Causes of Diversification in Agriculture over Time: Evidence from Norwegian Farming Sector

Richard CULAS
Mahen MAHENDRARAJAH

Paper prepared for presentation at the 11th Congress of the EAAE
(European Association of Agricultural Economists),
'The Future of Rural Europe in the Global Agri-Food System',
Copenhagen, Denmark, August 24-27, 2005

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Abstract

Farm planing generally focuses on optimal diversification with respect to risk and uncertainties, where the risk-management strategies combine production, marketing, financial and environmental responses of the production of farm firm. In this study an empirical examination of farm diversification has been carried out from a sample of farms in Eastern Norway in which four measures of diversification (indices) were defined to incorporate the risk and uncertainties in relation to farm production (total) income. Using these four alternative measures of diversification and panel-data techniques, it has been shown that larger farms are more diversified, and when there is productive location and access to labour the farmers have a greater incentive to spread risk. These results suggest that diversification and farm size are positively linked and that there may not be sufficient economies of scale to warrant specialisation. Alternatively, farm specialisation may not be environmentally desirable because of the soil and water pollution that have been caused by large scale farming systems usually practised in most of the developed countries like Norway. Hence, farm diversification can be used as a strategy for managing the pollution caused by large scale less diversified farming systems, as well as to spread the risk related to farm income.

***Keywords*: farm diversification, risk and uncertainty, environmental management, panel data.**

JEL: C23, Q12, Q20

1. Introduction

While uncertainty and risk to varying degrees surround all forms of activity, it is considered more of a problem for agricultural production than for industrial production due to the influence of climate and other natural factors on the agricultural output and the length of agricultural production cycle. Typically, the different types of uncertainties most farmers face are climatic factors, pests and diseases, price uncertainties and polices related to agricultural production, marketing and trade. In this respect, farm diversification may be considered as a spontaneous response to avoid many of these uncertainties. There are several reasons why diversification is an option for managing these uncertainties. First, the relationship between diversification and farm size is an indication of trade-off between risk reduction and return in a farming activity. A farmer may give up a large expected return by specialisation in order to insure against risk through diversification. Second, aside from farm size, there are a number of potentially interesting micro level variables which may affect diversification choices in a risk-preference (as well as alternative models of) behaviour. These variables may include form of farm organisation, technological and policy changes, geographical location, labour, experience of farmers, wealth of farmers, agricultural insurance, etc. Third, there are policy instruments designed to increase food security and to manage the environment and other resources in a sustainable manner rather than to maximize short-term farm profit.

There is a rich agricultural economics literature on farm diversification since the early 1950s. Following the work of Heady (1952) and Markowitz (1959), attention has focused mainly on mean-variance portfolio approaches (Stovall, 1966; Johnson, 1967). Indeed, the main purpose of diversification in agriculture is to reduce the risk of the overall return by selecting a mixture of activities that have net returns with low or negative correlation. Thus the aim should be to find the risk-efficient combination of farming activities, not the one that merely minimises variance. Usually, farm planing models solved by quadratic risk programmes, upon the portfolio selection framework, have been used to find such combination of farming activities (Hazell, 1971; Thomas et al., 1972; Chen and Baker, 1974).

While the potential gains in risk efficiency from farm diversification have been an empirical matter to be resolved on a case-by-case basis, it is often claimed that these gains are often less than what may be expected for a number of reasons. First, farm plans to maximise expected return will often be reasonably diversified before risk aversion is considered. Second, the mixture of activities will typically make best use of available resources, risk aside. Third, the mixed cropping allows more productive and sustainable crop rotations which again favouring some system diversification. Finally, if the majority of the risk-reducing benefits from diversification can be captured by having only two or three enterprises (although, it is an empirical matter), the returns from different strongly positively correlated activities will limit the gains from diversification on farm (Hardaker et al 1997).

Farm planning models generally focus on theoretical issue of optimal diversification under uncertainty. An empirical examination of diversification (using cross-sectional data) has been undertaken by a few authors (for example, White and Irwin, 1972; Pope and Presscott, 1980). According to these studies, ambiguities exist about the relationship of some farm characteristics and the farm diversification. In particular, the study by Pope and Prescott (1980), using alternative measures of diversification for a large cross-section of California farms, revealed some evidences that larger farms are more diversified, wealthier and less experienced farmers are more specialised, and the co-operative farms are more specialised than the other forms of farm organisation. However, their study indicates that the empirical examination of diversification needs further research in order to delineate more the ability of farmers to self insure through diversification.

Farm risk management strategies may incorporate a combination of production, marketing, financial and environmental responses. Therefore, a measure of diversification, i.e. an index, can be assumed to incorporate the management of farm risk as a combination of the production, marketing, financial and adaptive environmental responses. Where the measure of diversification, i.e. index, summarises the number and relative sizes of activities operated in by a given farm. We consider four different types of measures of diversification, i.e. indices, such as index of maximum proportion, number of enterprises, Herfindahl index and entropy index.

Farm risk will also be managed by being flexible in the short-term and having an ability to manoeuvre in the long-term. However, there has been no attempt made to study the farmer's behaviour in managing the risk over the longer term. Thus, the objective of this study is to analyse the ability of farmers in managing the risk and uncertainty in the long-term, with respect to farm size (which also include the environmental characters such as water and soil pollution in addition to the economies of scale) and other socio-economic characters. In order to study this objective, we use a set of panel data from Norwegian agricultural sector (eastern Norway). Using that data, first, we develop an appropriate variable over which to define the four measures of farm diversification (i.e indices). Then we regress the estimated indices (dependent variables) against the farm size and the other socio-economic characters.

The paper is organized as follows. Section 2 will provide a brief description of the Norwegian agricultural sector and the implication of farm diversification on the Norwegian agriculture. Some properties of the diversification measures (indices) will be considered in Section 3. Presentation of the data and the descriptive analysis will be followed in Section 4. The econometric results and the discussion of the results will be presented in Section 5. Finally, summary and conclusion will be given in Section 6.

2. Norwegian Agriculture and Farm Diversification

This section is intended to give a brief description of the Norwegian agricultural sector, particularly on the current agricultural policies and other specific characters, for their relevance on farm diversification in Norway. According to the parliament amendment (*st. prp. nr. 8/ 1992-93*), the Norwegian agricultural policies are targeted to provide a robust agriculture sector (*robust landbruk*). A robust agriculture sector is defined as an agriculture sector (*mat-sektor*) which is more adjustable (*tilpassningsdyktig*) to changes in internal as well as external conditions. Such conditions can imply a reduction in the transfers going to the agricultural sector and an increased competition in the market for the agricultural products (*Landbruksdepartmentet, 1992*). For robust agriculture to be successful the following measures are emphasised by the Norwegian government: achieving a low cost agriculture; better utilisation of market access, both internally and externally, to ensure better utilisation of the production capital and avoiding over production; reducing price differences within the country, and with neighbouring countries; providing necessary incentives that can make the farmers more capable of performing their role as the independent farmers (NILF, 1997).

The Norwegian agricultural sector has traditionally been protected by import restrictions of food products and has also received substantial financial support. The agricultural policies kept the domestic consumer prices higher than in the world market and neighbouring countries. The withdrawal of such support, as a result of market liberalisation policies, for example, will lead to changing, and possibly lower, agricultural prices. This might lead to increased uncertainty and therefore farmers may adopt strategies that can help them to manage these uncertainties. One way of overcoming those uncertainties could be farm diversification. It is also important to note that the farmers are influenced by a number of other factors that are not specific to the current agricultural policies in Norway. Those factors can be the natural factors such as topography, climate, soil and vegetation conditions. Farmers' adaptations also depend on the level of education and experience, family situation, farm organisation, and other interests.

In general, the economic, social, cultural, political and technological factors in a country influence farmer's decisions. For example, changes in income in the society change the demand for agricultural products, and the cost of living has a large influence on farmer's conditions. Higher wages and employment opportunities outside the agriculture sector have induced labour force to seek work outside the agriculture, as noted mainly in the Northern part of the Norway. World market for certain capital inputs, such as tractors and some machines also have an influence on the farmer's conditions. In addition to the import protection given by the agricultural policies, there are other direct and indirect supportive measures (*tilskuddsordninger*) available to the farmers. The direct farm support is through the producer prices and quotas, investment support and tax reduction, while the indirect supports are through the research, teaching and consultancy with the farmer.

Considerable regional specialisation has also taken place within Norwegian agriculture during the past few decades (i.e., the periods between the 1950 - 1990). This has led to an increase in animal production, such as milk production, in certain parts of the Norway, while dramatic increases in crop production, such as grains, have occurred in other areas. This process of specialisation has to a large extent been politically desired. However, when the specialisation has appeared to have "excess production" and recognised as an important reason behind the increasing pollution, policy changes were discussed (Vatn, 1989).

2.1 Implication of farm diversification on Norwegian agriculture

Although the Norwegian government has had an active agricultural policy for long time, the government policies varied and there have been changes over time (NILF, 1994). According to the parliament amendment, "S*tortingsmeldinger nr. 14 (1976-77)",* there were five main objectives in which the government should have placed consideration. These objectives are related to production in agriculture, income from agriculture, agriculture related to district (regional) development, environment and resource management in agriculture, and improvement in efficiency in agriculture. We can see how farm diversification can work towards achieving these policy objectives, other than just as a strategy to manage the private risk and uncertainties.

Production:

The agriculture sector should to a larger extent satisfy the food demand of the people. In particular, it should produce adequate amounts of cereals (grains), milk and milk-products, meat, egg, potato, vegetables and fruits, etc. This "multi-product" objective can be met through farm diversification.

Income:

The farmers should attain an income as same as an industry worker (and others). Further, the farmers should have the same economic and social status like the industry workers. One should have consideration on both the money income and the other means which can have an impact on their living standards. Attaining the income should be based on the assumption of effective use of the labour and the other production factors (assets). An effective use of the labour and the other factors of production are possible via farm diversification.

Environment and resource management:

The agriculture should be practised in a way that it should not reduce the possibility of future biological production, while satisfying the basic assumptions of the agricultural production. The resources which are utilised now should not be limited to the future generations. Therefore, farming should be practised as environmentally friendly, and an environmentally friendly farming is possible through farm diversification.

Efficiency:

In practice, the agricultural policies have so far been in favour of the income objectives than the efficiency in agriculture. For example, the import restriction policy has lead into higher prices for the products than the world market prices. It has also resulted into excessive production of the food than it was optimal. Further, the excessive production (as a result of the farm specialisation) has increased the pollution. But, farm diversification could be considered as a way of over coming these short of inefficiencies in the agriculture.

Regional (district) policy:

The agriculture should provide income and build up the necessary structures to secure employment in the remote regions (districts), where it has been a weaker sector and the only industry. One can, however, consider increase in production in the other regions while giving priorities to the remote regions. Possibility for farm diversification in the remote regions, depends on the nature of the production base, can generate income and provide employment opportunities than the options for specialising in certain product(s).

In Norway, regional specialisation in agriculture had to a large extent been politically desired. Farm specialisation has, very recently, been recognised as the mechanism behind the increasing agricultural pollution, and it has then led to a discussion if the agricultural policies should be turned around (Vatn, 1989). Thus, the future Norwegian agricultural policies would consider farm diversification as an option for the "sustainable agriculture".

There are also evidences from other countries for the positive consequences of farm diversification on agriculture. For example, in Northern Zambia, maize was produced as a mono-crop through various governmental supported incentives. Later, it was realised that just specialising in maize production had drawn much of the governmental resources than what was gained from increased maize production. Further, the Zambian maize policy had also negative environmental effects in those areas where soils are not suited for growing maize, or in the areas where the production had been without sustainable soil management practices. As a result, the new agricultural policy in Zambia does not emphasise maize production in the Northern region as the past policy did, and "diversification" from maize mono-cropping to other cash crops and animal husbandry are encouraged. And this diversification process is expected to make some positive developments in the farming systems, environment and in the household economy in the northern Zambia (Culas, 1995).

3. Measures of Farm Diversification (M_j)

Diversification can be measured in a number of alternative ways (Clarke, 1993). They can be examined with respect to farm production as well as non-farm sources depending on the information available, and on the relationship between farm and non-farm income. Further, depending on the limitations of the data, measurements of diversification in production can be examined using variables of area (land area under production), net income (net revenue) and/or total income (production income). Properties of a diversification measure, however, will depend on the nature of problem studied.

Although there are different types of indices to measure the diversification, we are primarily interested in four of them as noted in the introduction (chapter 1). While each of these indices has an intuitive appeal it should be noted that not all them have the same merits, therefore, in the following section we consider each of them briefly.

We define $A_i = \textit{the crop acreage in activity } i, \textit{ and}$

$$\sum A_i = \textit{total farm acreage cropped}; \textit{ and let,}$$

$$P_i = A_i \Big/ \sum_{i=1}^{N} A_i \text{ , } \textit{denoting the proportions}.$$

Then the following diversification measures are considered:

$$M_1 = \max_i P_i \; (\textit{index of maximum proportion})(\textit{where } i = 1, \ldots\ldots, n);$$

$$M_2 = \sum_{i=1}^{N} \mathrm{I}(P_i), \; (\textit{number of enterprises}); \textit{ where } \mathrm{I} \textit{ denote a zero} - \textit{one indicator};$$

$$M_3 = \sum_{i=1}^{N} P_i^2 \; (\textit{Herfindahl index});$$

$$M_4 = \sum_{i=1}^{N} P_i \log \frac{1}{P_i} \; (\textit{entropy index}).$$

When M_1 through M_4 are defined for net income, P_i can be the proportion of net income from crop i. All the measures, except M_2, can be computed such that they are bounded by zero and one.

Index of maximum proportion (M_1)

This index is defined as the ratio (proportion) of the farm's primary activity to its total activities. Thus, if the farm's activities are ranked from largest to smallest to its total activities, the index of maximum proportion should be the farm's largest activity. But, when the farm has only one activity (specialised), say i = 1, then P_i = 1 and that M_1 = 1. Thus, for increasing diversification M_1 should decrease.

Number of enterprises (M_2)

This is the simplest index in which we count the number of activities the farm operates. If the farm has no any activity, then $I(P_i)$ will assign the value of zero and that M_2 is zero. But, when the farm has n activities, say i = 1,...., n, then I (P_i) will assign the value of 1 for each of those n activities and that M_2 is n. Thus, for increasing diversification M_2 should increase. The weakness of this index is that it gives no weight at all to the distribution of the farm's employment over the activities.

Herfindahl index (M_3

This index, by squaring the shares of a farm's activities, gives particular weight to the farm's principal activities. It means that a farm's secondary activities are given only limited weight in calculating the index. That this index is insensitive to minor secondary activities. This is desirable since it focuses attention on the major activities of the farm. This index takes the value of one, when a farm is completely specialised in its primary activity, and should approach zero as N gets large. Thus, for increasing diversification M_3 should decrease.

Entropy index (M_4)

This index weights the shares of a farm's activity by a log term of the inverse of the respective shares. It takes then the value of zero when the farm is completely specialised, and it will approach its maximum when diversification is perfect. Thus, for increasing diversification M_4 should increase. This index gives less weight to larger activities than the Herfindahl index.

4. Data and Model Specification

The data used in this study are obtained from account statistics in agriculture and forestry (*driftsgranskingene i jord-og skogbruk)*, documented by Norwegian Institute for Agricultural Economics Research (*NILF*). The objective of the account statistics is to give knowledge about economic conditions of Norwegian agriculture for various purposes such as production, management, advice, research, extension and others. The account statistics (*regnskapresultater)* for Eastern Norway *(østland)* provides the results of (*driftsresultater*) about 434 farmers (on average) in the region for the period from 1991 to 1996. The statistics was worked out on the basis of tax accounts and other information on production, where the tax accounts were recorded by the farmers (or relevant accountants) and the rests by officials at the NILF.

When choosing the representative farmers (sample) greater emphasis was given to their income, where a significant proportion of total income should have come from agriculture and/or forestry. In addition, the farm-family should have devoted at least 400 hours of yearly work on farm. The farmers were also selected from the different locations of the region on the basis of farm types and the sizes. Participation of the farmers in the survey was voluntary, but usually the farmer cannot be older than 67 years (NILF, 1997). Since this study focuses on farmers in Eastern Norway for the period from 1991 to 1996, there are time series data available for the same cross-sectional units, i.e., panel data. Thus, by repeatedly surveyed at periodic (yearly) interval, the panel data consists totally about 2605 observations which can provide useful information on the dynamics of farmer's behaviour.

We consider eight micro level factors influencing farm diversification. The term diversification here is confined to both crop and animal production. The micro level factors are; farm size (area), farmer's experience (age), net worth (wealth) of the farmer, time devoted to farming (labour input), agricultural insurance, geographical or climatic and soil characteristics of the farm (location), organisational form of the farm (with regard to types of labour used), and access to forestry. We use reasonably balanced panel data-set in which only very few farmers have been less than six years in the analysis.

Table 1 shows an overview of number of farms (observations) by each category of qualitative variables, i.e., dummy variables, for the period 1991 to 1996 (note that the respective number of observations for each year are given in the parenthesis).

Table 1: Number of observations for qualitative (dummy) variables

Variable	Location (Eastern Norway)		Access to forestry		Farm organisation (labour hired)		Farm organisation (labour hired)	
Year*	lowlands (1)	other parts (0)	yes (1)	no (0)	within family (1)	other wise (0)	outside family (1)	other wise (0)
1991 (439)	179	260	274	165	193	246	116	323
1992 (440)	206	234	278	162	195	245	114	326
1993 (446)	179	267	281	165	201	245	121	325
1994 (443)	165	278	279	164	198	245	118	325
1995 (429)	170	259	278	151	200	229	145	284
1996 (408)	173	235	259	149	188	220	133	275
Total(2605)	1072	1533	1649	956	1175	1430	747	1858

*Five dummy variables are introduced into the empirical model to correct the data for yearly influences.

Table 2 shows an overview of mean values of quantitative variables, i.e., explanatory variables, for the period 1991 to 1996.

Table 2: Quantitative variables and their mean values

Variable Year	Land area (daa**)	Experience (age)	Wealth* (NOK/daa)	Labour (hours/daa)	Insurance* (NOK/daa)
1991 (439)	225,45	46,0	9949,22	16,79	63,93
1992 (440)	231,01	45,9	9748,58	16,02	57,66
1993 (446)	232,94	46,1	9559,72	15,86	56,44
1994 (443)	235,47	46,4	9497,99	15,56	53,05
1995 (429)	245,98	46,6	9271,38	14,74	47,81
1996 (408)	251,62	47,4	9316,67	14,55	49,42
Mean	236,85	46,4	9561,21	15,60	54,81

*adjusted to consumer price index 1994 = 100. ** 1 decare (daa) is equivalent to 0.1 hectare.

4.1 Description of the Explanatory Variables

The following is the short description of definitions and/or explanations for each of the explanatory variables specified in the model.

Location (Eastern Norway): R

Eastern Norway is divided into lowlands (*flatbygder*) and other parts (*andre bygder*). This is because the production basis is substantially better in the lowlands region. There will also be significant agro-ecological and climatic differences between the lowlands and other parts of the region. For this reason we specified a dummy variable, taking the value 1 for lowlands and 0 for other lands, to capture the location impacts on farm diversification.

Access to forestry (alternative and/or additional income): F

Forestry can be viewed as a close alternative and/or additional source of income to agriculture. According to survey the forestry sector contributed 17 % of total net income from agriculture and forestry in 1996. The average family labour input on these holdings in 1996 was 220 hours, whereas it was 2100 hours in the agricultural sector (NILF, 1997). Thus, by employing a dummy variable, taking the value 1 for having forestry and 0 for not having forestry, we can find how access to forestry has impact on farm diversification.

Farm organisation (with regard to labour): Z_1 and Z_2

The farmer is the person administratively responsible for the farm (holdings). He or she is normally the owner of all or part of the real property, and generally the person who works the largest number of hours on the holdings. Typically, a farm will employ its family labour consists of the farmer and spouse or partner, if any, and any children aged under 17. But for the additional labour requirements, the farmer can hire children aged over 17, if any, and/or hire labour outside the family (denoted respectively by Z_1 and Z_2).

Thus for these differences, we employ, firstly, a dummy variable taking the value 1 if the farmer hire labour within the family and 0 if not. Secondly, we employ another dummy variable taking the value 1 if the farmer hires labour outside the family and 0 if not. Then, the omitted category, i.e., family labour, could be denoted by the constant term of the model (Gujarati, 1988). By this way of employing the dummy variables, we may rationalise the effect of farm organisation with regard to the different types of labour on farm diversification.

Farm size (Land area): S

The size of each farm can be distinguished by its total land area. By specifying total land area as an explanatory variable in the model we can find how farm diversification is influenced by its size, and the confrontation, i.e., the influence of farm size on specialisation.

Experience of the farmer (age as a proxy): E

In the literature, we often find that factors such as experience, managerial skills, knowledge and information are meaningful for effective farming. However, it is also difficult to find appropriate variables to control for such factors. Therefore, we employ age as a proxy variable to find the influence of such factors on diversification.

Wealth of the farmer: W

The variable wealth is expressed as the yearly capital value in NOK and it is estimated by taking the average of openings-account and closing-balance. The openings-account is the balance at the beginning of the accounting year and the closing-balance is the balance at the end of the accounting year. The respective balances are estimated from the accounts on agriculture, forestry, private account, accounts receivable and other occupation. The value of wealth is price-adjusted for the year 1994 consumer price index.

Labour: L

Labour is an aggregate of family labour and hired labour. Both the hired labour and the family labour are recorded as hours of labour. For persons aged under 18 or over 65, the hours worked are converted to standard hours in accordance with a multiplication (reduction) factor.

Agricultural insurance: A

The variable insurance is considered under fixed costs in the account statistics in agriculture and forestry (NILF, 1997). Therefore, we consider it as an explanatory variable which can influence the farmers attitudes towards risk and thereby the farm diversification. The values of insurance are price-adjusted for the year 1994 consumer price index.

Time impacts (yearly effects): D

Since the data are time series extending over the period from 1991 to 1996, it may be felt that time conditions exert an additive influence upon the dependent variable. It is because the data have not been corrected for the yearly influences. Therefore, five dummy variables are introduced into the empirical model. They will assume the value 1 in the second (1992), third (1993), fourth (1994), fifth (1995) and sixth (1996) year respectively, whilst being equal to 0 in the remaining four years. This scheme will be followed for the dummy variables d_1, d_2, d_3, d_4 and d_5 (Lesser, 1974). By this way of employing dummy variables to represent the years, we can capture the external impacts, subject to technological development, policy changes and/or any other year specific effects on diversification. The dummy variables will show the differences between the year 1991 and the other years.

Table 5: Number of farms (observations) for different production income

	Activity (production income)	1991	1992	1993	1994	1995	1996	Mean
1	Barley	287	282	278	277	262	244	271,6
2	Oats	224	222	219	204	186	174	204,83
3	Wheat	159	166	186	186	162	156	169,17
4	Other corn	6	6	15	18	19	20	14,00
5	Oil seeds	27	34	42	39	40	33	35,83
6	Potatoes	184	174	163	163	153	140	62,83
7	Grass seeds	39	31	16	24	27	21	26,33
8	Vegetables	39	30	35	32	24	25	30,83
9	Fruits and berries	9	17	16	15	16	14	14,50
10	Other plant product (carrot and other root crops)	11	11	9	12	6	10	9,83
11	Cattle milk* ++	192	187	193	193	189	182	189,33
12	Cattle sold live	133	122	121	130	131	125	127,00
13	Cattle beef (cows)	193	198	208	211	210	203	203,83
14	Cattle beef (other)	205	214	220	223	224	212	216,33
15	Goats milk*	12	9	8	7	6	6	8,00
16	Goats meat	13	10	9	8	6	8	9,00
17	Pigs (sows and boars)	72	74	74	70	66	63	69,83
18	Pigs (piglets)	53	63	70	64	58	53	60,17
19	Pigs (pork)	108	113	108	104	88	87	101,33
20	Sheep sold live	25	26	25	24	20	27	24,50
21	Sheep (mutton and lamp)	63	68	67	71	67	64	66,67
22	Sheep (wool)	61	63	62	67	62	60	62,50
23	Poultry sold live / meat	53	47	43	41	37	34	42,50
24	Poultry egg++	194	174	155	170	141	98	155,33
25	Horses	6	3	4	6	6	2	4,50
26	Livestock, other products++	79	85	88	81	71	49	75,50
27	Coarse fodder	122	137	219	164	197	192	171,83
	Total	2569	2566	2653	2604	2474	2302	2528,00

*Production income includes subsidies. ++ Production income includes private use (household consumption).

Table 3 in the appendix shows the descriptive statistics of the quantitative variables. Over the years the means of the quantitative variables, except for the variable agricultural insurance, are not varying significantly. However, their maximum and minimum values (and also the standard deviations) suggest significant variations among the farms. Table 4 in the appendix shows the correlation matrix of the variables and there is no significant problem of multicollinearity, since the absolute values of the correlation coefficients are not greater than 0.9 in the sample according the thumb-rule.

4.2 The Variable to Define the Farm Diversification

Production income (total revenue) is the potentially interesting variable, i.e., the dependent variable, over which to define the farm diversification. A rationale for using the production income, as the variable over which to define the diversification, can be that we are really interested in the proportions (ratios), i.e., net income from an activity over the total net income. Thus a ratio, i.e., production income for an activity over the total production income, can be considered to be a close approximation to a ratio of the net income from that activity over the total net income. Table 5 presents the number of farms (observations) for the different types of production income, i.e., income based activities, for the period 1991 to 1996. There are altogether twenty-seven types of production income from the different crops and animal production activities.

Table 7: Averages of the production income under different activity (NOK 000)**

	Activity (production income)	1991	1992	1993	1994	1995	1996	Mean
1	Barley	75,08	45,67	56,86	43,53	46,85	58,35	54,39
2	Oats	53,85	30,18	31,04	21,51	27,20	27,19	31,83
3	Wheat	50,67	36,29	59,33	33,84	44,99	38,34	43,91
4	Other corn	0,83	0,62	1,15	0,63	1,78	2,02	1,17
5	Oil seeds	2,69	3,24	5,15	3,26	4,35	3,91	3,77
6	Potatoes	20,78	29,41	15,35	23,50	22,06	20,53	21,94
7	Grass seeds	4,69	2,19	1,37	3,35	3,36	2,81	2,96
8	Vegetables	6,02	4,44	4,09	3,74	3,67	4,01	4,33
9	Fruits and berries	4,56	3,78	6,34	3,88	1,99	2,62	3,86
10	Other plant product (carrot and other root crops)	0,50	0,42	0,21	0,33	0,08	0,62	0,36
11	Cattle milk* ++	172,76	165,24	162,21	147,02	152,98	148,79	158,17
12	Cattle sold live	8,14	6,60	6,90	7,71	7,59	8,00	7,49
13	Cattle beef (cows)	20,15	25,29	24,70	23,47	22,67	23,22	23,25
14	Cattle beef (other)	46,88	50,34	45,63	46,88	43,15	46,87	46,63
15	Goats milk*	5,98	4,50	3,50	3,16	2,86	2,80	3,80
16	Goats meat	0,38	0,45	0,28	0,24	0,18	0,20	0,29
17	Pigs (sows and boars)	5,52	5,11	4,98	5,30	4,87	5,06	5,14
18	Pigs (piglets)	12,79	9,64	9,74	9,91	9,95	10,81	10,47
19	Pigs (pork)	71,69	53,30	62,91	66,02	64,55	65,95	64,07
20	Sheep sold live	0,33	0,28	0,41	0,29	0,34	0,54	0,36
21	Sheep (mutton and lamp)	8,11	8,52	7,67	8,59	7,04	7,35	7,88
22	Sheep (wool)	1,98	2,12	1,57	1,76	1,54	1,26	1,71
23	Poultry sold live / meat	4,72	4,84	3,73	3,23	3,44	3,81	3,96
24	Poultry egg++	27,11	24,54	20,42	20,38	19,57	19,17	21,86
25	Horses	0,04	0,02	0,05	0,06	0,07	0,03	0,05
26	Livestock, other products++	0,79	0,74	0,87	0,90	0,63	0,49	0,74
27	Coarse fodder	2,34	2,47	5,65	3,81	5,89	5,69	4,31
	Total	609,39	520,25	542,13	486,32	503,64	510,44	528,69

*Production income includes subsidies. **Adjusted to consumer price index 1994 = 100.

++ Production income includes private use (household consumption).

4.3 The Dependent Variables: Estimated Indices (Measures of Diversification)

The four indices were estimated according to the variable production income. The descriptive statistics of the estimated indices are shown in table 6 in the appendix. When interpreting the estimated indices one should take care the way they are defined. For example, the three indices; index of maximum proportion, Herfindahl index and the entropy index, assign the values between zero (minimum) and one (maximum). But the fourth index, i.e., number of enterprises, takes the values between 1 (minimum) and 16 (maximum). We can also note that the entropy index should get, mostly, the value of one when the other indices, i.e., maximum proportion and Herfindahl index, get zero, and vice-versa. It is because of the "log" term involved in the definition of the entropy index.

Trend in diversification can also be seen another way. For example, for the variable production income, we plot the total number of farms under the different activity of production income (see table 5) against the total of the averages of the production income under different activity where the production is expressed in terms of income and the period of analysis is six years (see table 7).

Further, since the production is expressed in terms of income and the period of analysis is six years, it is necessary to adjust the prices. For this reason, we use the 1994 prices as constant, i.e., prices were adjusted to the consumer price index for 1994 is 100 (SSB, 1997).

The figure suggests that over the years the total number of farms under the different production income has changed significantly, whereas the total of the average production income has not changed that much (see figure 1).

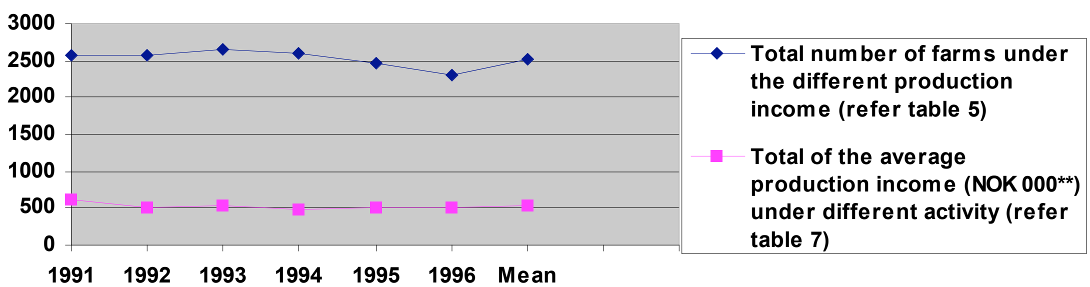

Figure 1: Trends in diversification in terms of production income

An implication of this trend can be that from year to year farmers should have changed the (total) number of income based activities they engaged in, although the (total) average of the production income from those activities remained more or less the same. It implies that there was diversification at different degrees.

4.4 The Empirical Model

The following linear model is considered for estimation where all of the four indices (dependent variables) are defined over the (total) production income.

$$M_{it}^{j} = a_0^j + a_1^j Z_{it} + a_2^j R_{it} + a_3^j D_{it} + a_4^j F_{it} + a_5^j S_{it} + a_6^j E_{it} + a_7^j W_{it} + a_8^j L_{it} + a_9^j A_{it} + \varepsilon_{it}$$

where;

M_{it}^{j} is the j^{th} diversification measure on i^{th} farm in time t for $j = 1, \ldots 4;\ i = 1, \ldots N;$ and $t = 1, \ldots, T$.

Z_{it} is a vector representing organisational form (wrt family labour and/or hired labour).

R_{it} is dummy variable for location.

D_{it} is a vector of time dummies.

F_{it} is dummy variable for access to forestry.

S_{it} is (farm size) land area under production.

E_{it} is experience (age of the farmer).

W_{it} is (wealth) net worth per unit area.

L_{it} is labour used per unit area.

A_{it} is agricultural insurance per unit area.

ε_{it} is the error term.

5. Econometric Results and Discussion

Following the theoretical arguments and the approaches discussed, "hypotheses" regarding the influence of each of the micro level factors on diversification were tested. The null hypothesis is that the tested variable has no influence on diversification whereas the alternative hypothesis is that it has influence on diversification. Alternatively, the null hypothesis can be that the tested variable has influence on specialisation but the alternative is that it has no influence on specialisation *ceteris paribus*.

Estimates of model for simple pooled regression were carried out. Comparing the model's estimates corrected for heteroscedasticity and autocorrelation with that of the uncorrected, there seemed to be no remarkable changes in the number of significant variables, except for the index M1, for which the variable D5 become insignificant at 95 per cent significance level, while being significant at 90 per cent level. Thus, both the corrected and the uncorrected estimates of the model are almost same in terms of the number of significant variables and the respective coefficients. It can therefore be safely inferred that there is no serious problems of heteroscedasticity and autocorrelation.

The estimates of the model for the fixed-effects and random-effects are elicited. The LM tests, Likelihood Ratio tests (including the F-tests), and the Hausman tests results are also carried out. First, from the LM tests, it is affirmed that for all the indices (M1, M2, M3 and M4) there exist the random-effects models at 99 per cent level of confidence. Secondly, from the Likelihood Ratio tests (and also from the F-tests), it is affirmed that for all the indices (M1, M2, M3 and M4) there exist the fixed-effects models at 99 per cent probability level of confidence. Finally, from the Hausman tests, it is affirmed that for all the indices (M1, M2, M3 and M4) the fixed-effects models should exist over the random-effects models, and the evidences are at 99 per cent probability level of confidence for the indices M2, M3 and M4, and 95 per cent for the index M1.

Thus, from the LM tests, we can rely on the random-effects regression results rather than that of the pooled regression results. And from the Likelihood Ratio tests (and the F-tests), we can rely on the fixed-effects regression results rather than that of the pooled regression results. But, according to the Hausman tests, there should be correlation between the individual (farm specific) effects and the other regressors in the random-effects models, thereby validating the fixed-effects regression results over the random-effects regression results.

On the basis of the sample used, and with respect to the different diversification measures applied, the results obtained under the fixed effects regressions are ‘robust’ only for the two variables, farm size (S) and farm labour (L). However, compared to the overall results obtained from both the random-effects and the pooled regressions, the robustness is poor for the fixed-effects regressions (see table 15). For example, under the fixed-effects regressions, only three indices support the positive effect of farm size on diversification, whereas under the random effects and the pooled regression all of the four indices support the positive effect of farm size on diversification.

Table 15: Summery of pooled, fixed-, random-effects and between-N regression results*				
Variable	Pooled reg.	Fixed-effects reg.	Random-effect. Reg.	Between reg.
Z1	$+^{2}$ $+^{3}$ $+^{4}$		$+^{2}$	$+^{2}$ $+^{4}$
Z2	$+^{2}$ $+^{3}$ $+^{4}$		$+^{2}$ $+^{4}$	$+^{2}$ $+^{4}$
D1			$-^{1}$	
D2				$-^{1}$ $-^{3}$
D3	$-^{1}$			
D4	$-^{1}$			
D5		$-^{2}$	$-^{2}$	
R	$+^{1}$ $+^{2}$ $+^{3}$ $+^{4}$	$+^{2}$	$+^{1}$ $+^{2}$ $+^{3}$ $+^{4}$	$+^{3}$ $+^{4}$
F				
S	$+^{1}$ $+^{2}$ $+^{3}$ $+^{4}$	$+^{1}$ $+^{3}$ $+^{4}$	$+^{1}$ $+^{2}$ $+^{3}$ $+^{4}$	$+^{2}$ $+^{3}$ $+^{4}$
E	$+^{2}$			
L	$-^{1}$ $+^{2}$ $+^{4}$	$-^{1}$ $-^{3}$	$+^{1}$ $+^{2}$ $-^{3}$	$-^{1}$ $+^{2}$
W				
A	$-^{1}$	$-^{2}$		

*Superscripts of the signs, i.e., 1, 2, 3 and 4 over the (+)’s and the (-)’s, refer the M1, M2, M3 and M4.

With respect to the effects of other variables on diversification, there are more consistent results for the variables, farm organisation (Z1 and Z2) and farm location (R) under the random-effects and the pooled regressions than under the fixed-effects regressions. Moreover, the overall results obtained even under the ‘between regression’ are in favour of the random-effects and the pooled regressions results. It is particularly true for the variables farm size (S), location (R), and farm organisation (Z1 and Z2).

However, with respect to rest of the variables, i.e., year dummies (D1, D2, D3, D4 and D5), farmers experience (E) and agricultural insurance (A), the results are evident only by one or two of the diversification measures under all of the estimated regression models. Further, for the variable farm labour (L), the results are inconsistent with the different diversification measures applied (see table 15).

Discussion: Overall Results

Considering the over all aspects of the results, the variable farm size (S) has a positive effect on diversification (see table 15). This is similar to the evidence from a study of large cross-section of California crop farms (Pope and Prescott, 1980), but in contrast to inconclusive evidence computed from U.S census (White and Irwin, 1972). The results, thus, shed some light on the nature of the trade-offs between scale economies. That is, if there are large-scale economies in an enterprise (farm), then one might expect larger farmer to be more specialised. Clearly our results refute this hypothesis.

Considerable regional specialisation has taken place within Norwegian agriculture during the last few decades (i.e., the periods between the 1950-1990). This has led to an increase in animal production, for example milk production, in certain parts of the Norway, while increased dramatically crop production, for example grains, some other areas. In Norway regional specialisation in agriculture has developed so far and this process has to a large extent been politically desired. However, when the specialisation has appeared to have "excess production" and recognised as an important mechanism behind the increasing pollution, discussion of policy changes raised (Vatn, 1989).

Thus, why our results refute the hypothesis that large-scale farmers are more specialised, may be a reason of recent realisation of increasing agricultural pollution resulted by the excessive production, and that a tendency towards farm diversification. Current Norwegian agricultural policy emphasises environmental friendly production measures, for example ecological agriculture, and the farmers are also encouraged by the provision of different types of subsidies for more environmental friendly agricultural production (NILF, 1996). In these aspects, farm diversification could also be regarded as one of the measures towards the environmental friendly agricultural production (Ellis, 1993), irrespective of the farm sizes in the region.

The location dummy variable (R) shows a positive effect on diversification (see table 15). It means that the farms located in the lowlands of the Eastern Norway are more diversified than the farms located in the other parts of the region. A possible reason for this difference is that production basis is substantially better in the lowland region.

The dummy variables representing farm organisation are the other (last) most influencing variables of farm diversification in the region. Remarkably, coefficients of the variable Z2 is greater than the coefficients of the variable Z1 in all the (significant) cases (see tables 8, 10 and 11 in the appendix). It implies that labour availability from outside the family (i.e., the labour that could be hired from outside the family), is more influential than the labour availability within the family (i.e., the labour that could be hired within the family). Further, irrespective of their level of influence on diversification, both variables suggest also a potential labour scarcity in the farms.

Among the other variables, farm diversification was negatively influenced over the years (from 1992 to 1996) as compared to that for the year 1991 (see table 15). It may be due to some year specific (external) effects, for example favourable prices for certain agricultural products that could have prevented the farmers to produce many others, or unusual weather condition during those years, or technological changes for certain products, or some other reasons. However, the influence of the variables D1, D2, D3, D4 and D5 are evidenced only under one or two of the regression(s) models, and also that influence is evident only for one or two of the diversification measures applied. Therefore, since the variables D1, D2, D3, D4 and D5 do not provide clear evidence for the yearly (time) effects, one might expect more evidence to belief.

The variable farmers experience (E) is positively related to the diversification, as indicated by the index M2 under the pooled regression (see table 15). It implies that younger or less experienced farmers are more specialised. One might speculate that younger farmers are less risk averse. But, more plausibly, young farmers may start small and specialised, and become more diversed as they expand their operation. This may be indicative of capital shortages for young farmers. Also, it may be difficult for less experienced farmers to manage diverse activities.

The evidences for influence of the variable labour per unit area (L) is some what complicated to predict any thing exactly (see table 15). However, on balance, it may be stated that labour per unit area has positive influence on diversification and the validity of this statement can also be supported by the other labour related variables, i.e., Z1 and Z2, for which we have positive effects.

Further, the variable agricultural insurance (A) shows a negative effect on diversification (see table 15). It is quite obvious, and expected, that when there is insurance farmers might not consider the diversification as a risk managing strategy. In particular, Norwegian farmers are highly insured against uncertainties related to production (i.e., crop failures and death of farm-animals) and even for their personal well-being like sickness.

The variable access to forestry (F) is significant for none of the indices that have been estimated. However, it was expected that when there is access to forestry it might have a negative effect on diversification because access to forestry can be considered as an alternative and/or additional income gsource to the farmers. On the other hand, having the forestry can also be considered as a kind of farm diversification for some farmers. But in the analysis, due to constraints related to data and the organisation of agriculture and forestry as separate main activities, we treated the forestry as a separate (off-farm) activity differing from the agriculture. Indeed, an explanatory variable for "nonfarm income (*inntekter utenom bruk)"* should have been incorporated in the analysis. Because, it is now evident that the nonfarm income-generating sources contribute increasingly to the total (net) income of the farmers. For example, on average, nonfarm income sources contributed 25 % of the total (net) income of the farmers in the year 1986, whereas its contribution has gradually increased to 44 % in the year 1996 (NILF, 1997).

The variable wealth per unit area (W) is significant only for the index M1 (under the pooled regression model). Further, its coefficient is very small thereby its effect on diversification should be negligible (see table 8). However, the sign of the coefficient is negative as expected and it can, therefore, imply that wealthier farmers are more specialised. In other words, according to risk theories farmers diversify to spread risk and wealthier farmers have fewer incentives to spread risk. The overall evidences suggest that, on the basis of the sample used, the results obtained are fairly 'robust' with respect to the diversification measures applied.

6. Summary and Conclusions

Farm planing models generally focus on theoretical issues of optimal diversification under uncertainty. In this study an empirical examination of farm diversification has been carried out for a sample of farms in Eastern Norway under the assumptions of pooled (classical), fixed-effects and random-effects regression models. The dependent variable of the empirical model has been four alternative measures of diversification (indices), and they were defined over farm production (total) income. The micro level explanatory variables which were considered to have influence on farm diversification are farm organisation (with respect to labour), location, time, access to forestry, farm size, experience of farmer, wealth of farmer, farm labour and agricultural insurance.

Farm diversification has, in principle, been considered as a way to spread the different kinds of risk that farmers might confront. In general, farm risk management strategies may incorporate a combination of production, marketing, financial and environmental responses. That is, the four measures of diversification (indices) were assumed to incorporate the combination of these responses with respect to the variable farm production (total) income, over which we defined those indices.

Panel data analysis has been used for the intention of examining the issues that could not be studied either in the cross-sectional or the time-series settings alone. According to the Breusch and Pagan LM tests, the estimated pooled regression models (in which we have assumed homogenous intercepts) might lead to biased estimates than that for the estimated random effects models (in which we have assumed heterogeneous intercepts). Likewise, according to the Likelihood Ratio tests (and the F-tests), the estimated pooled regression models might lead to biased estimates than that for the estimated fixed effects models (in which also we have assumed the heterogeneous intercepts). Then, for the existence of parameter heterogeneity among the farms, we have considered the random effects models against the fixed effects models. However, the test statistic according to the Hausman specification tests indicated that the fixed effects models might have had larger effects on the estimated (regression) coefficients than that for the random-effects models. The reason may be that in the longitudinal (panel) data set N is large and T is small (Greene, 1993).

Based on the over all results, using the alternative measures of diversification, the sample of Eastern Norway revealed evidences that larger farmers are more diversified, farms located in the lowland of the Eastern Norway are more diversified, and the farms that hire labour within the family and/or outside the family are more diversified. The evidences reported here suggest that diversification and farm size may be positively linked. That is, there may not be sufficient economies of scale to warrant specialisation and/or farm specialisation may not be environmentally desirable because of the pollution that can be caused by excess production. In general, the results here are consistent with the risk theories, i.e., the farm diversifies to spread risk. Further, when there is better location and access to labour, the farmers have more incentive to spread the risk.

However, one should exercise caution in interpreting the results. The essential point is that these results may be a cause for concern for those supporting policies which are tied to diversified farms that are presumed to be relatively small. Further, the conclusions reached in the analysis here must be tempered by the lack of nonfarm income-generating activities, and by any unique characteristics that can be specific to the individual farms. Furthermore, the study suggests that empirical analysis of diversification needs further research in order to delineate more fully the following issues: the economics of activity choice; the choice of appropriate variable(s) over which to define the measures of diversification; and the inclusion of ability of farmers to self insure through diversification in a long time horizon.

Farm diversification can also be regarded as a way to attain certain policy objectives other than to spread risk. In particular, in the Norwegian context, it can have positive consequences for product diversity and food security, alternative income sources and income stability, employment opportunity and rural (district) development, environmental and natural resources management, and efficiency in agriculture. It is also evident from our study that the attainment of the above policy objectives are possible because large farms can be more diversified, locations with better production bases can be used for diversified farms, and through diversification more labour can be absorbed.

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