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Policy impact on farm level efficiency in Sweden 1998-2008

AgriFood economics centre

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AgriFood Economics Centre working paper

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Abstract

The study provides empirical evidence for the efficiency of the Swedish farms for the period 1998-2008, and examines how selected Common Agricultural Policy (CAP) measures and farm and farmers characteristics contribute towards improving the farm efficiency. Furthermore the study checks if the CAP support has accomplished to compensate differences among the farms originating from the agri-environmental production practices and the regional agricultural potential. Unbalanced panel of the Swedish FADN is used. The result reveals that technical efficiency of the Swedish farms is fairly high; COP, milk and pig farms have a possibility for an increase of the farm efficiency for about 10%. Highest possibility for improvements is registered for the cattle farms (17%). To improve the efficiency, COP farms need to grow in size, whereas cattle and pig farms need technological improvements. More efficient are farms managed by younger farmers, and lower specialization (below 70%) in milk and pig production. Pillar I and Pillar II support have a potential to decrease the disparities among the farms, therefore to help farm to achieve higher efficiency. Both under compensation and over compensation in some regions are detected, thus revision for the distribution of the CAP support is recommended.

Keywords: *CAP, compensation, FADN, Pillar I, Pillar II, stochastic frontier, Sweden, technical efficiency*

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1. Introduction

For shaping the future of the Common Agricultural Policy (CAP) 2014-2020, development of the farm performance, the effects of the policy instruments and support distribution on the performance of farms remain to be relevant questions (European Commission, 2011c).

Subsidization of farmers is one of the principal mechanisms of the CAP, primarily applied to be growth enhancing (Bergström, 2000) and to drive the agricultural productivity in general (McCloud and Kumbhakar, 2008, Rizov et al., 2012). Within the framework of the Pillar I and Pillar II (Axis 1, Axis 2 and Axis 3 after 2008), CAP is undertaking constant adjustments, corresponding to the economic, environmental, and the social concerns. Such adjustments are to a large extent based on research findings (Latruffe et al., 2012), which help policy makers to make corrections for better targeting of the agricultural policies (Kumbhakar and Lien, 2010) and proper distribution of the policy support. Subsidization is ensured to be covered by the two integral CAP parts: Pillar I and Pillar II support, both expected to work simultaneously towards fulfilling the common CAP objectives. Pillar I (coupled – till 2004 and decoupled afterward), is provided as a fundamental income support for the EU farmers to keep the farming sustainable, and to retain the least competitive farmers from decisions to exit the farming because they do not earn adequate income. Agricultural policy potentially plays a key role in determining whether or not land is utilized for agriculture (Renwick et al., 2013). Decisions on land utilization and abandonment may have strong impact to the environment (natural capital, biodiversity), socio-economic, traditional and cultural aspect of the rural areas (Bojnec and Latruffe, 2013, MacDonald et al., 2000). Such aspects are of high concern for the rural development policy, incorporated in the supplemental Pillar II support. Indeed, the Pillar II support is provided to compensate the differences in the farm performance generated of the regional agricultural potential and application of agri-environmental production practices (such as: organic farming, conversion of arable to grazing land, preservation of natural and cultural elements etc). It needs to be stressed that neither Pillar I nor Pillar II payments are adjusted to farms' operational costs; Pillar I is distributed to all farmers as a direct support based on the production records, and Pillar II is rather based on general approximations at regional level. The difference in the farm performance coming from the regional and the agri-environmental potential should be compensated if proper distribution of funds is applied. According to the (European Commission, 2011a), rural development measures (Pillar II) are still not tailored to the regional/local needs thus regional differences in farm performance can be expected.

When the effects of CAP are assessed, both pillars should be considered a part of a common agenda (European Commission, 2011a). Yet, the influence of CAP support measures on the farm performance has mainly been explained by the Pillar I, direct payment measures (Latruffe et al., 2009, Kumbhakar and Heshmati, 1995, Zhu et al., 2008, Rizov et al., 2012, Latruffe et al., 2012), and by the overall farm dependence on subsidization (Zhu et al., 2008, Zhu and Lansink, 2010, Hadley, 2006, Latruffe et al., 2012). An evidence for the influence of Pillar II environmental subsides on the technical efficiency (TE) of the grain farms in Norway has been provided by (Kumbhakar et al., 2012). However, there are studies that emphasize that regional differences and/or the environmental sensitivity matter for the efficiency of farms (see e.g., Zhu et al., 2008, Barnes et al., 2011, Hadley, 2006, Wang et al., 2012, McCloud and Kumbhakar, 2008, Kumbhakar and Lien, 2010, European Commission, 2011b, Sipiläinen et al., 2009, Galanopoulos et al., 2006).

Sweden is among the countries with highest distribution of rural development support. During the period 2000-2006 rural development support has been distributed to 86% of the Swedish farms included in the Farm Accounting Data Network (FADN) (European Commission, 2009). The influence of the Pillar I subsidies on the technical efficiency of the Swedish farms specialized in milk and crop production is documented in several studies (Zhu et al., 2008, Zhu and Lansink, 2010, McCloud and Kumbhakar, 2008, Rizov et al., 2012). However, same as for the other EU countries, research where both the influence of the Pillar I and the complementary Pillar II support measures are considered is scarce. Yet, the effect of the CAP support compensation on the farm technical efficiency in different regions in Sweden is not explained. In addition, the literature lacks evidence for the efficiency of the pig and the cattle farms. Both sectors are considered vulnerable, struggling to compete with the pork and the beef meat import. Proper composition and distribution of the CAP policy instruments and improved efficiency of farms is a promising approach for decreasing the negative margins in both industries.

The principal objective of this study is to provide comprehensive evidence for the farm performance development (measured as technical efficiency) in Sweden during the period 1998-2008, and to improve the knowledge of how selected first and second pillar CAP measures, farm and farmers characteristics contribute towards improving farm efficiency. The second objective is to check if the CAP support has accomplished to reduce/eliminate the influence of the agri-environmental production practices and regional agricultural potential on the farm efficiency in Sweden. The CAP policy schemes are specific for different agricultural production; accordingly separate empirical applications are conducted for farms specialized in COP (specialized cereals, oilseeds and protein crops), milk, cattle and pig production. The analysis is based on a standard frontier methodology for efficiency analysis and provides comprehensive complementary evidence to the literature elaborating issues of policy implications on the farm performance. This analysis is purposely conducted for the Swedish Ministry for Rural Affairs, and is thus a direct input for the forthcoming discussions of the evaluation of the existing 2007-2013 RDP, as well as for suggesting adjustments for the coming 2014-2020 RDP.

2. Analytical and conceptual framework

2.1 Empirical application

This analysis employs the parametric Stochastic Frontier (SF) approach (Aigner et al., 1977; Meeusen and Broeck, 1977), and was conducted in STATA, using the frontier models. The agricultural production is assumed to be stochastic, highly related to the unpredictable natural/environmental conditions, thus the alternative nonparametric Data Envelopment Analysis (DEA), which is highly sensitive to data noise, was considered less appropriate to be applied. The application of meta-frontier approach (Battese and Prasada Rao, 2002; Battese et al., 2004; Sipilainen et al., 2008; Wang et al., 2012) used for analysing heterogeneous TE (due to regional and/or technological differences) was also considered. The procedure requires estimation of region-specific and optimal level production function. However, due to the limitation of the current data set, such as small number of farms in certain production regions, the model was not adopted.

The stochastic frontier function was specified as a log linear Cobb-Douglas production function (Aigner and Chu, 1968), which has been approved to perform at least as well as more flexible functional forms (e.g. translog) in measuring relative efficiency levels (Samarajeewa et al., 2012). Separate Cobb-Douglas production function is derived for each of the selected farm specializations (results in Table 1). This study estimates the relative technical efficiency in its output-orientation (Coelli et al., 2005), and explains the possibilities for improvements in the farms output by keeping the inputs fixed. Technical efficiency is estimated relative to the best performing farms included the data sample for each specialization. The value of the estimated technical efficiency coefficients ranges between 0 and 1, and denotes for farm efficiency between 0% - 100%. SF models have been developed both for cross-section and panel data frameworks (including: fixed models and random effects model for time-variant and time-invariant inefficiency (Greene, 2005)). In cases when balanced panel data are available, models for panel data are preferable. Panel data models are expected to control the unobserved differences between the observations, capturing the "firm effect", and add to time dimension to the analysis (Fried et al., 2008). However, the estimator of technical inefficiency has been found to perform poorly when the number of firms is large and the number of time observations is small (Wikström, 2012, 2013). The current analysis is based on a rotating panel data set; where, although the average appearance of the farms in the data set is six years, large numbers of farms appear for a period lower than 3 years. The empirical application used for estimation of the TE is therefore appropriate for unbalanced panel (frontier model using linear regression). Time-varying in the efficiency is obtained by additional inclusion of a time-trend variable (Hadley, 2006; Kumbhakar and Lien, 2010; McCloud and Kumbhakar, 2008). The model specification is as follows:

$$y_{it} = f(x_{it}, t, \alpha) e^{(v_{it} - u_{it})}; \qquad i = 1, 2 \dots N; \qquad \mathrm{t} = 1, 2, \dots 11 \qquad (1)$$

$$u_{it} = z_{it}^{e} \delta, \sigma_u^2 \qquad (2)$$

Where, in the production function equation (1), y_{it} is the total farm output (expressed as a natural logarithm), of the i^{th} farm in the t^{th} time period. $f(.)$ is the production function containing: x_{it} – a vector of inputs (expressed as a natural logarithm); t – a scale for the time period (t=1, 2,…11); α – marginal effects (production elasticity) parameters to be estimated; $e^{(.)}$, is the random error term containing: a random noise term v_{it} for the production shocks, and an inefficiency term u_{it}. In the inefficiency variance function (2), $u_{it} \geq 0$, independently half normally distributed $N(0, \sigma^2)$, and is explained by z_{it}^{e} – the vector of variables associated with the inefficiency sources, and δ which is the parameter to be estimated. The parameters α and δ of the equations (1) and (2) were estimated simultaneously, and thereby the possibility of producing biased results coming with the two-steps approach (Wang and Schmidt, 2002) is excluded. For comparison, both the predicted technical efficiency and the Jondrow inefficiency estimate (JIE) (Jondrow et al., 1982) are assessed.

In addition, to explain productivity and compare results obtained with the frontier approach, the Hicks-Moorsteen Total Factor Productivity (HM-TFP) index (Coelli et al., 2005) is used. The estimation is straightforward and is an indication of the growth in output, net of the input growth. Separate calculations are performed for labour, production unit (agricultural area or livestock units for animal production) and capital (materials use) productivity, for farms specialized in COP, milk, cattle and pig production, respectively. The following mathematical expression is used:

$$HM\ TFP\ Index = \frac{Growth\ in\ output}{Growth\ in\ input} = \frac{Output\ quantity\ index}{Input\ quantity\ index} \quad (3)$$

2.2 Efficiency, subsidization and compensation for environmental disadvantages

The study follows the concept that subsidies are expected to have direct influence on the farm output. Rasmussen (2011) argues that subsidies must be considered and included in the production technology system, either as a cost reduction or as an output. However, in order to be included as a cost reduction, details for the contribution of the cost support to the costs of specific inputs are necessary. In the current scheme, the amount of the CAP payments is not adjusted to farms' operational costs; therefore, inclusion of CAP support as a costs reduction is impossible. In the current study the total subsidy amount received by the farmers is integrated in the farm output (e.g. Hadley, 2006; Rasmussen, 2011) (total revenue is selected to be an output variable - y_{it} in equation 1). In addition, specific subsidy payments are included as exogenous variables (in equation 2). Alternatively, in the Kumbhakar and Lien (2010) "triangular system", subsidy payment is allowed to affect farms output (but is not a part of the total output value), by being considered both as an endogenous (input variable included in the production technology system) and exogenous variable (explanatory variable for the inefficiency model). In other studies, subsidies have been considered as traditional inputs (McCloud and Kumbhakar, 2008; Zhengfei and Lansink, 2006).

The model selection builds on the circumstance that large share of the total output (expressed in value terms) at farms with agri-environmental production orientation and/or in environmentally sensitive conditions come from the subsidies. Basically the losses in the output values and the higher operational costs (by that lower profits) originating from the decreased agricultural potential in such conditions are expected to be compensated by subsidizing. Satisfactory compensation should paid-out the constraints for farming, thus give a possibility for the least efficient farms to reach the output obtained by the best performing farms. It implies that the difference in the efficiency among the farms is decreasing, and by that the average efficiency of farms is expected to be improved. If the subsidy amount is excluded from the total output value, efficiency estimates cannot provide incentives for the subsidization effects. The model specification in this study is expected to capture the effect of subsidization in different production regions; thereby, to enable an evaluation of the Swedish CAP support accomplishment to reduce/eliminate the influence of the environmental/regional characteristics on the farm efficiency in Sweden. Small differences in efficiency among the farms operating under environmentally sensitive circumstances and under regular conditions for farming would imply a balanced distribution and well-functioning support system.

3. Data

Unbalanced rotating panel of the FADN provided by the Swedish Statistical Office, for the period 1998-2008 is used. Every year, the Swedish FADN sample survey includes about 1000 randomly selected farms exceeding the minimum threshold of eight economic size units (ESU, where 1ESU=1200€). Given the restriction, assumptions for farms below the threshold size should be done with caution. However, FADN is considered the most comprehensive and standardized farm-level data set for the European agriculture, thus is a base for agricultural policy analysis, calculations and investigations conducted both for scientific and policy decision purposes across all EU Member States. The rotating scheme implies that some farms drop from the sample and are replaced by new farms included in the sample. Farms participation in the survey is not compulsory, and the period for which farms are included in the sample is not limited.

In the study separate empirical application is conducted for farms specialized in COP (specialized cereals, oilseeds and protein crops), milk, cattle and pig production respectively. The farm selection is based on farm specialization characteristics, representing the percentage share of the main farm production in the total revenue. A threshold for the degree of specialization of 50% is selected. In total, 6481 observations are included in the analysis, among which 3879 observations represent farms specialized in milk production, 1487 are pig farms, 806 cattle farms, and 309 COP farms. The dataset provides detailed information on the farm characteristics, the farm output in quantity and value terms, inputs use in quantity and/or in value terms, amount of subsidy-based payments received by the farmers, regionalization/location details etc.

4. Variables

4.1. Farm efficiency variables

To estimate the output-oriented technical efficiency, one output and six input variables are used. *Output* (REVENUE) represents the farm revenue obtained from the farm production including subsidies. The unit of measurement is Swedish Kronor (SEK) deflated with the respective output price index with 1998 as a base year. *Labour* (LABOUR), corresponds to the total labour input of the farms expressed in total working hours. *Number of livestock units* (LU) for the livestock farms or *total utilized area* (TUA) for the COP farms. *Materials* (MATER) includes: total costs of seeds, fertilizers, crop protection, (for COP farms) and feeding staff costs, veterinary costs and other animal cost (for the livestock farms). *Machinery* (MACHIN): total costs of machinery use. Energy (ENERGY): total energy costs. *Time trend* (TIME1): a dummy 1=1998….11=2008, included to show the technology change/progress, shift of the production frontier (Hadley, 2006, Kumbhakar and Lien, 2010, O'Donnell, 2010) over the years. The inputs (materials, machinery and energy) represented in value units are measured in Swedish Kronor (SEK) and deflated with the respective input price index, with 1998 as a base year.

A presentation and descriptive statistics of the input-output variables are displayed in Table 1. Given the description, the average revenue per farm (including subsidies) is highest for the pig farms (2 218 915 SEK). However when the variable costs (materials, machinery, energy), and the labour need are taken into consideration, the highest farm profitability should be expected for the milk and cattle farms. The highest share of the farm variable costs at all farm production is for material costs (52% for COP farms, 71% for milk farms, 62% for cattle farms, 80% for pig farms). The most labour intensive are farms specialized in milk- and pig production.

4.2. Sources of inefficiency

The second set of variables represents the explanatory variables for the technical inefficiency variance function (u_{it} in equation 2) and thus indicates the sources of farm inefficiency. The explanatory variables are classified in four groups: time-trend variable, farmer and farm characteristics, grants and subsidies, and environmental condition/location. Farm efficiency is influenced by many other factors, (e.g. farm technology and management etc.), but as this paper is mainly concerned with the influence of the CAP policy on the farm efficiency, such factors are not the main focus. Descriptive statistics of the efficiency determinants variables is displayed in Table 1.

Table 1: Descriptive statistics: output-input and efficiency determinates variables, at COP, milk, cattle and pig farms, $n = 6481$

Variables	COP	Milk	Cattle	Pig
Output-input variables				
Mean revenue (REVEN) SEK	447 418	1 805 195	930 418	2 218 915
Mean total utilized area (TUA) ha/livestock units (LU)*	74	43	67	203
Mean labour use (LABOUR) hours	1243	4790	2571	3588
Mean cost of materials (MATER) SEK	114 659	549 668	234 728	949 720
Mean cost of machinery (MACH) SEK	52 148	118 741	78 237	110 483
Mean cost of energy (ENERGY) SEK	54 590	104 457	65 807	132 119
Time trend (TIME1)	1, 2….11	1, 2….11	1, 2….11	1, 2….11
Efficiency determinants variables				
Time trend (TIME2)	1, 2….11	1, 2….11	1, 2….11	1, 2….11
Experience (AGE) years	53	50	51	49
Specialization (SPEC) %	66	72	67	76
Organic farming (ORG)%	7	20	30	10
Less favoured area (LFA) scale 1, 2, 3	1.3	1.9	1.8	1.4
Area with environment rest (ENVAREA) %	14	15	14	7
Partnership (PARTNER)%	6	8	4	5
Dependence on subsidies (DEPSUB)%	42	19	41	9
Pillar I support (PILLAR I) %	45	24	22	40
Disaster payments (DISPAY) SEK	0	4092	0	1465
Set-aside support (SETASIDE) SEK	10385	4147	2199	6830
Environmental subsidies (ENVSUB) SEK	18347	85082	111080	26913
LFA subsidies (LFA) SEK	1705	29672	19135	3989
RD subsidies (RDother) SEK	7954	10469	4698	7628
Investment support (INVSUP) SEK	0	1630	150	1372
Labour support (LABSUP) SEK	805	3753	2203	4636
Quality support (QUALSUP) SEK	65	64	91	131
Region 710, farms N^{o}	257	1692	468	1134
Region 720, farms N^{o}	38	1346	253	255
Region 730, farms N^{o}	14	841	85	98
Stockholm, farms N^{o}	7	21	29	10
Östra Mellansverige, farms N^{o}	144	543	130	199
Småland med öarna, farms N^{o}	17	1031	179	195
Sydsverige, farms N^{o}	20	430	142	383
Västsverige, farms N^{o}	99	814	210	579
Norra Mellansverige, farms N^{o}	13	416	50	30
Mellersta Norralnd, farms N^{o}	2	290	21	47
Övre Norrland, farms N^{o}	7	334	45	44

*Note: Livestock unit coefficients. Bovine animals: under 1 year old = 0.4LU, between 1-2 year old = 0.7LU, male 2 years old and over = 1LU, heifers, 2 years old and over = 0.8LU, dairy cows =1LU, other cows 2 years old and over = 0.8. Pigs: piglets having a live weight of under 20 kg = 0.027, Breeding sows weighing 50 kg and over = 0.5LU, other pigs = 0.3LU

Time trend variable (TIME2 in Table 1) is expected to capture the trends in productivity explained as exogenous technical change (Kumbhakar and Heshmati, 1995), or the extent to which farms keep up or fall behind the frontier (Hadley, 2006, O'Donnell, 2010) over the years 1998-2008. A time-trend scale specified as: 1=1998,…11=2008 is used.

Farmer and farm characteristics are among the most often explained factors of farm efficiency. Such characteristics are largely related to farm decisions to adopt new technologies, or apply different managerial practices. This study focuses on four characteristics, represented by four respective variables: farmer experience, degree of farm specialization, organic production, and partnership. All characteristics are to a certain extend related to issues discussed for the programme of the coming CAP (2014-2020). *Farmers' experience* (AGE), is a proxied by the age of the farmers. Based on the descriptive statistics (Table 1), the average farmer's age across the different farm specializations is similar (53 for COP farms, around 50 for milk, cattle and pig farms). *Degree of specialization* (SPEC) is defined as a percentage share of the main farm production in the total revenue. 50% was set as a minimum threshold value for a farm to be classified as specialized in a certain type of production. Given the restriction, farms are assumed to be specialized in either i) COP production, ii) milk production, iii) cattle or iv) pigs fattening. Highest average specialization is found for the pig- (76%) and milk farms (72%) (Table 1). The average specialization of the COP- and cattle farms is 66%, 67% respectively. *Organic production* (ORGPROG), is a dummy variable with a value "0" for conventional farming and "1" for a farm that practices organic farming or is transforming towards organic; organic farming is most often applied for cattle (30%) and milk (20%) production (see Table 1). Only 7% of the COP farms and 10% of the pig farms have applied or are transforming towards organic farming. *Partnership* as an organizational form (PARTNER) is a dummy, with a value of "1" for farms where the economic result covers the compensation for the production factors brought into the farm by several partners, of which at least half participate to the work on the farm as unpaid labour and "0" for family farms or farms not classified as "1"; At the Swedish farms, such partnership arrangements are rare. Given the existing data set, partnership arrangements have been utilized at: 6% of the COP farms, 8% of milk farms, 4% of cattle farms, and 5% of the pig farms (Table 1).

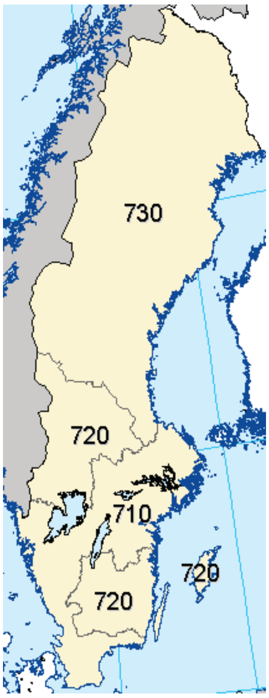
CAP measures – subsidies delivered to farmers as 'first pillar' (coupled – till 2004 and decoupled 2005-2008 and disaster payments), and rural development "second pillar" support payments. Ten variables (for each farm specialization) are constructed: *dependence on subsidy* (SUBDEP), *dependence on first pillar support* (PILLAR I), *disaster payments* (DISASTERPAY), *environmental subsidies* (ENVSUB), *less favoured area* *payment* (LFASUB), *set aside premium* (SETASIDEPREM), *other rural development support* (RDother), *investment subsidies* (INVSUB), *labour support* (LABSUB) (is a support available for the Swedish farmers, but instead of CAP it is part of the Swedish labour policy), and *quality support* subsidies (QUALSUB). Except for the first two variables which show the degree of farms dependence on subsidy, and dependence on first pillar (coupled and decoupled disaster payments) support, all variables are given in Swedish Kronor (SEK), showing the average amount of money received by the farmers for a specific subsidy/grant and deflated with the respective output price index, with 1998 as a base year.

As presented in Table 1, the highest average dependence on subsidies is found for farms specialized in COP- and cattle production (about 40%). The average dependence on subsidies of the milk- and pig farms is 19% and 9%, respectively. The contribution of the Pillar I support to the total farm support at the COP- and pig farms is 40 and 45%. Milk- and Cattle farms are found to be the main recipients of the Pillar II support. The contribution of the Pillar I support to the total support granted to the milk and cattle farms is on average 24% and 22%, respectively.

Environmental condition/location, is represented by four variables: less favoured areas (LFA), environmental restrictions of the area, farms' regionalization based on the FADN area division for agriculture and rural development (Map 1) and farms' regionalization based on the Nomenclature of Territorial Units for Statistics (NUTS 2) (Map 2). Each variable indicates if the farm is situated in a specific area. *Less favoured areas* (LFA), are classified according to a three-grade scale: "1" if a majority of the holding is not situated in LFA; "2" if a majority of the holding is situated in LFA; "3" if a majority of the holding is situated in a mountainous area. *Environmental restrictions* (ENVAREA) is a dummy variable, where the value "0" is given when the majority of the utilized agricultural area is not situated in an area assigned as environmentally restricted, and "1" is given otherwise.

The *FADN area division for agriculture and rural development* is represented by 3 regions (see Map 1): Region 710 – Southern and central plain areas; Region 720 – Southern and central forest and valley areas; and Region 730 – Northern Sweden.

Map 1: Sweden – FADN Region codes. Source: European Commission. http://ec.europa.eu/agriculture/rica/regioncodes_en.cfm?CodeCountry=SVE

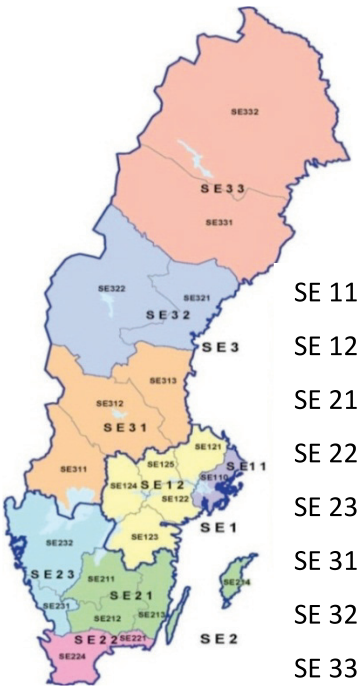


710 – Southern and central plain areas: Stockholms, Uppsala, Södermalands, Östergötland, Blekinge, Skåne, Hallands, Västra Götaland - Skaraborgs, Örebro and Västmanlands län

720 – Southern and central forest and valley areas: Jönshopings, Kronobergs, Kalmar, Gotlands, Västra Götalands: Göteborg, Bohus and Älvsborgs, Värmlands and Dalarnas län

730 – Northern Sweden: Gävleborgs, Västernorrlands, Jämtlands, Västerbottens and Norrbottens län

Map 2: Sweden – NUTS 2 regional division. Source: Statistics Sweden. http://www.scb.se/Grupp/Hitta_statistik/Internationell_statistik/_Dokument/NUTS_1_2_3_20080101.pf



SE 11 – Stockholm

SE 12 – Östra Mellansverige

SE 21 – Småland med öarna

SE 22 – Sydsverige

SE 23 – Västsverige

SE 31 – Norra Mellansverige

SE 32 – Mellersta Norrland

SE 33 – Övre Norrland

NUTS 2 is a part of the territorial hierarchical system of the EU, developed for socio-economic analysis of basic regions for application of regional policies. The Swedish NUTS 2 regional division is represented by seven dummy variables, each for a specific NUTS 2 region (see Map 2): Östra Mellansverige, Småland med öarna, Sydsverige, Västsverige, Norra Melansverige, Mellersta Norrland and Övre Norrland, with Stockholm as a benchmark. In both cases (FADN regional division for agriculture and rural development and NUTS 2 regionalization) a dummy variable is used; "0" was given for farms not belonging to a specific region, and "1" otherwise.

Given the descriptive statistics presented in Table 1, Swedish agricultural production is mainly organized in the southern and the central part (710 and 720 on Map 1) of the country (95% of the COP farms, 78% of the milk farms, 93% of the cattle farms, and 89% of the pig farms). Analysed at NUTS 2 level, most of the farms specialized in COP farms (78%) are located in Östra Mellan- and Västsverige (both located in Region 710 Map 1). Farms specialized in milk and cattle are the most flexible towards regional specifics requirements. Although 48% of the milk- and cattle production is organized in Västsverige and Småland med Öarna, and these regions are typically identified as regions appropriate for milk and cattle farms, a large number of farms (36% - milk farms, and 40% - cattle farms) with such specializations can also be found in Östra Mellan-, Syd- and Norra Mellansverige. Most of the farms specialized in pig production are located in Väst- and Sydsverige (65%) (both situated in Region 710 – Map 1). 26% of the pig farms are situated in Östra Mellansverige and Småland med öarna, and the remaining 8% are found in areas up from Norra Mellansverige. This analysis is based on characteristics of farms included in the FADN data set, (farm equal or exceeding 8ESU units), which implies that country level generalizations need to be done with cautions.

In the subsidy payment equation (equation A.2 in appendix A2), farm dependence on subsidy s_{it} (SUBDEP) was explained in an additional step. The following variables are used: year, farm size – TUA for COP production and LU for livestock farm, manager/farmer experience, farm specialization, FADN and NUTS 2 regional characteristics. HM TFP index, equation (3) shows the net growth of the farm output (REVENUE) corresponding to the net growth of three different inputs: total capital value (CAPITAL), livestock units (LU) or total utilized area (TUA) (depending on the farm production), and labour use (LABOUR). Total capital value corresponds to the variable costs at the farm (materials, machinery, and energy). The results of the subsidy payment equation are displayed in Table A.2, and are discussed in the next chapter.

5. Results and Discussion

5.1. Technical efficiency, scale efficiency and technological change

Technical efficiency estimates for the period 1998-2008 are displayed in Table 2. The mean technical efficiency of the Swedish farms is fairly high: 90%, 92%, 83% and 89% for COP, milk, cattle and pig farms, respectively.

Table 2: Production function parameters, returns to scale and technical efficiency estimates for the period 1998-2008

	COP		MILK		CATTLE		PIG	
Production function	Coef.	P>z	Coef.	P>z	Coef.	P>z	Coef	P>z
LU or TUA	.751	.000 [a]	.399	.000 [a]	.328	.000 [a]	.152	.000 [a]
Labour	.007	.782	.091	.000 [a]	.104	.000 [a]	.170	.000 [a]
Materials	.196	.000 [a]	.287	.000 [a]	.200	.000 [a]	.382	.000 [a]
Machinery	.041	.015 [b]	.032	.000 [a]	.114	.000 [a]	.101	.000 [a]
Energy	.048	.000 [a]	.181	.000 [a]	.194	.000 [a]	.164	.000 [a]
Year	.040	.000 [a]	.022	.000 [a]	.012	.026 [a]	.029	.000 [a]
const	6.376	.000 [a]	5.634	.000 [a]	5.778	.000 [a]	4.058	.000 [a]
RTS	1.04		1.0		.94		.96	
Mean TE	.90		.92		.83		.89	
St dev of TE	.11		.08		.15		.09	
Min TE	.35		.37		.22		.39	
Max TE	1.0		1.0		1.0		1.0	
Jondrow inefficiency JIE	.12		.09		.20		.13	
Min JIE	0		0		0		0	
Max JIE	1.1		1.0		1.6		1.0	
Correlation TE and JIE	-.991		-.995		-.988		-0.995	

Note: [a] statistically significant at 1%, [b] statistically significant at 5%, [c] statistically significant at 10%.

As this study analyse the output-oriented TE, the result suggests that, while keeping the inputs amount fixed, the output value can be increased by: 10% at the COP farms, 8% at the milk farms, 17% at the cattle farms, and 11% at the pig farms. The most heterogeneous, thus with the lowest average TE (83%) and minimum value of TE (22%) are the cattle farms (see Table 2). The corresponding minimum TE of the COP, milk and pig farms is 35%, 37% and 39%, respectively (see Table 2). Details for the frequencies of the predicted technical efficiency are displayed in Table 3. Technical efficiency higher than 80% was found at 92% of the milk farms, 85% of the COP and pig farms, and 71% of the cattle farms.

Table 3: Frequency of predicted TE for COP, milk, cattle and pig farms, 1998-2008

TE	COP	Milk	Cattle	Pig
0-19	0 %	0 %	0 %	0 %
20-39	1 %	0 %	1 %	0 %
40-59	1 %	1 %	7 %	1 %
60-79	13 %	7 %	21 %	13 %
80-100	85 %	92 %	71 %	86 %

The result can be interpreted in from several perspectives. The first interpretation relates to the high average values obtained for the technical efficiency of the farms (Table 2), and directly leads to a conclusion that Swedish farms are performing well. High average TE among the farms is an indication for application of commonly accepted production practices and well distributed support for lowering the disadvantages originating from agri-environmental and regional constraints for farming. Given that highest variability in the TE is found among the cattle farms (Table 3), the result is also an indication that the Swedish cattle production is the most sensitive when the relative farm performance is discussed. When interpreted the results may also be associated with the biasness of the FADN data set and the model selection. FADN has largely been criticized for its representativeness referring to the farms size. Farms having below 8 ESU are not included in the survey; on the other hand, TE analysed in this study is a relative measure of the achievements of the farms included in the data sample. It implies that if farms that are included in the data sample are homogenous (in the farm size, the production structure, practices or production intensification etc.) high values of TE will be obtained. For a confirmation of the TE results, the supplementary Jondrow (Jondrow et al., 1982) inefficiency coefficient (JIE) is estimated, and a correlation of about 99% is obtained (see Table 2).

Technical efficiency coefficients obtained in the current analysis are in line with the results values obtained both for Sweden and the EU member countries. For example, the average TE of the Swedish dairy farms reported by (Zhu et al., 2008), (Sipilainen et al., 2008), (Hansson and Ohlmer, 2008) was 79% (1998-2002), 80% (2003) and 86% (1998-2002), respectively. According to Bakucs et al., (2012), TE of the Swedish crop production over the period 1990-2006 ranged between 74-83%. The ten-year average TE (1995-2004) of the Swedish crop farms obtained by Zhu and Lansink, (2010) was 71%. In another study (Larsén, 2010), the average TE of the Swedish crop and livestock farms (2001-2004) was found to be 52% and 65%. The last analysis has been performed by an application of the non-parametric DEA, implementing bootstrapping for non-parametric analysis, thus the low TE values were assumed to result from the model selection. Relatively high levels of TE have also been found for the agricultural production in other EU countries. Estimations of TE of crop farms in the EU8 members ranged from 72% to 92% for the period 1990-2006 (Bakucs et al., 2012). Barnes and Revoredo-Giha (2011) reported that the average TE of the crop and dairy farms at EU8 covering the period 1995-2007 was about 90% (relative to their country-specific frontiers). Similar results have been obtained by Latruffe et al. (2012); the average TE of dairy farms at EU11 ranged from 85% for Italy to 96% over the period 1990-2007. Average TE of the pig farms in Greece (1997-1998) (Galanopoulos et al., 2006) and the Netherlands (1994/1995–1998/1999) (Lansink and Reinhard, 2004) was 80% and 98%, respectively.

Average TE at farms specialized in COP, milk, cattle and pig farms across the regions are presented in Figure 1 – Figure 4. In addition, details for the number of farms and the average TE at the farms included in the analysis in specific regions (based on FADN and NUTS2 regionalization) can be found in Appendix 1. However, it is important to emphasize that the average TE of the farms belonging to the FADN and the NUTS2 regional division is given as an orientation. The influence and the statistical significance of the regional characteristics on the TE of the Swedish farms is a part of the regression analysis and the result is presented in Table 4.

Given the Figure 1a, Figure 2a, the difference between the average TE of the COP and the milk farms located in the southern and the central parts of Sweden (Region 710 and 720) is minor. For farms located in the Northern Sweden (Region 730) the opposite result was obtained. Though COP farms located in the Northern Sweden are found to be the least efficient, milk farms from the northern parts of Sweden have slightly higher TE. Based on the results obtained for the NUTS 2 regionalization (Figure 1b), lowest average efficiency is found for the milk farms located in Sydsverige. COP farms located in Syd- and Norra Mellansverige (Figure 2b), are represented only by one farm each, (Appendix Table A.1.1), thus generalization based on the average estimated TE of the COP farms at NUTS 2 level is not recommendable.

Figure 1: Average technical efficiency of COP farms across regions, FADN (a) and NUTS 2 (b) regionalization

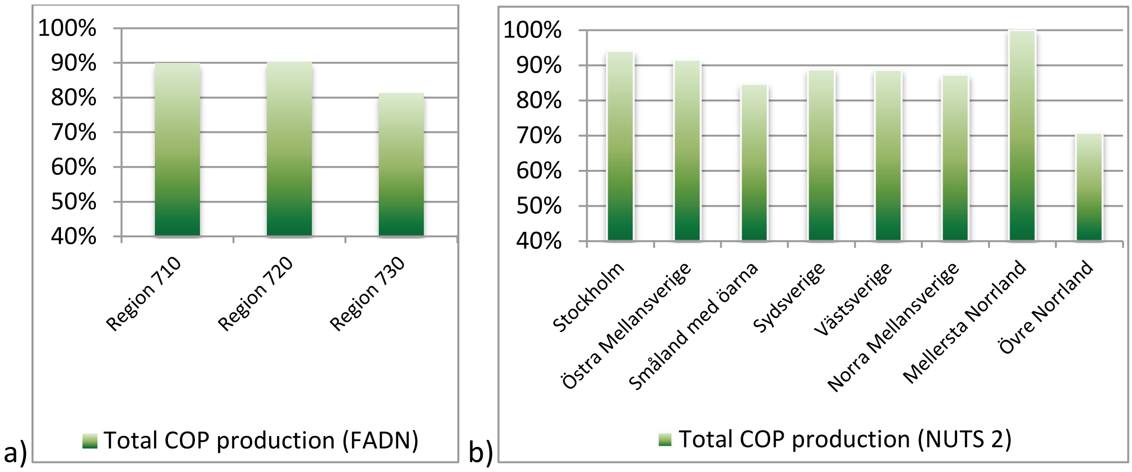
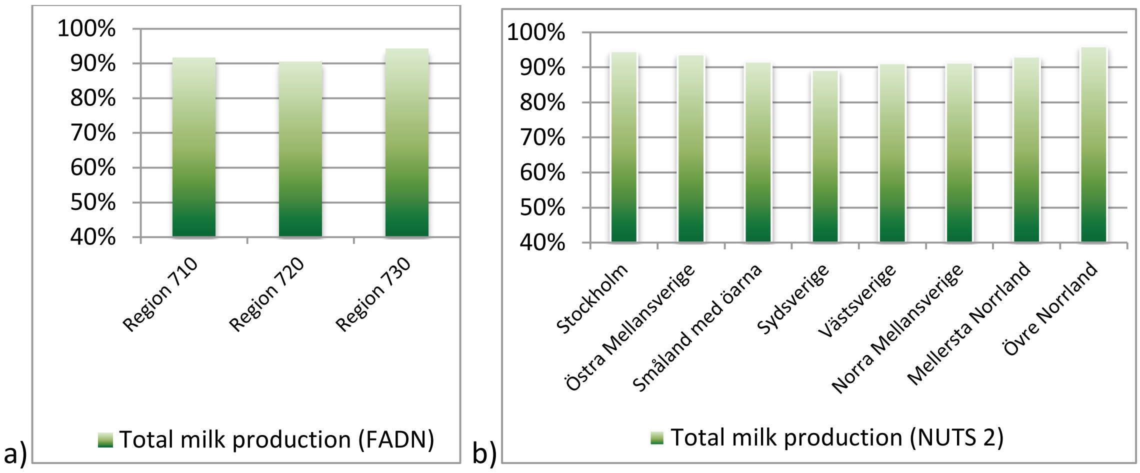


Figure 2: Average technical efficiency of Milk farms across regions, FADN (a) and NUTS 2 (b) regionalization



Average TE of the cattle farms across the FADN regions is similar (Figure 3a). Compared to Region 710 and 720 (Figure 4a) pig farms located in the Northern parts of Sweden (Region 730) have lower average efficiency. Both for the cattle and the pig sector the average TE at NUTS 2 level is less balanced (Figure 4a and Figure 4b). However same as for the COP farms, and due to representativeness constraints, generalizations based on the average estimated TE of the pig farms at NUTS 2 level is not recommendable.

Figure 3: Average technical efficiency of cattle farms across regions, FADN (a) and NUTS 2 (b) regionalization

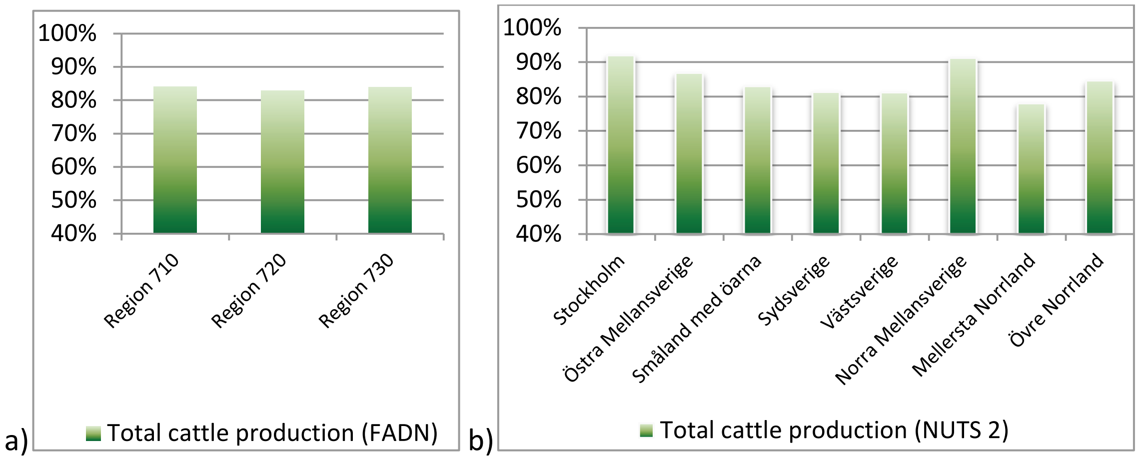
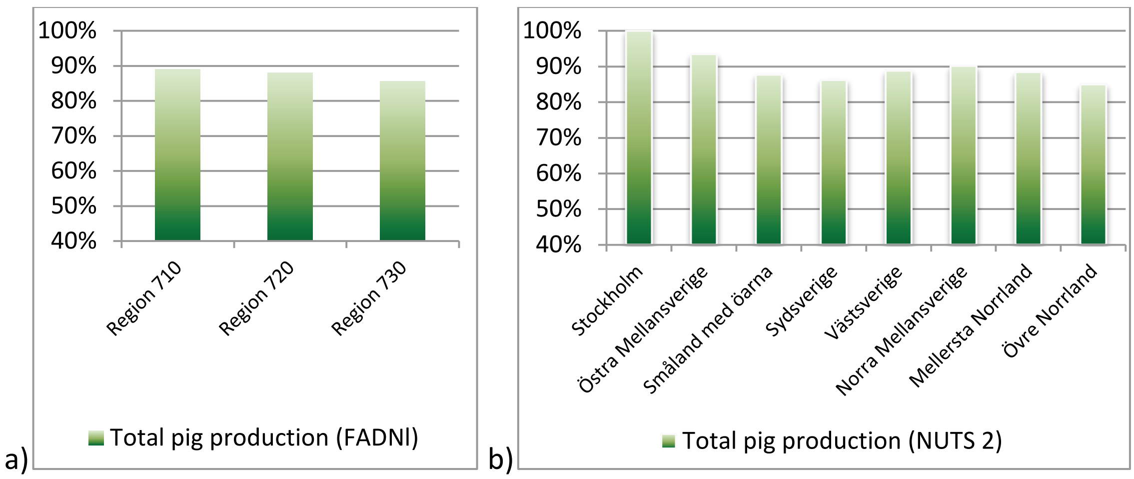


Figure 4: Average technical efficiency of pig farms across regions FADN (a) and NUTS 2 (b) regionalization



5.2. Scale efficiency and technological change

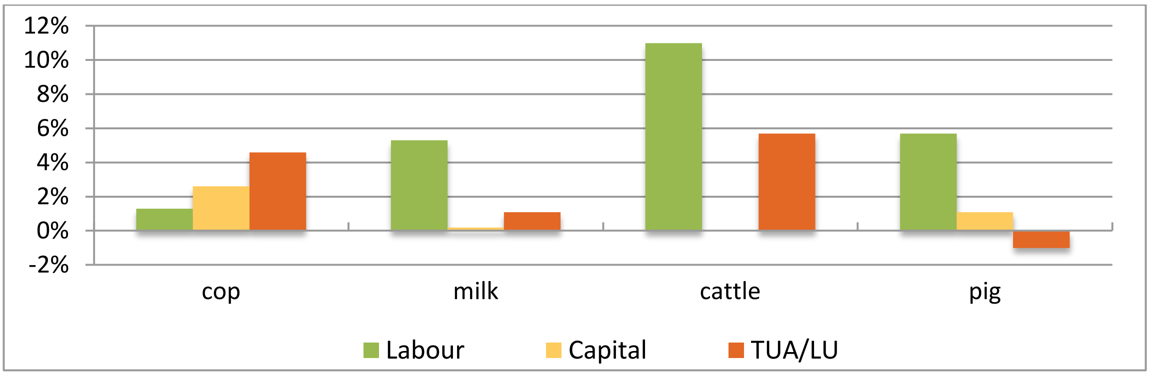
A description of the production function parameters and the results for the returns to scale analysis is displayed in Table 2. With an exception for the labour use at the COP farms, the elasticity of all variables representing the production function is significantly positive; thus the monotonicity assumption is not violated. The marginal contribution of labour use at the COP farms is also positive, but statistically insignificant. The result is a confirmation of the finding presented by (Zhu and Lansink, 2010), in an analysis that refers to the TE of the Swedish crop production during the period 1995-2004. An insignificant and negative sign was obtained for the labour use at the COP farms in Germany (Zhu and Lansink, 2010).

The structure of marginal returns is quite homogeneous for the COP, milk and cattle farms, where the farm production units TUA or LU, and the use of materials have the highest marginal contributions. TE of the Swedish pig farms is highly influenced by the utilization of production materials, whereas the marginal contribution of the other inputs is lower. COP farms tend to exhibit increasing returns to scale (IRS = 1.04) (similar as in Zhu and Lansink, 2010; 1.06 over the period 1995-2004), which is an indication that farms could improve their TE if they increase their production size. Milk farms were found to be close to the size optimum exhibiting CRS (1.0). The cattle and pig farms tend to operate under decreasing returns to scale (DRS: 0.94 and 0.96 respectively), meaning that farmers have reached the upper end of the production capacity and investments in new technology is required to produce more.

The time trend variable included in the production function (TIME1) shows improvements of technological progress at all farm specializations. The highest technological progress was obtained for COP farms, with an average increase of 4% per year. (Zhu and Lansink, 2010) have reported average technological progress of the Swedish crop farms of 1.6%, over the period 1995-2004. Average improvements in the technology for the milk, cattle, and pig farms ranged from 1% to 3%. Although technological improvements are expected to drive farm efficiency, it needs to be stressed that there is a risk the average TE at the specializations with highest technological improvements to stagnate or even decrease. It is a case when farms do not respond to the technological changes to the same extend, thus the differences in TE across the farms is increasing. Changes in the TE over the years are a part of the regression analysis presented in the next heading.

Improvements in farm productivity were also found by the Hicks-Moorsteen Productivity index. The results are presented in Figure 5. Farms specialized in livestock production have experienced the largest labour productivity improvement. Milk farms have improved their labour productivity by 5.3%; cattle farms by 11.2%; and pig farms by 5.7%. Improvements in the capital utilization range from 0.2% for the milk farms, to 1.1% for pig- and 2.6% for the COP farms. The largest productivity improvements of the production units (TUA and LU) are obtained for the COP and cattle farms. Both farm specializations are highly dependent on subsidies (42% and 41% for the COP and cattle farms respectively, in Table 1), predominantly Pillar I direct payments support; thus high influence of the subsidization effect on the result can be expected. Milk farms have increased LU productivity of 1.1%, whereas the LU productivity change at the pig farms was negative, and decreased by 1%.

Figure 5: Hicks-Moorsteen productivity indexes: labour, capital and production unit productivity (TUA/LU) at COP, milk, cattle and pig farms (1998-2008).

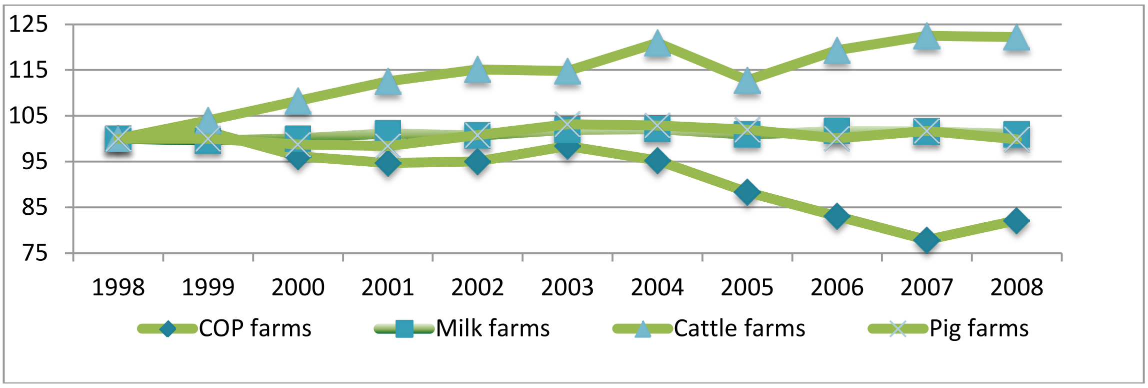


5.3 Regression analysis

The parameter estimates from the inefficiency effect model indicates the direction of the effects of the selected explanatory variables. A positive sign is a notification of a negative influence on the technical efficiency, and *vice versa.* Summary results of the inefficiency effect model are displayed in Table 4.

Positive and statistically significant **technical efficiency change (TEC)** is obtained for milk-, cattle- and pig farms (TIME2 in Table 4). The mean technical efficiency is decreasing over time only at COP farms, but statistical significance is not found. Confirmation of the result is provided with the analysis of the TEC based on the base-index numbers (1998=100) (Figure 7). As an unbalanced panel data set is used, the procedure requires the average TE scores to be calculated for each year, and then to be included in the TEC analysis. Opposite results for the TEC of the Swedish dairy- and crop farms have been reported in two previous studies, by (Zhu et al., 2008) and Zhu and Lansink (2010), respectively. Neither study considers farm subsidies to be part of the farm revenue, thus differencies in the result are anticipated.

Figure 7: Technical efficiency change at COP, milk, cattle and pig farms, using base-index number 1998=100



For all of the selected **farm and farmer characteristics,** a negative and statistically significant influence on the TE of the Swedish farms is found (positive signs presented in Table 4 indicate technical inefficiency is increasing). Yet, there is no common understanding if more efficient farms being managed by less experienced farmers (e.g. in: Manevska-Tasevska, 2013a, Manevska-Tasevska and Hansson, 2011), or farmers' experience is reducing variability in TE (e.g. in: Puig-Junoy and Argiles, 2004, Kumbhakar et al., 2012, Wilson et al., 2001). Learning is an individual and social process (Lee et al., 1999), thus differences may originate from the farmers interest for long-live learning practices. In this study, **farmers' experience** has a negative influence on the TE of the milk-, cattle- and pig farms. Younger farmers are usually more educated, but if educational practices, training courses etc. are provided, older farmers can benefit both from their experience and the updated knowledge.

A negative and statistically significant influence on the TE of the Swedish milk and pig farms is also obtained for the **degree of farm specialization** (as presented in Table 4, technical inefficiency is increasing). Diversification is often seen as a way to reduce risk, and ensure a better outcome in an uncertain production environment (Manevska-Tasevska, 2013b). For instance, farm diversification in crop production, enables on-farm feedstuff production to buffer shocks coming from the animal food market, and can thus keep the TE stable. Though, with low contribution to the total revenue, Swedish farms are increasingly engaging in diversified activities (Hansson et al., 2010). Within the new set of greening measures (for the CAP 2014-2020) the crop diversification measure would limit farm specialization to up to 70%. Average diversification in farm activities outside the main production at the COP-, milk-, cattle- and pig farms is about 30% (Table 1). The most specialized are milk and pig farms, with an average specialization of 72% and 76%. Given the results presented in Table 2, the marginal contribution of the materials use at the milk farms and the pig farms is fairly high (29% and 39%), compared with COP- and cattle farms (20%). Therefore, availability of feedstuff at lower cost (not affected by price shocks) is a way of ensuring higher farm efficiency.

Table 4: Summary results of the inefficiency effect model

	COP		MILK		CATTLE		PIG	
Determinants for *technical* inefficiency variance*	Coef.	P>z**	Coef.	P>z	Coef.	P>z	Coef	P>z
1) **TIME2**	.1651	.259	-.1529	.000 [a]	-.2110	.000 [a]	-.0762	.098 [c]
Farm/farmer characteristics								
Experience	.0049	.817	.0304	.000 [a]	.0154	.095 [c]	.0273	.012 [b]
Specialization	2.4010	.197	2.4480	.000 [a]	.2839	.717	2.931	.001 [a]
Organic farming	-.2013	.808	.2328	.218	-.1998	.486	.9055	.003 [a]
Partnership	.3484	.640	.6563	.002 [a]	.3659	.528	-1.1862	.192
2) **Environmental condition**								
Less favoured area	.6241	.313	.3810	.008 [a]	.4231	.086 [c]	.9800	.000 [a]
Area with envir. restrictions	-0015	.999	.2893	.135	.1091	.742	.0638	.868
Region 1 (used as a base region)								
Region 2	.6.2293	.875	-.0450	.864	.2643	.498	.1296	.802
Region 3	-7.2911	.854	-7627	.076 [c]	-1.1421	.403	1.9511	.283
Stockholm (used as a base region)								
Sydsverige	.1216	.963	.9552	.378	1.3303	.181	27.0100	.994
Småland med öarna	7.1176	.859	.5752	.604	.9850	.368	26.1402	.994
Östra Mellansverige	.3759	.883	.6395	.556	1.5022	.144	25.9300	.994
Västsverge	.6825	.789	.5983	.579	1.0280	.299	26.7853	.994
Norra Melansverige	6.4570	.871	.0949	.933	.7447	.576	24.4956	.994
Mellestra Norrland	-20.5477	.993	-9371	.431	1.5481	.384	21.9690	.995
Övre Norland	7.2724	.856	-1.6341	.184	1.5126	.383	21.8439	.995
3) **Policy measures**								
Dependence on subsidies	6.0963	.003 [a]	9.7957	.000 [a]	3.7911	.000 [a]	11.8851	.000 [a]
Degree of coupling	1.9442	.119	-.5846	.020 [b]	1.5428	.002 [a]	-0055	.982
Disaster payments	-	-	-.00002	.663	-	-	-.00003	.463
Environmental subsidies	-.00001	.332	-.00004	.000 [a]	-00002	.000 [a]	-.00005	.000 [a]
LFA payments	-.00001	.678	.0000	.340	-00001	.132	-.0000	.537
Set aside premium	-.00001	.669	-.0002	.000 [a]	-.0002	.005 [a]	-.00005	.005 [a]
Other RD support	-.0003	.128	-0002	.000 [a]	-.0001	.013 [b]	.0001	.007 [a]
Investment subsidies	-	-	-	-	-	-	-.00001	.627
Labour support	.00004	.129	-.00003	.122	-.0001	.329	-.00002	.043 [b]
Quality support	-.0001	.830	-.0021	1.00	.0000	.942	-.0001	.768
lnsig2u constant	-10.7020	.000 [a]	-7.1758	.000 [a]	-4.6870	.000 [a]	-34.563	.992
lnsig2v constant	-2.7793	.000 [a]	-3.6725	.000 [a]	-2.7238	.000 [a]	-3.0661	.000 [a]

*Note: Positive sign is an indication of negative influence on TE.

**Note: [a] statistically significant at 1%, [b] statistically significant at 5%, [c] statistically significant at 10%.

The result is in line with the previous literature. Lower specialization in certain production makes farmers more able to adjust to the market changes (Hadley, 2006), and farmers can focus on the production lines that are more profitable at the moment (Hansson, 2007). Zhu and Lansink (2010) have found positive influence of the degree of specialization at the Swedish crop farms.

Pig farms applying **organic practices** are significantly less efficient (see Table 4, positive sign is an indication that technical inefficiency is increasing). Animals raised on organic farms produce lower yield per sow in quantity terms; however, if the market is working properly, the loss should be compensated with higher product prices. The failure of the Swedish organic pig production may result from the highly competitive Danish pig industry. Managerial and breeding practices are important for the efficiency of a pig farm (Galanopoulos et al., 2006). The current breeding strategy in organic pig production in Sweden is in most cases to use the same genetic material as that used in conventional production (Wallenbeck, 2009). Managing an organic farm requires application of organic farming regulations, with strict control of animal medicine and fodder. None of the other specializations (COP-, milk- and cattle farms), shows statistical significance of the organic farm practices on the TE. Subsidisation for organic farming is a part of the Pillar II support. Given the result, it is likely that the differences in TE that originate from the organic-farming production orientation for the COP-, milk- and the cattle farms are compensated.

Partnership as an organizational form has a negative and statistically significant influence on the Swedish dairy farms (in Table 4, positive sign is an indication that technical inefficiency is increasing). In another study a positive and statistically significant influence of machinery-sharing on the TE of the Swedish crop and livestock production have been found (Larsén, 2010). Although, partnership is expected to contribute to the increased resource efficiency (European Commission, 2011c, Larsén, 2010, Andersson et al., 2005), the potential disadvantages resulting from the moral-hazard problem and the timeliness cost (Larsén, 2010, Andersson et al., 2005) should not be ignored. Partnership collaborative arrangements can be analysed from many perspectives (e.g. organizational form, sharing resources, contractual agreements for cooperation at different levels of the production chain etc…), which implies that a clear description for the collaboration practice is essential for the analysis.

Dependence on subsidies has negative influence on the TE (as presented in Table 4, technical inefficiency is increasing) at all farm specializations (COP-, milk-, cattle-, and pig farms). In recent studies, higher dependence on subsidies has usually been associated with farms with lower TE (Latruffe, 2010; Latruffe et al., 2012; Zhengfei and Lansink, 2006). For the Swedish crop farms, a negative influence of the degree of subsidy dependence has been found by Zhu and Lansink (2010). The negative impact of farm subsidization has usually been explained as a result of farms over capitalization (Brümmer and Loy, 2000) decreasing farmers' motivation to perform well (Bergström, 2000; McCloud and Kumbhakar, 2008; Zhengfei and Lansink, 2006; Zhu and Lansink, 2010), or market imperfections (such as credit problems or risk attitudes) in the agricultural sector (Rizov et al., 2012). When the subsidy payment is substantial, farmers spend more time on other activities which can also negatively affect farm productivity (Kumbhakar and Lien, 2010). Results showing contribution of different factors to higher dependence on subsidies are displayed in the appendix (Table A.2). A positive sign indicates higher dependence on subsidization. Based on the results (Table A.2), dependence on subsidies is increasing over the years (Year) only at the milk farms. COP farms with higher degree of specialization, organic farming orientation, and location in LFA are more dependent on subsidies. The results obtained for the milk and the cattle farms are similar. More dependent on subsidies are milk and cattle farms with: lower number of LU (smaller farms), organic farming orientation, and location in LFA, environmentally restricted areas, or in the northern part of Sweden. Milk farms with higher specialization and location in the southern part of Sweden are significantly less dependent on subsidies, whereas higher specialization in cattle production increased farm dependence on subsidies. Pig farms with lower number of LU (smaller farms), less specialized in pig production, organic farming orientation, and location in LFA or Region 3 are more dependent on subsidies. Pig farms located in the regions up to Norra Mellansverige, are significantly less dependent on subsidies.

The degree of coupling (Pillar I) has a positive (negative) statistically significant influence on the TE of the milk (cattle) farms. Statistical significance of the first pillar support on the TE of COP- and pig farms is not found. In the literature, both positive and negative influences of direct payment measures on the farm efficiency have been obtained. For example, a negative impact of coupled subsidies has been found for the TE of Norwegian farms (Kumbhakar et al., 2012). Zhu, et al., (2008) claim that coupled (decoupled) livestock subsidies had no significant (significantly negative influence) for Swedish dairy production (1995-2004). The share of the crop subsidies in the total subsidies has been found to have a positive impact on the TE at the crop farms in Sweden (Zhu and Lansink, 2010). In both studies (Zhu et al., 2008, Zhu and Lansink, 2010), subsidies are not considered a part of the farm income, thus the differences in the result might originate from the model selection. Latruffe et al. (2012) claim that the effect of decoupled payments on the TE is mainly positive and significant for the EU dairy farms. Rizov, et al., (2012) compared the impact of subsidies on farm technical efficiency before and after the decoupling, at farms representing EU-15 Member states, and argue that for some countries decoupled payments have switched the negative influence of the first pillar payments to positive. Basically, compared to coupled payments, decoupled payments are considered less distortive (Rizov et al., 2012), and can even be expected to stimulate farmers' response to market changes (European Commission, 2008, Brady et al., 2011). A negative impact, preferably on the farm investments, can be obtained in a case when capital markets are not functioning properly (Brady et al., 2009). However, higher growth under the decoupled policy is expected for the better performing farms (Brady et al., 2011).

The investment subsidy does not show any significant influence on the TE of the Swedish farms. The insignificant influence of the investment subsidies could be interpreted as a poor targeting of investment support. The result is a confirmation of the findings presented in the mid-term evaluation of the Swedish RDP (SLU, 2010), where no evidence for increased total factor productivity, value added per employee or reduced raw material consumption per unit was found. However, a notation for the support paid for investments aimed at improving the environment says that the effect of positive externalities can be at least partially underestimated, as it does not have direct influence on the farm output. The effect of the investment subsidies should be expected in long run (Ferto et al., 2012). The result is also in line with the existing literature; the farm credit programme has failed to increase the TE of farms in Northern

Germany (Brümmer and Loy, 2000), whereas capital investment was not found to have an effect on the productivity growth of Dutch arable farms (Zhengfei and Lansink, 2006). Farm subsidization is considered beneficial when farmers need to intensify production (Bergström, 2000, McCloud and Kumbhakar, 2008, Zhu and Lansink, 2010). (McCloud and Kumbhakar, 2008) and (Ferto et al., 2012) argue that subsidized producers are less credit constrained, and can thus invest in farm development and achieve higher technical progress.

Environmental subsidies and the **set-aside premium** provide positive and statistically significant influences on the TE of the milk-, cattle-, and pig farms. The environmental subsidy income share has been found to have a negative influence on TE of the Norwegian farms (Kumbhakar et al., 2012). **Other rural development subsidies** have a positive influence on the milk- and cattle farms, and negative for the pig farms. **Labour support subsidies** have a positive and statistically significant influence only for the pig production. The marginal contribution of labour in the production function is highest for pig farms 17%, compared to 7% for the COP farms, 9% for milk- and 10% for cattle farms. Therefore, policy support that compensates some part of the labour costs is anticipated.

As presented in Table 4 a common characteristic for the Pillar II measures and the labour support subsidies (provided by labour support policy not by CAP) is the positive marginal effect to the farm efficiency. As notified previously, the study assumes that rural development subsidies promote a balanced territorial development, by compensating the disadvantages originating from the environmental agricultural potential. After the compensation, the farm performance should be related to farm and farmers characteristics incorporating: production orientation/practices, personal characteristics, managerial potential etc. Besides the variations in the average TE presented in Figure 1 to Figure 4 (details in Appendix 1) no statistically significant influence from the regional specifics at NUTS 2 level on the farm efficiency is found. Milk-, cattle- and pig farms located in less favoured areas (LFA) are significantly less efficient. The negative influence from the LFA on the TE might be an indication for under-compensation for competitive disadvantages caused by natural handicaps. An exception are milk farms located in northern Sweden (Regions 730) which on average have higher efficiency than the farm located in Region 710. Given that milk farms located in Norra Mellansverige, Mellersta Norrland, and Övre Norland are highly dependent on subsidies (Table 4: positive and statistically significant influence on the subsidy dependence for these regions was found), the Region 730 can be seen as over-subsidized in respect to Region 710 which is taken as a benchmark. Regional variation in the TE, is a common finding in various research. For instance, farms located in the LFA in UK have been discovered to have lower TE (Hadley, 2006, Barnes, 2008). (McCloud and Kumbhakar, 2008) have found regional differences in the TE at the dairy farms in Denmark, Finland, and Sweden. Compared to the remaining Nordic regions included in their study, dairy farms in Northern Sweden (Region 730 in this study) has been identified as the least technically efficient. However, a notation on the output not considering the amount obtained from subsidies is necessary.

6. Conclusions

This paper analyses the efficiency of Swedish farms and the implications of the applied first and second pillar measures on farms specialized in COP-, milk-, cattle- and pig production. Patterns of the technological and the technical progress, as well as the successfulness of the policy measures to compensate the losses from the agri-environmental and regional potential are also discussed.

Technical efficiency of the Swedish farms is fairly high, 90%, 92%, 83% and 89%, for COP-, milk-, cattle- and pig farms, respectively. Though technological progress and increasing TEC (except for COP farms) is found for all farm specializations, further improvements in TE requires increase in the farm size of the COP farms, and investments in technological development at cattle and pig farms. Milk farms are the most efficient farms, operating under optimal scale.

More efficient are the milk-, cattle- and the pig farms that are managed by younger (less experienced) farmers; milk and pig farms having a lower degree of farm specialization; milk farms without partnership arrangements, and the conventional pig farms. Issues on farm education, social policy for young farmers, farm diversification, environmental and rural development etc. are on the agenda on the forthcoming 2014-

2020 CAP reform. Given the results, in this study proper implementation of such measures could be beneficial for the TE of the Swedish farms.

In this study, the Swedish CAP is expected to drive farms' efficiency, and to compensate the TE variations resulting from differences in agri-environmental practices and regional agricultural potential. A positive and statistically significant influence of the Pillar I measures is found only for the milk farms. Rebalancing of the direct support in line to the farm characteristics can be underlined as a principal approach. The Pillar II support appears to stimulate farm TE, and to large extend have compensated loses originated from the agri-environmental, and regional potential. For instance influence on the average TE from the regional differences at NUTS 2 level is not found, thus TE distribution of the subsidies at NUTS 2 level in Sweden seems to be well under control. Due to the under subsidization, further revision of the distribution of subsidies for the milk-, cattle- and pig farms located in LFA is necessary. Potential for over subsidization is found for the milk farms located in northern Sweden (region 730 based on FADN regionalization), thus revision of the subsidy distribution at those farms is also recommended.

In addition, the environmental and cultural benefits arising from CAP should not be under estimated. The estimation of the scale of these effects is not included in this study, thus the overall impact of the measures in Pillar II is therefore larger and more comprehensive than this study shows.

Although the study aims at drawing conclusions for the farm efficiency at national level, the limitations of FADN considering the farms' threshold size and the availability of additional farm/farmer characteristics (such as diversification, education, managerial experience) in the FADN data set call for attention. Furthermore, when compared with other studies, the results showing the influence of different subsidy payments on the TE of farms should always be related to the model application.

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Appendix A1: Number of observations and average technical efficiency of the farms at regional level: FADN and NUTS 2 regionalization, 1998-2008

Table A.1.1: Average TE of COP farms, FADN and NUTS 2 regionalization, 1998-2008

Region	**N° full data set**	**TE full data set**	**N° organic farms**	**TE organic farms**	**Share organic farms**
COP farms: average TE – FADN regionalization					
Region 710	257	90%	19	86%	7,4%
Region 720	38	90%	0		
Region 730	14	81%	4	91%	28,6%
SUM	**309**		**23**		
Average		**87,1%**		**88,6%**	**7,4%**
COP farms: average TE - NUTS 2 regionalization					
Stockholm	7	94%	0		
Östra Mellansverige	144	92%	7	85%	4,9%
Småland med öarna	17	85%	0		
Sydsverige	20	89%	1	96%	5,0%
Västsverige	99	89%	11	86%	11,1%
Norra Mellansverige	13	87%	1	94%	7,7%
Mellersta Norrland	2	100%	2	100%	100,0%
Övre Norrland	7	71%	1	71%	14,3%
SUM	**309**		**23**		
Average		**88,2%**		**88,6%**	**7,4%**

Table A.1.2: Average TE of milk farms, FADN and NUTS 2 regionalization, 1998-2008

Region	**N° full data set**	**TE full data set**	**N° organic farms**	**TE organic farms**	**Share organic farms**
MILK farms: average TE – FADN regionalization					
Region 710	1692	91,6%	290	96,4%	17,1%
Region 720	1346	90,4%	242	93,3%	18,0%
Region 730	841	94,2%	267	95,3%	31,7%
SUM	**3879**		**799**		
Average		**92,1%**		**95,0%**	**20,6%**
MILK farms: average TE - NUTS 2 regionalization					
Stockholm	21	94,6%	12	94,5%	57,1%
Östra Mellansverige	543	93,7%	114	97,3%	21,0%
Småland med öarna	1031	91,7%	164	94,2%	15,9%
Sydsverige	430	89,3%	30	93,9%	7,0%
Västsverige	814	91,2%	158	95,8%	19,4%
Norra Mellansverige	416	91,4%	111	93,5%	26,7%
Mellersta Norrland	290	93,1%	119	93,5%	41,0%
Övre Norrland	334	96,0%	91	97,2%	27,2%
SUM	**3879**		**799**		
Average		**92,6%**		**95,0%**	**20,6%**

Table A.1.3: Average TE of cattle farms, FADN and NUTS 2 regionalization, 1998-2008

Region	N° full data set	TE full data set	N° organic farms	TE organic farms	Share organic farms
CATTLE farms: average TE – FADN regionalization					
Region 710	468	84%	135	90%	28,8%
Region 720	253	83%	72	91%	28,5%
Region 730	85	84%	33	87%	38,8%
SUM	**806**		**240**		
Average		**83,6%**		**89,3%**	**29,8%**
CATTLE farms: average TE - Average TE - NUTS 2 regionalization					
Stockholm	29	92%	10	94%	34,5%
Östra Mellansverige	130	87%	45	92%	34,6%
Småland med öarna	179	83%	45	91%	25,1%
Sydsverige	142	81%	34	86%	23,9%
Västsverige	210	81%	59	90%	28,1%
Norra Mellansverige	50	91%	19	92%	38,0%
Mellersta Norrland	21	78%	12	79%	57,1%
Övre Norrland	45	85%	19	91%	42,2%
SUM	**806**		**243**		
Average		**84,8%**		**89,4%**	**30,1%**

Table A.1.4: Average TE of pig farms, FADN and NUTS 2 regionalization, 1998-2008

Region	N° full data set	TE full data set	N° organic farms	TE organic farms	Share organic farms
PIG farms: average TE – FADN regionalization					
Region 710	1134	89,0%	71	87,8%	6,3%
Region 720	255	88,0%	54	83,4%	21,2%
Region 730	98	85,6%	21	88,3%	21,4%
SUM	**1487**		**146**		
Average		**87,5%**		**86,5%**	**9,8%**
PIG farms: average TE - NUTS 2 regionalization					
Stockholm	10	100,0%	0		0,0%
Östra Mellansverige	199	93,5%	15	96,3%	7,5%
Småland med öarna	195	87,7%	41	82,1%	21,0%
Sydsverige	383	86,2%	16	79,6%	4,2%
Västsverige	579	88,8%	50	87,2%	8,6%
Norra Mellansverige	30	90,1%	3	99,2%	10,0%
Mellersta Norrland	47	88,4%	17	88,8%	36,2%
Övre Norrland	44	84,9%	4	86,4%	9,1%
SUM	**1487**		**146**		
Average		**89,9%**		**88,5%**	**9,8%**

Appendix A2: Factors contributing to the farm dependence on subsidies

The subsidy payment equation (A.1) (Kumbhakar and Lien, 2010) provides information for the marginal effect of the factors contributing to the farm dependence on subsidies. Where, s_{it} denotes the farm subsidy dependence, and is represented through the function $h(.)$, containing:, t – trend scale, parameter vectors ∂ to be estimated, an unobserved farm effect $c_i = N(0, \sigma_c^2)$ and a random noise component $\varepsilon_{it} = N(0, \sigma^2)$. Empirical specification is as follows:

$$s_{it} = h(z_{it}^s, t, \partial) + c_i + \varepsilon_{it}; \qquad i = 1, 2 \dots N; \qquad \mathrm{t} = 1, 2, \dots 11 \qquad \text{(Equation A.2)}$$

The vector of farm and regional variables z_{it}^s is represented by: year, farm size – TUA for COP production and LU for livestock farm, manager/farmer experience, farm specialization, FADN and NUTS 2 regional characteristics. Variables included in the analysis and the results are displayed in Table A.2. Results are discussed in subheading 5.3.

Table A.2: Factors contributing to the farm dependence on subsidies for the period 1998-2008

	COP		MILK		CATTLE		PIG	
Dependence on subsidy	Coef.	P>z*	Coef.	P>z	Coef.	P>z	Coef	P>z
Year	-.0160	.000 [a]	.0018	.000 [a]	-.0029	.121	-.0023	.000 [a]
Experince	.0009	.158	-.00003	.815	-.0006	.209	-.0003	.053 [c]
LU or TUA	-.0156	.155	-0126	.000 [a]	-.0137	.015 [b]	-.0113	.000 [a]
Specialization	.2781	.000 [a]	-0704	.000 [a]	.1454	.000 [a]	-.2664	.000 [a]
Organic farming	.1071	.000 [a]	.0437	.000 [a]	.0994	.000 [a]	.0268	.000 [a]
Less favoured area	.0416	.017 [b]	.0242	.000 [a]	.0291	.012 [b]	.0042	.248
Area with environmental restrictions	.0072	.728	.0253	.000 [a]	.0312	.055 [c]	.0141	.011 [b]
Region 1 (used as a base region)								
Region 2	.0168	.633	.0055	.376	-.0228	.323	.0086	.324
Region 3	.0576	.434	.0121	.173	.0663	.159	.0698	.003 [a]
Stockholm (used as a base region)								
Sydsverige	-.0109	.825	-.0384	.007 [a]	.0457	.136	-.0667	.000 [a]
Småland med öarna	-0236	.659	-.0298	.713	.0653	.019 [b]	-.0427	.008 [a]
Östra Mellansverige	.0067	.878	-.0004	.973	.0892	.000 [a]	-.0375	.022 [b]
Västsverge	.0276	.532	-.0232	.098 [c]	.0653	.032 [b]	-.0426	.008 [a]
Norra Melansverige	-.0704	.315	.0617	.000 [a]	.1047	.018 [b]	-.0500	.017 [b]
Mellestra Norrland	-.1334	.262	.1380	.000 [a]	.1426	.022 [b]	.0291	.325
Övre Norland	.0994	.313	.1477	.000 [a]	.0269	.640	.0222	.453
lnsig2v constant	-4.3927	.000 [a]	-5.5268	.000 [a]	-4.3859	.000 [a]	-5.9933	.000 [a]
lnsig2u constant	-12.0292	.881	16.574	.000 [a]	-4.0544	.000 [a]	-16.386	.848

*Note: [a] statistically significant at 1%, [b] statistically significant at 5%, [c] statistically significant at 10%.