The Rural Economy Research Centre Working Paper Series

Working Paper 07-WP-RE-05

Part-time farming: off-farm and on-farm household efficiency measurement of Ireland farm households

Tao Zhang

Department of Economics, NUI, Galway & Rural Economy Research Centre, Teagasc

For More Information on the RERC Working Paper Series
Email: CODonoghue@rerc.teagasc.ie,
Web: www.tnet.teagasc.ie/rerc/

For More Information on the RERC Working Paper Series
Email: CODonoghue@rerc.teagasc.ie, **Web:** www.tnet.teagasc.ie/rerc/

Part-time farming: off-farm and on-farm household efficiency measurement of Ireland farm households*

Abstract:

The reliance of farm households on non-farm income is a growing phenomenon in Irish farming. This is a growing area of research but the effects of work change on efficiency of differing strategies have rarely been examined. The main objective of the paper is to contribute to the research stream on farm household income strategies and farm efficiency. To satisfy this purpose, two stages of models are applied. In the first stage, household efficiency (both on and off the farm) is estimated. In the second stage, the relationship between efficiency and various factors is estimated using Tobit or SUR system regressions. Because more and more farmers now go to take off-farm work, this research will yield useful information for policymakers.

JEL Classification C61 D13

Corresponding Author:

Tao Zhang - **Tao.zhang@teagasc.ie**

* The paper was presented at annual conference of Irish Economic Association on 29 April 2007. The author thanks Dr. Eoghan Garvey, Dr. Thia Hennessy and Dr. Fiona Thorne for their help for earlier draft. I also appreciate the fund from RERC Teagasc.

Introduction (Off-farm work and efficiency)

The reliance of farm households on non-farm income is a growing phenomenon on irish farming. The Agri-vision 2015 report showed that about 40% of farm households have an off-farm income and that almost 30% of the farming population are sustainable because of off-farm income (Hennessy, 2004). An increase in the number of farmers working off the farm may have implications for the productivity of the farm sector. Presently, only little research has been conducted in Ireland about the productivity of farms that are operated on a part-time basis. Internationally the issue of overall household efficiency (where labour time is allocated between off and on-farm work) has been studied by Chavas and Aliber (1993) using a stochastic frontier model. This paper proposed to examine the on-farm and off-farm household efficiencies of Irish farm households as well as the relationship between them and other influential factors, using non-parametric DEA analysis (not hitherto used in analyzing Irish agriculture). We examine overall household efficiency of both full and part time farmers (and try also to determine the effect of being in off-farm work on on-farm efficiency) using a procedure first used by Chavas et al. (2005).

Within Ireland, while work has begun on allocation of household labour on and off the farm (Brick et. al., 2005; Keeney, 2000, Hennessy 2005), little has been attempted in the way of measuring how efficient that inter-sectoral household labour allocation is.

Questions like these have strong policy applications. From the policy point of view, as more and more young farmers participate in off-farm and as on-farm options are less and less determined by subsidies, the relationship between farm efficiency and off-farm work is likely to become more important. Will part time farmers be as efficient as or more efficient than full time farmers, all else equal, or will they 'choose to be' less efficient? Questions like these have not been answered in an Irish context, and only recently internationally. Now is a good time to begin to do so.

For More Information on the RERC Working Paper Series
Email: CODonoghue@rerc.teagasc.ie, **Web:** www.tnet.teagasc.ie/rerc/

At the household and farm level, on and off-farm household technical efficiency will be examined. Apart from the fact that household efficiency itself will be measured in a different way from common farm efficiency, there are several reasons that off-farm work should affect on-farm technical efficiency (and indeed scale and allocative efficiency). Firstly, on-farm technical efficiency may be improved by know-how gained and contacts made in off-farm work. It may be improved if improved cash-flow due to off-farm work results, through a smoother flow of working capital, in a more efficient use of factors or better quality factors from more distant markets. On the other hand it may be that off-farm work reduces managerial capacities on the farm, leading to a more extensive type of farming. van der Ploeg (1990) argues that this is the case for one part of the South America.

Secondly, in some situations (though hardly in Ireland) on-farm allocative efficiency may also be affected by off-farm work. If off-farm work is risk reducing, then allocative efficiency on the output side may improve if less risky but low-priced crops are being produced to minimize risk. If apparent allocative inefficiency is not really an inefficiency at all, but a deliberate strategy necessitated by the failure of local food markets, say, then it is quite likely that off-farm work will have no effect on measured allocative efficiency whatsoever.

In addition, studying the relation between off-farm work and efficiency allows the discussion of the relationship between demographic status and efficiency. A study by Chavas *et al.* (2005) contains evidence on 115 farm households in Gambia and concludes that, on the whole, the burden of too many children decreases household efficiency. Studies from Asia also support a negative effect of such status on on-farm productivity, but evidence from Latin America and Africa is mixed. From Chavas *et al.* (2005), we have seen that too many children decreases the household efficiency, but that higher educated adult house member is associated with higher off-farm earnings and overall household efficiency. The relationship between demographic status and on-farm off-farm household efficiency is something that has not yet been looked at in a European context.

Method (Data envelopment analysis)

The non-parametric approach to measuring efficiency was first formulated as a linear programming model by Charnes *et al. (*1978), following on Farrell's 1957 posing of the question of relative technical efficiency in the form of a unit isoquant model. DEA has been used to measure technical efficiency in agriculture relatively frequently (Weersink *et al.* 1990; Cloutier *et al.* 1993; Chavas *et al.* 1993; Ray *et al.* 1993; Townsend *et al.* 1998; Jaforullah *et al.* 1999; Sharam *et al.* 1999; Fraser *et al.* 1999; Zaibet and Dharmapala, 1999; Jha et al., 2000; Shafiq et. al, 2000; Brummer, 2001; Fraser *et al.* 2005; Chavas *et al.* 2005). The third, fourth, tenth and last of these go on to measure allocative efficiency. However, the relationship between off-farm work and technical on-farm efficiency or household efficiency has not been looked at using DEA.

To measure efficiency, non-parametric Data Envelopment Analysis (DEA) can be used. But, economists tend more often to use a parametric approach rather than a non-parametric approach to measure efficiency on farms. The main parametric approach used is stochastic frontier estimation (Coelli *et al.* 1998). One disadvantage of DEA as far as economists are concerned is that it is not easily amenable to statistical analysis. Only very recently has this been possible, mainly through the use of bootstrapping techniques.

It is as likely that either measured technical efficiency or allocative efficiency affects income strategies in the household as it is that income strategies affect technical or allocative efficiencies. It is quite possible also that missing variables affect both. So endogeneity is an extremely likely problem. One other disadvantage of DEA compared to stochastic frontier analysis is that it is often felt to be sensitive to outliers or errors in the data (Coelli, 1998). Our data is fairly reliable data on a national level. DEA can also be sensitive to sample size (a larger sample size reduces the proportion of farms achieving efficiency) and to the degree of input and output aggregation.

However, Kalirajan and Shand (1999) show that DEA outperforms stochastic frontier analysis if the underlying technology is unknown (that is, if the chosen functional form does not happen to accidentally fit the unknown technology), which is certainly the case here. One other attraction for economists of the programming approach (DEA) (apart from the robustness to functional form issues) is that it allows easily for multiple outputs.

DEA models

The linear programme for the basic output oriented DEA is:

$$\max_{u,v} \sum_k u_k y_{k,j0}$$

$$\text{s.t. } \sum_i v_i x_{i,j0} = 1$$

$$\sum_k u_k y_{k,j} \le \sum_i v_i, x_{i,j} \forall j$$

$$u_k, v_i \ge 0$$

y are the outputs, indexed by k. x are the inputs, indexed by i. Each farm is indexed by j, and u and v are output and input weights. This programme has to be solved for each farm (each $j0$), where the weighted output for each farm is maximized with the proviso that the efficiencies of all other farms is less than or equal to 1. This gives us a relative measure of efficiency, where efficiency is defined as weighted output divided by weighted input. The denominator – weighted input – as we can see from the first constraint – will be equal to 1. In DEA each farm optimally sets its own weights.

The farm level measure of efficiency is the value of the objective function. It measures constant returns to scale (CRS) technical efficiency. If variable returns (VRS) are allowed, and scale efficiency and technical efficiency are to be analytically separated, then a further constraint is added: the sum of the output weights must be equal to 1. This ensures that farms are being compared for technical efficiency with other farms of similar size, so the data envelope fits closer, and (pure) technical efficiency measures are higher (or the same). Scale efficiency measures can be found by dividing pure technical efficiency by CRS technical efficiency measures. The programme can then be estimated for a third time, where the VRS constraint is changed so that the sum of output weights is less than or equal to 1. In this case farms are being compared with other farms of the same size or smaller. If this efficiency measure is the same as the pure VRS measure, then diminishing returns exist (the farm is 'too big'), and if it is not the same, then increasing returns exist (the farm is 'too small'). Allocative efficiency measures can be found by changing the objective function to one where revenue is maximised, subject to the same constraints, where measured output is first adjusted to account for technical inefficiencies (all outputs are divided by the farm level technical efficiency coefficient). Hypothetical revenue (were output on the technical frontier) is then divided by maximum possible revenue (the new objective function) to yield, again, a measure of efficiency in the [0,1] interval.

But in the actual calculations, we will use the dual function of the DEA model. The dual VRS output-oriented DEA technical efficiency can be rewritten as:

$$\max_{\lambda} \theta_j$$

$$\text{s.t. } \sum_i \lambda_i = 1$$

$$\sum_k \lambda_k y_{k,j} \geq \theta y_j$$

$$\sum_k \lambda_k x_{k,j} \leq x_j$$

$$\lambda_k \geq 0$$

Here, λ are output and input weights, and $1/\theta$ is the output oriented technical efficiency. Efficiency measures are calculated for full time farm households and for part-time households and compared. Also, regressions are run to determine the effects of a number of exogenous variables, as well as off-farm status, on efficiency.

DEA for Overall Household Efficiency

Consider a farm household with some family members making production, income, and labor allocation decisions. Let FL be the amount of family labor time spent on the farm. The household uses family labor FL and all other costs to produce farm output **y**. In addition, the household members can also spend their time on off-farm activities. Let WL be the amount of off-farm labor time spent by the family members on off-farm work, while generating off-farm income N. Traditionally, the above problems were simplified by measuring farm efficiency using a standard farm-level approach. However, such method needs at least two assumptions: first, the relationship between work time and income is linear and off-farm income can be interpreted as the wage rate received by the family member from off-farm activities. Second, the farm and off-farm technology is non-joint and the household technology can be expressed completely in terms of the separate technologies as on-farm technology and off-farm technology. This indicates that, if the opportunity cost of family labor is not the wage rate and if farm and off-farm activities are part of a joint technology, then measurements produced by the standard farm-level approach would be invalid. In this context, a household efficiency framework would be preferred (Chavas J.P. R. Petrie and M. Roth, 2005).

In this paper, following Chavas et. Al. (2005) we also consider a farm household involved in both farm and off-farm activities characterized by use of both on-farm input and off-farm input while producing both on-farm output and off-farm output. The output-oriented household technical efficiency can be defined as:

$$1/TE=\theta\ (x, fl, wl; y, n)=Max(\theta : (x, fl, wl; \theta y, \theta n) \in X, \theta>0)$$

Here, x refers to on-farm input, fl is on-farm labour time, and wl is off-farm labour time. Y is on-farm output and n is off-farm income. In general, the household technical efficiency is >=0 and <=1. When TE=1, the household is operated on the production frontier and is technically efficient.

Based on the household technical efficiency, to calculate household allocative efficiency, we would need to maximize profit implying the following revenue maximizing problem:

$$R(x, fl, wl; y, n, p)=Max(py+n : (x, fl, wl; y, n) \in X\ )$$

In this function, p is the price of farm output, and py is total farm income. For the household allocative efficiency, the AE can be defined as

$$AE(x, fl, wl; y, n, p)=(py/TE+n/TE)/R$$

Here, if AE is 1, indicating that the unit farm household is allocatively efficient. And, if AE is lower than 1, representing that efficiency can be improved by relocating activities including relocating labour time between on-farm and off-farm work.

Data and variables

Both the output oriented DEA and the household model are separately estimated for

Table1 descriptive statistics of farm variables

Variable	Obs	Mean	Std. Dev.	Min	Max
Laborday	606	277.8883	233.8486	4.49	1370.5
Farmland	606	48.42373	38.83952	4.09	371.1
Livecost	606	20871.72	23944.92	0	230092.9
Cropcost	606	2988.691	12592.96	0	216535
Workhours	606	1740.647	939.3244	25	4368
Workincome	606	6.529703	3.423537	1	16
Farmoutput	606	72971.87	75882.25	3951	590424

Ireland. The farm output chosen is total farm output. In addition, the subsidies which are directly related to the production will also be included in the total farm output (Cattle and dairy subsidies, sheep subsidies, and crop subsidies). The off-farm output is off-farm income. The farm input includes farm utilized land, labor input, total livestock direct costs, and total crops direct costs. The off-farm input is only off-farm work time. All the raw data come from farm survey managed by Teagasc. There are cross-sectional data for 2004. The number of observations for 2004 is 606 farms.

Table 1 depicts the descriptive statistics of farm variables. The standard man days are measured as on-farm labor input. This variable has a mean at 277.89 days with a range from 4.49 to 1370.5 days. The Standard deviation of man days is about 233.84. The average of total livestock direct costs is 20871 euro and this variable ranges from 0 to 230092.9 euro. The standard deviation of this variable is 23944.92. Another input variable, total crop direct costs, has a mean at 2988.69, ranging from 0 to 216535, with the standard deviation at 12592.96. Total farm output value has an average at 72971.87, ranging from 3951 to 590424 with the standard deviation at 75882.25. Another output variable is off-farm work income, ranging from 1 to 16 with the mean at 6.5. Here, the off-farm income was measured by category code in farm survey. One indicated the income range from 0 to 4000 euro, two represented the income range from 4000 to 8000 euro, and so on. We combined the income code of householder and that of spouse together. The utilized farm land ranged from 4.09 to 371.1 hectares, with a mean of 48.4. In addition, it should be noted that two data sets are applied in the paper. One data set

Table 2 Descriptive Statistics (606 observations)

Variables	Minimum	Maximum	Mean	Std. Deviation
TE(VRS)	0.201568	1	0.748611	0.174939
TE(CRS)	0.199387	1	0.701768	0.173792
Scale Efficiency	0.446	1	0.940419	0.0947
Allocative Efficiency	0.243117	1	0.887525	0.173703
Economic Efficiency	0.142322	1	0.665229	0.211639

used in the DEA model to estimate efficiencies is site-specific data set which has been explained in detail in this paper. Another data set is used and listed in the second stage analysis, which will be applied in Tobit model and system regressions.

The results from DEA

Because CRS technical efficiency is composed of VRS technical efficiency and scale efficiency, we only discuss VRS technical efficiency. In addition, the frequency distribution of the calculated CRS technical efficiency is only listed in appendix.

Table2 depicts the summary statistics of calculated efficiencies. VRS technical efficiency ranges from 0.2 to 1 with a mean of 0.748. This indicates that on average Irish farm families have the potential to increase their household incomes by 25 percentage points through improving technical efficiency on farm work and off-farm work. The scale efficiency changes from 0.446 to 1 with a mean of 0.94, indicating that, on average, Irish farm households can possibly increase the family incomes by 6 percentage points through improving scale efficiency. The allocative efficiencies range from 0.24 to 1, suggesting that for some farm families there has great potential to increase their output and household revenue through increasing allocative efficiency. The mean of AE is about 0.887, representing that on average Irish farm households can possibly increase their revenue by 11.3 percentage points through improving allocative efficiency. The overall economic efficiency is ranged from 0.14 to 1 with a mean of 0.665, indicating that on average the overall household revenue has the potential to be increased by 33.5 percentage points.

Table 3 VRS Technical Efficiency Frequency Distribution (606 observations)

	Frequency	Percent	Valid Percent	Cumulative Percent
0.2-0.3	3.00	0.50	0.50	0.50
0.3-0.4	7.00	1.16	1.16	1.65
0.4-0.5	44.00	7.26	7.26	8.91
0.5-0.6	77.00	12.71	12.71	21.62
0.6-0.7	112.00	18.48	18.48	40.10
0.7-0.8	130.00	21.45	21.45	61.55
0.8-0.9	83.00	13.70	13.70	75.25
0.9-1.0)	65.00	10.73	10.73	85.97
1.0	85.00	14.03	14.03	100.00
Total	606	100	100	

Table3 depicts the frequency distribution of the estimated VRS technical efficiency scores for the farm households in Ireland. Besides 85 fully technically efficient farm households whose VRS TE are 1, the calculated technical efficiencies concentrate on the range from 0.6 to 0.8, in which there are 242 households occupying 40% of total farm households. There are only 3 farm households whose estimated technical efficiency scores are 0.3 or below. Except for 54 farm households, all other 552 estimated technical efficiency scores are higher than 0.5. Obviously, apart from 85 full technically efficient farm households occupying about 14% of total farm households, all other farm households (about 86%) have the potential to increase the family output and revenue through improving pure technical efficiency.

Table 4 Scale Efficiency Frequency Distribution (606 observations)

	Frequency	Percent	Valid Percent	Cumulative Percent
0.4-0.5	3.00	0.50	0.50	0.50
0.5-0.6	8.00	1.32	1.32	1.82
0.6-0.7	11.00	1.82	1.82	3.63
0.7-0.8	32.00	5.28	5.28	8.91
0.8-0.9	55.00	9.08	9.08	17.99
0.9-1.0)	449.00	74.09	74.09	92.08
1.0	48.00	7.92	7.92	100.00
Total	606	100	100	

Based on the results from CRS TE and VRS TE, we calculated the scale efficiency. From Table4, the frequency distribution of the estimated scale efficiency is listed. It is manifest that, besides 48 fully efficient farm households, 449 farm households are located in the range from 0.9 to 1 occupying 74% of all households in the model. There are only three farm households whose scale efficiencies are lower than 0.5 and there are 106 farm households whose scale efficiencies range from 0.5 to 0.9 occupying about 17.5% of total farm households. It is obvious that nearly 92% of total farm households have the potential to increase their scale efficiencies, but most of them only can increase no more than 10% efficiency.

Table 5 Allocative Efficiency Frequency Distribution (606 observations)

	Frequency	Percent	Valid Percent	Cumulative Percent
0.2-0.3	6.00	0.99	0.99	0.99
0.3-0.4	10.00	1.65	1.65	2.64
0.4-0.5	18.00	2.97	2.97	5.61
0.5-0.6	26.00	4.29	4.29	9.90
0.6-0.7	28.00	4.62	4.62	14.52
0.7-0.8	38.00	6.27	6.27	20.79
0.8-0.9	62.00	10.23	10.23	31.02
0.9-1.0)	353.00	58.25	58.25	89.27
1.0	65.00	10.73	10.73	100.00
Total	606	100	100	

The allocative efficiency is measured by dividing economic efficiency by technical efficiency. Table5 depicts the frequency distribution of calculated allocative efficiencies. It can be found that there are 34 farm households whose allocative efficiencies are lower than 0.5, representing that they can improve their family outputs and incomes greatly through allocating their labor between farm work and off-farm work more efficiently. Most allocative efficiency scores range from 0.9 to 1.0, representing that the space for these farm households to increase the revenue through allocative efficiency is limited. Thus, it can be concluded that, although for some farm families there still have a large space for revenue improvement through increasing allocative efficiency, most of them can not gain a lot from allocating labor inputs more efficiently.

Table 6 Economic Efficiency Frequency Distribution (606 observations)

	Frequency	Percent	Valid Percent	Cumulative Percent
0.1-0.2	4.00	0.66	0.66	0.66
0.2-0.3	23.00	3.80	3.80	4.46
0.3-0.4	52.00	8.58	8.58	13.04
0.4-0.5	66.00	10.89	10.89	23.93
0.5-0.6	81.00	13.37	13.37	37.29
0.6-0.7	117.00	19.31	19.31	56.60
0.7-0.8	97.00	16.01	16.01	72.61
0.8-0.9	60.00	9.90	9.90	82.51
0.9-1.0)	42.00	6.93	6.93	89.44
1.0	64.00	10.56	10.56	100.00
Total	606	100	100	

The economic efficiency is the overall household efficiency measured by calculating the proportion of real household revenue to maximum possible revenue on the frontier. Table6 shows the frequency distribution of calculated economic efficiency. Of 606 total farm households, there are 64 fully economic efficient households occupying 10.56% of all families in the model, indicating that for these farm households there is no potential to increase total household revenue under current technologies. About 24% of all farm households have economic efficiencies lower than 0.5, indicating that they can improve their family revenue greatly. About 58% of total farm households are located in the efficiency range from 0.5 to 0.9, indicating that these farm households have some potential to increase their total family revenue. In addition, according to estimate result, 4 farm households are operated in the areas of 0.1 to 0.2, and 23 farm households are in the areas of 0.2 to 0.3, indicating that some farm households in Ireland are operated with nearly no economic efficiency.

The second-stage analysis

The results reported in above tables indicate the presence of inefficiency, especially in technical, allocative and therefore overall economic efficiency. The inefficiency possibly comes from idiosyncratic factors of each household, such as managerial abilities, the factor market, or household organizations specific to each household. To discern the sources of inefficiency, we regress technical efficiency, allocative efficiency, and scale efficiency on a set of explanatory variables. Here, because economic efficiency consists of technical efficiency and allocative efficiency and CRS technical efficiency is composed of VRS technical efficiency and scale efficiency, we only concern VRS technical efficiency, allocative efficiency, and scale efficiency. Considering the latent factors influencing inefficiency, the censored Tobit model was used with 1 as an upper bound and 0 as a lower bound. The Tobit model was estimated by maximum likelihood method. The censoring results are from the fact that all measures are in the [0, 1] interval. Considering the cross-function effect among TE, AE, and SE regression functions, the system functions using seemly unrelated regression method also were applied.

The explanatory variables are listed in table7. As opposed to the productivity variables used in measuring efficiency, the explanatory variables in table7 are used to reflect idiosyncratic factors that may influence the performance of farm households and therefore the efficiency scores. Because the estimated results of individual Tobit regressions and the system functions have the similar results, we will focus on the results of Tobit models and the estimated results of SUR system functions will be listed in the appendix.

For More Information on the RERC Working Paper Series
Email: CODonoghue@rerc.teagasc.ie, **Web:** www.tnet.teagasc.ie/rerc/

Table 7 Explanatory variables in the regressions

Variables	*Definition*
Extensivesub	= the subsidies for extensive farm
Landnousesub	= the subsidies for the land not used
Subs	= some other subsidies including disadvantage area payment, rural environmental protection scheme, and environmentally sensitive area grants
GrantslandImpro	= grants for land improvement
Grantsyoung	= young farmer installation grants
Longloan	= the loan for long term
Mediumloan	= the loan for medium term
Insurance	= insurance fees
Soilcode	= the soil code for soil quality, lower number represents better soil quality
Landrented	= the rented land
Landletout	= the land let out
Consultantfee	= consultants fees
Teagascfee	= Teagasc advisory fees
Married	=1 if householder is married
Separated	=1 if householder is separated
Widow	=1 if householder is widowed
Gender	=1 if householder is male
Hage	= the age of householder
Housemembers	= the number of house members
Primaryedu	= the number of house members receiving primary education
Secondedu	= the number of house members receiving second-level education
Thirdedu	= the number of house members receiving third-level education
Fulltime	= the number of house members working on farm full-time
Parttime	= the number of house members working on farm part-time
Hpension	=1 if householder has pension
Pensionothers	= the number of other house members who have pension
Farmtype1	=1 if the farm type is specialist dairy
Farmtype2	=1 if the farm type is mixed dairy
Farmtype3	=1 if the farm type is cattle rearing
Farmtype4	=1 if the farm type is sheep
Farmtype5	=1 if the farm type is tillage

Note: the variable 'single' is dropped (=1 if householder is single.). The variable Farmtype6 is dropped (=1 if the farm type is cattle other).

Table8 Estimated results of Tobit model for Technical efficiency

variables	Coefficient	S.E.
Landnousesub	0.000168	0.001211
Subs	-0.00029	0.000216
GrantslandImpr	-0.00036	0.00036
Longloan	0.000018	0.0000211
Mediumloan	0.0000677**	0.0000339
Insurance	0.001583**	0.000693
Soilcode	-0.0115**	0.005957
Landrented	0.038842**	0.020314
Landletout	-0.01387	0.057465
Consultantfee	0.002867**	0.001431
Teagascfee	0.003311	0.002934
Married	0.002916	0.028798
Separated	0.061135	0.083588
Widow	-0.0278	0.062164
Gender	-0.01021	0.047
Hage	0.000362	0.000894
Housemembers	0.015222*	0.008529
Primaryedu	-0.00384	0.011264
Secondedu	-0.01258	0.011763
Thirdedu	-0.00357	0.015271
Fulltime	0.017993	0.034761
Parttime	-0.02595	0.017824
Hpension	0.089475***	0.034439
Pensionothers	-0.00911	0.015837
Farmtype1	-0.05502**	0.024294
Farmtype2	-0.08843***	0.029571
Farmtype3	-0.07949***	0.023541
Farmtype4	-0.02471	0.028466
Farmtype5	0.118231***	0.03664
Cons.	0.724741***	0.070323
Log likelihood	81.23	
LR chi-square	152.86***	

Note: * significant at 10% level, ** significant at 5% level, *** significant at 1% level.

The Tobit results of technical efficiency are reported in table8. The subsidies (including Subs) hold an insignificant impact on technical efficiency. This means that there is no clear relationship between these subsidies and technical efficiency. The loan for medium term has a positive effect on technical efficiency. The impacts of all other loans are statistically insignificant. A possible explanation for it is that the medium loan is mostly invested in purchasing machine for farming, and this will enhance productivity of farming. The insurance has a positive and 5% significant effect on technical efficiency. The soil code has a negative relationship with technical efficiency and statistically significant at 5% level. Because lower soil code number represents better soil quality, this result shows that better soil quality has higher technical efficiency. The rented land variable holds a 5% significant and positive effect on technical efficiency, suggesting that the households renting more land will have higher technical efficiency. Consultant fees are statistically significant at 5% level and hold a positive effect on technical efficiency. This suggests that, if farm householders can get more scientific information from professional institutes, they can have higher household technical efficiency. The coefficients of marriage status and gender are found to be statistically insignificant for technical efficiency. However, the number of house members is shown to have significant and positive impacts on household technical efficiency. Another statistically significant coefficient is Hpension holding positive impacts on the technical efficiency of farm households. This may come from the issue that the people who get the pension will be more likely to transfer the farm work and off-farm business to the younger successor. Another important possible explanation is that the stable pension income from government can guarantee cash-flow for farm household, and a smoother flow of capital can enhance the overall efficiency of farming. The farm type dummies for specialist dairy, mixed dairy, and cattle rearing are shown to have a negative and highly significant effect on technical efficiency, indicating that the farm households of these farm types have relatively lower technical efficiency. The farm type of sheep has not clear effects on technical efficiency. The dummy for tillage farm type is found to have a 1% significant and positive effect on technical efficiency, suggesting that farm households planting crops can make more efficient use of family resources. This may be due to traditionally the crop farms have high quality land and other farms hold relatively low quality land. The changing price of crops may be another interpretation. All other variables are statistically insignificant.

Table9 Estimated results of Tobit model for scale efficiency

variables	Coefficient	S.E.
Landnousesub	0.000242	0.000633
Subs	-0.00019*	0.000114
GrantslandImpr	6.51E-05	0.000191
Longloan	-3.74E-07	1.13E-05
Mediumloan	5.18E-07	1.81E-05
Insurance	0.000618*	0.00037
Soilcode	-0.00395	0.003146
Landrented	0.017863*	0.0108
Landletout	0.025928	0.030898
Consultantfee	0.000819	0.000761
Teagascfee	0.003799**	0.001557
Married	-0.00949	0.01523
Separated	0.00757	0.043577
Widow	0.02123	0.033582
Gender	-0.00909	0.025209
Hage	0.00101**	0.000473
Housemembers	-0.00532	0.004481
Primaryedu	0.004954	0.00592
Secondedu	0.002849	0.00624
Thirdedu	0.015772*	0.008108
Fulltime	0.007294	0.018303
Parttime	0.007059	0.009444
Hpension	0.009101	0.017926
Pensionothers	0.014982*	0.008397
Farmtype1	0.021829*	0.012872
Farmtype2	0.002902	0.015655
Farmtype3	-0.03301***	0.01243
Farmtype4	-0.03899***	0.015017
Farmtype5	0.020656	0.019174
Cons.	0.922393***	0.037325
Log likelihood	501.87	
LR chi-square	107.34***	

Note: * significant at 10% level, ** significant at 5% level, *** significant at 1% level.

For More Information on the RERC Working Paper Series
Email: CODonoghue@rerc.teagasc.ie, **Web:** www.tnet.teagasc.ie/rerc/

The Tobit results of scale efficiency are depicted in table9. The subsidies (Subs) have a significant and negative impact on scale efficiency, suggesting that the disadvantaged area and environmentally sensitive area in the farm household land will weaken the scale efficiency of farm households although the household can get grants from government. All coefficients of loans are found to be statistically insignificant for scale efficiency. Insurance is statistically significant at 10% level with a positive impact on scale efficiency, indicating a positive relationship between the activity of buying insurance and scale efficiency. The rented land is shown to have a positive and 10% significant effect on scale efficiency. This means that the farm householders renting land should have higher scale efficiency than those who do not rent land. In addition, Teagasc advisory fees are also statistically significant and have a positive effect on scale efficiency, suggesting that Teagasc advices can enhance household scale efficiency. It should be noted that the coefficient of Teagasc advisory fees is insignificant in technical efficiency regression but significant in this regression. This means that although Teagasc advices have not clear effects on technical efficiency they hold significant and clear effects on farm householders' decisions for scale efficiency. The coefficient of household age is statistically significant at 5% level and has a positive effect on scale efficiency, indicating that with the increasing age the experience of farm householders makes an important role in deciding scale efficiency. The significant coefficient of Thirdedu shows that more house members in third education will enhance the scale efficiency. This may come from the house member in third education can provide better on-farm and off-farm work as labor force. The pensions of other house members also have a weakly significant and positive effect on scale efficiency, which may be due to better cash-flow. The dummies for specialist dairy have a significant and positive impact on scale efficiency, indicating that the farm households for specialist dairy have relatively higher scale efficiency. However, the dummies for cattle rearing and sheep hold negative and significant effects on scale efficiency, indicating that compared with specialist dairy farm households they have relatively lower scale efficiency. All other variables are statistically insignificant.

The Tobit results of allocative efficiency are depicted in table10. Insurance is again statistically significant with a positive impact on allocative efficiency, suggesting that insurance can enhance all three efficiencies. Soil code is statistically significant at 1% level with a negative impact on allocative efficiency, indicating that better soil quality can enhance allocative efficiency. The rented land again holds a significant and positive effect on allocative efficiency, indicating that the households renting more land also can allocate their family labour resources more efficiently.

Table10 Estimated results of Tobit model for allocative efficiency

variables	Coefficient	S.E.
Landnousesub	-0.00008	0.001073
Subs	-0.00017	0.000197
GrantslandImpr	0.000192	0.000327
Longloan	-3.46E-06	0.0000194
Mediumloan	0.0000116	0.0000314
Insurance	0.001429**	0.00064
Soilcode	-0.02166***	0.005426
Landrented	0.036583**	0.018454
Landletout	0.02316	0.053292
Consultantfee	0.002377*	0.001308
Teagascfee	0.002524	0.002674
Married	-0.06732**	0.026348
Separated	0.14245*	0.078932
Widow	0.057807	0.058111
Gender	0.036528	0.043499
Hage	0.002695***	0.000817
Housemembers	-0.00079	0.007785
Primaryedu	0.009527	0.010233
Secondedu	-0.01855*	0.01075
Thirdedu	0.005714	0.013951
Fulltime	0.005102	0.031519
Parttime	0.007011	0.01613
Hpension	0.045142	0.031472
Pensionothers	0.018528	0.014476
Farmtype1	0.06327***	0.022222
Farmtype2	-0.00644	0.02692
Farmtype3	-0.08543***	0.021438
Farmtype4	-0.06484**	0.025883
Farmtype5	0.05432*	0.033275
Cons.	0.822404***	0.064468
Log likelihood	178.72	
LR chi-square	201.78***	

Note: * significant at 10% level, ** significant at 5% level, *** significant at 1% level.

The coefficients of Consultantfee has a significant and positive impact on household allocative efficiency, indicating that those farm households which pay more attention to professional information and scientific advices will have better performance in allocating family labour resources. It is found that a significant barrier to allocative efficiency is the status of married householders. Although both householders and spouses are engaged in on-farm or off-farm work activities, relatively married householder is inefficient in allocating labour inputs. Factors related to the married householder's life might play a role. The married householders have to pay more attention to their family life and tend to spend more time on baby rearing. In addition, the significant and positive coefficient of separated householders shows that separated farm householders may have relatively higher efficiency in allocating family labour resources. The coefficient of Hage is statistically significant at 1% level and can enhance the allocative efficiency, suggesting that, although the older householders may be lower in technical efficiency, they have higher allocative efficiency. This might be explained by their abundant experience in allocating household resources. The 10% significant and negative coefficient of Secondedu shows that more children in second-level school will weaken the allocative efficiency. These younger children can not provide any work and the householders or other adults have to spend some time on them. The dummy for specialist dairy is shown to have a positive and 1% significant effect on allocative efficiency. This means that the farm households working for specialist dairy have relatively higher allocative efficiency. The dummies for cattle rearing and sheep again have negative and significant effects on allocative efficiency. One possible interpretation is that the family that raises more sheep or cattle has lower efficiency for bad quality of land. The statistically significant and positive coefficient of tillage dummy shows that the household working in tillage and planting crops might have relatively higher efficiency in allocating resources and labour.

Conclusions

The important purpose of this research is to investigate how the change of farm households will influence the on-farm or off-farm efficiency. To satisfy this purpose, two stages of models are applied. In the first stage, household efficiency including both on-farm and off-farm work is estimated. From the estimated results of pure technical efficiency (VRS), on average, Irish farm families have the potential to increase their household revenue by 25 percentage points through improving technical efficiency on both farm work and off-farm work. From the estimated allocative efficiencies, on average, Irish farm households can possibly increase their revenue by 11 percentage points through allocating household labor force efficiently in both farm work and off-farm work. The scale efficiency also has the potential to be increased but with limited space. The overall economic efficiency ranges from 0.14 to 1 with a mean of 0.665, suggesting that the overall household revenue has the great potential to be increased especially through increasing technical and allocative efficiencies.

In the second stage, the relationship between efficiency and various factors is estimated using Tobit and SUR system regressions. It is obvious that insurance is one of important variables which will influence all three efficiencies strongly for it can reduce risk in production. The variable of rented land is another interesting factor shown to have significant effects on all efficiencies. The coefficient of this variable suggests that the farm households renting more land might have relatively higher technical, allocative, and scale efficiencies. The Farm types of specialist dairy and cattle rearing are the final two variables influencing all three efficiencies. The dummy for cattle rearing shows a negative effect on all three efficiencies. However, the dummy for specialist dairy has negative effects on technical efficiency, but positive impacts on both scale and allocative efficiencies. The consultants have significant and positive effects on technical and allocative efficiency, but not on scale efficiency. As for Teagasc advices, they prefer impacting scale efficiencies strongly instead of technical efficiency. Some other variables, such as marriage status, only have clear effects on allocative efficiency.

The main objective of this paper is to contribute to the research stream on farm household income strategies and farm efficiency. This is a growing area of research but the effects of work change on efficiency over the long term of differing strategies have rarely been examined. In addition, although Irish farm technical efficiency has been measured using stochastic frontier models, there is no research which measures the efficiency by DEA method and estimates the off-farm household efficiency. Because more and more farmers now go to take off-farm work, this research stream can give some useful information for the government and extension services.

References

Brick, A., E. Garvey and M. Cuddy (2005). "Off-Farm Participation in Co. Mayo". Department of Economics, National University of Ireland Galway. Working Paper Series 102.

Brummer, B. (2001). "Estimating Confidence Intervals for Technical Efficiency: the Case of Private Farms in Slovenia". *European Review of Agricultural Economics*, 28 (3): 285-306

Chavas J.P. R. Petrie and M. Roth. (2005). "Farm Household Production Efficiency. Evidence from the Gambia" *American Journal of Agricultural Economics 87(1) Feb. 160-179*

Coelli, T.J., R.D.S. Prasada and G.E. Battese (1998). "An Introduction to Efficiency and Productivity Analysis". Kluwer Academic Publishers, Boston/ Dordrecht/London.

Cloutier, L.M. and R. Rowley (1993). "Relative Technical Efficiency: Data Envelopment Analysis and Quebec's Dairy Farms". *Canadian Journal of Agricultural Economics*, 41: 169-176.

Charnes, A., W.W. Cooper and E. Rhodes (1978). "Measuring the Efficiency of Decision Making Units". *European Journal of Operations Research*, 46: 185-200.

Chavas J.P and Aliber M. (1993) An Analysis of Economic Efficiency in Agriculture: a Non-Parametric Approach. *Journal of Agricultural and Resource Economics,* 18. 1-16.

Fraser, I. and Graham M. (2005). "Efficiency Measure of Australian Dairy Farms: National and Regional Performance". *Australian Agri-business Review*, 13(7) web-based.

Farrell, M.J. (1957). The Measurement of Production Efficiency. *Journal of the Royal Statistical Society Series A* 120 253-290

Fraser, I. and D. Cordina (1999). "An Application of DEA to Irrigated Dairy Farms". *Agricultural Systems*, 59: 267-82

Hennessy T (2004) Projecting Farm Numbers. Paper Prepared for 2015 Agrivision Committee and included as appendix 4 in the 2015 Agri-Vision Report. Irish Department of Agriculture and Food.

Jaforullah, M. and J. Whiteman (1999). "Scale Efficiency in New Zealand Dairy Industry: a non-Parametric Approach". *The Australian Journal of Agricultural and Resource Economics*, 43 (3), 523-41

Jha R., Chitkara P. and Gupta S. (2000) *Productivity, Technical and Allocative Efficiency and Farm Size in Wheat Farming in India*, a DEA Approach. Applied Economics Letters 7(1): 1-5.

For More Information on the RERC Working Paper Series
Email: CODonoghue@rerc.teagasc.ie, **Web:** www.tnet.teagasc.ie/rerc/

Kalirajan, K. and R. Shand (1999). "Frontier Production Functions and TechnicalEfficiency Measure". *Journal of Economic Surveys*, 13 (2): 148-72

Keeney, M. (2000) "The Economic Effects of Direct Payment Support of Irish Agriculture" Ph.D. thesis, Trinity College (University of Dublin)

Lockheed, M.E., D.T. Jamison and L.J. Lau (1980). "Farmer Education and Farm Efficiency: A Survey". *Economic Development and Cultural Change*, 29(1), 37-76.

Newman (2004) Measuring and Understanding Productivity Growth in Irish Agriculture. Wissenschaftsverlag Vauk Verlag: Kiel , 2004.

O Neill, S. and Matthews, A. (2001). Technical Change and Efficiency in Irish Agriculture. *The Economic and Social Review*. 32 (3) 263-284

Phillips, J.M. (1987). "A Comment on Farmer Education and Farm Efficiency: A Survey". *Economic Development and Cultural Change*, 35(3): 637-644. April. 1987.

Richard Nehring, Jorge Fernandez-Cornejo and David Banker (2005). Off-farm labour and the structure of US agriculture: the case of corn/soybean farms. *Applied Economics*, vol. 37, issue 6, pages 633-649

Ray S.C. and Bhadra D. (1993) "Nonparametric Tests of Cost Minimizing Behaviour: a Study of Indian Farms". *American Journal of Agricultural Economics*, v. 75, n 4, p 990-999.

Simar, L. and P.W. Wilson (2000). "Statistical Inference in Nonparametric Frontier Models., the State of the Art". *Journal of Productivity Analysis*, 13, 49-78

Shafiq, M. and T. Rehman (2000). "The Extent of Resource Use Inefficiencies in Cotton Production in Pakistan's Punjab: An application of DEA". *Agricultural Economics,* 22: 321-330.

Sharam, K. R., P. Lueng, H.M. Zaleski (1999). "Technical, Allocative and Economic Efficiencies in Swine Production In Hawaii: A Comparison of Parametric and Nonparametric Approaches". *Agricultural Economics,* 20: 23-35.

Townsend R. F., J. Kirten, N. Vink (1998). "Farm Size Productivity and Returns to Scale in Agriculture Revisited: A Case Study of Wine Producers in South Africa". *Agricultural Economics,* 19: 175-180.

Van der Ploeg, J.D. (1990). "Sistemas de conocimiento, metafora y campo de interaccion el caso del cultivo de la papa en el altiplano peruano". *Agricultura y Sociedad* 56 (julio/septiembre) 143-166

Weersink A. C.G. Tunvey and A. Godah (1990) "Decomposition of Technical Efficiency Measures for Ontario Dairy Farms". *Canadian Journal of Agricultural Economics*. 38(3) 439-456.

Xue, M. and P.T. Harker (1999). "Overcoming the Inherent Dependency of DEA Efficiency Scores: A Bootstrap Approach". Wharton Financial Institutions Centre. Working Paper 99-17.

Zaibet, L. and P.S. Dharmapala (1999). "Efficiency of Government-Supported Horticulture: The Case of Oman". *Agricultural Systems*, 62: 159-68.

Zhang, Y. and R. Bartels (1998). "The Effect of Sample Size on the Mean Efficiency in DEA with an Application to Electricity Distribution in Australia, Sweden and New Zealand". *Journal of Productivity Analysis*, 9: 187-204.

Appendix

CRS Technical Efficiency Frequency Distribution (606 observations)

	Frequency	Percent	Valid Percent	Cumulative Percent
0.1-0.2	1.00	0.17	0.17	0.17
0.2-0.3	2.00	0.33	0.33	0.50
0.3-0.4	17.00	2.81	2.81	3.30
0.4-0.5	58.00	9.57	9.57	12.87
0.5-0.6	100.00	16.50	16.50	29.37
0.6-0.7	130.00	21.45	21.45	50.83
0.7-0.8	126.00	20.79	20.79	71.62
0.8-0.9	75.00	12.38	12.38	83.99
0.9-1.0)	49.00	8.09	8.09	92.08
1.0	48.00	7.92	7.92	100.00
Total	606	100	100	

R-square	0.22	0.14	0.28
Wald(Chi-sq)	172.44***	99.31***	232.33***

Note: * significant at 10% level, ** significant at 5% level, *** significant at 1% level.

Estimated results of system functions using SUR

	TE Equation		SE Equation		AE Equation	
variables	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
Landnousesub	-0.00077	0.000823	-0.00026	0.000468	-0.00089	0.000788
Subs	-0.00019	0.000188	-0.00014	0.000107	-7.7E-05	0.00018
GrantslandImpr	-0.00034	0.000318	7.66E-05	0.000181	0.00021	0.000304
Longloan	1.33E-05	1.81E-05	-3.68E-06	1.03E-05	-9.67E-06	1.74E-05
Mediumloan	5.82E-05**	2.94E-05	-3.77E-06	1.67E-05	-2.32E-06	2.81E-05
Insurance	0.001453**	0.000591	0.000487	0.000336	0.001151**	0.000565
Soilcode	-0.01106**	0.005206	-0.00348	0.00296	-0.02072***	0.004981
Landrented	0.032441**	0.016831	0.014742	0.009572	0.033632**	0.016104
Landletout	-0.03214	0.048524	0.009055	0.027596	-0.00914	0.046429
Consultantfee	0.002654**	0.001229	0.000535	0.000699	0.002075*	0.001175
Teagascfee	0.002772	0.002565	0.003111**	0.001459	0.001822	0.002454
Married	0.00577	0.025096	-0.00901	0.014272	-0.06166***	0.024012
Separated	0.050124	0.072726	0.008733	0.04136	0.116359*	0.069585
Widow	-0.03035	0.054131	0.00929	0.030785	0.039023	0.051793
Gender	-0.00485	0.040901	0.001196	0.023261	0.049805	0.039135
Hage	-9.5E-05	0.000779	0.000714	0.000443	0.002009***	0.000745
Housemembers	0.012215*	0.007343	-0.0065	0.004176	-0.00305	0.007026
Primaryedu	-0.00162	0.009712	0.005773	0.005523	0.01072	0.009293
Secondedu	-0.01184	0.010124	0.002556	0.005757	-0.01654*	0.009686
Thirdedu	-0.00481	0.01319	0.013878*	0.007501	0.004494	0.01262
Fulltime	0.010715	0.029817	0.004907	0.016957	0.00131	0.028529
Parttime	-0.01941	0.015487	0.009599	0.008807	0.016717	0.014818
Hpension	0.065601**	0.028078	0.000127	0.015968	0.023171	0.026866
Pensionothers	-0.01113	0.013778	0.012591	0.007836	0.014501	0.013183
Farmtype1	-0.03745*	0.021126	0.029036**	0.012014	0.077666***	0.020213
Farmtype2	-0.06874***	0.02581	0.010931	0.014678	0.01102	0.024695
Farmtype3	-0.07014***	0.020527	-0.02964**	0.011674	-0.0752***	0.01964
Farmtype4	-0.01574	0.024813	-0.03344**	0.014111	-0.05393**	0.023741
Farmtype5	0.10674***	0.030413	0.019726	0.017296	0.046782	0.029099
Cons.	0.731501***	0.061025	0.926076***	0.034705	0.829273***	0.05839
RMSE	0.154		0.088		0.148	

For More Information on the RERC Working Paper Series
Email: CODonoghue@rerc.teagasc.ie, **Web:** www.tnet.teagasc.ie/rerc/