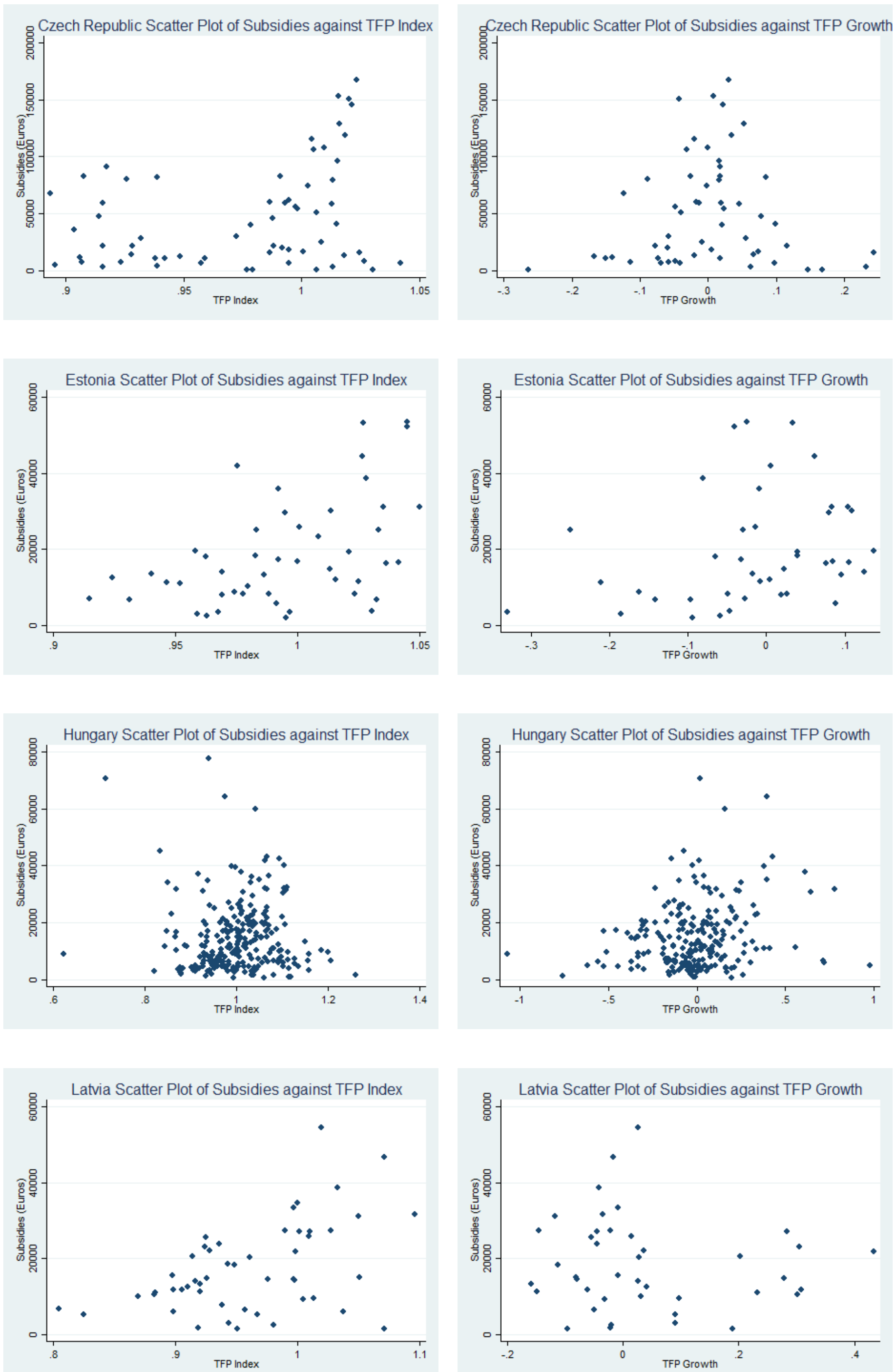


Figure A.2: Scatterplots for the Seven Eastern European Nations continued

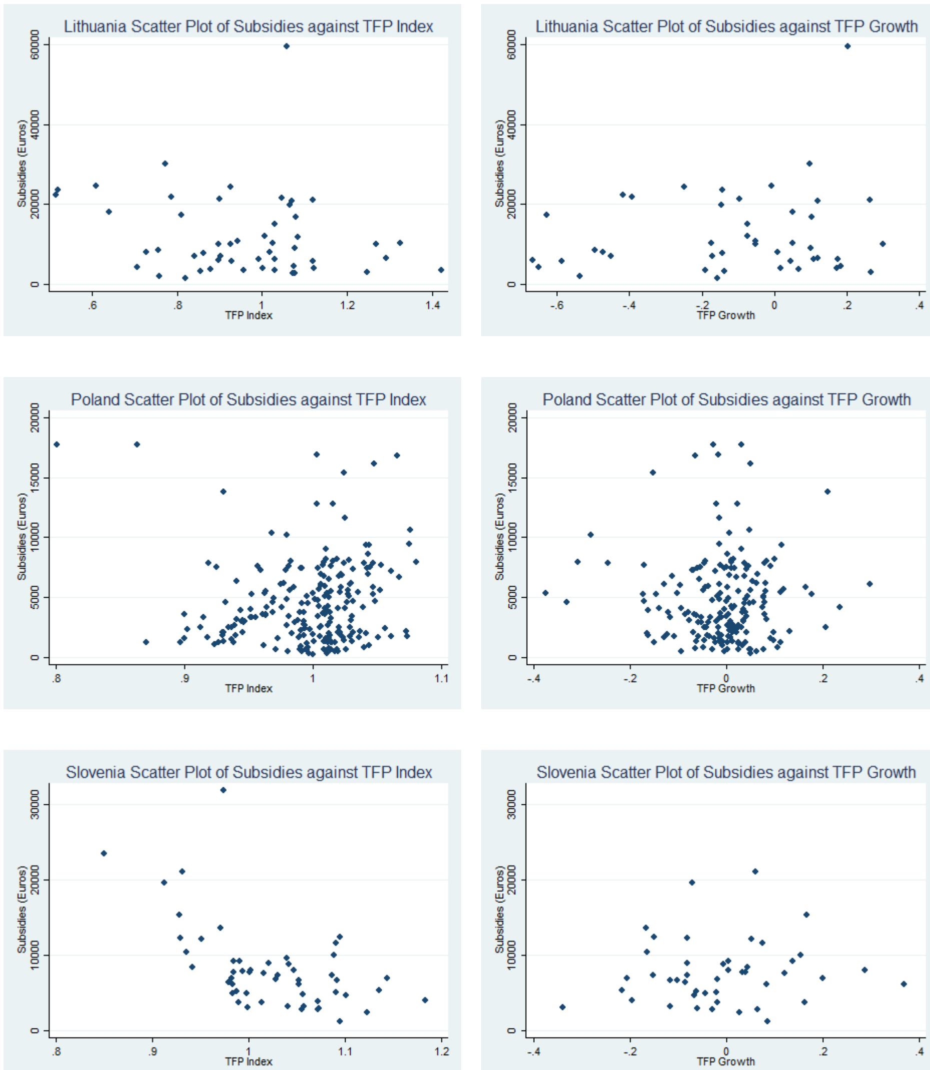
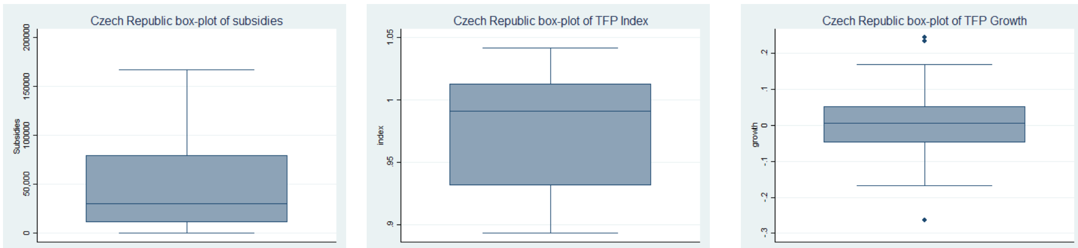
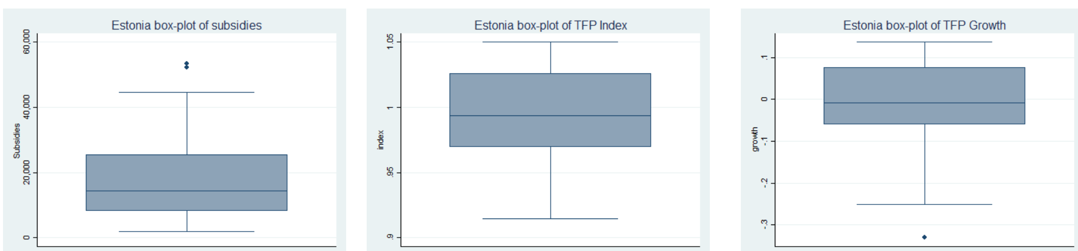


Figure A.3: Box Plots for Czech Republic



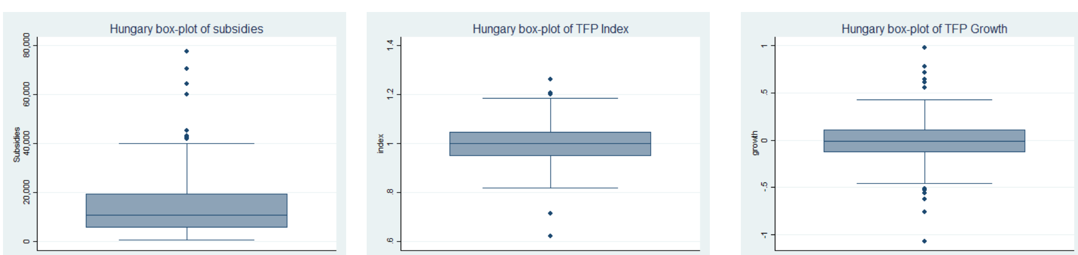
(a) Subsidies (b) TFP Index (c) TFP Growth

Figure A.4: Box Plots for Estonia



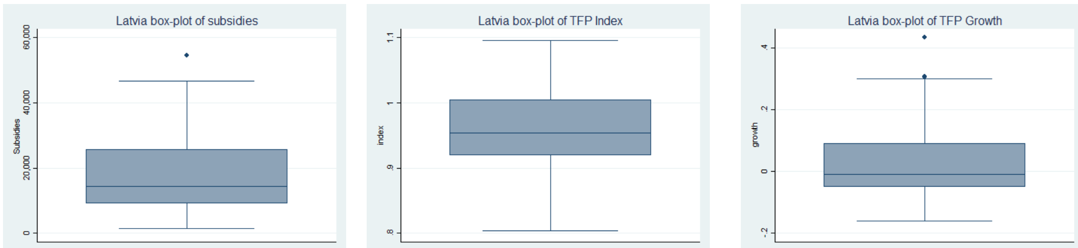
(a) Subsidies (b) TFP Index (c) TFP Growth

Figure A.5: Box Plots for Hungary



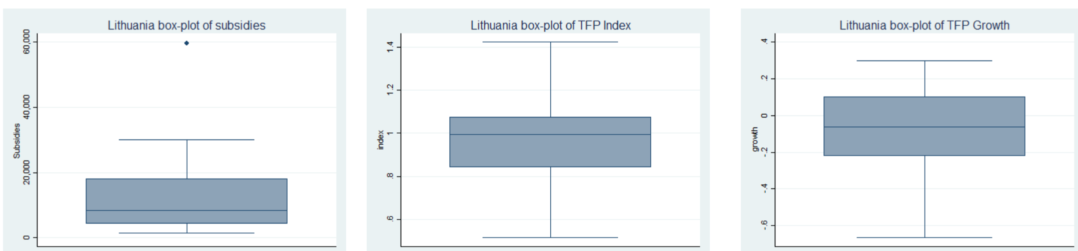
(a) Subsidies (b) TFP Index (c) TFP Growth

Figure A.6: Box Plots for Latvia



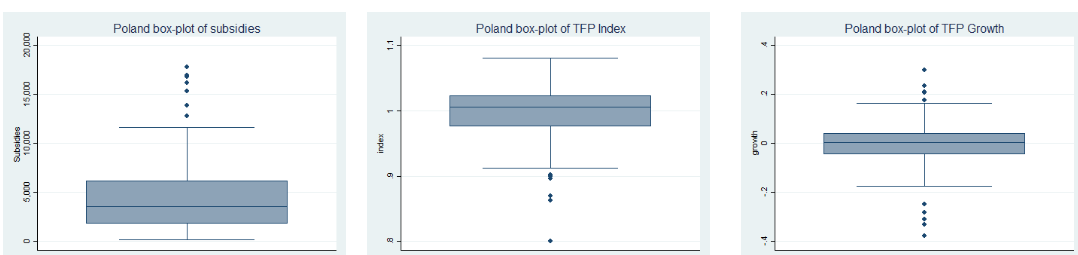
(a) Subsidies (b) TFP Index (c) TFP Growth

Figure A.7: Box Plots for Lithuania



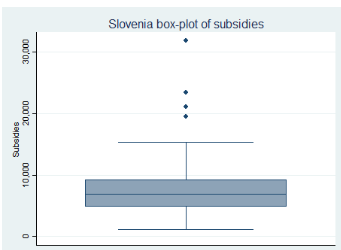
(a) Subsidies (b) TFP Index (c) TFP Growth

Figure A.8: Box Plots for Poland

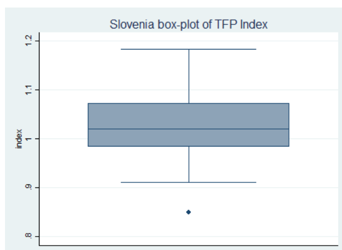


(a) Subsidies (b) TFP Index (c) TFP Growth

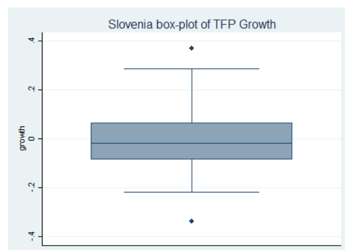
Figure A.9: Box Plots for Slovenia



(a) Subsidies



(b) TFP Index



(c) TFP Growth

Appendix B

Graphs of TF8 Markets

Note that in graphs where nations are not included, means that there was no data from the FADN sample for that particualar TF8 market.

Figure B.1: Graphs summarising Output from TF8 Markets

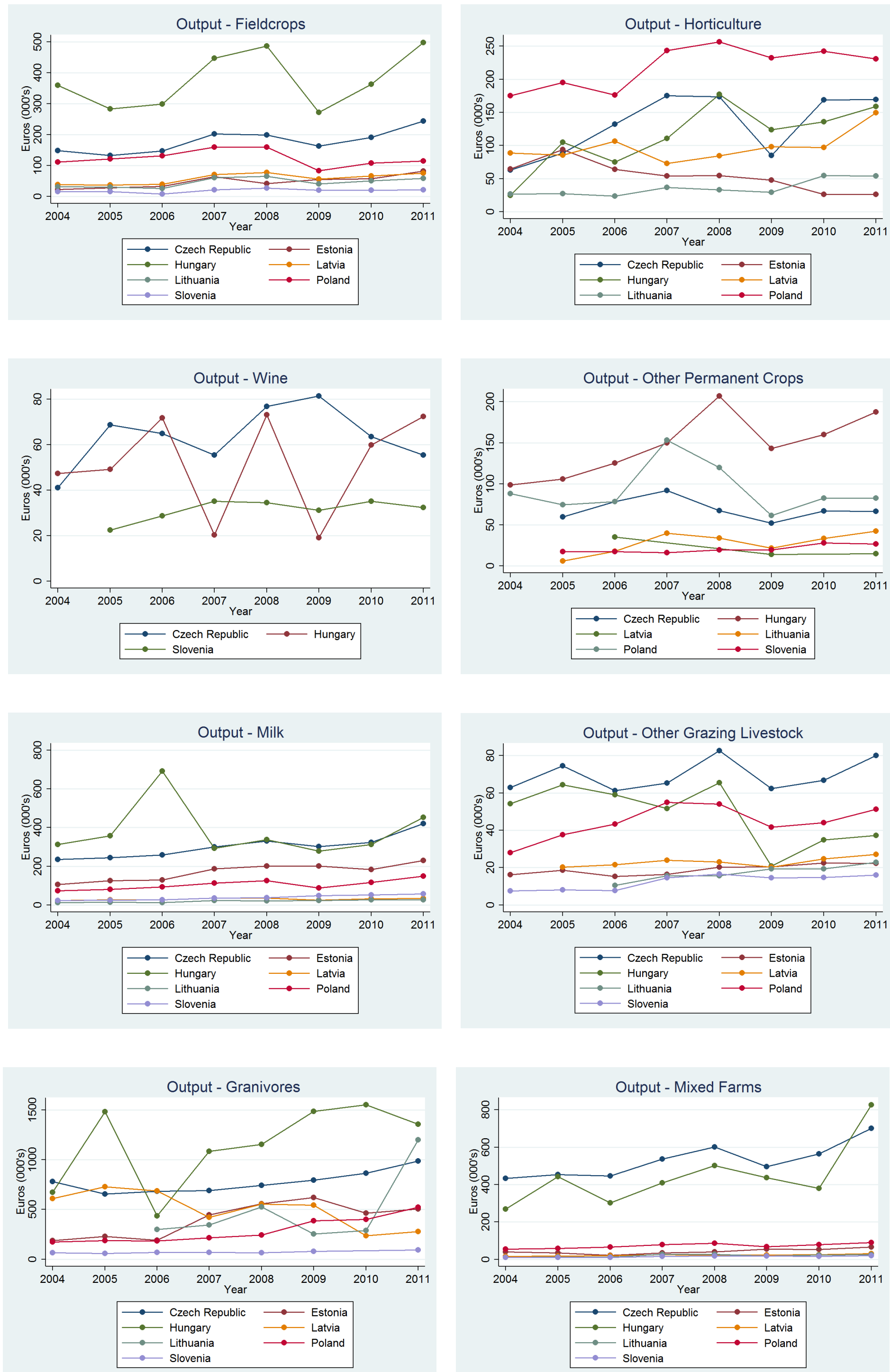


Figure B.2: Graphs summarising Capital from TF8 Markets

Figure B.3: Graphs summarising Investment from TF8 Markets

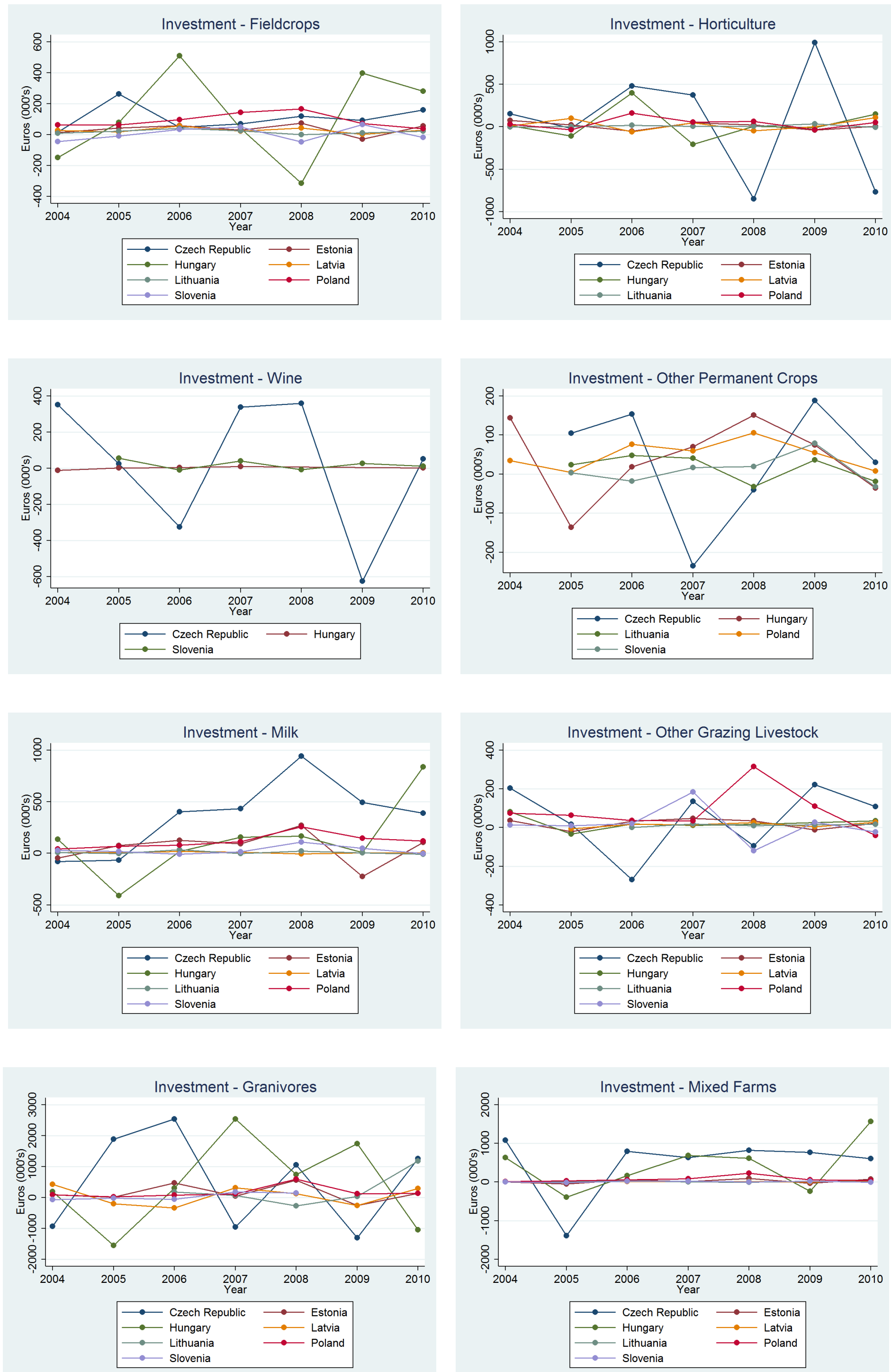


Figure B.4: Graphs summarising Labour from TF8 Markets

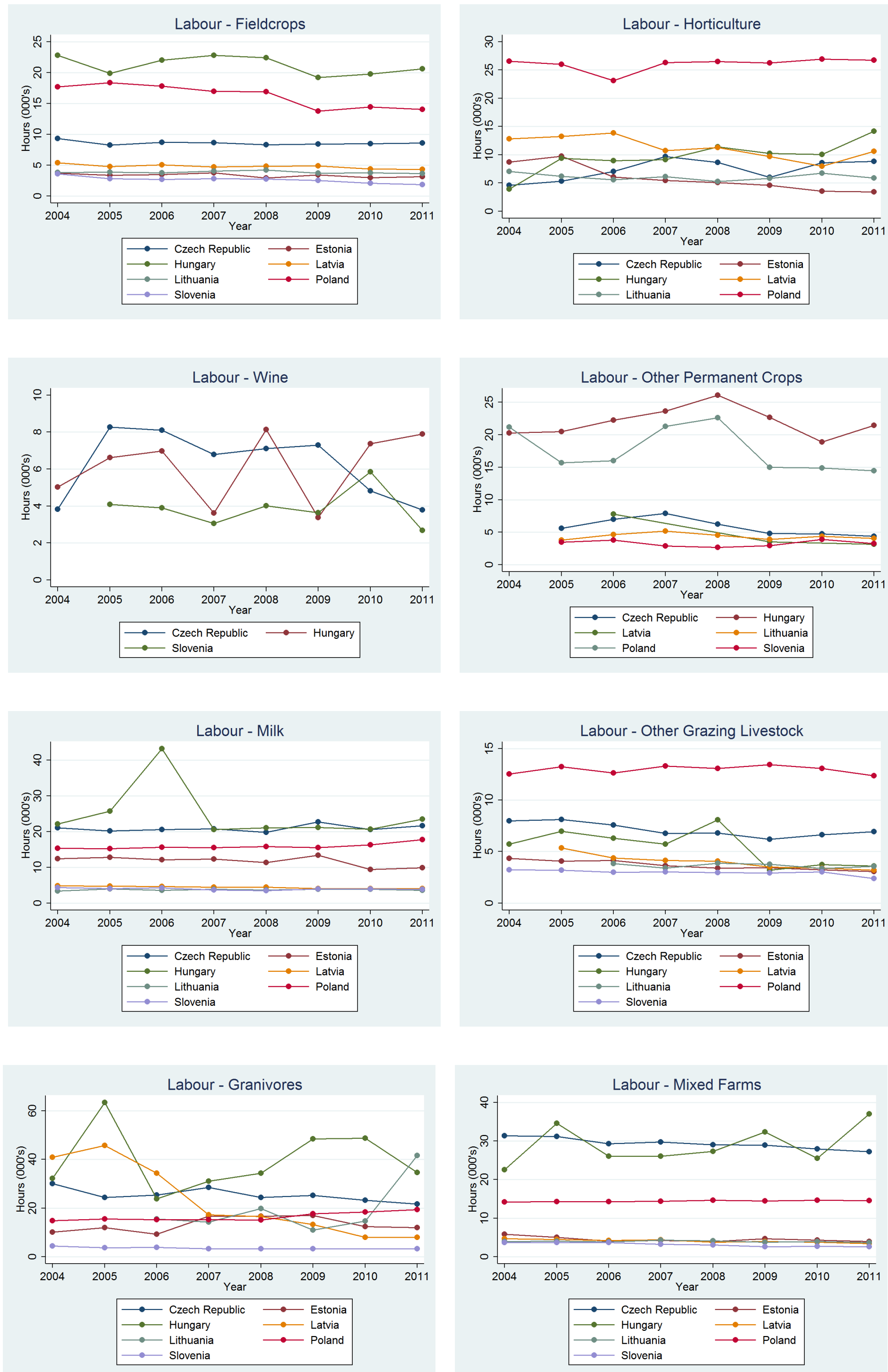


Figure B.5: Graphs summarising Materials from TF8 Markets

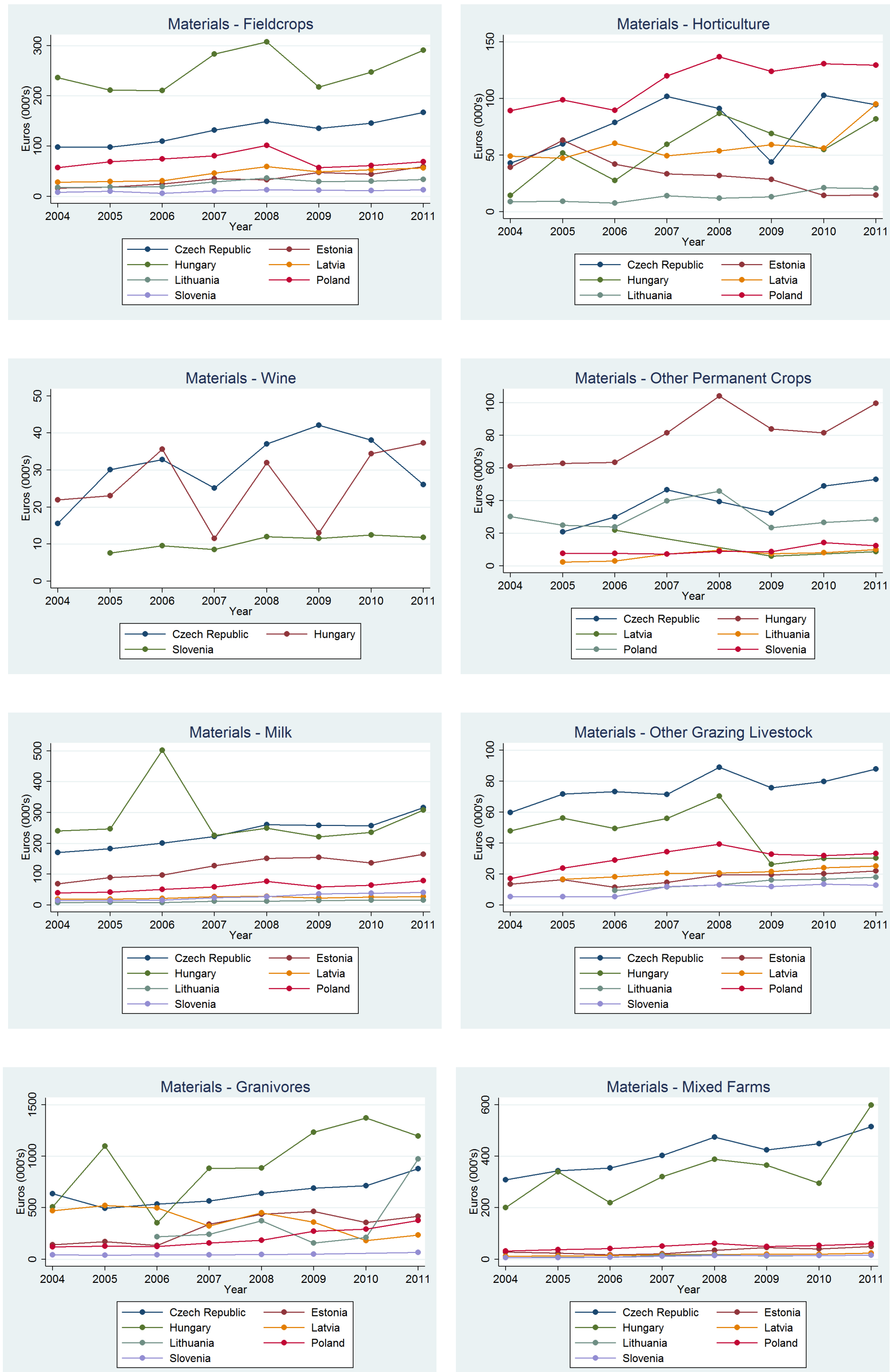
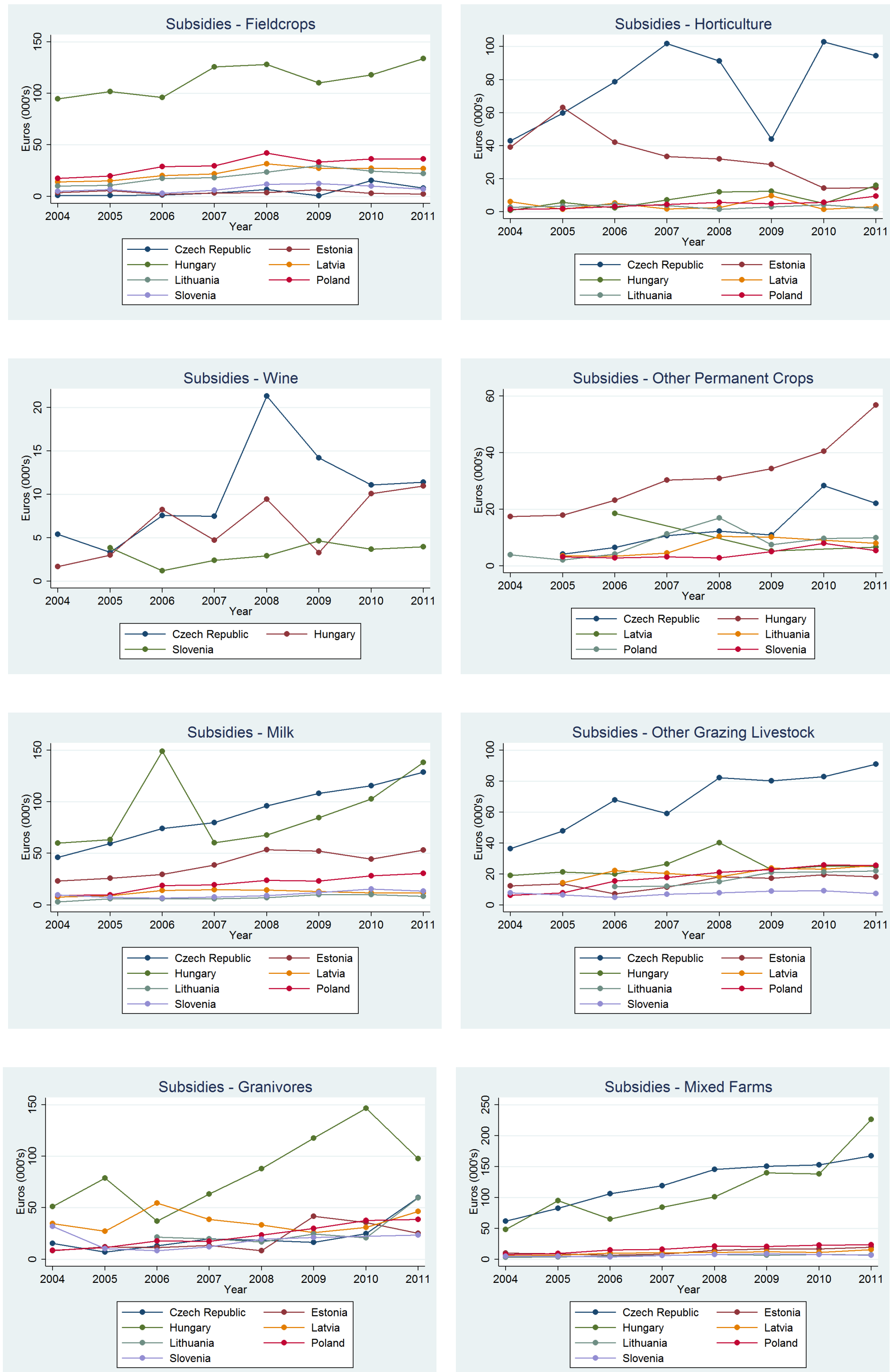


Figure B.6: Graphs summarising Subsidies from TF8 Markets



Appendix C

Robustness Check

Note that *** is significance of 1%, ** is significance of 5%, * is significance of 10%.

Table C.1: Estimation results for Czech Republic

Olley Pakes Estimation		
Variable	**Coefficient**	**(Std. Err.)**
capital	0.334*	(0.174)
labour	6.68-e06	(0.000)
materials	1.50e-06	(0.000)
Levinsohn and Petrin Estimation		
Variable	**Coefficient**	**(Std. Err.)**
capital	0.137*	(0.119)
labour	0.00003	(0.000)
investment	-0.097	(0.091)
OLS Estimation		
Variable	**Coefficient**	**(Std. Err.)**
capital	0.244***	(0.081)
labour	0.00002	(0.000)
materials	2.36e-06***	(0.000)
investment	0.022	(0.070)
Intercept	6.001***	(1.031)
Adj. R^2: 0.92		
Fixed Effects Regression		
Variable	**Coefficient**	**(Std. Err.)**
capital	0.289***	(0.073)
labour	0.00002*	(0.000)
materials	2.03e-06***	(0.000)
investment	0.031	(0.044)
Intercept	7.732***	(0.923)
R^2: 0.92		

Table C.2: Estimation results for Estonia

Olley Pakes Estimation		
Variable	**Coefficient**	**(Std. Err.)**
capitaln	-0.113	(0.285)
labour	0.00001*	(0.000)
materials	5.37e-06*	(0.000)
Levinsohn and Petrin Estimation		
Variable	**Coefficient**	**(Std. Err.)**
capital	0.718***	(0.287)
labour	4.63e-06	(0.000)
investment	-0.104	(0.115)
OLS Estimation		
Variable	**Coefficient**	**(Std. Err.)**
capital	0.494***	(0.149)
labour	0.0001***	(0.000)
materials	1.80e-06**	(0.000)
investment	0.247	(0.203)
Intercept	3.903**	(1.77)
Adj. R^2: 0.89		
Fixed Effects Regression		
Variable	**Coefficient**	**(Std. Err.)**
capital	0.916***	(0.135)
labour	0.0001***	(0.000)
materials	1.00e-06	(0.000)
investment	0.371***	(0.112)
Intercept	-1.021	(1.722)
R^2: 0.86		

Table C.3: Estimation results for Hungary

Olley Pakes Estimation		
Variable	**Coefficient**	**(Std. Err.)**
capital	0.436**	(0.212)
labour	0.00002	(0.000)
materials	6.01e-06	(0.000)

Levinsohn and Petrin Estimation		
Variable	**Coefficient**	**(Std. Err.)**
capital	0.678***	(0.112)
labour	-0.00001	(0.000)
investment	0.012	(0.021)

OLS Estimation		
Variable	**Coefficient**	**(Std. Err.)**
capital	0.602***	(0.056)
labour	0.00001	(0.000)
materials	5.22e-06***	(0.000)
investment	0.108***	(0.036)
Intercept	3.833***	(0.676)
Adj. R^2: 0.79		

Fixed Effects Regression		
Variable	**Coefficient**	**(Std. Err.)**
capital	0.522***	(0.054)
labour	8.76e-07	(0.000)
materials	2.50e-06***	(0.000)
investment	0.014	(0.030)
Intercept	4.389***	(0.649)
R^2: 0.76		

Table C.4: Estimation results for Latvia

Olley Pakes Estimation		
Variable	**Coefficient**	**(Std. Err.)**
capital	0.029	(0.327)
labour	0.0001	(0.000)
materials	4.44e-06***	(0.000)

Levinsohn and Petrin Estimation		
Variable	**Coefficient**	**(Std. Err.)**
capital	0.314	(0.236)
labour	3.18e-06	(0.000)
investment	-0.122	(0.085)

OLS Estimation		
Variable	**Coefficient**	**(Std. Err.)**
capital	0.719***	(0.135)
labour	0.00003**	(0.000)
materials	1.24e-06	(0.000)
investment	0.331*	(0.204)
Intercept	2.008	(1.525)
Adj. R^2: 0.89		

Fixed Effects Regression		
Variable	**Coefficient**	**(Std. Err.)**
capital	0.366***	(0.084)
labour	-7.21e-06	(0.000)
materials	3.43e-06***	(0.000)
investment	0.098	(0.082)
Intercept	6.377***	(0.989)
R^2: 0.88		

Table C.5: Estimation results for Lithuania

Olley Pakes Estimation		
Variable	**Coefficient**	**(Std. Err.)**
capital	0.634	(0.475)
labour	0.0004***	(0.000)
materials	-0.00001	(0.000)

Levinsohn and Petrin Estimation		
Variable	**Coefficient**	**(Std. Err.)**
capital	1.33***	(0.412)
labour	0.0003**	(0.000)
investment	0.288	(0.266)

OLS Estimation		
Variable	**Coefficient**	**(Std. Err.)**
capital	0.971***	(0.107)
labour	0.0003***	(0.000)
materials	-0.00001***	(0.000)
investment	-0.182	(0.148)
Intercept	-1.936	(1.275)
Adj. R^2: 0.92		

Fixed Effects Regression		
Variable	**Coefficient**	**(Std. Err.)**
capital	1.083***	(0.104)
labour	0.0001	(0.000)
materials	-2.99e-06	(0.000)
investment	-0.014	(0.120)
Intercept	-2.531**	(1.256)
R^2: 0.87		

Table C.6: Estimation results for Poland

Olley Pakes Estimation		
Variable	**Coefficient**	**(Std. Err.)**
capital	0.058	(0.087)
labour	0.0002***	(0.000)
materials	0.00002***	(0.000)

Levinsohn and Petrin Estimation		
Variable	**Coefficient**	**(Std. Err.)**
capital	0.142	(0.116)
labour	0.0001***	(0.000)
investment	0.060***	(0.021)

OLS Estimation		
Variable	**Coefficient**	**(Std. Err.)**
capital	0.436***	(0.065)
labour	0.0002***	(0.000)
materials	0.00002***	(0.000)
investment	0.164***	(0.044)
Intercept	3.738***	(0.751)
Adj. R^2: 0.81		

Fixed Effects Regression		
Variable	**Coefficient**	**(Std. Err.)**
capital	0.208***	(0.041)
labour	0.0002***	(0.000)
materials	7.64e-06***	(0.000)
investment	-0.005	(0.026)
Intercept	6.582***	(0.508)
R^2: 0.74		

Table C.7: Estimation results for Slovenia

Olley Pakes Estimation		
Variable	**Coefficient**	**(Std. Err.)**
capital	0.046	(0.525)
labour	0.0003**	(0.000)
materials	0.00007***	(0.000)

Levinsohn and Petrin Estimation		
Variable	**Coefficient**	**(Std. Err.)**
capital	0.084	(0.571)
labour	0.0002**	(0.000)
investment	-0.105	(0.418)

OLS Estimation		
Variable	**Coefficient**	**(Std. Err.)**
capital	0.447**	(0.197)
labour	0.0002***	(0.000)
materials	0.00005***	(0.000)
investment	-0.104	(0.256)
Intercept	13.961***	(2.353)
Adj. R^2: 0.75		

Fixed Effects Regression		
Variable	**Coefficient**	**(Std. Err.)**
capital	0.603**	(0.266)
labour	0.00008	(0.000)
materials	0.00004***	(0.000)
investment	0.086	(0.183)
Intercept	2.209	(3.256)
R^2: 0.60		