Farmers' technical efficiency, decisions regarding the use of production factors, and the influence of public policy

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Throughout this period it has been a great pleasure to work in a field which is close to my heart – agriculture – studying the status and needs of this sector, as well as considering the well-being and social usefulness of those working in agriculture. I am happy and grateful that, from the outset, the people I have met in the academic field and the agricultural sector have provided me with constant opportunities to learn new things and challenge myself.

I consider the purpose of economic research to be the generation of ideas which may assist public decision-making to improve the well-being of economic agents. To me it seems obvious that by working together we can produce research which is faster, more reliable and more open. This philosophy is reflected in the list of my publications given at the end of this document: the majority of my published work has indeed been produced in collaboration with researchers and engineers from various different fields, and I thank them sincerely for their trust and commitment.

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1. Introduction

From the outset, my research has focused on the micro-economic behaviour of farmers, as well as the determining factors which influence their decisions. My main goal is to contribute to improving our understanding of how agricultural operations function and evolve, and also to attempt to offer some answers to the questions surrounding the future of the agricultural sector and the form it takes within the European Union (EU).

In the old EU member states, the number of farms has been decreasing since the 1950s. In France, for example, the number of farms has decreased from 2.3 million in 1955 to 0.6 million in 2003 (Desriers, 2007). Meanwhile, the average size of farms has been on the increase. Another example: the proportion of farms in France with over 100 hectares of land rose from 0.8% in 1955 to 12% in 2000. This development has been encouraged by the Common Agricultural Policy (CAP), introduced after the Second World War with the aim of helping the European agricultural sector rebuild itself after the conflict and modernising the structures of production. Initially founded upon a system of supporting agricultural prices (guaranteed prices), which meant subsidies 'coupled' with the level of production, the policy has seen three successive reforms since beginning of the 1990s, gradually changing the 'coupled' form of support into a system which is increasingly 'decoupled' from production. The idea is to reorient the principal support mechanism towards a system of fixed allocations. The declared purpose of decoupling subsidies is to encourage farmers to be more responsive to market signals, and particularly to limit the agricultural over-production which resulted from the guaranteed price system. The most recent reform, the 2003 Luxembourg reform, establishes a decoupled mechanism. In the old member states, this mechanism is the Single Farm Payment (SFP), provided per hectare of agricultural land. The introduction of this new payment scheme is no longer based on production (farmers can even leave their fields fallow), and does not require farmers to produce a certain type of good to qualify for the relevant payments (the SFP). Nonetheless, farmers are obliged to follow a certain number of practices intended to maintain their land in good agricultural and environmental condition (GAEC), whether their fields are currently in use or not. This is the cross-compliance aspect of the support system. Moreover, the value of the SFP received by farms depends either on their location (the 'regionalised' support system) or the amount of subsidies they received in certain reference years (the 'historical' support scheme, chosen by France). The choice between these two systems, or even of opting for a hybrid system, was left at the discretion of the old member states. In new EU member states, on the other hand, decoupled CAP subsidies come in the form of direct payment per hectare: the entirely regionalised Single Area Payment (SAP). In other words, the value of this area-based payment is equal within a country, regardless of the use of the land or the identity of the farmer (the identity of the beneficiary of the payment for each hectare is checked and updated annually).

Several studies have given evidence of the impact which the farm subsidies awarded under the CAP system in old member states have on the decisions made by the farmers who receive them. Decisions about exiting the farming sector (see for example Breustedt and Glauben, 2007; Brady *et al*., 2009), the type and level of production (see Guyomard *et al*., 1996; Breen *et al*., 2005), the use of production factors (see Tranter *et al*., 2007; Lobley and Butler, 2010) and the allocation of family labour (see Woldehanna *et al*., 2000; Serra *et al*., 2005) are all susceptible to change depending on the level and type of support received ('coupled' or 'decoupled'). The aim of my research is to add to this literature and contribute to our understanding of farmers' decision-making processes, and the influence that agricultural policy has on their decisions. Within this framework I focused particularly on farms' technical efficiency and the determinants of this efficiency, particularly in new EU member states. In these countries, the main challenge facing farmers was to accomplish the transition from a centralised economy to a market economy, with new institutions and new economic indicators. The way in which agricultural structures, previously either very small (subsistence farming) or very large (collective or state-administered farms), would evolve after the disintegration of the Soviet Union was difficult to predict. Once the transition was made to a market economy, farmers were obliged to adapt to a new agricultural policy – the CAP. Indeed, before they joined the EU in 2004 and 2007, the countries of Central and Eastern Europe (CEE) had their own national agricultural policies, often based on direct subsidies 'coupled' to agricultural production, but such subsidies were often unreliable and of limited value. For farmers in these new member states, the arrival of the CAP removed the link between the level of support received and decisions about production. However, the value of the subsidies received through the CAP turns out to be greater than the support they previously received under the national agricultural policy in effect before accession to the EU. In these countries, the literature on technical efficiency for different types of farm structure (depending on size, legal status, type of production) was still rare when I began my research, and material regarding the influence of farm subsidies on efficiency was simply non-existent. These themes were also under-represented in the available literature on the agricultural sectors of old member states. The aim of my research is to make an active contribution to this literature.

I also focused on the decisions made by farmers regarding the use and acquisition of primary production factors, particularly land and capital. Since the introduction of the SFP in old member states, and direct SAP in new member states, decisions on land use now hinge upon a choice of using land for production or leaving it fallow. Moreover, the fact that these payments are not dependent upon production criteria may act as an incentive for non-farming landowners to recover land previously rented out to tenant farmers. This issue, not explored in the existing academic literature, is important to understanding the evolution of the agricultural sector in terms of land use. As for decisions on acquisition of capital, I studied such choices in the context of the imperfect markets observed in new member states, as well as in terms of analysing the role of public policies on the financial constraints of investment. This latter topic had been entirely neglected in existing works at the time that I began my research. Finally, I focused on the issue of capitalisation of agricultural subsidies in the price of farmland, a crucial factor in predicting the decisions of future generations of farmers, and thus the future dynamic of the agricultural sector. This topic, already widely discussed in the available literature, was in need of an exhaustive review of the methods used and the results obtained; I collaborated on such a review. Moreover, I have adopted an empirical approach to this subject with reference to a new member state, something which had not previously been done.

My research consists of a series of empirical investigations based upon conceptual frameworks of micro-economics of production (maximisation of the agricultural producer's profit or of the farm household's utility). The data I have employed are individual farm-level data, taken from surveys conducted specifically or on the basis of pre-existing databases. Amongst these existing sources, I draw greatly upon the accounting databases of the national Farm Accountancy Data Networks (FADN), which collect annual accounting data from a sample of farms in their respective countries.

The rest of this thesis is organised around three classes of studies, as mentioned above: i) studies dealing with technical efficiency and the productivity of farms, focusing particularly on the improvement of methods and the role of certain determinants including public policy; ii) studies dealing with farmers' decisions regarding the use and acquisition of the primary factors that are agricultural land and capital, particularly the influence of imperfect markets and public policies; iii) studies focusing on the capitalisation of public subsidies in farmland price, in the form of a review of the existing literature and an investigation for a new member state. With reference to this compilation of previous research, the final part of this thesis will lay out the perspectives for my own research. My publications are listed at the end of the text, and throughout the body of this paper they will be cited with numbers in square brackets.

2. Farm technical efficiency and productivity

The majority of my research concerns the technical efficiency and productivity of farmers: the evolution of these indicators and the factors which determine them, with particular focuses on the improvement of methods of calculation and estimation (taking into account sampling variation, and the problems resulting from the endogenous nature of the explanatory variable of debt level), and on the importance of farm size and public policy as contributing factors. The first section of this chapter will seek to define technical efficiency and productivity, and to explain the general methods which I employed in the course of my work. Subsequent sections record the results of selected studies, which represent contributions to the existing literature on the calculation of technical efficiency and productivity of farms, and on the factors which determine these two indicators.

2.1. Defining and calculating technical efficiency and productivity

Technical efficiency allows us to assess whether or not a farm is using existing technology in an optimal way, i.e. whether or not the farm is capable of achieving the maximum output possible with a given set of factors, or of using the minimum possible amount of factors to achieve a given level of output. The major advantage of using technical efficiency as an indicator of quantitative performance is that it allows us to take account of the combinations of production factors and their possible substitutions, which is not the case with partial productivity indicators such as yield or amount produced per unit of labour.

Efficiency can be calculated using parametric or non-parametric methods. In the first case, the stochastic frontier method is generally employed, and in the second case the Data Envelopment Analysis (DEA) method is most commonly used.

The stochastic frontier method was proposed simultaneously by Aigner *et al*. and Meusen and van den Broeck (both 1977). The idea is to estimate a production function with a composite error term: one representing a random term and the other representing inefficiency. Each observation receives an efficiency score between 0 and 1: the higher the score, the greater the efficiency. The difference between 1 and the efficiency score of a farm represents the percentage of additional production that the farm could achieve with the same input factors (or inversely, the percentage by which the farm could reduce all its production factors while still maintaining the same level of output). The determinants of technical efficiency can be assessed through an econometric regression in a second stage, but this two-stage approach can introduce estimation bias. It is for this reason that the efficiency determinants are estimated at the same time as the production function is estimated, as suggested by Battese and Coelli (1995). The principal weakness of the stochastic frontier method is its potential vulnerability to errors of specification (of the production function, of the error term).

This is not so with the DEA method. Introduced graphically by Farrell (1957), then mathematically by Charnes *et al*. (1978), this method uses mathematical programming to construct a frontier composed of different pieces, which together envelop all observations from the sample. Thus the observations situated on the frontier are those which are completely efficient, receiving an efficiency score of 1. Farms below the frontier are therefore considered to be inefficient compared to this reference level. As a result, the further a farm is from the frontier, the more inefficient it is. The distance away from the frontier represents the degree of efficiency of the farm under consideration. Inefficient farms have an efficiency score which is below 1 but above 0. The lower the score, the lower the level of efficiency. The difference between 1 and a farm's efficiency score can be interpreted in the same way as the score obtained by the stochastic frontier method. With the DEA method, efficiency can be calculated under the assumption of constant returns to scale, or of variable returns to scale. In the first case, the term 'total technical efficiency' is used to describe the score obtained, while 'pure technical efficiency' is used in the second case. The pure technical efficiency score is one of two components of total technical efficiency. The other component is scale efficiency. This latter value gives an indication of the amount of inefficiency which results from a sub-optimal production scale, whereas pure technical efficiency provides information on the efficiency of the farmer's management practices. With regard to the determinants of technical efficiency, these are estimated by an econometric regression in a second stage, using the Ordinary Least Squares (OLS) method, or with a model with a limited dependent variable (censored or truncated models) if it so happens that a large percentage of farms are found to be on the frontier (i.e. with an efficiency score of 1).

The DEA method also allows us to calculate changes in the total factor productivity with the Malmquist indices, introduced by Caves *et al*. (1982), for which the technical efficiency change and technical change decompositions were subsequently proposed by Färe *et al*. (1992). Calculation of these indices is based upon the movement over time of the efficiency frontier and the movements of the farms in relation to the annual frontier. The indices of change in total factor productivity (or Malmquist indices), the efficiency change indices and the technical change indices are interpreted as follows: a value of 1 means that there has been no change between the two periods considered, while a number greater than 1 indicates progress and a number below 1 represents decline.

The DEA method suffers from two major problems resulting from the construction of the efficiency frontier based upon farms in the sample. The first is the issue of constructing the frontier in case of extreme observations, which can lead to the construction of a frontier which is too far removed from the sample average, and thus lead to an underestimation of the efficiency of the observations considered. To avoid this problem, it is necessary to check for the presence of outliers in the sample used, or to apply the statistical method specifically adapted to the DEA approach, as proposed by Wilson (1993). The second problem is the issue of sampling variation, which arises when the most efficient farms in the population under analysis are not included in the sample. In this case, comparatively inefficient farms will make up the general frontier, and the degree of efficiency of other farms in the sample will therefore be measured against the frontier produced by this sample, which will be 'lower' than the frontier of the actual population. This will result in a general underestimation of the distance to the efficiency frontier, and thus an overestimation of the efficiency of the farms in the sample considered. This leads to a bias of the efficiency scores, shifting them closer to 1. To mitigate this problem, Simar and Wilson have proposed bootstrapping techniques (1998, 1999, 2000a, 2000b, 2007), correcting the scores for sampling bias or producing confidence intervals (for efficiency scores and for productivity change indices).

2.2. Taking into account the problem of sampling variation in efficiency and productivity calculations made using the DEA method.

I have co-authored several articles about taking account of sampling variation in calculations made using the DEA method via bootstrapping techniques: i) calculating technical efficiency scores (**[10]**, **[16]**, **[22]**, **[24]**); ii) calculating productivity indices (**[14]**); and iii) second-stage estimation of the determinants of technical efficiency and productivity (**[9]**, **[13]**). Before these articles, the literature on the subject rarely took into account the effect of sampling on the calculation of technical efficiency with the DEA method, and the problem was almost unheard of in the literature dealing with farm efficiency. Brümmer was the only author to have taken notice of this variation in his article (2001) on the efficiency of Slovenian agriculture.

Initially I studied the influence of sampling variation on efficiency results (i). In article **[22]** my co-authors and I compared the average technical efficiency of farms in Poland specialising in livestock-rearing with that of Polish farms specialising in crop production, in 1996 and 2000. Technical efficiency was calculated separately for these two types of farm: as the technology used is different, it is more appropriate to establish separate efficiency frontiers. Comparing the two types of farms is thus a matter of comparing the average efficiency scores of the two sub-samples. The existing literature dealing with efficiency comparison between samples which contain farms with different production orientations gives contradictory results as to the superiority of one or the other specialisation. On the one hand, livestock farms might have a lower average technical efficiency than arable farms as a result of a technology which requires more manpower, leading to greater spreads in efficiency between husbandry practices. On the other hand, arable farms might have a lower average efficiency as a result of climatic conditions which have the potential to affect their efficiency to a variable extent, but are not taken into account during efficiency calculations. The efficiency scores obtained for our two Polish samples using the DEA method demonstrated that livestock farms were, on average, more technically efficient than arable farms in the two years we considered. By using the bootstrapping method and calculating confidence intervals, as proposed by Simar and Wilson (1998 and 2000b), we confirmed the greater average efficiency of the livestock farms subsample: indeed for both subsamples (livestock farms and arable farms) the averages of lower and upper confidence intervals' bounds show that there is generally no overlapping of confidence intervals.

Subsequently we applied the bootstrapping method specifically adapted by Simar and Wilson (1999) to productivity indices calculated with the DEA method to the analysis of productivity evolution in Polish farms between 1996 and 2000 (ii). This method had been little used in the literature in general, and had never been applied to the agricultural sector. In our article **[14]**, the calculations of Malmquist indices made using the DEA method revealed an average productivity decline of 2% over the period. This decline corroborated the findings of existing studies on this subject. Nonetheless, by applying the bootstrapping technique and constructing confidence intervals for the Malmquist indices of all of the farms considered, we illustrated the uncertainty which hangs over these results. Indeed the average lower bounds of the confidence intervals in the sample indicate an average decline of 31% over the period, whereas the average of the upper bounds of the confidence intervals indicated an average increase of 18%. These results thus suggested that the negative image of a decline in productivity in Poland during the transitional period, as presented in the existing literature, was not indisputable: indeed our sample demonstrates that there could well have been an increase in productivity.

Lastly, we took account of the problem of sampling variation when identifying the effect of determinants on technical efficiency and productivity (iii). In this article **[13]**, we applied the double bootstrap method proposed by Simar and Wilson (2007) to a sample of Czech farms taken in 1999. This method allows us to take the problem of sampling variation into account during the first stage of the efficiency calculation but also during the second stage of the estimation of the determinants. Comparison of the results of standard estimation (without bootstrapping) with those generated by estimation with double bootstrapping revealed only slight differences of significance. Finally, we took sampling variation into account in our estimation of the determinants of the productivity indices for a Polish sample between 1996 and 2000 **[9]**. Although a method does exist for correcting sampling bias when calculating Malmquist indices (Simar and Wilson, 1999), up until now no approach had been suggested to take into account this bias during the second stage of regression analysis of the indices. We therefore proposed an approach which would allow remedy this problem. The idea was to use, during the second-stage regression, estimated standard errors of the Malmquist indices generated by the bootstrapping of the first stage, by introducing a double error term: one random homoscedastic term and one heteroscedastic term, which is a function of the estimated standard errors of the indices. Our results revealed differences in sign and significance for some coefficients.

Nonetheless, we concluded that the results generated by heteroscedastic regression analysis are a better match with the *a priori* hypotheses made about the effect of the determinants.

These articles, which compare the results obtained using standard efficiency calculation and regression methods within the framework of the DEA approach with those obtained by integrating the problem of sampling variation, sometimes reveal inconsistencies but still allow us to corroborate the results. It is, however, difficult to draw any general conclusion on the necessity or otherwise of applying bootstrapping techniques to these calculations, since we considered only isolated empirical studies. We would need to apply the method to other samples to reach a more systematic conclusion.

2.3. Analysing the influence of a farm's size on its technical efficiency

The question of the influence of a farm's size on its technical efficiency and productivity is one of the issues which have received the most attention in studies in development economics (see for example Johnson and Ruttan, 1994; Le Mouël, 2004). The debate over the superiority of small or large farms emerged several decades ago with respect to developing countries, and was initiated by evidences of an inverse relationship between size and productivity (see for example Cornia, 1985; Verma and Bromley, 1987). The arguments put forward to explain this relationship are twofold: firstly, the separation between ownership and management in large farms, which means the workers do not receive strong enough incentives to increase their effort, as their wages are only loosely bound to the farm's performance (Buckwell and Davidova, 1993). The other argument is that the difficulties of supervising labour in large-scale farms leads to high transaction costs (Pollak, 1985; Schmitt, 1991). Nonetheless, this inverse profit relationship is often questioned, for example by the imperfect markets argument, which would explain why large farms enjoy preferential access to the markets for produce and production factors such as credit (Hall and LeVeen, 1978; Feder, 1985). In the 1990s the focus of the debate shifted to those countries making the transition from a centralised economy to a market economy. At the beginning of this transitional period, the coexistence of very small subsistence farms and very large state-controlled or collective farms begged the question of the farm size which would prevail after the restructuring. Positing the theory that the most efficient farms would have a greater chance of survival, several studies were undertaken on the relationship between size and technical efficiency. In their review of these studies, Gorton and Davidova (2004) note that the results are ambiguous. One of the reasons the authors give for this ambiguity is the common use of agricultural land as an indicator of farm size, an indicator which is not pertinent for all production systems. Furthermore, the influence of size on efficiency is sometimes demonstrated by separating farms into size categories; the boundaries dividing these categories are often defined by arbitrary criteria. Finally, analyses of different types of efficiency, for example technical efficiency or scale efficiency, do not necessarily produce identical size-efficiency relationships. The existing literature underlines how difficult it is to produce a theoretical model of the influence of size on efficiency, due to the multiplicity of underlying mechanisms, prompting us to fall back upon a greater number of empirical evaluations.

Several articles which I have co-authored on the determinants of technical efficiency in transitional European countries (Czech Republic, Lithuania, Poland) have analysed the influence of size (**[1]**, **[9]**, **[13]**, **[14]**, **[16]**, **[20]**). The results, based upon the comparison of average efficiency between different size categories, or the comparison of average sizes in the different efficiency quartiles, or the estimation of the effect of size variables (continuous variables, dummy class variables), are ambiguous, like the results produced by the previous literature on the subject. In addition, I have presented more detailed analysis of the influence of size on efficiency in two further articles. In article **[22]** I calculated the technical efficiency of Polish farms specialising in livestock rearing and crop farming, in 1996 and 2000, using the DEA and stochastic frontier methods. Average efficiency scores were then compared between size categories, classed in terms of hectares used and defined according to the thresholds used by the Polish Ministry for Agriculture. The results of both methods reveal a higher level of efficiency in large-scale livestock farms compared to medium-size and small livestock farms, and a greater level of efficiency in large and medium-scale arable farms than in small farms. Moreover, in article **[24]** the DEA method analysis is pursued further by dividing technical efficiency into pure technical efficiency and scale efficiency, and by producing confidence intervals for the efficiency scores. The efficiency scores calculated with the DEA method suggest that very small farms have the upper hand in terms of pure efficiency, but are weaker in terms of scale efficiency. Nonetheless, comparison of the averages lower and upper bounds of the confidence intervals between classes suggests uncertainty over these results. Indeed the confidence intervals for each category overlap on average, and the lowest average lower bound for pure technical efficiency is found in the very small farms category. This casts doubt upon the conclusions reached without the bootstrapping analyses, which suggested that pure technical efficiency was greater in very small farms. Finally, in article **[32]**, which has yet to be published, we consider various size indicators, i.e. utilised agricultural area, total labour on the farm and the value of the farm's capital, in order to analyse the influence of size on the efficiency of Slovenian farms over the period 1994-2003. The results indicate a negative effect of land area and capital on technical efficiency, but a positive effect of labour.

My work on the influence of farm size on technical efficiency contributes to the literature on the subject, as there were previously very few studies dealing with this issue in relation to the transitional countries which I examined (Czech Republic, Lithuania, Poland, Slovakia). My work confirms the ambiguity of results identified in the existing literature, and underlines the importance of not drawing general conclusions, but of specifying very clearly the context and parameters of one's study. It might also be interesting to ascertain whether or not there are factors which can explain the variability of these results (for example type of data used, the assumptions of the method, the institutional and political context of the country being studied etc.) via a meta-analysis of the existing studies on the subject.

2.4. Taking account of endogeneity when estimating the effect of a farm's indebtedness level on its technical efficiency

The impact of a farm's indebtedness level on its efficiency during the transitional period is a crucial issue. Due to the absence of a credit market under the previous centralised regime, farmers in transition countries are not familiar with debt, and this can have negative consequences on their production decisions and efficiency. However, this issue facing transitional economies is not one which has really held the attention of many researchers. On the other hand, in the literature dealing with developed countries, such as the USA, there have been several studies addressing this issue (e.g. Nasr *et al*., 1998). These studies refer to some theoretical approaches with regard to the link between debt levels and technical efficiency, and recognise that this is an ambiguous relationship. However, none of them takes account of the potential endogeneity of indebtedness with the efficiency score, an aspect considered in my joint article on Czech farms in 1999 (**[16]**). On the one hand, indebtedness may play a role in determining the level of technical efficiency, but on the other hand technical efficiency itself may very well determine the debt level of a farm. Three theoretical approaches, founded upon financial theory, can be advanced. 1) In the first approach, a farm's debt level can have a positive impact on its technical efficiency. In the literature, this impact is predicted by the 'free cash flow approach' proposed by Jensen (1986) and revised by Nasr *et al*. (1998) for the agricultural sector. This approach posits that debt might inspire farmers to make a greater effort, leading to an increased technical efficiency, since the farmer would want to avoid defaulting on the repayment of the debt. Jensen (1986) considers free cash flow to be the residual profit of a company once all profitable investments have been completed. This profit is then used to repay the debt. A greater level of efficiency therefore allows for increased profit. 2) On the other hand, debt may have a negative impact on the technical efficiency of a farm, according to the 'agency theory approach' proposed by Jensen and Meckling (1976). This approach posits that the costs incurred by banks in monitoring agricultural borrowers are in fact passed onto these borrowers, and that as a result the most indebted farmers may have to endure greater constraints and costs, leading to a decline in efficiency. 3) Finally, the inverse relationship according to which technical efficiency exerts a positive influence on the level of debt may also be valid. This approach is known in the literature as the 'credit evaluation approach', and is based upon the hypothesis that lenders might prioritise lending to those farmers who are the most technically efficient, since they would present a reduced financial risk (Nasr *et al*., 1998). The causality in the relationship proposed by this approach demonstrates that there is a possible endogeneity of debt indicators with technical efficiency.

In article **[16]** my co-author and I took account of this potential endogeneity in the Tobit model used to estimate the determinants of technical efficiency calculated using the DEA method. The Tobit model was chosen because of the high proportion of farms which received an efficiency score of 1 (meaning that they were situated on the frontier). We tested the exogeneity of the debt variable by applying a version of the Hausman test adapted to the Tobit model, as proposed by Smith and Blundell (1986). Amemiya's efficiency estimator (1978) was then used in cases where the exogeneity hypothesis was rejected. With this method, the Generalised Least Squares (GLS) are applied to the relationship between structural parameters and the reduced form parameters of the Tobit model. The results indicated that the exogeneity of debt levels is rejected for individual farms but not for collective farms (estimation by separate regressions). The 'credit evaluation' hypothesis is therefore valid for individual farms. Thus, almost ten years after the beginning of the transition in the Czech Republic, individual farms were treated more strictly by lenders than collective farms. In addition, the results revealed that the technical efficiency of individual and collective farms specialised in livestock rearing is negatively affected by the indebtedness ratio; on the other hand, for farms specialising in crop production the effect is positive for individual farms and non significant for collective farms (estimation by four separate regressions). This goes to show that livestock farms are subject to the agency theory (monitoring costs passed onto farmers), and that the free cash flow hypothesis (motivation to pay back the loan) holds true for individual farms specialising in crop production.

2.5. Analysis of the influence of public policy on the technical efficiency of farms

It is only fairly recently that I have begun to focus some of my research on the role of public policy, and particularly on environmental regulations and public subsidies within the CAP framework, examining the impact these measures have on the technical efficiency of farms. I considered the impact of environmental regulations on farms' technical efficiency through an empirical analysis of pig farms in France, in the context of my supervision of a PhD candidate for one chapter of her thesis (Larue, 2009). Pig farming accounts for a great deal of water pollution in industrialised countries, as the waste produced contains high levels of nitrates and phosphates, its production techniques are intensive and its farms often combine to form large establishments. Several countries have introduced regulations intended to limit agricultural pollution resulting from animal waste. In the EU, the 1991 Nitrate Directive stipulates a maximum level of 170kg of nitrogen per hectare of land being spread with animal manure. In France, to ensure that this threshold is not exceeded, farmers are allowed to spread their manure on the land of other farms, as well as on their own. These regulations may influence the decisions of pig farmers, with regard to their use of production factors and thus their technical efficiency. The change in technical efficiency can go either way. On the one hand, environmental regulations might give incentives to pig farmers to rationalize their use of production factors in order to reduce waste. This proposition was first formulated in the frame of the Porter hypothesis (Porter and Van der Linde, 1995), which posits that environmental regulations stimulate increased competitiveness by modifying input-output combinations. This has been demonstrated for the French pig farming sector by Piot-Lepetit and Le Moing (2007) for the period 1996-2001. On the other hand, technical efficiency may be negatively affected by environmental regulations as a result of increased competition for spreadable farmland, and the need to spread the manure on land which is increasingly far away from the farm of origin. This constraint can create conflicts over the allocation of production factors on the farm, particularly labour and capital, leading to a decline in technical efficiency.

Piot-Lepetit and Le Moing (2007) conducted their empirical analysis by calculating one environmental component of technical efficiency, using data on pig farmers extracted from the FADN between 1996 and 2001. The approach used in article **[26]** differs from their method in two ways. Firstly, the data we used were specific to the pig-related activity of French pig farmers; the source was a 2004 database compiled by the French Institute of Pig Farming (IFIP). Moreover, we evaluated the effect of environmental constraints on technical efficiency without the environmental component with a second-stage regression of the efficiency scores calculated with the DEA method on the basis of local exogenous data (population, availability of animal feed, access to slaughterhouses, animal pollution in the region and spatial lag in the neighbouring regions). Our results reveal: i) the total level of animal-related nitrogen pollution in the region of the farm had a positive effect on the technical efficiency of the farm; and ii) the spatial lag of this pollution in the farm's neighbouring regions had a negative effect. The first effect (i) confirms Porter's hypothesis and demonstrates that environmental constraints can give incentives to farmers to be more efficient. On the other hand, the second effect (ii) suggests that if the environmental regulations governing the spreading of manure are too tight, the first positive effect (i) might be cancelled out.

As for public support in the form of farm subsidies, it is generally accepted that they reduce the technical efficiency of farmers. Nonetheless, this conclusion is founded largely upon empirical results, as theoretical demonstrations of the subject are rare. There are currently two theoretical approaches which seek to explain the influence of public subsidies on the technical efficiency of farmers: the Martin and Page model (1983) for industry, according to which subsidies reduce the effort invested by the manager, and therefore negatively impact upon the quality of his/her management practices, i.e. his/her efficiency; the second, more recent model is that of Serra *et al*. (2008), which suggests that it is farmers' risk-aversion which changes under the influence of support policies, and thus decisions regarding allocation of inputs, but with no certain conclusion (conclusions vary depending upon whether or not the changes in decisions lead to increased use of an input which increases risk). There is nonetheless a consensus in the empirical literature that subsidies have a negative impact on the technical efficiency of farmers, as the overview of the existing literature which I produced for the Organisation for Economic Cooperation and Development (OECD) illustrates (**[42]**). The method generally employed in the existing studies is a two-stage approach, that is to say an econometric estimation of the impact of subsidies (in terms of absolute value of subsidies received by farms or value of subsidies attributed to a unit of size) on the efficiency scores calculated in the first stage. My co-authors and I used this methodology for our empirical studies on Hungary and Slovenia (**[2]**, **[6]**, **[27]**, **[33]**). These studies were the first to demonstrate a negative impact made by subsidies in CEE countries, before or after their accession to the EU. However, two studies (not yet published) which I recently conducted on French agriculture allow us to moderate somewhat our view of the systematically negative effect of farm subsidies on technical efficiency.

The first of these two studies, which focuses on French FADN farms specialising in cereal, oilseed and protein (COP) and beef production in the year 2000, adopts a four-stage approach, following the method established by Fried *et al*. (1999). This approach allowed us to isolate managerial inefficiency from unfavourable external conditions thanks to the use of climatic data at municipality level (**[28]**). In a fifth stage, the managerial efficiency scores were regressed on explanatory variables including the CAP direct payments. The results show a strong negative impact of the CAP direct payments per unit of size on the managerial efficiency of the farms considered. This negative impact persists when the influence of payments is evaluated separately according to their type (payments coupled to hectares cultivated; payments coupled to number of livestock; agro-environmental payments, payments for less favoured areas); nonetheless, certain effects are not significant in certain sectors, for example the effect of payments coupled to number of hectares cultivated for farms specialising in beef production, and the effects of payment coupled to number of livestock and payments for less favoured areas on farms specialised in COP production.

The second study on French agriculture, based upon data taken from FADN farms between 1990 and 2006, takes into account the problem of sampling variation which is inherent to the DEA method, as previously mentioned in section 2.1 (**[58]**). Total technical efficiency scores, pure technical efficiency scores and scale efficiency scores were all calculated using the standard DEA method. The total technical efficiency scores and pure technical efficiency scores were then corrected for sampling bias with the help of the bootstrapping method outlined in section 2.1. Significant changes in average efficiency over the periods between the various CAP reforms (1992, 2000 and 2003) were then studied. Moreover, regression analyses for the five types of efficiency score were conducted using OLS on explanatory variables including values, by unit of size of the farm, of the various types of subsidy. The farms considered fell into three categories: those specialising in COP, those specialising in beef and those specialising in dairy production. The results reveal a substantial decline in average efficiency, whatever the type of efficiency under consideration, in the years following the implementation of the first CAP reform in 1992. Thereafter, and until the end of the period studied (2006), efficiency never recovered this initial level, and further decline was observed after implementation of the 2003 reform concerning COP farms. Meanwhile, our econometric regressions show that if investment subsidies generally tend to increase efficiency while operational subsidies reduce it as predicted by the theory, the effects are sometimes non-significant or even contradictory. Thus the main conclusion reached by this study is that the negative impact of public subsidies on the technical efficiency of farms, as established by the Martin and Page theoretical model (1983) and by the existing empirical studies, is not always confirmed. Indeed much depends upon the type of subsidy, the type of efficiency being measured, the production orientation of the farm and the time period studied.

This question is therefore worthy of further study, in order to understand the underlying mechanisms at play and to allow us to draw systematic conclusions. Besides, from an econometric point of view it would be necessary to correct for potential selectivity bias (using the Heckman method [1979]): subsidies are not actually automatically awarded, and farmers are not all systematically eligible.

3. Decisions concerning the use and acquisition of primary production factors, and public policies

The second aspect of my work is my focus on decisions regarding the use and acquisition of the primary production factors of land (namely the decision of whether or not to leave the land fallow) and capital (namely investment demand). For both cases I analysed the influence of public policy on decision-making. As for the third primary production factor, labour, this is a subject which I have recently begun to explore. Further details are given in the concluding section on the future research perspectives which I wish to pursue.

3.1. Using land for production or leaving it fallow: the influence of agricultural policy

While there are many factors which might explain farmers' decisions to use land to produce or to leave it fallow (e.g. agronomical, sociological, financial or institutional factors), noted in the review of the existing literature presented in article **[63]**, public policy is another factor which may have an impact upon such decisions. Some policies may lead to a reduction in the area of land left fallow, something demonstrated by Goodwin and Mishra (2006) with regard to the Agricultural Market Transition Act (AMTA) subsidies distributed in the USA. Price support measures may also influence decisions to leave land fallow, as shown by Schoney (1995) with reference to price stabilisation policies in Canada. The CAP is a special case because, up until the most recent reform in 2003, beneficiaries were obliged to leave a portion of their land fallow. The land left fallow was generally the least fertile (Rygnestad and Fraser, 1996), although this phenomenon was initially limited by certain measures, such as set-aside rotation (Guyomard *et al*., 1996). Since the implementation of the 2003 reform and the introduction of the SFP, farmers are no longer required to produce on land in order to qualify for the direct subsidies attributable to this land. This may influence decisions regarding land use. Nonetheless, problems may arise if this lack of production obligations leads to abandonment of agricultural land, particularly in the most disadvantaged areas. This effect may be encouraged by the fact that landowners who do not farm their land now also have the chance to claim decoupled CAP subsidies without any requirement to put this land into production. Article **[3]** deals with this issue, considering two types of landowner: farmers who own their own land and landowners who are not themselves farmers. The existing empirical studies addressing the impact of the 2003 CAP reform on farmers' intentions for their farmland reveal a slight decrease in the total area of land in production (Breen *et al*., 2005; Genius *et al*., 2008; Tranter *et al*., 2007). However, no existing study had considered the intentions of non-farming landowners, the topic of article **[3]**. The conceptual framework employed is founded upon comparison of the land's marginal profits when in production and when left fallow, and proposes some financial determinants which might influence the decision to leave land fallow (loss of farming profit, costs of fallowing, costs of cross compliance) along with some non-financial factors (e.g. social characteristics of the landowner). The data used were taken from a survey of intentions conducted on French landowners in 2006. The results revealed that 88% of these landowners, whether or not they are farmers, did not wish to put their land out of production and still receive the decoupled CAP subsidies. Econometric estimation of intentions to leave land fallow revels that financial aspects are not the only factors influencing these intentions, which corroborates the observations of previous studies (Breen *et al*., 2005; Genius *et al*., 2008): environmental education has a positive influence on this intention, while age has a negative influence. The fact that only a small proportion of non-farming landowners intended to recover their land and leave it fallow in order to receive decoupled CAP subsidies may be explained by the difficulties which landowners taking this decision might encounter. Land lease contracts in France are long-term (9 years minimum, often 18 years), and at the end of the contract landowners may recover their land if and only if they commit to use the land (for production or fallow) for at least 15 years. They must also meet the prerequisite conditions for starting up a farm (such as having undertaken agricultural training).

As part of the 6th EU Framework Programme's IDEMA project ("Impact of Decoupling and Modulation on Agriculture"), I studied the impact that the implementation of the CAP in Slovakia and the Czech Republic had on the intentions of landowners holding land used for collective farms (**[17]**). Just as in the case of the French landowners mentioned above, the owners of land farmed by agricultural collective farms in new member states are 'absentee' landlords, living in urban areas and with no links to agriculture, having inherited the land. Nonetheless, the introduction of the CAP to these countries in 2004, and along with it the introduction of the direct payment of the same amount per hectare (the SAP) whatever the use of the land (in production or not, but on the condition that cross-compliance requirements are met), may encourage some landowners to end their rental contracts in order that they themselves might receive this direct payment for land left fallow. By applying a conceptual framework representing the relationship between a landowner and a collective farm I put forward the proposition whereby the optimal strategy for landowners would be to terminate their leasing contract if the collective farms did not pay them all or part of the CAP direct payment via increased rents. However, surveys of landowners' intentions taken in Slovakia and the Czech Republic in 2005 show that only 12% of them were planning to terminate their leasing contract. I subsequently produced an econometric estimation which shows that, as in the case of the study conducted on French landowners (**[3]**), non-monetary factors, particularly the length of the relationship and the frequency of contact between landowner and collective farm, are more important factors in the decision than the level of rent.

3.2. Investment in capital and the influence of public policies

I studied the way in which public policies influence capital acquisition in an imperfect market context. The capital, or credit, markets are often characterised by imperfections, which limit the opportunities to borrow, and thus the ability of farmers to make investments. These imperfections are particularly prominent in countries making the transition from a centralised economy to a free market economy with an emerging credit market. For example, I gave evidence of the presence of such imperfections in the case of Poland in articles **[19]** (with a calculation of the transaction costs faced by borrowers, based on the results of a survey), **[21]** (with an estimation of an investment model using data from the Polish FADN) and **[41]** (with interviews conducted with farmers and banks). These imperfections are due to information asymmetry and non-null transaction costs. Indeed, lenders are not fully informed of the profiles of their prospective borrowers (adverse selection) or their actions (moral hazard): those requesting funding do not yet have a 'credit history' since the credit market did not exist under the communist regime. These information asymmetries make it difficult to establish an interest rate which can reflect the probability (poorly understood) of default by the borrowers. This situation gives rise to higher background checking and monitoring costs. Furthermore, other types of transaction cost exist, for example coercive costs. So, in order to cover these costs, lenders charge additional fees, meaning that they pass on their transaction costs to their borrowers. Lending institutions may also add a premium to the interest rate, to reflect the high cost of background identification, monitoring and coercion (Hoff et Stiglitz, 1990). For example, the results of article **[19]** show that the transaction charges imposed upon borrowers in Poland (in terms of additional fees, transport costs and opportunity costs of the time spent on the procedure) increased the rate of interest by a third, on average. But this increase in interest rates can have a negative impact on the profit of the lending institutions, as it may lead to self-selection by the more risky credit-seekers. Indeed borrowers who present a small risk of default may be discouraged by high interest rates which do not, in their opinion, reflect their probability of default (Stiglitz et Weiss, 1981). For this reason, lenders sometimes prefer to simply refuse loans, which equates to credit rationing which is not based on price. Moreover, it was sometimes not easy for banks to impose compliance with loan contracts, as was the case in Poland where the law only allowed lenders to recover a portion of the collateral of a loan in the event of default, hence their demand for a high level of collateral. Some farms may thus be turned down because of a lack of collateral, despite a high level of marginal investment return. The result of imperfections in the rural credit market is thus to force (in the event that their credit request is turned down) or encourage (in cases where the opportunity cost of their internal resources is lower than the cost of external finance) some farms to use their internal resources. This could lead to underinvestment in the agricultural sector, if this self-financing is not sufficient to attain the optimal level of investment.

I have provided evidence of the existence of imperfection on the credit markets in Poland, Slovenia and Lithuania before their accession to the EU (**[4]**, **[21]**, **[25]**), with the help of an investment model, namely the accelerator model introduced by Clark (1917). This model assumes that a firm's investment demand is solely a function of growth in the firm's sales. This model was not founded upon any solid theory when it was first proposed, but was based upon simple observation of the industrial sector, and none of the existing literature provided a theoretical foundation. However, in article **[25]** I bound this model to a simple theoretical foundation, by using the producer's profit maximisation framework and the Cobb-Douglas production function. To verify the existence of imperfections on the credit market, Fazzari *et al*. (1988) propose a method which involves augmenting the base model of the accelerator of the cash flow variable, which represents the internal resources at the farm's disposal (in general, profit is used). This method, which does not rely on a structural model but introduces an additional variable on an *ad hoc* basis, is founded upon the idea that if farms are not subject to financial constraints, then financing with internal resources (profit) or with external resources (credit) represent the same cost and are thus perfect substitutes. In this case, the variable which represents the internal resources, cash flow, has no significant impact on the investment model. On the other hand, if financial constraints are present, there is a disparity between the cost of internal financing and the cost of external finance (Hubbard, 1998). In this case, the cash flow variable has a significant positive effect on investment demand in the accelerator model. My econometric estimations, based upon data from individual farms, reveal a positive and significant impact of the cash flow variable for farms in the samples considered (in Poland 1996-2000 **[21]**, in Slovenia 1994-2003 **[25]** and in Lithuania 2000-2002 **[4]**), indicating that the credit markets in these countries were imperfect during these periods. The farms most affected by credit market imperfections may then be identified using the approach proposed by Fazzari *et al*. (1998), based upon the division of farms into two groups according to a criterion which distinguishes farms *a priori* according to their situation in the rural credit market (for example, farm size). The investment model augmented of the cash flow variable is then applied to the two groups, and the group with the highest coefficient for this variable (measured with a Chow test) is judged to be the group most affected by the imperfections. This method was applied to the Polish and Lithuanian samples, and in an equivalent way the interaction term between 'cash flow' and 'farm size' was introduced to the investment model applied to Slovenia. The results demonstrate that small farms were most affected by financial constraints in Lithuania, but size was not observed to have any effect in Poland or

Slovenia. The absence of a size effect in these two countries is somewhat surprising, since we might have expected small farms to face greater difficulty in obtaining loans, as a result of their limited capacity to offer collateral or their weaker capacity to pay back the loan, in absolute terms. Nonetheless, in relative terms, small farmers may own a higher percentage of the land they farm, and thus have greater collateral than larger farms. This situation was observed in the case of the Polish sample (**[21]**).

While the evidence of market imperfections and the influence of borrower profiles on their credit constraints via the accelerator method may already have been a familiar feature in the economic literature on transition countries, this method had always been applied to firms, and had not yet been applied to the agricultural sector. My articles therefore represent an original contribution to the literature. Furthermore, no previous study had focused on the influence of public subsidies on capital acquisition in the context of imperfect credit markets. My articles on Lithuania and Slovenia were the first to attempt this (**[4]**, **[25]**). In the Lithuania article (**[4]**), my co-authors and I divided farms into two classes according to the percentage of their total revenue made up of subsidies. Applying the augmented accelerator model to these two classes of farms shows that those receiving the biggest subsidies, by percentage of total revenue, were the least financially constrained, before accession of their country to the EU. This suggests that subsidies allowed farms to increase their liquidity and cover their investment expenditure. Furthermore, we compared the intentions of financially-constrained Lithuanian farmers with regard to increasing their size (in terms of land area) with the intentions of unconstrained farmers on the same subject; this comparison was made for a (realistic) scenario of CAP payments being introduced (SAP) after accession to the EU, and for a (hypothetical) scenario wherein the pre-EU national agricultural policy was continued (these surveys of intentions were carried out as part of the research for the 6th EU Framework Programme's IDEMA project, see description in **[51]**). The results obtained show that those farmers who face the greatest financial constraints before accession the EU are the most inclined to expand their farm. This suggests that the CAP payments, which are higher in level than the national subsidies paid before EU accession, have a positive effect on the relaxation of credit constraints. In the study on Slovenian farmers (**[25]**) we included in the augmented investment model in an *ad hoc* way, several variables proxying the subsidies received by farmers, this in addition to the amount of profit before the subsidy, already included as a cash flow variable. These additional variables include subsidies to current operations (direct payments, subsidies for production factors etc.), investment subsidies and variables of interaction between ‘subsidies’ and ‘size of the farm’ (in hectares). The econometric results show that investment subsidies have no effect on the relaxation of credit constraints (the coefficient for investment subsidies is non-significant). Conversely, subsidies for current operations have a positive effect for small farms but a negative effect for large-scale farms. This suggests that investment subsidies do not allow Slovenian farms to fully satisfy their requirements for new capital, and that subsidies for current operations are used by small farms to cover their investment expenses, whereas large farms use the same subsidies for purposes other than the replacement of obsolete capital.

Governments are often advised to tackle institutional problems in order to remove imperfections from the credit market, also in a view to increasing investment in the agricultural sector. However, while this strategy may turn out to be profitable in the long term, it may be quicker or less costly to stimulate a relaxation of investment constraints by paying farmers operational subsidies which are not tied to investment projects. Indeed my research shows the important role played by direct payments received by farms in facilitating their investment, in the context of imperfect credit markets. This work is, however, founded upon an *ad hoc* approach, and we would need to introduce subsidies to the structural accelerator model in order to understand the underlying mechanisms.

4. Public policy and capitalisation in land prices

Agriculture is set apart from other economic sectors by its need of land for production. This necessity leads to a competition for land not only between farms, but between agriculture and other land uses (urbanisation, recreational activities, nature reserves, forests). Another important aspect linked to land is the fact that public support for agriculture plays a more important role in the land market than it does in the markets for other production factors (capital and labour). In fact, support is increasingly tied to the land, which may potentially work in the favour of parties originating outside the agricultural sector (landowners who are not farmers): this is the case if the public funding gives rise to an increase in land prices, i.e. the capitalisation of public support in prices. Finally, land markets are subject to stricter regulations than other production factor markets; these include environmental zoning regulations, or even regulations governing prices and transactions, as seen in France. For these reasons, and to a greater extent than the markets for other production factors, the influence of public policy on the functioning of the market for land has received much attention in agricultural research in general, and in my own research also.

My research on land markets began with an analysis of the land market regulations and imperfections affecting these markets in France and other European countries (**[53]**), as well as in the context of expertises on France (**[46])**, and on the Balkans (**[44]**). I subsequently turned my attention more specifically to the influence of public policies on the price of land, and more particularly the capitalisation of public financial support in land prices. My review of the existing theoretical and empirical literature on this subject (**[8]**) demonstrates that, from a theoretical point of view, the level of capitalisation depends greatly on the elasticity of the land supply, and on the possibility of substitution between factors. From an empirical point of view, the different studies of industrialised nations which have been undertaken (USA, Canada, United Kingdom, France) show that public subsidies have a greater impact on land prices than profits generated from the land (profit without public support) do, and that the level of capitalisation depends on the type of public support available. I then performed an econometric estimation of the level of capitalisation of national subsidies in the price of agricultural land in the Czech Republic between 1995 and 2001, using regional data. This was the first study of its kind conducted in a CEE country (**[15]**). The underlying structural model is the Present Value Model, used in the majority of studies which assess the factors governing land prices (for example, Weersink *et al.*, 1999). The model states that the price of a profit-generating property is the actualised expected value of future profits. In the case of land prices, profit is the sum of profit generated by agricultural production, subsidies received and the value of the option to convert the land to non-agricultural use. This model therefore allows us to identify the effects of the principal determinants: agricultural profit, subsidies, variables representing other land uses, interest rates. The results show that over the period 1995-2001 there has been capitalisation of several types of support (direct payments, production support, income support) in the prices of Czech agricultural land, but that the greatest capitalisation involved direct payments, which was of a low level during the period under consideration. These two studies (**[8]**, **[15]**) confirm the existence of capitalisation of public financial support in the price of land. This effect is of great significance, as a high rate of capitalisation is detrimental to farmers who farm rented land, and may prevent the CAP from achieving its goal of supporting the revenues of farmers. Nonetheless, it is possible that the degree of capitalisation might be limited by landholding regulations, such as those which govern the price of land rents at a sub-regional ("département") level in France, and the regulation of transactions by the SAFER bodies (Associations for Land Management and Rural Establishment). On this subject, I contributed to the conception of a PhD thesis topic and I am currently helping supervise a PhD student who, over the next few years, will seek to demonstrate these effects theoretically and empirically.

5. Research perspectives

In addition to the extensions and improvements to my current work which I have explained above, the future perspectives of my research follow two major directions. The first, based upon results produced by my research, is to further our understanding of the underlying mechanisms of the effect which public policy can have on the technical efficiency of farms. The second is a thematic expansion to include hired labour in agriculture, and the social efficiency of the agricultural sector.

5.1. Mechanisms underlying the effect of public policy on the technical efficiency of farmers

My empirical studies, described above, illustrate the major role played by public policy, and specifically support measures, on the productive behaviour of farmers. Building on this base, I now hope to identify the channels by which public policy modifies the decision-making of farmers, in order to be able to predict in a theoretical and quasi-systematic manner the impact which modifications of these policies might have on the behaviour of farmers. I particularly hope to improve my understanding of the mechanisms which explain the influence that public support has on farmers' technical efficiency: why does this influence produce opposite effects depending upon the type of farm and the type of support received? To do this, I would look to establish a structural model allowing me to explain the methods by which public support exerts influence upon decisions regarding production combinations of inputs and products, and thus on the technical efficiency of farmers.

At present there are two articles in the literature proposing a structural framework for analysis of the impact of public subsidies on the technical efficiency of an agent: the one by Martin and Page (1983) applied to industry, and that of Serra *et al*. (2008) applied to the farming sector. Martin and Page (1983) use the utility maximisation framework and put forward the hypothesis of a positive effect of managerial effort on a firm's production. The model makes it possible to conclude theoretically that a fixed allocation negatively impacts on effort and thus on the production level; since the level of inputs used remains unchanged, technical efficiency diminishes. Serra *et al*. (2008) use a stochastic frontier whereby technical efficiency depends on the allocation of production factors via the production mean and variance. This variance is modified by public subsidies which affect the farmer's risk-aversion coefficient, and the indirect effect on efficiency can thus be deduced. Nonetheless, theoretical propositions can only be generated in the simplified case of just one output and just one input, and the authors conclude that the question can only be analysed empirically.

I envisage using the analytical framework proposed by Martin and Page (1983), introducing subsidies per hectare and investment subsidies. I would also like to analyse the effect of subsidies in a dynamic framework, considering the role of information and farmers' anticipations. Indeed, depending on the information that farmers have on planned policies, changes in behaviour as regards the use of factors and technical efficiency may be initiated well before a policy reform is put in place or a new regulation is introduced. Such an approach has yet to be employed in the literature dealing with the effect of agricultural policy on the efficiency of farmers.

5.2. Place of paid labour and social efficiency

My participation in various multi-theme research projects (6th Framework Programme's IDEMA project "Impact of Decoupling and Modulation on Agriculture in the Enlarged Union"; 7th Framework Programme's project CAP-IRE "Impact of the Common Agricultural Policies on Rural Economies"), and my interactions with farmers and local actors of the rural world over the years of my research have shown me that it may be simplistic to study the role of public policies solely in terms of the economic performance of farms without considering the indirect effects induced by the presence of agriculture on a territory (see for example **[49]**). This role in terms of environmental performance and social performance is also crucial to determining the importance or necessity of public support to agriculture. Although the environmental aspect has been included more and more extensively in the evaluations of impacts of the CAP (see for example Cooper *et al*., 2009) or in the forecasts of various policy scenarios (see for example CGAAER, 2010), the social aspect is more seldom taken into consideration. The definition of the multifunctionality of agriculture and its contribution to the welfare of society is generally limited to environmental services. And yet in certain rural areas (notably the so-called less favoured rural areas), agriculture helps maintain vitality and rural dynamism, partly thanks to the workers employed on the farms themselves and in the upstream and downstream sectors. This is why I began to take an interest in the changes emerging in demand for paid labour and contract work in France over the last 15 years and their determinants, such as CAP subsidies (**[34]**). I would therefore like to focus my research on the concept of the social efficiency of farms and the role of public policies in that efficiency. If this efficiency is defined according to paid labour, it may very likely depend on the type of rural area under consideration (remote or otherwise) and the type of farm productions (whether their demand for hired labour is high, whether seasonal labour or otherwise). As regards the way that the social aspect is integrated into the efficiency calculation and, similarly as there are desirable (landscape) or undesirable (pollution) environmental outputs, there could be desirable (paid labour) or undesirable (mechanisation) social outputs. We would then have to model the trade-off between the reduction in paid labour as a production factor (which would be socially undesirable) and the increase in paid labour as a social output (which would be socially desirable).

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