The effect of the 2003 CAP reform on investments of European farms

An econometric panel data study

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Preface

This is it!

It is almost the end of my masters in Economics, Environment and Policy. I never thought that agricultural economics would become my specialisation, but it did. The main reason for this was that the econometric courses belonged to the Agricultural Economics and Rural Policy (AEP) group and during my bachelor thesis I already experienced the fun of econometric research. Since I like to work with numbers, the choice was easily made to do something with econometrics again. The topic was chosen in association with the University of Rennes in France, since I would write half of the thesis there. However, due to circumstances this cooperation did not continue.

Writing this thesis was something I really dreaded, but six months later the time seems to have flown by. First of all I would like to thank my supervisor dr. ir. Peerlings for that. Many times I got lost or I got stuck with the data, but thanks to the ideas and support of my supervisor I always found my way out. His encouragement and enthusiasm really helped me a lot. Secondly I want to thank all my friends who helped me getting through the days at the Leeuwenborch with having lunch and coffee together. I am also thankful to the friends who mentally supported me, a pep talk really helps a lot! I also want to thank Robin for his care, motivation and understanding while writing this thesis. At last but not least I would like to thank my parents, for giving me the opportunity to study, giving me everything I need and supporting me in what I am doing. Thank you all!

The next and last thing I have to do for finalizing my masters is an internship at Rabobank International. The topic of this thesis helped me getting this internship, what makes this thesis very valuable for me. So by September I am done, finished! Five years of studying flown by.

Goodbye student life, welcome working life!

Inge Koster

April 2012, Wageningen

Summary

In 2003 the European Union reformed the Common Agricultural Policy (CAP) and introduced the Single Payment Scheme (SPS). This means that income payments are no longer related to what and how much farmers produce and therefore it guarantees farmers a stable income component. The 2003 CAP reform may have increased investments since a stable income component reduces the risk of investing. However, since the support is not coupled to production anymore the profitability of agriculture reduced, what makes investing in agriculture less attractive. The amount of the farm payments is based on historical support levels or production, also called *grand-fathering*.

The main question of this thesis is whether or not the 2003 CAP reform influenced farmers' investments decisions. Other questions considered in this thesis are "What determines investments?" and "What determines farm resilience according to the estimation results?".

There is not just one way to determine investments. The basis of investment decision-making is the trade-off between investment costs and returns. Irreversibility, uncertainty and timing are important characteristics of investments. The net present value theory, option theory and adjustment cost theory all include different factors to explain farm investments. The net present value method focusses on the *discount rate, investment returns* and *salvage value* as explanatory variables for investment behaviour. The option theory adds to these factors the *option to wait*. The adjustment cost theory includes the *adjustment costs, depreciation, input-* and *output prices* as variables. Olsen and Lund (2009) include in their model several *socioeconomic factors* and *investment incentives*. Also *net income after tax* is a relevant variable for farmers.

A combination of factors from the different theories is used to create an empirical investment model estimated with data from the Farm Accountancy Data Network (FADN). Data is selected for 12 continuing years (1998-2009) and two sectors (field crops and milk) for eight European countries who base their SPS on grandfathering. The empirical model consists of the dependent variable *gross investment on fixed assets* and the explanatory variables *economic size, yield, subsidies, farm net income* and *liabilities* and the dummy variable *capreform,* which takes the 2003 CAP reform into account.

The model is estimated using cross-section data with OLS and SUR and using panel data with the fixed effects and first differences methods in OLS and SUR. Considering that the data is panel data (no cross-section data) and the first differences regression led to an inappropriate model with a very low goodness of fit, the best way of estimating is with the fixed effects method. Choosing between OLS and SUR is a bit harder but it is better to

choose OLS when the differences are that small. The next conclusions are therefore based on the results from the estimation with the fixed effects regression in OLS.

The resilience of a company is the ability and capacity to survive discontinuities. The 2003 CAP reform is considered to be such a discontinuity, since it disturbs the financial situation of a farmer. Investments are assumed to be a positive indicator for resilience since the farming business cannot continue without investments made. Investments increase the adaptive capacity of a farm. So if investments are a positive measure for resilience, then the results suggest that subsidies have a positive effect on resilience (investment) of the farm in both the field crops and milk sector. In the field crops sector also the farm’s net income and the economic size are important factors explaining resilience (investment) . The larger the farm and the higher the net farm income and subsidies, the better the resilience of a farm in the field crops sector. However, the 2003 CAP reform has a negative effect on the investments made in the field crops sector. This implies that the 2003 CAP reform did not improve the resilience of farms in the field crops sector. However, in the milk sector the 2003 CAP reforms shows no significant effect on investments. Remarkable is that subsidies have a significant effect in this sector, so government policy does effect the investment behavior of European farmers in both the field crops sector and the milk sector.

Content

1 Introduction

The European Union (EU) is known for its large government support programs for the agricultural sector. One third of the value of agricultural gross-production in 2003 consisted of subsidies (OECD, 2005), what corresponds to €775 per hectare of utilized agricultural land in the EU. This is more than seven times bigger than the agricultural support in the US (Happe et al., 2008). However, in 2003 the European Union reformed the Common Agricultural Policy (CAP) and introduced the Single Payment Scheme (SPS). In contrast to the former system of price support, SPS is a decoupled direct income payment system. This means that the income payment is no longer related to the current volume of commodity output and is directly paid to the farmer on an annual basis (EAAP, 2008; European Commission, 2009). After the CAP reform in 2003 there has been a Health Check in 2008, which increased the percentage of agricultural support that should be decoupled from 85% by 2008 to 92% by 2013 (European Commission, 2011a).

With the SPS system producers receive their income from the market plus the direct income payment from the government. The amount of the direct income payment (the so-called farm payments) is in most countries based on historical support levels or production (see appendix A), also called *grandfathering* (Jongeneel and Brand, 2010). The main objective of decoupled direct income payments is to guarantee farmers a more stable income independently of what and how much they produce (European Commission, 2009). In exchange, farmers have to comply with standards for environmental protection, animal welfare, food safety and soil care. This is called cross-compliance (see Jongeneel and Brand (2010) for more details). Farmers are now encouraged to base their production decisions on market demands (European Commission, 2011a). Supporting systems in the past, price support and coupled direct income support, stimulated production, which influenced world market prices and therefore caused unfair competition between countries. Without this support coupled to production, both the world market and the domestic market function better (Jongeneel and Brand, 2010).

The 2003 CAP reform changed the financial situation of European farmers. This can influence the resilience of the farm. Resilience is defined in Dalziell and McManus (2004) as: *“Resilience expands on vulnerability and may be viewed as the qualities that enable an individual, community or organization to cope with, adapt to and recover from a disaster event.”* Polman et al. (2010) defined resilience as *”The ability of a complex system to maintain its structural and functional capacity after a disturbance of the system.”* The resilience of a company is the ability and capacity to survive discontinuities. Of big importance is that the company can adapt easily to the new situation (Starr et al., 2003). A big policy change, like the 2003 CAP reform, can be seen as a disturbing factor in the financial situation of a farmer. The organization of the farm is an important factor in the resilience level of a farm (Polman et al., 2010). Investment decisions are part of the farm management and strategy. Investments are assumed to be a positive indicator for resilience since the farming business cannot continue without investments made. According to Gardebroek and Peerlings (2011) investment decisions are essential in farming, since it has a significant effect on the development of a farm. Making investments increases the adaptive capacity of a farm. So, farmers who invest are supposed to have a more resilient farm business than those who do not invest (that much).

The investment theory is about the factors that play a role in deciding whether to invest or not. The basis of investment decision-making is the trade-off between investment costs and returns (Goetzmann, 1997). Investments can be real investments (e.g. machines, buildings) or financial investments (e.g. securities, bank deposits). In exchange for these investments a future cash return is expected (Vasavada and Chambers, 1986). In this thesis I focus on agricultural real investment, which affects the productivity and income development of the farmer. Investments have three important characteristics. First, investments are more or less *irreversible*, which makes the investment (partially) a sunk cost. Second, investments are associated with *uncertainty*, which makes future investment returns precarious. Third, there is some space for *timing* when making an investment (Dixit and Pindyck, 1994).

Investment decisions of farmers might have changed since the 2003 CAP reform. During the price support system there was an incentive to invest and increase production since more products led to more subsidy. The 2003 CAP reform may have increased wealth and investments by risk-averse farmers (OECD, 2001; Anton and Mouel, 2004) because having a stable income component reduces the risk of investing. Even in the absence of risk aversion, a direct payment may stimulate farm investment (Vercammen, 2007). So, according to Vercammen (2007) there are more farm investments made since the 2003 CAP reform. As a result, this might have a positive influence on the resilience of the farms. Li et al. (2010) show that investments in agriculture increase resilience rapidly. However, the farm payments substitute coupled support which has reduced the profitability of agriculture, what makes investing in agriculture less attractive. Moreover, reduction of price support could increase price risk and higher risk also negatively affects investment levels (Jongeneel and Brand, 2010). In that case resilience of the farms will decrease as a result of the CAP reform. However, also other factors may play a role in investing e.g. policy uncertainty and the farmer’s time horizon.

Studies have already investigated resilience of agricultural systems (e.g., Li et al., 2011; Milestad and Darnhofer, 2003) and consequences of the 2003 CAP reform on farm structure (Brady et al., 2009; Happe et al., 2008; Schmid and Sinabell, 2007). In this thesis I will try to investigate whether or not the 2003 CAP reform influenced European farmers' investments decisions. Four research questions are formulated:

- What determines investments?
- What determines farm resilience according to the estimation results?
- Did the 2003 CAP reform influence farmers' investment decisions?

The research will be applied to data from eight European countries. All these countries used historical data (reference period 2000-2002) to determine the level of decoupled income support. Data from the Farm Accountancy Data Network (FADN) is used to construct a panel data set with annual data between 1998 and 2009. Panel data techniques are used to answer the research questions.

Next, chapter 2 provides a theoretical background on what determines investment using different investment theories. Chapter 3 will outline the data used, the empirical model and the estimation methods. Chapter 4 shows the econometric research results on the influence of the 2003 CAP reform on farmers' investment decisions. Finally, conclusions and a general discussion will be provided in chapter 5.

2 Investment theories

In this chapter I will answer the research question of this thesis on what determines investments. Section 2.1 will discuss the net present value theory and the option theory. The adjustment cost theory is based on a dynamic model and is discussed in section 2.2. In section 2.3 other investment theories are outlined. Finally, a brief conclusion is given in section 2.4.

2.1 Net present value theory

The first method to consider is the net present value (NPV) method, which takes the time value of money into account. €1 today has a not the same value as €1 in the future, this is the time-value-of-money (Gardebroek and Peerlings, 2011). For example, if you receive €500 next year with an interest rate of 5% it has a value today of €500/1.05=€476.19. If you receive the €500 two years from now, it has a present value of €500/(1.05)^2=€453.51.

In the net present value method the investment returns of each year (P_1,P_2,..,P_n) are discounted to its present value and are summed up to the net present value (NPV). Any salvage or terminal investment value (V_n) should be included in the NPV. If this net present value is bigger than the initial investment (INV), then it is profitable to make the investment. In the following model the discount rate is i and the length of the planning horizon of the investment is n. The (static) net present value model is set up as follows:

$$\mathrm{NPV} = -INV + \frac{P1}{1+i} + \frac{P2}{1+i^{\ 2}} + \cdots + \frac{Pn}{1+i^{\ n}} + \frac{Vn}{1+i^{\ n}} \qquad (2.1)$$

If the NPV is positive, the investment should be done; if it is negative, the investment should be rejected. Appendix B1 shows an example of the NPV method. The *internal rate-of-return* (IRR) is the discount rate i that results in a NPV equal to zero. Investment returns are in this case equal to the initial investment (Barry et al., 2000). The discount rate can therefore be seen as an important factor in investment behaviour. Also risks are taken into account in the discount rate i (Goncharova, 2007).

However, when dealing with investments there is often the option to wait. When factors are uncertain, it might be better to wait with the investment until more information is available. This is called the real option theory. Uncertainties are caused for example by government policies, price and output fluctuations, upcoming technical innovations, etc. The NPV method ignores the opportunity cost of investing now, compared to the option to wait. Investing now “kills” the option to wait and the value of that option can be calculated in the real option theory (Gardebroek and Peerlings, 2011).

In the option theory the expanded NPV (equation 2.2) is calculated by the NPV model (equation 1), including the option to wait (Alleman and Noam, 1999; Trigeorgis, 2001; Kim and Sanders, 2002). With this method risk due to uncertainty is smaller. The expanded NPV model is set up as follows:

Expanded NPV = NPV + value of options from active management (2.2)

The option value is positive for risk-neutral and risk-averse farmers, resulting in a less than optimal investment according to NPV levels (Goncharova, 2007). There may also be a cost when an investment is delayed (e.g. foregone cash flows), but this should be weighted against the value of waiting due to less uncertainty (Gardebroek and Peerlings, 2011). However, it is very hard to measure the value of waiting, since uncertainty, timing and irreversibility are difficult to measure. Moreover, the static NPV method can predict how much we would invest if certain factors change but it lacks in explaining how these changes arise (Gardebroek and Oude Lansink, 2008). A numerical example of the option theory is given in appendix B2.

The 2003 CAP reform can influence the net present value of an investment. Direct payments provide the farmers a stable income component, which reduces the risk of investing. This will be reflected in a lower discount rate i. The costs of investments will be lower, and investing will become more interesting. In case of the option theory, the uncertainty due to the governmental policy change can be reduced. In 2003 the direct payments were introduced, in 2004 there might have been a more precise indication of the effect on the discount rate.

2.2 Adjustment cost theory

The second method used for investment measurement is the adjustment cost theory. This dynamic method is based on the idea that variables change over time, so any action today will also affect the future. E.g. buying an agricultural machine today will increase the capital stock directly, but it will also affect the future and the financial situation. The NPV method ignores this, so changes in between periods (e.g. increased output) are not considered there (Gardebroek and Oude Lansink, 2008).

The adjustment cost theory is about the adjustment of quasi-fixed factors (e.g. capital, land and labour). The main components of this model are uncertainty and adjustment costs (e.g. searching costs, administrative fees, licences etc.). The theory states that firms suffer from additional costs (short-run output loss) when changing their stocks of quasi-fixed factors (Gardebroek and Oude Lansink, 2008; Vasavada and Chambers, 1986). In the adjustment cost model, investment is included as a factor in the production function (f):

y = f(L, K, I).

Output y is produced by variable factors (L) and quasi-fixed factors (K); I represents gross investments in quasi-fixed factors (Vasavada and Chambers, 1986)). Gardebroek and Peerlings (2011) show that there is a relationship between capital stocks in different years *t*, investment *I* and depreciation *d:*

$$I_t = K_{t+1} - (1\text{-}d)K_t \qquad (2.3)$$

So, the amount invested in year t is equal to the capital stock in year t+1 minus the depreciation of the capital stock in year t. Investment I_t is part of the function to maximise cash flows:

$$\max CF = E \left[\sum_{t=1}^{H} \left(\frac{1}{1+r}\right)^{t} \left(\pi_t \left(p, w, K_t, G_t, L_t, t \right) - p_t^I I_t - \varphi \left(I_t \right) \right) \right] \qquad (2.4)$$

When maximising the expected (E) discounted future cash flows (CF) short-run profits, cost of investments and adjustment costs are taken into account. H indicates the number of years over which the firms optimises. The short run profits (π) are determined by output prices (p), input prices (w), capital goods (K), land (G) and labour (L). Investment (I_t) times the price of the invested capital good (p_t^I) is the investment cost. The last term represents the adjustment cost φ of an investment (I_t), which is zero when there are no investments made (Gardebroek and Peerlings, 2011).

Government policy changes over time, which causes uncertainty by farmers who are willing to invest. This is also the case with the 2003 CAP reform. When switching from coupled payment to decoupled payments the adjustment costs might become less. With a more stable income uncertainty is reduced and it will be easier to get a loan, so costs for searching a lender will be less and investing becomes more attractive.

2.3 Other theories

There are a lot of factors that influence investment behaviour of a farmer. Olsen and Lund (2009) present a conceptual model of the analysis of farmers' investment behaviour (figure 1). This model shows that investment behaviour in agricultural assets is determined by investment incentives and socioeconomic factors. The socioeconomic factors used are *off-farm income, farm income, size, debt, management, interest rate, age of the farmer* and *years of settlement* (Olsen and Lund, 2009). The incentive to invest might for example be generated by policy changes, like the 2003 CAP reform.

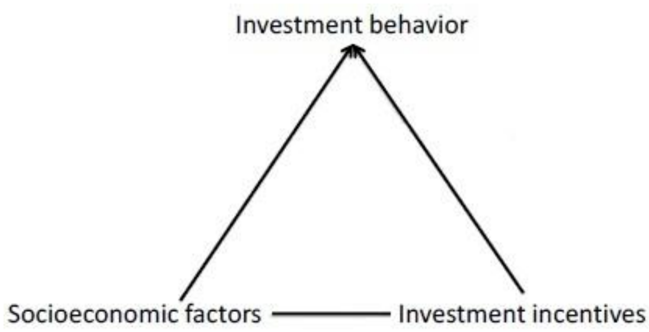

Figure 1. Conceptual model of the analysis of farmers' investment behaviour

Source: Olsen and Lund, 2009

To investigate investments we need to identify the factors that influence the farmer's decision whether to invest or not. For policy makers it is important to know what those factors are, in order to investigate how new policy influences farmers' investment behaviour (Olsen and Lund, 2009). Olsen and Lund (2009) show that a reduction of risks is for half of the Danish pig farmers an incentive to invest in land. So, if the 2003 CAP reform reduces risk since the subsidy is a direct payment, it will increase the investments made. Investments in land are mainly based on the farmer's perceptions of the future economic conditions for farming; ensuring future investment possibilities. Future prospects are believed to be a more important investment factor than interest rates. The most important reason to invest in machinery is that the old machinery is worn out (Olsen and Lund, 2009).

2.4 Conclusion

Concluding we can say that there are a lot of different factors that influence farmers' investment behaviour. Summarizing the theories, the net present value method focusses on the *discount rate, investment returns* (*input-* and *output prices* included) and *salvage value* as explanatory variables for investment behaviour. The option theory adds to this the *option to wait*. The adjustment cost theory includes the *adjustment costs, depreciation, input-* and *output prices* as variables. Olsen and Lund (2009) include in their model several *socioeconomic factors* and *investment incentives*. Also taxes might influence investment behaviour as *net income after tax* is the relevant variable for farmers (Jorgenson, 1971).

3 Data, Empirical model and Estimation

This chapter provides a description of the data, specification of the empirical model and the estimation procedure used. Section 3.1 gives an overview of the data available. In section 3.2 we try to link the investment theory of chapter 2 with the available data discussed in 3.1. The last section, 3.3, gives a brief description of the estimation procedure.

3.1 Data

In this thesis a panel data set is used. The data set is mainly created from the European Farm Accountancy Data Network (FADN). The FADN data is used as an instrument for evaluating the impact of the CAP on agricultural firms, so it perfectly fits the goal of this thesis. The FADN dataset consists of annual data of 80.000 holdings, representing about 6.4 million farms in the EU-27 (including Bulgaria and Romania) (European Commission, 2010). Also some data from Eurostat is used, which is just like the FADN a database of the European Union.

To create my own panel data set I used data from eight European countries, which all base their single farm payments on historical data with reference period 2000-2002. The countries used are Austria, Belgium, France, Ireland, Italy, the Netherlands, Portugal and Spain. The year of implementation of the single farm payment differs a little between the countries. This might influence the results, but due to a lack of information I am not able to take this into account (see also appendix A). The panel data set includes a sample of countries from 1998-2009, so twelve continuing years will be used. 2009 is the most recent year for which information is available, 1998 is arbitrarily selected to get a time period before the 2003 CAP reform that is not too long compared to the period after the implementation.

Table 3.1 shows which variables are available in the panel data set for all eight countries in all continuing years between 1998 and 2009. Data is available for eight different agricultural sectors. I will focus on the sectors field crops and milk as these sectors are relevant for all selected countries and data is available for all years and countries.

Table 3.1 Panel data variables

Variable	**Label**	**Description**	**Unit**
machine	*Machinery*	Machines, tractors, cars and lorries, irrigation equipment [1]	euro
building	*Buildings*	Buildings and fixed equipment belonging to the holder [1]	euro
land	*Land, permanent crops & quotas*	Agricultural land, permanent crops, improvements to land, quotas and other prescribed rights and forest land [1]	euro

gross_inv_fa	*Gross investments in fixed assets*	Purchases - sales of fixed assets + breeding livestock change of valuation [1]	*100 euro
net_inv_fa	*Net investments on fixed assets*	Gross Investment – depreciation [1]	euro
eco_size	*Economic size*	Economic size of holding expressed in European size units. Total standard gross margin in euro / 1200 [1]	/10 ESU
sfp	*Single Farm Payment*	Single farm payment	euro
tfa	*Total fixed assets*	Agricultural land and farm buildings and forest capital + buildings + machinery and equipment + breeding livestock [1]	euro
fieldcrops	*Field crops*	Dry pulses, potatoes, sugar beet, herbaceous oil seed and fibre crops including seed (excluding cotton), hops, tobacco, other industrial crops (including cotton and sugar cane), grass seeds and other seeds [1]	ha
yield	*Total crops output / ha*	= [Sales + farm use + farmhouse consumption + (closing valuation – opening valuation)] / ha [1]	*10 euro
t_input	*Total inputs*	= Specific costs + overheads + depreciation + external factors. Costs linked to the agricultural activity of the holder and related to the output of the accounting year.[1]	euro
farminc_gross	*Gross farm income*	Output - intermediate consumption + balance current subsidies & taxes [1]	
farminc_net	*Farm net income*	Remuneration to fixed factors of production of the farm (work, land and capital) and remuneration to the entrepreneurs risks (loss/profit) in the accounting year [1]	*100 euro
liabilities	*Total liabilities*	Value at closing valuation of total of (long- , medium- or short-term) loans still to be repaid [1]	*100 euro
subsidies	*Total subsidies – excluding on investments*	Subsidies on current operations linked to production (not investments). Payments for cessation of farming activities are therefore not included. Entry in the accounts is generally on the basis of entitlement and not receipt of payment, with a view to obtain coherent results (production/ costs/ subsidies) for a given accounting year 1	*100 euro
gdp_change	*Percentage change in gross domestic product (gdp)*	Index, 2005=100	

[1] European Commission, 2011b

Table 3.1 shows that data are not available for all relevant variables from the investment theories. However, some variables in table 3.1 can function as an indicator for the theoretical variables. Note that not all variables from table 3.1 will be used for estimation, but just a few of them are selected. This will be further elaborated in the next section.

3.2 Empirical model

As mentioned above, I do not have data for all relevant variables. This implies proxies have to be selected for these variables. The empirical model formulated in this section will be used to determine the influence of the 2003 CAP reform on farmers' investment decisions.

The dependent variable in the empirical model (equation 3.1) is *gross investment on fixed assets*. Gross investments on fixed assets is the change in buildings, machinery, land and breeding livestock (see table 3.1 for more details). Data of gross investments are more reliable than net investments, since there are a lot different methods to take depreciation into account. The explanatory variables selected from table 3.1 are economic size, yield, subsidies, farm net income and liabilities. A dummy variable for the 2003 CAP-reform is created, which takes before and after the 2003 CAP reform into account with values of zero and one respectively.

$$I_{ijt} = \beta X_{ijt} + \varepsilon_{ijt} \qquad (3.1)$$

Where *I* is gross investment, β is the vector of coefficients to be estimated, *X* is the vector of the explanatory variables, ε is the vector of error terms, *i* are the countries *(i=1,2,..,8), j* are the sectors field crops and milk, and *t* are the different years *(t=1998,1999,...,2009).*

E*conomic size* of the farm is an indicator for the theoretical variable farm size from the model of Olsen and Lund (2009). Economic size is expected to have a positive influence on the dependent variable because the bigger the economic size of a farm, the bigger the portfolio of investments and the better they are able to use economics of scale (Olsen and Lund, 2009).

Net farm income is an explanatory variable in the investment model of Jorgenson (1971) and it is expected to be positive. Net farm income can also be considered as an indicator for future farm returns, which is an important variable in the net present value and options theory. If net farm income is high, then there is more money to spend and returns are expected to be higher; high net farm income indicates high profitability. Net farm income is considered to be a better variable than gross farm income, since it shows the disposable income of the farm better. *Liabilities* are included as an indicator for the debts of the farm. The variable debt is a socioeconomic factor in de model of Olsen and Lund (2009) and is expected to be negatively related to the investments made; it is not likely that the farmer is going to invest when he has a lot of debts already.

S*ubsidies* is the total amount of money which the farm receives as subsidy, excluding the subsidies on investments. Subsidies are an indicator for government policy which is an investment incentive factor in the model of Olsen and Lund (2009) and is expected to have a positive effect on investment. Direct payments, including single farm payments, are also included in the subsidies variable.

Yield is the total crops output per hectare. It is a productivity measure which is an indicator for the farm management variable from the model of Olsen and Lund (2009) and is expected to be positive. In the milk sector is milk the main activity, but also crops are produced at several farms. In this case the variable yield indicates the ratio of the profitability of producing crops against investing in dairy. Since the main activity is milk less investments will be made if the profitability of crops is increasing. The panel data set with the dependent variable and all explanatory variables explained above is given in appendix C.

Beside the five variables stated above, also a dummy variable is included. For the periods before and after the 2003 CAP reform the dummy variable *capreform* is created. For the year 1998 till 2002 this dummy shows a zero and for the years 2003 till 2009 the dummy will show a one. The interpretation of *capreform* is different for the milk sector. From 2003 till 2005 there was the implementation of direct payments in the milk sector while in the field crops sector direct payments got decoupled.

The adjustment cost theory assumes that any action today will also affect the future, which implies that some variables can better be used in the lagged form. The variables *liabilities* and *net farm income* will be lagged, since it is the past value that influences the decision to invest and not the current value. For example, if I do not lag the variable *liabilities* it would be logic that the liabilities in a specific year are high if the gross investment on fixed assets in that specific year are high, since investing often requires getting a loan. Investing takes time, so current income does not influence investments made, but income from the previous year does. All variables are scaled in order to improve estimation.

3.3 Estimation

In order to estimate the model I will do panel data analysis using the econometric programme Stata. Linear regression in combination with fixed effects (FE) and first differences (FD), which is also a fixed effects method, will be used. FE and FD will be performed with both Ordinary Least Squares (OLS) and Seemingly Unrelated Regressions (SUR) in order to take the effect of correlation between the error terms into account. However, first I will run the model with OLS and SUR assuming the data is a cross-section data set instead of a panel data set.

In case of a cross-section data set the observations will not be linked in a chronological order. Every number is just a random observation, which makes it possible to check whether the explanatory variables do affect the dependent variable in general. With cross-section I assume that the country specific intercept (α_i) is equal for all countries. I am able to include dummies and trends in the model.

Equation 3.2 shows the basic model for panel data, where X_{ijt} is a *K*-dimensional vector (e.g. $x_1, x_2, \ldots, x_k$) and a constant is not included. The eight countries are denoted by *i*, the two sectors by *j*, time by *t* (years 1998 till 2009) and α_i are the country-specific intercepts.

$$I_{ijt} = \alpha_i + X'_{ijt}\beta + \varepsilon_{ijt} \qquad (3.2)$$

FE is commonly used for panel data analysis. With the FE method it is assumed that a country specific effect on gross investment exists (Torres-Reyna, 2011). The disadvantage of FE is that it does not allow for estimating parameters corresponding with time-invariant but country-specific variables (Gardebroek, 2001). With FE I am able to investigate the relation between the dependent and explanatory variables within a country. To calculate fixed effects the averages of a country are used. The averages of each variable for each country in the model are taken and this average is subtracted from every variable (equation 3.3). Equation 3.3 represents the change of a variable with respect to the average of that variable in a specific country and the unit-specific intercept is eliminated as its value is equal to its average value.

$$(I_{ijt} - I_{ij}) = X_{ijt} - X_{ij}\ '\beta + (\varepsilon_{ijt} - \varepsilon_{ij}) \qquad (3.3)$$

The fixed effects model of equation 3.3 will be estimated with both OLS and SUR. With the Seemingly Unrelated Regressions (SUR) method I am able to investigate whether the error terms of the two regression equations are correlated. In other words whether unexpected effects impacted investment in field crops and milk similarly.

Another fixed effects estimation method is first differences regression, which also eliminates the country specific effects α_i. The basic model is equation 3.2 again. The difference with the regular fixed effects method is that not the country average is subtracted, but the observation of the previous year (equation 3.4), so that the yearly changes are used instead of the deviation from the average. This model will also be estimated with OLS and SUR again in order to investigate whether or not the unexpected effects are similar in the two sectors.

$$I_{ijt} - I_{ij,t-1} = \; X_{ijt} - X_{ji,t-1}\;{}'\beta + \;\varepsilon_{ijt} - \varepsilon_{ij,t-1} \qquad (3.4)$$

With the fixed effects and first difference methods it is assumed that α_i is not equal for all countries, due to country specific effects. These effects can be institutional factors like government intervention and political stability. With first differences some caution is needed when including a dummy or trend. For example, if the dummy exists of [0,0,1,1,1] then first differences will give [0,0,1,1,1] – [0,0,0,1,1] = [0,0,1,0,0]. In this case the output will not be relevant. In case of a trend the example will look a little bit different. With first differences you get [1,2,3,...] – [0,1,2,...] = [1,1,1,...], what shows that the trend becomes a constant. The estimated coefficient of the constant will therefore show the trend. With fixed effects a dummy or trend will not be a problem. For example, in case of the trend you get [1,2,3] – [2,2,2] = [-1,0,1], which results still in a trend.

4 Empirical results

This chapter presents the results of estimating the empirical models presented in chapter 3. First the model is estimated as a cross-section with Ordinary Least Squares (OLS) and Seemingly Unrelated Regressions (SUR). Second, the model is estimated with the fixed effects method in OLS and SUR. Then the model is estimated with the first differences method in OLS and SUR. Finally, some conclusions will be stated.

4.1 Correlation

If the explanatory variables in a model correlate, then there might be multicollinearity which leads to unreliable regression estimates. Tables 4.1 and 4.2 show the partial correlation coefficients between the explanatory variables estimated with the pairwise correlation calculation in Stata (see appendix D1). The coefficients go from -1 to 1, where the closer to |1| means the stronger the relationship. A significant relationship indicates that it is unlikely that with the given correlation coefficient there is no relationship in the population (Janda, 2001).

The results in tables 4.1 and 4.2 show that *liabilities (lagged)* and *yield* are the strongest correlated variables (0.87) in the field crop sector. The strongest correlated variables in the milk sector are *liabilities (lagged)* and the *economic size* (0.83). The partial correlation coefficients are not so high that I had to decide to omit variables from the model.

Table 4.1 Partial correlation coefficient matrix of the explanatory variables in the field crops sector

Variables Field Crops sector	eco_size	yield	subsidies	liabilities _lag	farminc _lag
eco_size	1				
yield	0.68 *	1			
subsidies	0.49 *	-0.09	1		
liabilities_lag	0.78 *	0.87 *	0.18 *	1	
farminc_lag	0.67*	0.39*	0.53*	0.44*	1

*Significant at α=0.05

Table 4.2 Partial correlation coefficient matrix of the explanatory variables in the milk sector

Variables Milk sector	eco_size	yield	subsidies	liabilities _lag	farminc_ lag
eco_size	1				
yield	-0.18	1			
subsidies	0.37 *	-0.33*	1		
liabilities_lag	0.83 *	-0.37 *	0.36 *	1	
farminc_lag	0.59*	0.32*	0.43*	0.31*	1

*Significant at α=0.05

4.2 Cross-section data

Table 4.3 and appendix D2 show the output for Ordinary Least Squares (OLS) with the cross-section data set. The p-value of the model is 0.000 for both sectors, which indicates that there is a statistically significant relationship between investments and the explanatory variables. The goodness of fit (R^2) shows that 68% of the variance in investments is explained by the explanatory variables for the field crops sector. However, almost all individual parameters are not significantly different from zero. The milk sector has a much higher goodness of fit (85%) which means that the model suits the milk sector better than the field crops sector. Besides, the milk sector has more significant parameters.

For both the field crops sector and the milk sector lagged liabilities is significantly different from zero. It seems strange that having debts in year t-1 has a positive influence on investment in year t, since debts are not expected to be a stimulating factor when deciding whether to invest or not. However, farmers with debts might be less risk-averse and therefore invest more. Another explanation is that higher debts is an indicator for good past performance because otherwise banks would not have lent out money.

In the milk sector the economic size of the farm is significantly different from zero. The economic size has a positive influence on investments, which is just as I expected beforehand. Also subsidies are significantly different from zero in the milk sector, at a 10% confidence interval. The influence of subsidies on investments are quite big and positive. The variable capreform is negative for both sectors, but not significantly different from zero. Therefore I am not allowed to conclude that the 2003 CAP reform had a negative effect on investments.

Table 4.3 Ordinary Least Squares with cross-section data

OLS	*Field crops*	*Milk*
eco_size	0.127	0.199*
yield	0.235	-0.055
subsidies	0.054	0.319**
liabilities_lag	0.062*	0.076*
farminc_lag	0.175	-0.017
capreform	-22.22	-23.69
_cons	-52.30	21.29

*Significant at α=0.05

Table 4.4 and appendix D2 show the results of SUR with the cross-section data set. The parameter estimates for SUR are very similar to the parameter estimates of OLS. In the field crops sector is now, besides the lagged liabilities, also the economic size variable significantly different from zero. In the milk sector the variable subsidies is no longer significant, but the yield variable is significant now. Yield has a small negative effect on the investments made. Taking into account that crops are not the main activity in the milk sector, I have to interpret the yield variable differently than in the field crops sector (where it is the main activity). So farmers who have beside milk also crops will invest less when the productivity of crops increases. This is as expected.

According to the theory SUR should give more efficient estimates than OLS if the error-terms are correlated. So when unexpected effects impact investment decisions in both sectors similarly SUR is the best method to use. With SUR the goodness of fit is a bit lower and the standard errors a bit smaller than with OLS, this does not result in a clear preference for one of the two methods. The differences are very small. If the efficiency gain is negligible, the equations might be better estimated with OLS, since that will give more consistent estimates.

Table 4.4 Seemingly Unrelated Regression with cross-section data

SUR	*Field crops*	*Milk*
eco_size	0.153*	0.201*
Yield	0.187	-0.095*
Subsidies	0.039	0.235
liabilities_lag	0.061*	0.071*
farminc_lag	0.147	0.076
capreform	-19.68	-23.12
_cons	-49.15	14.78

*Significant at α=0.05

4.3 Panel data

The results for the fixed effects model estimated with OLS is shown in table 4.5 and appendix D3. Economic size, subsidies and lagged farm income have a significant positive influence on the gross investments in the field crops sector. So, a higher income, more subsidies and a bigger economic size all lead to more investments. Also the dummy variable for the 2003 CAP reform is significant, at a 10% confidence interval. The result indicates that the 2003 CAP reform led to a decline in investments made. In the milk sector only the variable subsidies has a positive significant influence on investment behaviour.

Table 4.5 Fixed Effects in OLS for field crops and milk

FE in OLS	*Field crops*	*Milk*
eco_size	0.387**	0.119
Yield	-0.432	0.003
subsidies	0.841*	0.894*
liabilities_lag	0.020	-0.008
farminc_lag	0.305*	-0.055
capreform	-43.53**	-29.33

*Significant at α=0.05, ** Significant at α=0.10

The variance in investments explained by the explanatory variables has decreased to 27% for the field crops sector and 32% for the milk sector. This is much lower than the respectively 68% and 85% with cross-sectional OLS. However, according to Dougherty (2007) is the R^2 rarely higher than 0.5 in a fixed effect model, even in a well-specified model, so 27% and 32% is in not that bad in that perspective.

Table 4.6, with the results of fixed effects in the SUR model, shows almost the same results as table 4.5. In the field crops sector the variable economic size became more significant and the variable subsidies became less significant. The R^2 of both sectors decreased a with 1% in both sectors and the standard errors became somewhat smaller, what does again not result in a clear preference for OLS or SUR.

Table 4.6 Fixed Effects in SUR for field crops and milk

FE in SUR	*Field crops*	*Milk*
eco_size	0.445*	0.099
yield	-0.050	-0.055
subsidies	0.652**	0.911*
liabilities_lag	0.019	-0.014
farminc_lag	0.234*	0.019
capreform	-41.47**	-32.41

*Significant at α=0.05, ** Significant at α=0.10

When using the first differences regression (appendix D4) in OLS we see that lagged farm net income is significant for both sectors. The lagged income in first differences is (t-1)-(t-2). For example, the change in income between 2001 and 2002 effects significantly the investments made in 2003. Subsidies are not significant anymore in the milk sector. The R^2 is decreasing even further now to 5% for the field crops sector and 10% for the milk sector. When estimating the first differences with SUR the lagged farm income became less significant in the field crops sector and more significant in the milk sector. The goodness of fit is decreasing 1% in both sectors with respect to OLS. The p-value of the models is higher than 0.05 with both OLS and SUR, which indicates that there is not a statistically significant relationship between investments and the explanatory variables. Therefore, first differences regression does not seem to be the best estimation method for this investment method.

Table 4.7 First Differences in OLS for field crops and milk

FD in OLS	*Field crops*	*Milk*
eco_size	0.199	0.239
yield	0.177	-0.192
subsidies	-0.092	0.070
liabilities_lag	-0.026	0.088
farminc_lag	0.222*	0.274**

*Significant at α=0.05, ** Significant at α=0.10

Table 4.8 First Differences in SUR for field crops and milk

FD in SUR	*Field crops*	*Milk*
eco_size	0.112	0.251
yield	0.333	-0.211
subsidies	0.103	0.164
liabilities_lag	-0.051	0.064
farminc_lag	0.178**	0.383*

*Significant at α=0.05, ** Significant at α=0.10

4.4 Conclusions

Concluding I can say that when the data is assumed to be cross-sectional the lagged liabilities have in all cases a significant and positive effect on investment, and also the variable economic size was three out of four times significant and positive. The dummy variable which takes the 2003 CAP reform into account was not significant, so according to this model it does not seem to effect investments. The goodness of fit was high with cross-section data regression. Looking closely at the R^2 value and the standard errors, it seems that OLS should be chosen over SUR. The differences are very small and therefore the efficiency gain with SUR does not offset the more consistent estimates with OLS.

When considering the data as panel data, the outcomes are quite different. The lagged farm net income variable seems to have the biggest impact on the investment behaviour of farmers, since the variable was six out of eight times significant. The variable subsidies is also an important variable with the fixed effects method in both sectors. According to the fixed effect method with a 10% confidence interval the 2003 CAP reform influences negatively the investment behaviour of farmers in the field crops sector but not in the dairy sector.

Looking at all tests together, the model seems to fit better to the milk sector than the field crops sector according to the goodness of fit score, R^2. Though, the field crops sector had more significant variables. In the milk sector the subsidies variable seems to be the most important factor in decision behaviour for investment and for the field crops sector it is the lagged net farm income.

It is hard to say witch estimation procedure, OLS or SUR, fits the model better. Considering the fact that when the SUR procedure would be the best when unexpected effects impact investment decisions in both the field crops sector and the milk sector similarly, than SUR should be preferred. Most farms in the milk sector do also have field crops, what makes the sectors more similar than maybe expected beforehand. However, looking at the change in R^2 and the standard errors it seems better to choose for OLS, for more consistent estimates.

5 Conclusions and discussion

5.1 Conclusion

In 2003 the European Union reformed the Common Agricultural Policy (CAP) and introduced the Single Payment Scheme. Income payments are no longer related to what and how much farmers produce and therefore it guarantees farmers a stable income component. The main question of this thesis is whether or not the 2003 CAP reform influenced European farmers' investments decisions. Other questions considered in this thesis are "What determines investments?" and "What determines farm resilience according to the estimation results?".

There is not just one theory to explain investments. The net present value theory, option theory and adjustment cost theory all include different factors to explain farm investments. Summarizing the theories, the net present value method focusses on the *discount rate, investment returns* and *salvage value* as explanatory variables for investment behaviour. The option theory adds to these factors the *option to wait*. The adjustment cost theory includes the *adjustment costs, depreciation, input-* and *output prices* as variables. Olsen and Lund (2009) include in their model several *socioeconomic factors* and *investment incentives*. Also *net income after tax* is a relevant variable for farmers.

A combination of factors from the different theories is used to construct an investment model estimated with data from the Farm Accountancy Data Network (FADN). The model is estimated with cross-section data using OLS and SUR and with panel data using the fixed effects and first differences methods in OLS and SUR. Considering that the data is panel data (not cross-section data) and the first differences regression led to an inappropriate model with a very low goodness of fit, the best way of estimating is the fixed effects method. Choosing between OLS and SUR is a bit harder but as explained in the previous chapter it is better to choose OLS when the differences are that small. The next conclusions are therefore based on the results from the estimation with the fixed effects regression in OLS.

The resilience of a company is the ability and capacity to survive discontinuities. Investments are assumed to be a positive indicator for resilience since the farming business cannot continue without investments made. Investments increase the adaptive capacity of a farm. So if investments are a positive measure for resilience, than the results suggest that subsidies have a positive effect on resilience of the farm in both the field crops and milk sector. In the field crops sector also the farm net income and the economic size are important factors for explaining investment (resilience). The bigger the farm and the higher the net farm income and subsidies, the better the resilience of a farm in the field crops sector. However, the 2003 CAP reform has a negative effect on the investments made in the field crops sector. This implies that the 2003 CAP reform is not a good policy change in order to improve the resilience of farms in the field crops sector. However, in the milk sector the 2003 CAP reforms shows no significant effect on investments (resilience). Remarkable is that subsidies have a significant effect in this sector, so government policy does effect the investment behavior of European farmers in both the field crops sector and the milk sector.

Concluding, for European farms in the field crops and milk sector, investments are partly determined by the lagged net farm income, the subsidies received and the economic size of a farm. The best estimation method is fixed effects, since it suits the panel data model best. If the 2003 CAP reform has influence on investments of European farms in the field crops and milk sector, it would be a negative effect. So, the impact of a decrease in profitability of agriculture is bigger than the impact of the lower risk level because of a guaranteed income component. Finally, the higher the net farm income, the amount of received subsidies and the economic size of the farm, the more resilient the farm is. Note that all these conclusions are stated for the data set used in this research, so it only counts for the field crops and milk sector in the eight stated countries.

5.2 Discussion

Several issues raised during the research. First of all I had to deal with data issues. As mentioned before, not all desirable data was available. Variables like *age of the farmer*, *off-farm income* and *adjustment costs* were not available. For some missing data proxies are included in the model, but these indicators probably differ from the real values. Price variation is not used as an explanatory variable, since it was too time-consuming to search for this data for eight countries and two sectors. Another problem with this data is that the empirical investment model is now estimated at country level, while investment decisions are made at company level. Besides, there is a lot of heterogeneity between companies, so taking all companies in a country together might not result in the best estimation results. The empirical model in this thesis might also be vulnerable for misspecification, since the different estimation methods do not show constantly the same significant variables. However, there is not much research done on this topic, so therefore this research is even without perfect data a good indication what the effect is of the 2003 CAP reform on farmers' investment decisions. What I recommend for further research is to do better data collection. With better data, the model may be improved.

Secondly, the investment theories are ambiguous. There are different theories about investment behaviour. They all take different explanatory factors into account which makes it unclear how to explain investment behaviour within one consistent framework. Constructing such a framework might therefore worthwhile doing but was not within the scope of this research.

Finally, the link between resilience and investments is now made on qualitative arguments, a quantitative link has not been established. In this thesis I assumed that investing has a positive influence on the resilience of a farm. But how big should the investment be before it really affects resilience? For example, if a small increase in received subsidies leads to small farm investments, it might have no influence on the resilience of the farm and may therefore not be called a positive measure for resilience. My recommendation for further research is that more research should be done on constructing good quantitative indicators of farm resilience.

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Appendix A: Agricultural policy between 1998 and 2009

Between 1998 and 2009 there were several big European agricultural policy changes. Table A1 shows the development of the common EU agricultural market and price policies. Between 1992 and 2003 there was farm income compensation, to compensate farmers for lower prices, which were coupled payments. From 2003 on, these direct income payments became decoupled.

Table A1 Development of the common EU agricultural market and price policies

1992-2003	Transformation - started by the Mac Sharry reforms of 1992 and followed by the 1999 decisions on Agenda 2000 - to price reduction and farm income compensation, coupled to volume restrictions (set-aside obligation), and a more market-oriented approach.
2003-present	In the Fischler (2003/2004) and the Health Check (2008) reforms, decoupling (from current production) of direct income payments, and introduction of management guidelines ('cross-compliance'). Export refunds substantially reduced. A single common market organisation. Market, price and farm income policy partly replaced by rural development policy.

Source: Silvis and Lapperre, 2010

Table A2 shows a summary of the 2003 CAP reform decisions. The table shows that the countries used in this study all base the single farm payments on a historical reference period. The start of decoupling differs between the European countries, some of them start in 2005, other in 2006. In general de decoupling may begin in 2005, but not later than 2007. However, for dairy (the milk sector in this study) the decoupling may begin in 2005, but not later than 2008 (Burrell, 2004). It is not clear for every European country when the milk sector exactly got decoupled. Table A2 also shows the coupling rates. These rates indicate for which products the countries will still keep the direct payments coupled. For example, the Netherlands kept of the direct payments 100% of the calf slaughtering, 40% of the adult cattle slaughter and 100% of the seed for linseed coupled.

Table A2 Summary of 2003 CAP Reform Decisions

Country (regions)	Start	SFP Basis	Coupling Rates, Notes
Belgium	2005	historical	100% suckler cows, 100% calf slaughter, 100% seeds (partial)
Denmark	2005	static hybrid	75% special male cattle, 50% sheep
Germany	2005	dynamic hybrid, to FR	25% hops, 60% tobacco (until 2009)
Greece	2006	*historical*	*40% durum wheat, 50% sheep*

Spain	2006	historical	100% seeds, 100% for all products in outermost regions
France	*2006*	*historical*	*25% arable crops, 50% sheep, 100% suckler cows, 100% calf slaughter, 40% adult cattle slaughter.* 100% for all products in overseas territories
Ireland	2005	historical	no coupling
Italy	2005	historical	100% seeds, NEs for arable crops (7%), beef (8%) and sheep
Luxembourg	2005	static hybrid	no coupling
Netherlands	*2006*	*historical*	*100% calf slaughtering, 40% adult cattle slaughter, 100% seed for linseed*
Austria	2005	historical	100% suckler cows, 40% adult cattle slaughter, 100% calf slaughter, 25% hops
Portugal	2005	historical	100% suckler cows, 40% adult cattle slaughter, 100% calf slaughter, 50% sheep, 100% seeds, 100% for all products in outermost regions
Finland (3 regions)	2006	*dynamic hybrid*	*75% special male cattle, 10% arable crops?, 100% seed?, 50% sheep? 10% NE for quality beef*
Sweden (5 regions)	2005	static hybrid	74.55% for special male cattle, 0.45% NE for beef
United Kingdom - England (3 regions) - Scotland - Wales - N. Ireland	 2005 2005 2005 2005	 dynamic hybrid, to FR historical historical static hybrid	 no coupling 10% NE for quality beef no coupling no coupling

Notes:
1. Entries in *italics* indicate informal notification only to Commission by 5 August.
2. SFP = single farm payment; NE = national envelope; FR = flat-rate (area)
Source: Shucksmith et al., 2005

Figure A1 shows a graph of the average subsidies received between 1998 and 2009 in the field crops sector (blue line) and the milk sector (red line). In 2003 is decided to lower the intervention price for skimmed milk powder and butter. To compensate for this financial loss, the farmers in the milk sector got 60% of their loss in direct payments, which was coupled to the quota (Silvis and Lapperre, 2010). Figure A1 shows that this caused a large increase in subsidies received by the farmer in the milk sector.

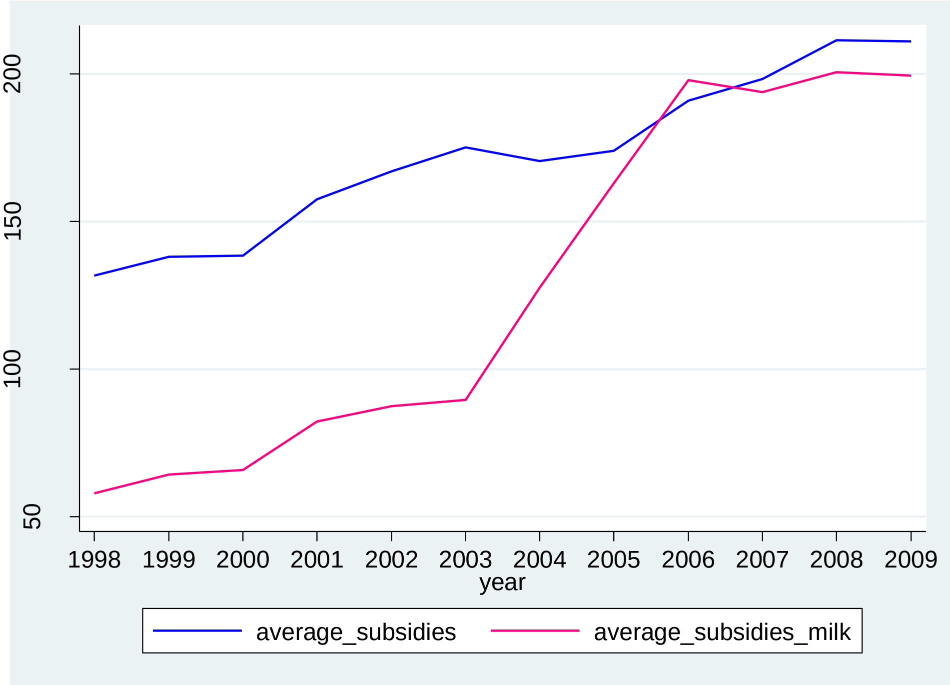

Figure A1 Average subsidies for the field crops and milk sector

Appendix B: Numerical Examples

B1. Net Present Value

A farm is considering an investment of €50.000, which is expected to generate a return of €7.000 per year for the next 8 years. Such an investment looks profitable at first sight since the sum of revenues (€56000) is greater than the investment. However, the €50.000 is paid today, while the €56.000 is received in the future. When there is an interest rate of 10% the net present value will be:

$$NPV = \sum_{t=1}^{8} \frac{€7.000}{(1+0.1)^t} - €50.000 = -€12.656$$

So, when taking the time-vale-of-money into account the investment is not that attractive anymore since it has a negative NPV. However, with a lower interest rate the investment might become profitable, due to a lower depreciation of future returns.

B2. Option Theory

A farmer is considering to invest in milk quota, while the subsidy for milk is uncertain. There is a probability of 0.5 that the milk subsidy will rise next year and stay at that new level for the next five years; with a probability of 0.5 the subsidy level will remain unchanged. If the milk subsidy increases, the revenue of milk production is €250 per year. If the subsidy remains unchanged, the revenue will be only €100 per year (see figure B1 below).

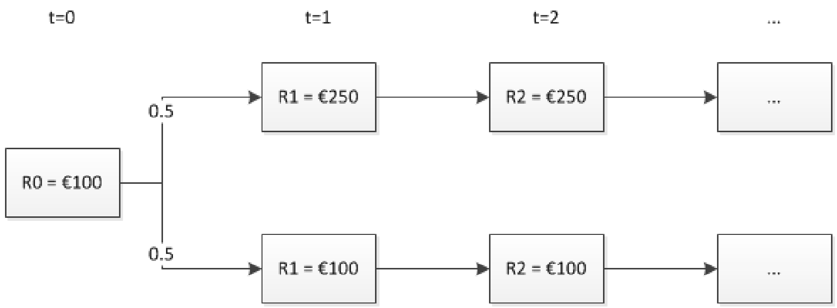

Figure B1 Extra revenue of milk quota investment

We assume that the investment costs equal €700 and the milk quota system will be abolished in 6 years from t=0. So, there will be a subsidy revenue for 5 years after the investment. With an interest rate of 10%, the expected *NPV* of investing now is:

$$NPV_0 = -700 + 100 + 0.5 \sum_{t=1}^{5} \frac{€100}{(1+0.1)^t} + 0.5 \sum_{t=1}^{5} \frac{€250}{(1+0.1)^t} = -€600 + 190 + 474 = €64$$

The *NPV* of this investment is positive and according to the traditional NPV model we should invest straightaway. However, this conclusion is incorrect since calculations above ignore the option to wait and see if the subsidies will increase or not. We can calculate the value of the option to wait and not ‘killing the option by investing now. The alternative of investing now is to wait with the investment until in t=1 the milk subsidies increases. If the milk subsidy would not increase next year, the farmer would not invest since with the low milk subsidy the investment cost would not be earned back.

The subsidy increases next year with the probability of 0.5. The NPV when investing next year becomes:

$$NPV_1 = 100 + 0.5 \frac{-€700}{(1+0.1)} + \sum_{t=1}^{5} \frac{€250}{(1+0.1)^t} = 0.5 -€636 + €948 = €256$$

In t=0 there is a revenue of €100 and no expenditure since the farmer chooses to wait for new information before deciding whether to invest or not. In year 1 €700 is spent on buying milk quota only if the milk subsidy rises, which will happen with probability 0.5. For 5 years there will be a revenue of €250 starting at t=1. The NPV of the delayed investment is in this case 4 times greater than the NPV of immediate investment. Therefore, it is better to wait one year for extra information than invest directly. The value of the option to wait is calculated by the difference between the two NPV’s, that is €192. The farmer should be willing to pay €192 more for a flexible investment opportunity which does not kill the option to wait, than choosing between investing right away or not at all.

Appendix C: Panel Data Set

C1. Field crops sector

country	tf8	year	eco_size	yield	gross_inv_fa	subsidies	liabilities_lag	farminc_lag
Austria	Fieldcrops	1998	283	92.2	142.98	213.5	257.31	283.09
Austria	Fieldcrops	1999	276	95.8	137.51	213.29	281.9	263.4
Austria	Fieldcrops	2000	286	89.5	114.69	222.53	296.23	273.73
Austria	Fieldcrops	2001	286	89.6	116.37	238.6	365.07	264.52
Austria	Fieldcrops	2002	280	94	116.42	248.08	363.15	282.65
Austria	Fieldcrops	2003	285	90.3	140.97	262	363.72	274.17
Austria	Fieldcrops	2004	331	87.9	148.6	270.55	327.51	275.93
Austria	Fieldcrops	2005	334	77.9	151.62	288.2	408.36	276.41
Austria	Fieldcrops	2006	349	88	124.83	300	390.06	247.5
Austria	Fieldcrops	2007	354	112	143.35	279.09	378.03	301.48
Austria	Fieldcrops	2008	366	119.6	191.99	296.21	328.35	405.9
Austria	Fieldcrops	2009	355	88.3	184.97	302.29	344.37	411.92
Belgium	Fieldcrops	1998	610	199.1	132.75	98.28	795.15	379.77
Belgium	Fieldcrops	1999	728	177.6	130.95	111.83	778.56	429.74
Belgium	Fieldcrops	2000	715	180.9	110.24	120.46	932.59	343.35
Belgium	Fieldcrops	2001	726	190.7	117.32	132.02	919.98	415.86
Belgium	Fieldcrops	2002	713	184.3	149.35	142.48	987.63	439.67
Belgium	Fieldcrops	2003	732	209.1	187.46	174.7	938.84	425.68
Belgium	Fieldcrops	2004	792	177.3	213.09	150.28	1520.81	549.57
Belgium	Fieldcrops	2005	792	174	215.53	172.27	973.12	421.67
Belgium	Fieldcrops	2006	796	185.2	192.27	208.74	1006.33	394.54
Belgium	Fieldcrops	2007	806	205.3	260.94	297.46	954.62	503.49
Belgium	Fieldcrops	2008	785	175.7	270.75	292.8	1045.01	615.94
Belgium	Fieldcrops	2009	838	173.2	493.63	285.86	1027.42	366.53
France	Fieldcrops	1998	685	97.4	187.73	305.04	892	313.33
France	Fieldcrops	1999	746	92	164.66	322.76	921.18	307.95
France	Fieldcrops	2000	742	94.3	162.39	319.33	955	270.77
France	Fieldcrops	2001	747	95.3	166.09	327.35	1010.07	263.42
France	Fieldcrops	2002	814	92.4	200.18	348.79	977.52	226.77
France	Fieldcrops	2003	819	93.3	177.52	356.89	1023.22	255.03
France	Fieldcrops	2004	836	91.9	240.72	371.7	980.36	274.9
France	Fieldcrops	2005	820	90.5	214.8	357.53	1074.74	256.06
France	Fieldcrops	2006	833	96.7	167.31	375.46	1090.59	214.89
France	Fieldcrops	2007	819	123.7	210.05	363.64	1117.62	305.58
France	Fieldcrops	2008	828	121.9	267.82	372.99	1109.41	530.02
France	Fieldcrops	2009	829	103.6	239.68	366.65	1252.71	379.82
Ireland	Fieldcrops	1998	386	83.6	146.89	232.16	281.4	183.6
Ireland	Fieldcrops	1999	493	81.9	-4.44	225.22	275.39	224.89
Ireland	Fieldcrops	2000	401	95.7	82.65	197.29	260.94	198
Ireland	Fieldcrops	2001	441	94.4	114.77	215.96	223	232.46
Ireland	Fieldcrops	2002	523	88.7	26.48	250.49	401.24	244.48
Ireland	Fieldcrops	2003	564	96.6	26.54	254.29	318.06	239.14
Ireland	Fieldcrops	2004	413	103.5	55.92	209.48	334.49	316.41
Ireland	Fieldcrops	2005	329	98.9	-573.71	187.69	213	228.99
Ireland	Fieldcrops	2006	328	103.9	-206.61	215.81	214.31	196.57
Ireland	Fieldcrops	2007	381	154.6	-7.89	226.34	234.38	269.37
Ireland	Fieldcrops	2008	353	115.3	64.23	232.1	234.3	451.75
Ireland	Fieldcrops	2009	305	80.4	81.3	227.86	399.06	215.9
Italy	Fieldcrops	1998	124	124.7	11.82	45.33	14.81	94.11
Italy	Fieldcrops	1999	149	124.7	18.67	54.36	17.03	93.02
Italy	Fieldcrops	2000	152	118.5	13.07	58.93	23.88	100.59
Italy	Fieldcrops	2001	149	134.2	24.91	59.44	16.25	94.38
Italy	Fieldcrops	2002	205	131	21.22	76.04	22.51	107.18
Italy	Fieldcrops	2003	215	155.3	15.13	74.72	21.33	135.1
Italy	Fieldcrops	2004	216	173.5	17.77	74.19	28.3	150.86
Italy	Fieldcrops	2005	217	166.5	115.92	76.46	20.94	150.94

Italy	Fieldcrops	2006	274	159	28.45	83.18	23.19	174.58
Italy	Fieldcrops	2007	276	201.4	21.57	78.84	45.04	167.19
Italy	Fieldcrops	2008	276	196.1	13.9	81.49	44.85	230.35
Italy	Fieldcrops	2009	264	179.2	38.65	83.17	40.45	177.69
Netherlands	Fieldcrops	1998	1008	335.5	412.11	56.6	1709.24	359.46
Netherlands	Fieldcrops	1999	1088	261.8	512.48	60.64	1958.01	453.26
Netherlands	Fieldcrops	2000	1087	270.9	491	64.89	2457.15	138.44
Netherlands	Fieldcrops	2001	1078	346.3	287.33	142.9	2457.15	147.66
Netherlands	Fieldcrops	2002	943	331.1	347.4	124.85	3797.84	454.75
Netherlands	Fieldcrops	2003	910	387.4	444.04	135.07	4055.7	178.4
Netherlands	Fieldcrops	2004	908	314.3	496.84	143.06	4010.93	401.73
Netherlands	Fieldcrops	2005	930	336.3	262.02	166.05	4359.37	53.34
Netherlands	Fieldcrops	2006	960	377.4	290.73	188.01	4640.62	347.68
Netherlands	Fieldcrops	2007	970	387.7	676.42	191.48	4212.29	540.01
Netherlands	Fieldcrops	2008	1012	369.3	558.69	210.53	4779.65	578.59
Netherlands	Fieldcrops	2009	991	402.9	615.17	215.27	5225.65	371.39
Portugal	Fieldcrops	1998	67	71.7	24.17	20.91	17.56	21.21
Portugal	Fieldcrops	1999	58	79.4	41.99	17.03	24.94	31.27
Portugal	Fieldcrops	2000	57	71.7	12.1	17.78	17.89	26.66
Portugal	Fieldcrops	2001	100	70.4	23.96	37.4	14.67	38.8
Portugal	Fieldcrops	2002	85	78.9	16.38	39.6	31.43	43.3
Portugal	Fieldcrops	2003	89	72.6	39.55	40.11	36.24	45.68
Portugal	Fieldcrops	2004	105	83.6	39.73	48.27	30.05	48.11
Portugal	Fieldcrops	2005	109	83.1	11.9	48.05	33.26	47.76
Portugal	Fieldcrops	2006	98	103.4	14.17	47.05	25.92	37.56
Portugal	Fieldcrops	2007	99	111.7	17.74	48.37	33.31	73
Portugal	Fieldcrops	2008	103	126.7	15.85	53.18	31.69	76.95
Portugal	Fieldcrops	2009	105	118.5	20.88	55.8	9.42	119.09
Spain	Fieldcrops	1998	197	50.2	13.45	80.93	37.62	162.27
Spain	Fieldcrops	1999	218	46.4	18.28	98.75	42.05	165.83
Spain	Fieldcrops	2000	218	55.3	17.3	104.96	44.77	163.29
Spain	Fieldcrops	2001	212	51.2	15.19	105.56	42.84	207.54
Spain	Fieldcrops	2002	241	53.8	16.22	105.16	40.32	177.7
Spain	Fieldcrops	2003	243	54.7	12.05	101.83	57.13	202.85
Spain	Fieldcrops	2004	236	70.9	5.34	94.95	47.13	207.89
Spain	Fieldcrops	2005	240	50.1	8.44	93.94	50.65	218.49
Spain	Fieldcrops	2006	257	55.5	-3.33	109.16	49.1	137.69
Spain	Fieldcrops	2007	240	78.9	15.27	99.96	54.1	202.53
Spain	Fieldcrops	2008	298	73	8.07	150.54	45.92	283.06
Spain	Fieldcrops	2009	296	53.2	20.72	150.86	62.85	279.38

The values of the variables used in estimation are scaled in order to improve estimation, for the real values table C1 should be consulted.

Table C1 Real values of variables

eco_size	ESU / 10
yield	€ * 10
gross_inv_fa	€ * 100
subsidies	€ * 100
liabilities_lag	€ * 100
farminc_lag	€ * 100

C2. Milk sector

country_m	tf8_m	year_m	eco_size_m	yield_m	gross_inv_m	subsidies_m	liabilities_lag_m	farminc_lag_m
Austria	Milk	1998	171	66	134.2	119.29	200.65	236.55
Austria	Milk	1999	176	65	153.65	110.73	248.45	245.52
Austria	Milk	2000	177	65	137.75	121.62	297.69	232.14
Austria	Milk	2001	176	61	129.96	146.72	298.31	245.62
Austria	Milk	2002	230	69	145.77	145.53	291.39	279.31
Austria	Milk	2003	230	52	157	150.66	308.81	266.52
Austria	Milk	2004	241	50	178.22	178.74	297.59	205.94
Austria	Milk	2005	245	50	187.08	189.81	361.73	229.91
Austria	Milk	2006	260	53	179.76	200.48	386.13	259.61
Austria	Milk	2007	262	90	230.03	190.35	378.04	295
Austria	Milk	2008	258	65	269.12	195	410.25	318.07
Austria	Milk	2009	262	57	263.23	201.17	456.69	369.11
Belgium	Milk	1998	651	160	148.22	71.3	1069.2	341.97
Belgium	Milk	1999	690	139	183.57	96.67	1118.72	372.25
Belgium	Milk	2000	695	151	155.75	79.78	1136.01	383.13
Belgium	Milk	2001	699	147	169.41	103.08	1112.44	390.24
Belgium	Milk	2002	753	158	138.76	102.57	1043.64	418.58
Belgium	Milk	2003	758	189	128.46	102.2	1125.82	355.52
Belgium	Milk	2004	800	209	201.11	132.14	1150.14	405.73
Belgium	Milk	2005	804	205	254.94	171.99	1100.54	402.64
Belgium	Milk	2006	863	196	383.19	227.71	1105.38	508.13
Belgium	Milk	2007	884	245	401.25	233.53	1256.41	519.25
Belgium	Milk	2008	907	203	529.67	251.39	1388.23	701.07
Belgium	Milk	2009	915	195	345.16	246.03	1506.15	500.28
France	Milk	1998	388	103	167.65	88.76	652.79	232.41
France	Milk	1999	546	112	217.83	103.32	678.73	260.02
France	Milk	2000	547	122	191.86	119.8	816.96	268.68
France	Milk	2001	553	110	175.08	134.25	844.96	281.07
France	Milk	2002	582	112	232.61	155.39	868.83	255.7
France	Milk	2003	589	110	198.06	171.56	988.56	266.34
France	Milk	2004	605	112	216.44	200.1	997.84	254.05
France	Milk	2005	608	105	241.49	231	1080.11	265.26
France	Milk	2006	639	120	233.64	271.32	1098.76	295.43
France	Milk	2007	647	164	272.9	261.75	1198.71	290.99
France	Milk	2008	654	157	313.66	258.88	1246.42	352.01
France	Milk	2009	661	127	274.48	256.92	1311.8	324.68
Ireland	Milk	1998	389	16	74.03	65.24	277.56	282.29
Ireland	Milk	1999	454	30	67.51	59.01	275.21	236.43
Ireland	Milk	2000	472	33	157.23	67.62	296.18	259.2
Ireland	Milk	2001	475	33	67.15	90.72	344.88	299.05
Ireland	Milk	2002	478	10	133.91	106.54	334.08	343.21
Ireland	Milk	2003	482	24	92.62	94.8	383.79	315.9
Ireland	Milk	2004	506	28	113.37	130.14	359.76	359.25
Ireland	Milk	2005	531	22	-82.41	182.28	397.91	391.63
Ireland	Milk	2006	544	19	98.36	215.77	422.71	414.8
Ireland	Milk	2007	585	37	306.26	229.68	417.94	353.85
Ireland	Milk	2008	597	206	481.93	233.73	527.11	525.69
Ireland	Milk	2009	601	181	160.87	230.21	740.97	448.11
Italy	Milk	1998	267	783	110.94	46.44	104.21	469.94
Italy	Milk	1999	533	812	133.01	51.94	104.6	410.03
Italy	Milk	2000	457	799	89.31	52.75	102.48	398.81
Italy	Milk	2001	627	870	135.54	75.05	88.37	356.23
Italy	Milk	2002	563	903	85.38	61.58	142.51	456.31
Italy	Milk	2003	667	1034	84.1	58.07	119.77	501.87
Italy	Milk	2004	601	1028	106.65	90.49	131.21	504.97
Italy	Milk	2005	636	931	213.16	154.55	218.9	576.71
Italy	Milk	2006	717	1030	155.82	198.83	197.91	669.99
Italy	Milk	2007	705	1111	76.83	158.05	256.76	767.39
Italy	Milk	2008	708	1015	26.38	143.15	253.78	744.24
Italy	Milk	2009	713	957	192.64	145.3	147.05	741.67
Netherlands	Milk	1998	1140	70	538.8	24.19	2670.98	377.53

Netherlands	Milk	1999	1108	70	714.9	24.81	2781.25	305.97
Netherlands	Milk	2000	1107	75	678.13	35.29	3252.52	283.88
Netherlands	Milk	2001	1146	134	435.71	58.13	3272.43	475.8
Netherlands	Milk	2002	1177	97	707.65	70.26	4379.67	433.79
Netherlands	Milk	2003	1211	84	664.85	72.82	5054.15	380.79
Netherlands	Milk	2004	1178	88	648.53	133.06	5452.75	387.3
Netherlands	Milk	2005	1195	86	805.1	205.82	5806.96	425.28
Netherlands	Milk	2006	1213	84	663.48	275.09	6148.43	566.93
Netherlands	Milk	2007	1219	92	577.44	269.56	6190.37	505.03
Netherlands	Milk	2008	1252	76	880.28	273.13	6530.01	685.55
Netherlands	Milk	2009	1255	56	778.1	282.09	6661.67	491.85
Portugal	Milk	1998	150	382	45.33	36.16	54.54	75.84
Portugal	Milk	1999	181	497	50.83	59.48	56.63	73.11
Portugal	Milk	2000	216	432	73.31	36.54	78.4	104.92
Portugal	Milk	2001	197	448	46.21	38.83	113.53	116.12
Portugal	Milk	2002	225	331	37.56	34.29	97.03	104.21
Portugal	Milk	2003	245	450	57.08	40.46	73.66	122.96
Portugal	Milk	2004	265	466	44.11	70.73	68.47	150.11
Portugal	Milk	2005	275	411	62.64	82.43	70.85	171.55
Portugal	Milk	2006	271	504	47.09	105.11	70.05	182.64
Portugal	Milk	2007	296	486	60.79	111.29	83.94	182.79
Portugal	Milk	2008	280	476	56.51	111.8	136.97	223.64
Portugal	Milk	2009	271	467	50.29	111.66	110.88	241.89
Spain	Milk	1998	140	471	22.34	10.63	62.56	154.89
Spain	Milk	1999	148	531	43.07	8.01	65.16	175
Spain	Milk	2000	151	517	45.54	12.7	78.94	201.97
Spain	Milk	2001	150	530	37.52	10.53	78.35	201.79
Spain	Milk	2002	266	523	44.14	22.74	74.71	247.36
Spain	Milk	2003	271	478	28.85	24.99	114.85	292.23
Spain	Milk	2004	309	434	64.13	85.27	117.08	289.89
Spain	Milk	2005	336	463	70.51	84.28	123.8	396.13
Spain	Milk	2006	361	525	15.5	88.17	127.94	467.41
Spain	Milk	2007	374	510	53.39	96.4	136.32	444.46
Spain	Milk	2008	455	604	85.82	137.04	147.1	533.39
Spain	Milk	2009	391	510	68.95	121.29	172.61	641.6

The values of the variables used in estimation are scaled in order to improve estimation, for the real values table C2 should be consulted.

Table C2. Real values of variables

eco_size_m	ESU / 10
yield_m	€ * 10
gross_inv_m	€ * 100
subsidies_m	€ * 100
liabilities_lag_m	€ * 100
farminc_lag_m	€ * 100

Appendix D: Stata output

D1. Correlation matrixes

```
. pwcorr  eco_size yield subsidies liabilities_lag farminc_lag, sig star(.05)

             | eco_size    yield subsid~s liabil~g farmin~g
-------------+---------------------------------------------
    eco_size |   1.0000 
             |
             |
       yield |   0.6825*  1.0000 
             |   0.0000
             |
   subsidies |   0.4874* -0.0850   1.0000 
             |   0.0000   0.4101
             |
liabilitie~g |   0.7807*  0.8689*  0.1810   1.0000 
             |   0.0000   0.0000   0.0776
             |
 farminc_lag |   0.6662*  0.3946*  0.5282*  0.4432*  1.0000 
             |   0.0000   0.0001   0.0000   0.0000
             |

. pwcorr   eco_size_milk yield_milk subsidies_milk liabilities_lag_milk farminc_lag_milk, sig star(.05)

             | eco_si~k y~d_milk s~s_milk l~g_milk f~g_milk
-------------+---------------------------------------------
eco_size_m~k |   1.0000 
             |
             |
  yield_milk |  -0.1815   1.0000 
             |   0.0768
             |
subsi~s_milk |   0.3729* -0.3251*  1.0000 
             |   0.0002   0.0012
             |
liabi~g_milk |   0.8300* -0.3682*  0.3557*  1.0000 
             |   0.0000   0.0002   0.0004
             |
farminc_la~k |   0.5943*  0.3212*  0.4278*  0.3131*  1.0000 
             |   0.0000   0.0014   0.0000   0.0019
```

D2. OLS and SUR as cross-section

- OLS for field crops sector

```
. regress  gross_inv_fa eco_size yield subsidies liabilities_lag farminc_lag  capreform

      Source |       SS       df       MS              Number of obs =      96
-------------+------------------------------           F(  6,    89) =   32.08
       Model |   1924779.3     6  320796.551           Prob > F      =  0.0000
    Residual |  890128.853    89  10001.4478           R-squared     =  0.6838
-------------+------------------------------           Adj R-squared =  0.6625
       Total |  2814908.16    95  29630.6122           Root MSE      =  100.01

------------------------------------------------------------------------------
gross_inv_fa |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    eco_size |   .1265355   .0775926     1.63   0.106    -.0276394    .2807104
       yield |   .2348797   .3140596     0.75   0.457      -.38915    .8589094
   subsidies |   .0541978   .1749628     0.31   0.757    -.2934495    .4018451
liabilitie~g |   .0618715   .0209414     2.95   0.004     .0202614    .1034815
 farminc_lag |   .1754492    .108162     1.62   0.108    -.0394665    .3903648
   capreform |  -22.22245   22.78024    -0.98   0.332     -67.4863     23.0414
       _cons |  -52.29973     39.426    -1.33   0.188    -130.6384    26.03889
------------------------------------------------------------------------------
```

- OLS for milk sector

```
. regress  gross_inv_milk eco_size_milk yield_milk subsidies_milk liabilities_lag_milk

      Source |       SS       df       MS              Number of obs =      96
-------------+------------------------------           F(  6,    89) =   81.83
       Model |  3421342.89     6  570223.815           Prob > F      =  0.0000
    Residual |  620175.341    89  6968.26226           R-squared     =  0.8465
-------------+------------------------------           Adj R-squared =  0.8362
       Total |  4041518.23    95  42542.2971           Root MSE      =  83.476

------------------------------------------------------------------------------
gross_inv_~k |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
eco_size_m~k |   .1986544   .0643308     3.09   0.003     .0708305    .3264784
  yield_milk |  -.0547228   .0434173    -1.26   0.211    -.1409921    .0315464
subsi~s_milk |    .318914   .1899776     1.68   0.097    -.0585675    .6963955
liabi~g_milk |   .0756934   .0108903     6.95   0.000     .0540547    .0973321
farminc_la~k |  -.0165492   .1014229    -0.16   0.871    -.2180743    .1849758
   capreform |  -23.69222   23.87944    -0.99   0.324    -71.14017    23.75572
       _cons |   21.28538   26.18125     0.81   0.418    -30.73621    73.30697
------------------------------------------------------------------------------
```

- SUR

```
. sureg (gross_inv_fa eco_size yield subsidies liabilities_lag farminc_lag  capreform)
> dies_milk liabilities_lag_milk farminc_lag_milk capreform)

Seemingly unrelated regression
----------------------------------------------------------------------
Equation          Obs  Parms        RMSE    "R-sq"       chi2        P
----------------------------------------------------------------------
gross_inv_fa       96      6    96.37904    0.6832     210.07   0.0000
gross_inv_~k       96      6    81.05452    0.8439     538.88   0.0000
----------------------------------------------------------------------

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
gross_inv_fa |
    eco_size |    .152823   .0709978     2.15   0.031     .0136699    .2919761
       yield |   .1865024   .2774717     0.67   0.501    -.3573322     .730337
   subsidies |   .0394838   .1570546     0.25   0.802    -.2683375    .3473051
liabilitie~g |   .0611004   .0193834     3.15   0.002     .0231096    .0990912
 farminc_lag |   .1469087   .0950542     1.55   0.122    -.0393941    .3332116
   capreform |  -19.67838   21.74495    -0.90   0.365    -62.29769    22.94093
       _cons |  -49.14671   36.36921    -1.35   0.177    -120.4291    22.13563
-------------+----------------------------------------------------------------
gross_inv_~k |
eco_size_m~k |   .2009809   .0593702     3.39   0.001     .0846175    .3173443
  yield_milk |  -.0949645   .0383633    -2.48   0.013    -.1701552   -.0197738
subsi~s_milk |   .2349142   .1684175     1.39   0.163     -.095178    .5650065
liabi~g_milk |   .0707842   .0102349     6.92   0.000     .0507241    .0908442
farminc_la~k |   .0761498   .0895442     0.85   0.395    -.0993536    .2516532
   capreform |  -23.12476    22.2191    -1.04   0.298     -66.6734    20.42388
       _cons |   14.78014   24.01389     0.62   0.538    -32.28622     61.8465
------------------------------------------------------------------------------
```

D3. Fixed effects in OLS and SUR as panel data

- OLS for Field Crops

```
. regress  d_grossinvestments d_ecosize d_yield d_subsidies d_liabilitieslag d_farminclag d_capreform, noconstant
```

Source	SS	df	MS
Model	208983.248	6	34830.5413
Residual	567173.001	90	6301.92224
Total	776156.249	96	8084.96092

Number of obs	=	96
F(6, 90)	=	5.53
Prob > F	=	0.0001
R-squared	=	0.2693
Adj R-squared	=	0.2205
Root MSE	=	79.385

d_grossinv~s	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
d_ecosize	.3866911	.2057098	1.88	0.063	-.0219873	.7953696
d_yield	-.4317523	.4648657	-0.93	0.355	-1.355289	.4917845
d_subsidies	.8405134	.3596419	2.34	0.022	.126022	1.555005
d_liabilit~g	.0197074	.0289886	0.68	0.498	-.0378835	.0772983
d_farminclag	.3049661	.1106851	2.76	0.007	.0850709	.5248613
d_capreform	-43.52972	22.15559	-1.96	0.053	-87.54566	.4862177

- OLS for Milk

```
. regress d_grossinvestments_milk d_ecosize_milk d_yield_milk d_subsidies_milk d_liabilitieslag_milk d_farminclag_milk d_capref
> noconstant
```

Source	SS	df	MS
Model	203934.135	6	33989.0225
Residual	439236.98	90	4880.41089
Total	643171.114	96	6699.69911

Number of obs	=	96
F(6, 90)	=	6.96
Prob > F	=	0.0000
R-squared	=	0.3171
Adj R-squared	=	0.2715
Root MSE	=	69.86

d_grossinv~k	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
d_ecosize_~k	.1185314	.1804236	0.66	0.513	-.2399116	.4769745
d_yield_milk	.0032568	.1755429	0.02	0.985	-.3454897	.3520033
d_subsidie~k	.8943791	.2719013	3.29	0.001	.3541999	1.434558
d_liabilit~k	-.0077666	.019969	-0.39	0.698	-.0474384	.0319053
d_farmincl~k	-.0553482	.1222773	-0.45	0.652	-.2982734	.1875769
d_capreform	-29.33153	24.46897	-1.20	0.234	-77.94341	19.28034

- SUR

```
. sureg (d_grossinvestments = d_ecosize d_yield d_subsidies d_liabilitieslag d_farminclag  d_capreform, noconstant) (d_grossinve
> nts_milk = d_ecosize_milk d_yield_milk d_subsidies_milk d_liabilitieslag_milk d_farminclag_milk d_capreform, noconstant)
```

Seemingly unrelated regression

Equation	Obs	Parms	RMSE	"R-sq"	chi2	P
d_grossinv~s	96	6	77.43186	0.2584	29.46	0.0000
d_grossinv~k	96	6	67.85878	0.3127	48.64	0.0000

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
d_grossinv~s						
d_ecosize	.4450229	.1907378	2.33	0.020	.0711836	.8188621
d_yield	-.0497781	.4319803	-0.12	0.908	-.8964439	.7968877
d_subsidies	.6517511	.3348591	1.95	0.052	-.0045606	1.308063
d_liabilit~g	.0185028	.0274247	0.67	0.500	-.0352488	.0722543
d_farminclag	.2335987	.1027652	2.27	0.023	.0321826	.4350147
d_capreform	-41.46614	21.20457	-1.96	0.051	-83.02633	.0940392
d_grossinv~k						
d_ecosize_~k	.0994862	.1673068	0.59	0.552	-.2284291	.4274016
d_yield_milk	-.0545461	.1626331	-0.34	0.737	-.3733011	.2642088
d_subsidie~k	.911253	.2525701	3.61	0.000	.4162247	1.406281
d_liabilit~k	-.0140887	.0190357	-0.74	0.459	-.051398	.0232206
d_farmincl~k	.0194724	.1135419	0.17	0.864	-.2030657	.2420104
d_capreform	-32.40835	23.20815	-1.40	0.163	-77.89548	13.07879

D4. First differences in OLS and SUR as panel data

- OLS for field crops

```
. reg d.gross_inv_fa d.eco_size d.yield d.subsidies d.liabilities_lag d.farminc_lag, noconstant

      Source |       SS       df       MS              Number of obs =      88
-------------+------------------------------           F(  5,    83) =    0.95
       Model |  54654.4738     5  10930.8948           Prob > F      =  0.4512
    Residual |  951523.813    83  11464.1423           R-squared     =  0.0543
-------------+------------------------------           Adj R-squared = -0.0026
       Total |  1006178.29    88  11433.8442           Root MSE      =  107.07

------------------------------------------------------------------------------
D.           |
gross_inv_fa |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    eco_size |
         D1. |   .1991876   .3255261     0.61   0.542    -.4482707    .8466459
       yield |
         D1. |   .1772331   .5619529     0.32   0.753    -.9404686    1.294935
   subsidies |
         D1. |   -.09166    .6810255    -0.13   0.893    -1.446192    1.262872
liabilitie~g |
         D1. |  -.0262519   .0550462    -0.48   0.635    -.1357365    .0832328
 farminc_lag |
         D1. |   .2217406   .1094718     2.03   0.046     .0040056    .4394756
------------------------------------------------------------------------------
```

- OLS for Milk

```
. reg d.gross_inv_milk d.eco_size_milk d.yield_milk d.subsidies_milk d.liabilities_lag_milk

      Source |       SS       df       MS              Number of obs =      88
-------------+------------------------------           F(  5,    83) =    1.78
       Model |  73740.2378     5  14748.0476           Prob > F      =  0.1250
    Residual |  685962.551    83  8264.60905           R-squared     =  0.0971
-------------+------------------------------           Adj R-squared =  0.0427
       Total |  759702.789    88  8632.98624           Root MSE      =   90.91

------------------------------------------------------------------------------
D.           |
gross_inv_~k |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
eco_size_m~k |
         D1. |   .2394731    .211202     1.13   0.260    -.1805991    .6595453
  yield_milk |
         D1. |  -.1921113   .2159573    -0.89   0.376    -.6216417    .2374192
subsi~s_milk |
         D1. |   .0697669   .4485959     0.16   0.877    -.8224724    .9620061
liabi~g_milk |
         D1. |   .0881413   .0581049     1.52   0.133    -.0274269    .2037095
farminc_la~k |
         D1. |   .2738615   .1547083     1.77   0.080    -.0338471      .58157
------------------------------------------------------------------------------
```

- SUR

```
. sureg (d.gross_inv_fa d.eco_size d.yield d.subsidies d.liabilities_lag d.farminc_lag, noconstant) (d.gross_inv_milk d.eco_siz
> k d.yield_milk d.subsidies_milk d.liabilities_lag_milk d.farminc_lag_milk, noconstant)
```

Seemingly unrelated regression

Equation	Obs	Parms	RMSE	"R-sq"	chi2	P
D_gross_in~a	88	5	104.4205	0.0464	4.47	0.4841
D_gross_in~k	88	5	88.72228	0.0882	13.23	0.0213

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
D_gross_in~a						
eco_size						
D1.	.1118265	.3064984	0.36	0.715	-.4888994	.7125524
yield						
D1.	.3331924	.5286511	0.63	0.529	-.7029446	1.369329
subsidies						
D1.	.1029077	.6431146	0.16	0.873	-1.157574	1.363389
liabilitie~g						
D1.	-.051076	.0526426	-0.97	0.332	-.1542535	.0521015
farminc_lag						
D1.	.1784438	.1032156	1.73	0.084	-.0238551	.3807427
D_gross_in~k						
eco_size_m~k						
D1.	.250942	.1986768	1.26	0.207	-.1384573	.6403413
yield_milk						
D1.	-.210981	.2030829	-1.04	0.299	-.6090161	.1870541
subsi~s_milk						
D1.	.1644345	.4220259	0.39	0.697	-.662721	.9915899
liabi~g_milk						
D1.	.0638204	.0556428	1.15	0.251	-.0452374	.1728782
farminc_la~k						
D1.	.3827794	.146092	2.62	0.009	.0964443	.6691145