Off-farm Labor Supply
and Various Related Aspects of Resource Allocation
by Agricultural Households

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Contents

List of Tables

List of Figures

1 Introduction

1.1 Motivations

Agricultural sectors in the developed capitalistic countries in the second half of this century have experienced remarkable reductions in agricultural workforce and in farm numbers and considerable increases in production size of individual farms. However, even after these considerable changes, concentration of agricultural production on ‘industrial farms’, which could be characterized by high degree of specialization and production sizes that are big enough to require large number of hierarchically organized hired labors, has not taken place. On the contrary, the dominant form of the organization for agricultural production is family farm, whose labor input is covered mostly by the family labor. Furthermore, both proportion of the farm families with off-farm labor supply and contribution by off-farm labor supply to the income of agricultural households[1] have increased. The farms managed by agricultural households with off-farm labor supply, which are usually termed ‘part-time farms’, have typically smaller farm sizes, lower labor intensity, and lower economic return for labor input and land input than ‘full-time farms’.

Such agricultural structure, which is characterized by the farm size that is restricted by family labor capacity and by significant proportion of part-time farms, is often considered to be inefficient. Such opinion is based on various estimations about the cost structure of agricultural production, which are believed to show that the size of many family farms is too small to utilize technically feasible economies of scales. Consequently, the size of many full-time farms is considered to be suboptimal. In addition, in many cases, the part-time farms are considered to perform extremely inefficient resource allocation because their size is usually much smaller even than the ‘suboptimal’ size of full-time farms. The existence persistence of such suboptimal structure is often attributed to the imperfectness of labor and land market and the ‘specific behavior pattern of farmers’ which could not be explained within the framework of economic rationality.

The explanation of such seemingly suboptimal agricultural structure on the premise of economic rationality becomes possible when we realize, above all, the economic and technological conditions which favor families or households as subjects of agricultural

1 In spite of possibility for conceptual differentiation, we use ‘farm family’ and ‘agricultural household’ interchangeably in this dissertation.

production vis-à-vis 'agricultural firms'.[2] First, remarkable progresses in mechanical technologies, which have labor-saving character, have increased the production size which agricultural households can manage within their family labor capacity. Second, the agricultural household, which employs family labor for agricultural production, has advantage in transaction cost vis-à-vis an 'agricultural firm' that employs hired labor. Even when economies of scales can be expected at firm sizes that exceed family labor capacity in terms of narrowly defined production cost, they seem to be canceled out by the high transaction cost that is related to hired labor.

Given dominance of the agricultural household as an organization of agricultural production, it should be clear that the theory of utility maximizing household is suitable for understanding the allocation of agriculture resources rather than the theory of profit maximizing firm. From the point of agricultural household, it is rational to allocate the resource in such a way that the utility is maximized rather than only the income from agricultural production. This point is relevant especially for the time resource of the agricultural household in the developed countries due to two reasons. First, general economic development causes increases in off-farm wages and in off-farm job availability for agricultural households. Second, lack of product innovation in agriculture limits the employment of the labor which can be saved by application of newly developed mechanical technologies.

The above considerations make clear that the off-farm labor supply of agricultural households is one of the important aspects of rational resource allocation in agricultural households as well as of structural changes in agriculture.

1.2 Objectives

Because of the significance and the increasing importance of off-farm labor supply of agricultural households, there has been increasing number of researches on off-farm labor supply. As important categories of such researches, the following can be listed.(A few studies are named in the parentheses after the subjects).

(i) The determinants of off-farm labor supply decisions (Sumner (1982), Huffman and Lange (1989), Gebauer (1987), Schulz-Greve (1994)) : Many studies, most of which made use of concepts and econometric methods developed originally in labor economics, tried to identify

[2] For detailed discussion of economic advantages of family farms, see Schmitt (1991).

the variables which influence the off-farm labor supply decision of agricultural households and to measure the magnitude of their influences.

(ii) Off-farm labor supply and agricultural resource allocation (Bollman (1991)) : Some studies were carried out to compare the resource allocation pattern in agricultural production between the farmers with and without off-farm labor supply. Various aspects such as technical efficiency (the question whether the production is taking place on the production possibility frontier), output mix, input intensity, or partial productivity were compared.

(iii) Off-farm labor supply and income distribution (Bollman (1991), Schmitt (1994)): The contribution of off-farm labor supply to the total income of agricultural households and the income comparison between the agricultural households with and without off-farm work are of special political interest. Studies on this aspect has led to the understanding that a picture of income situation of agricultural households based only on the agricultural income or only on the household members who are engaged in farm production might be distorted in many cases.

(iv) Dynamic aspects of off-farm labor supply (Gould and Saupe (1989), Stadler (1990), Klare (1990), Weiss (1996), Weiss (1997)): Given the significant proportion of agricultural households with off-farm labor supply, the stability of ‘part-time’ farms and the relationship between off-farm labor supply and permanent exit from agriculture in a dynamic context are important to understand the structural change in agriculture.

The objective of this dissertation is to help us to understand off-farm labor supply better by analyzing the following three topics:

(1) differences between farm labor supply patterns of the farmers with and without off-farm work

(2) intrafamily interdependence in off-farm work participation decisions

(3) influence of off-farm work experience on exit from agriculture and on the off-farm labor supply in the subsequent periods.

These three topics fall into subject field (ii), (i) and (iv), respectively.

Topic (1): Off-farm labor supply can entail changes in the structures of agricultural product supply and the factor demand functions. However, previous empirical studies have paid little attention to these differences partly because they concentrated on the off-labor supply behavior itself. The scope of some studies which did compare agricultural resource allocation of part-time farms and of full-time farms was limited to technical efficiencies or to some specific aspects of production structure measured by indices such as output mix or input intensities. On the premise that labor input of farm family members is an important determinant of the agricultural production adjustment and of the income of agricultural households, this dissertation analyzes the source of the differences between the farm labor supply patterns of part-time farms and of full-time farms and presents some empirical evidences.

Topic (2):The intrafamily interdependence, which is a relatively new aspect to be studied among the determinants of off-farm labor, is of importance because farm family or household is more relevant decision unit of resource allocation and consumption than its individual members. This dissertation points out some theoretical and econometric problems in the analysis of this theme and suggests a framework which is somewhat different from the already established one in the literature.

Topic (3): Regarding dynamics of off-farm labor supply, this dissertation analyzes the influences of off-farm work experience on exit from agriculture and on off-farm labor supply in the subsequent periods. Knowledge about these dynamic influences of off-farm work experience is important to understand the role played by off-farm labor supply in the mid- or long-term structural changes in the agricultural sector. Extending the models used in previous researches on this theme, this dissertation measures the magnitudes of the influences.

1.3 Theoretical Framework and Data for Empirical Analysis

In many previous studies on off-farm labor supply of agricultural households, the agricultural household model has proved to be a useful framework. This model enables analysis of consumption, production, and time allocation of agricultural households in unified microeconomic framework. This dissertation adopts this agricultural household model as the basis for theoretical discussion about the three topics.

The theoretical discussions of this dissertation are accompanied by the empirical analysis. The empirical analysis is based on two different data sets. The first one, which we refer to as **'VW data'**, is constructed from a survey in Landkreis Emsland (**LEM**) in Niedersachsen and Werra-Meissner-Kreis (**WMK**) in Hessen in 1991. The survey was originally carried out for an interdisciplinary research project [3], which was titled as 'rural regions in the context of agricultural structural change' (Ländliche Regionen im Kontext agrarstrukturellen Wandels).

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[3] This project was financed by the Volkswagen foundation.

The VW data set will be used for the empirical analyze of the topic (1) and (2) mentioned in the section 1.2.

The second data set, which we refer to as **'NRW data'**, is from the agricultural census and the accompanying representative surveys in Nordrhein-Westfalen (**NRW**) in 1979 and 1991. The NRW data set will be used for the empirical analysis of the topic (3) mentioned in the section 1.2.

1.4 Overview

As an ideal approach to treat the three topics mentioned in the section 1.2, one could try to construct one model which integrates all three topics and to carry out theoretical analysis and econometric estimations. In this dissertation another rather pragmatic approach is chosen, namely, to consider each aspect separately due to the following reasons.

First, a model which accommodates the three topics at the same time would readily become so complicated that understanding the theoretical relationship between the different factors at work could be difficult.

Second, a comprehensive model would need a highly complicated econometric model whose estimation could be expensive.

Thirdly, unfortunately, the two data sets (i.e. the VW data and NRW data) which were available for the empirical parts in this dissertation, do not seem to fulfill the requirements for estimation of a unifying model. The VW data is a cross-section data set which is not suitable for the dynamic analysis. The NRW data used for the third topic do not have such detailed information about the households as VW data, although it has the merit of being a panel data set.

Based on the topic-by-topic approach, the dissertation will proceed in the following manner. Chapter 2 describes briefly general economic situation and agricultural structural changes in Landkreis Emsland and Werra-Meißner-Kreis where the VW data originate. Chapter 3 describes briefly general economic situation and agricultural structural changes in Nordrhein-Westfalen where the NRW data originate. Chapter 4 presents the basic structure of the agricultural household model which serves as the theoretical framework in this dissertation. Chapter 5,6, and 7 form the main body of this dissertation, dealing with the three topics mentioned in section 1.2, respectively. In each of these chapters, the basic model will be extended to the problem at issue, and the econometric models will be estimated. Chapter 8 summarizes the conclusions from the theoretical discussions and the results from the empirical analysis of this dissertation.

2 General Economy and Agricultural Structure in Landkreis Emsland and Werra-Meißner-Kreis

2.1 Introduction

In this chapter, general economic situations and agricultural structural changes of Landkreis Emsland and Werra-Meißner-Kreis, where the VW data originate, will be described on the basis of official statistics as well as of results from some researches in the interdisciplinary project ‘rural regions in the context of agricultural structural change’ mentioned in section 1.3. This presentation will serve as prerequisite for understanding the results of empirical analysis in Chapter 5 and Chapter 6.

2.2 Rural Characteristics and Development on Regional Labor Market

As shown in Table 2-1 , both regions are characterized by the low population density and the low level of economic activity (measured by gross value added).

Table 2-1 Rural characteristics of LEM and WMK

Region	LEM	WMK	Rural labor market(1)	Urban labor market(1)
population density (2) (person/km^2)	90	112	139	253
gross value added per capita(3) (DM/person)	22,607	23,269	26,756	32,236
share of agriculture in total employment (4),(5)(%)	7.8	3.8	N.A.	N.A.

Source: Philipp (1994)

Note: (1) A labor market is classified as ‘rural’ if its population density is lower than 234 person/km^2 and ‘urban’ otherwise. See Philipp (1994), p.14 ff.

(2) as of 1990 (3) as of 1988 (4) as of 1990

(4) Defined as the sum of employees in agriculture with obligatory social insurance and the farm family members with more than half of work time in agriculture.

In addition to general, rural characteristics, LEM and WMK, which are located at the border near the Netherlands and East Germany, respectively, have peripheral location in common. Peripheral location is generally thought to be disadvantageous for the development of regional economy. The population densities and the gross value added per capita of LEM and MWK are relatively low even among 123 rural labor markets in West Germany.

There are two noteworthy differences between the two regions. First, LEM is more of rural character than WMK as suggested by the lower population density and by the higher importance of agriculture in employment. Second, LEM had more favorable development in labor market situation in recent decades. According to Schroers (1994), almost all economic sectors had over-average increases in employment in LEM between 1970 and 1987, whereas most sectors had under-average increases in employment in WMK during the same period [4]. Also the movement of the unemployment rates in both regions indicates the favorable development in LEM in recent years.(Table 2-2)

Table 2-2 Unemployment in LEM and WMK

Region	LEM		WMK	
Unemployment	Number of Persons	Rate(%)	Number of Persons	Rate(%)
1984	10,649	16.0	4,178	10.6
1986	9,184	13.6	3,134	8.1
1988	8,782	12.9	3,360	8.8
1990	7,050	7.6	4,180	8.6
1992	7,246	7.3	4,180	9.6

Source: Schulz-Greve (1994)

According to Philipp (1994), who classified the regional labor markets of West Germany in four groups (deteriorating, problematic, catching-up, and prosperous) using factor analysis and cluster analysis based on more than 60 indicators about labor market situation, LEM belongs to catching-up regions whereas WMK to deteriorating regions.[5] Schroers (1995) attributed this advantageous dynamism of LEM to its relatively low industrialization grade in the beginning of 70's, relatively rich land endowment, its more advantageous age structure, and more economy-friendly regional policies and regulations[6].

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[4] See Schroers (1994), p.107 ff.

[5] See Philipp (1994), p.186 ff

[6] See Schroers (1994), p. 195 ff

2.3 Agricultural Structural Changes

General tendency of agricultural structural changes, such as reduction in the farm numbers and in the employment in agriculture as well as increase in farm size, is also observed in the two regions.

Table 2-3 shows that structural changes were more rapid in Werra-Meißner-Kreis than in Emsland. For example, in Emsland the number of farms reduced by 17 % from 1971 to 1979 and by 22 % from 1979 to 1991, whereas Werra-Meißner-Kreis showed 26 % and 39 % reduction during the same periods.

Table 2- 3 Agricultural Structure on Different Regional Levels

Region	year	Farms	Employed in Agriculture (persons)	Average Land Size (ha)
LEM	1971	11,557	19,905	
	1979	9,639	10,800	22.57
	1991	7,577	8,248	26.72
WMK	1971	4,400	6,490	
	1979	3,258	2,480	14.31
	1991	2,013	1,660	22.12
W. Germany	1970	1083.1 (in 1000)	1526 (in 1000 AK)	11.67
	1980	797.4	987	15.27
	1991	598.7	749	19.62

Source: Schulz-Greve(1994), Statistisches Jahrbuch (1992)

The share of the farms with off-farm income shows remarkable differences between the two regions (Table 2-4). In Emsland the share of the farms without off-farm income is slightly over 50 % and is higher than the average of Niedersachsen or West Germany. In Werra-Meißner-Kreis the share of the farms with off-farm income is more than 75 % and is higher than the average of Hessen or West Germany. On the other hand, the distributions of farm types according to off-farm income share did not change substantially in the 80's. It is rather exceptional for Niedersachsen that the share of the farms with off-farm income increased slightly in Emsland. On the other hand, the share of the farms with off-farm income decreased on average in Hessen as well as in WMK.

Another point to be noted is that there was a remarkable increase in farm size of 'full-time farms' (the farms whose main income source is agriculture) in WMK (Table 2-5). Although the average farm land size of these farms was about the same in both regions in 1979, there was an increase of about 60% in WMK from 1979 to 1991 while there was an increase of only about

20 % in LEM during the same period. In 1991 the average farm size in WMK was almost 55 ha, whereas it was under 40 ha in LEM.

Table 2-4 Distribution of Farms by share of off-farm income in total income

Region	year	Total	Share of Off-Farm Income in Total Income		
			0%	above 0 and below 50 %	above 50%
LEM	1971	11,446	.	.	4,052
	1979	9,639	5,208	395	4,036
	1991	7,577	3,898	437	3,242
Niedersachsen	1971	162,511	59,143	32,892	63,476
	1979	129,432	57,889	16,059	55,484
	1991	94,694	46,549	5,638	42,507
WMK	1971	.	.	.	.
	1979	3,258	716	196	2,346
	1991	2,013	467	53	1,493
Hessen	1971	88,090	19,791	16,195	52,104
	1979	66,798	19,143	5,543	42,112
	1991	45,634	12,533	1,524	31,577
W. Germany (in 1,000)	1971	1,049.3	337.4	238.5	473.5
	1979	845.5	319.3	100.8	425.3
	1987	718.4	256.3	73.2	388.9

Source:Schulz-Greve (1994).p21

Table 2-5 Average Farm Land Size by Main Income Source (ha/Farm)

region	year	Main Income Source		
		Total	Farm	Off-farm
LEM	1979	22.57	31.40	7.58
	1991	26.72	38.57	9.80
WMK	1979	14.31	34.42	6.45
	1991	22.12	54.80	10.74

Source: Schulz-Greve (1994)

3 General Economy and Agricultural Structure in Nordrhein-Westfalen

3.1 Introduction

As mentioned in Chapter 1, the empirical analyze on the role of part-time farming in a dynamic context (Chapter 7) will be based on the data set from Nordrhein-Westfalen (**NRW**). In this chapter, general economic situations and agricultural structural changes of Nordrhein-Westfalen will be briefly described on the basis of official statistics. This presentation will serve as prerequisite for understanding the results of empirical analysis in Chapter 7.

3.2 Characteristics of General Economy in Nordrhein-Westfalen

With 17 million population, NRW is the largest state (‘Land’) in Germany in terms of population and gross regional product, claiming a quarter of West German population and GDP.

Table 3-1 Distribution of Gross Value Added and Employed

Gross Value Added by Economics Sectors. (1985 price in billion DM. % in parentheses)

	Agriculture	Industry	Commerce	Other Service	Total
W. Germany ’80	29.3 (1.76)	735.0 (44.18)	247.1 (14.85)	652.1 (39.20)	1663.5 (100)
W. Germany ’91	34.2 (1.60)	841.5 (39.42)	329.3 (15.42)	929.9 (43.56)	2134.9 (100)
NRW ’80	4.7 (1.19)	211.6 (53.73)	67.2 (17.06)	110.4 (28.02)	393.9 (100)
NRW ’91	5.3 (1.14)	220.9 (47.39)	85.0 (18.23)	155.0 (33.25)	466.2 (100)

Employed in 1,000 persons. % in parentheses

W. Germany ’79	1,410(5.29)	11,476(43.06)	5,016(18.82)	8,750(32.8)	26,652(100)
W. Germany ’91	927(3.21)	11,081(38.36)	5,628(19.48)	11,250(38.9)	28,886(100)
NRW ’79	171.8(2.52)	3,289.5(48.20)	1,261.8(18.49)	2,101.7(30.8)	6,824.8(100)
NRW ’91	144.3(1.93)	3,182.2(42.53)	1,350.2(18.04)	2,805.8(37.5)	7,482.5(100)

Source: Satistisches Jahrbuch 1992, Statistisches Jahrbuch NRW 1980, 1992

As it can be seen in Table 3-1, the economy of NRW is characterized by the dominance of industrial sector in terms of both production value and employment. The shares of industry sector lie considerably higher than the national average. Although it was in the

Table 3-2 Unemployment Rate of Germany and NRW

in %

	1980	1982	1984	1986	1988	1991
W. Germany	3.8	7.5	9.1	9.0	8.7	6.3
NRW	4.6	8.6	10.6	10.9	11.0	7.9

Source: Statistisches Jahrbuch 1992

sector that the major growth took place in NRW as well as in the whole West Germany during the pertinent period, the traditional industry sector including chemistry and machine construction still claimed more than 40% of production and employment in NRW in 1991. It can be considered to be one of the reasons why the unemployment problem, which has struck the whole German economy since the early 80's, has been more severe in NRW.(Table 3-2) .

3.3 Agricultural Structural Change in Nordrhein-Westfalen

The share of agriculture in NRW economy in terms of production and employment was low even in comparison to the German average. However, the process of agricultural structural change, which is most strongly reflected by 34 % reduction in the number of the employed in the agriculture (Table 3-1) in the whole west Germany from 1979 to 1991 , took place in NRW as wel even against the unfavorable labor market situation. The numbers of farms and the farm family members engaged in agricultural production decreased by about 20% in NRW during the same period. (Table 3-3) In the process of structural change, the share of the so-called part-time farms increased in NRW as well as in Germany (Table 3-4). The official statistics as presented in Table 3-4 have the problem of being based on the income composition and work time of the operator couples only and not on family or household, which is considered to be more appropriate unit for economic analysis. However, it can be inferred even from such statistics that the importance of off-farm work and off-farm income have increased.

Table 3-3 Farm numbers and agricultural workforce

	W.Germany '79	W. Germany '91	NRW '79	NRW '91
Farms over 1ha (in 1,000)	815.2	598.7	102.2	77.8
Average LF(ha)	15.07	19.62	16.32	20.27
Family Member	1940	1600.0	217.7	172.2
full-time	540	351.3	85.2	60.5
part-time	1100	986.0	149.3	111.7
Non-family	310	189.5	N.A.	N.A.
regular	97	82.6	16.8	15.2
temporary	213	96.9	N.A.	N.A.
AK (1,000)	1081	705.9	N.A.	N.A.

Note: Family and non-family members in 1,000 persons
Source: Statistisches Jahrbuch über Landwirtschaft 1992 , Agrarberichtserstattung Nordrhein-Westfalen 1979, 1991

Table 3-4 Farms by socio-economic type

	W.Germany '91	W.Germany '91	NRW '79	NRW '91
Farms over 1ha	815.2 (100)	598.7 (100)	102.2 (100)	77.8 (100)
Full-time farm (1)	401.6 (49.3)	293.0 (48.9)	44.7 (43.7)	39.8 (51.2)
Part-time type I (1)	95.1 (11.7)	51.7 (8.6)	12.0 (11.7)	
Part-time type II (1)	318.5(39.0)	254.0 (42.4)	45.2 (44.2)	37.7 (48.5)
Farms with off-farm work (2)	N.A.	N.A.	40.1 (39.2)	32.4 (41.6)

Source: Statistisches Jahrbuch über Landwirtschaft 1992 , Agrarberichtserstattung Nordrhein-Westfalen 1979, 1991

Note: (1) Definitions of the farm types for Germany and NRW are somewhat different from each other. [7,8]
(2) Farms in which at least one person of operator couple has off-farm work

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[7] For Germany, the definition of Agrarbericht is used, according to which:
full-time farm is a farm in which labor input of operator couple is at least 0.5 AK and the off-farm earned income of the couple is less than 10 % of the total earned income,
type I part-time farm is a farm in which labor input of operator couple is at least 0.5 AK and the off-farm earned income of the couple is more than 10 % and less than 50 % of the total earned income,
type II part-time farm is as defined as the rest of the farms.

[8] For NRW, the classification in the Agrarberichtausstattung NRW is used, according to which :
full-time farm is a farm with operator couple that has no non-farm income,
type I part-time farm is a farm with non-farm income in which the farm income of the operator couple is greater than their off-farm income.
type II part-time farm is a farm with non-farm income in which the off-farm income of the operator couple is greater than their farm income.

4 The Basic Structure of the Agricultural Household Model

4.1 Introduction

As mentioned in Chapter 1, the agricultural household model provides a unifying microeconomic framework for understanding the decisions of the agricultural households on consumption, production, and time allocation. In this chapter, the basic structure of the model, which serves as a reference point for theoretical discussions in the following chapters, will be presented. As this dissertation concentrates on the theme of time allocation, the presentation will be mainly on this theme.

The essence of the agricultural household model can be found in the insight that the agricultural household, which is the dominant economic subject that organizes the agricultural production, is a complex of the farm firm, the supplier of agricultural production factors (including labor) and the consumer[9]. The agricultural household distinguishes itself from a profit maximizing manager in that it supplies significant proportion of the labor input and, in some cases, other inputs for the agricultural production. Moreover, the economic decisions of the agricultural household are determined by the utility maximization principle, whereby not only the monetary surplus from the sales of the agricultural products but also the inputs or the outputs of the agricultural production have utility connotations. The prototype of the agricultural household model can be found in a work by Chayanov (1986), a Russian agricultural economist from early twentieth century. He developed a prototype model within the cardinal marginal utility and disutility (drudgery) framework to explain the volume and the composition of income of Russian peasant households.

The neo-classical version of the Chayanovian model was developed to help to understand how the decisions of agricultural households in developing countries regarding production, labor, and consumption are made. In the new version of the agricultural household model, the cardinal utility concept is reposed by the ordinal utility function. Barnum and Squire (1979) is a standard example of early applications. Nakajima (1986) shows the theoretical versatility of

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[9] This formulation is similar to the definition of ‘the farm household’ in Nakajima (1986) p.xi. but captures the fact that the agricultural household can supply not only labor but also other production factors.

the model mainly to address various the situations of subsistence or partially commercialized agriculture. Singh, Squire, and Strauss (1986) show the refinements of the model in a duality framework and various possibilities of the model modification. In addition, their book contains various achievements of empirical applications for the developing countries. By applying this model to the developing countries, much attention is paid to the fact that considerable portion of inputs and outputs are directly supplied and consumed by agricultural household and that markets for some of them might be absent or underdeveloped.

As the usefulness of the framework, of course with appropriate modification, for the analysis of the economic decisions of agricultural households in the developed countries was recognized in some articles in the early 1980's, [10] the framework was soon applied in many researches. The majority of applications for the developed countries concentrate on the allocation of time among home time, farm work, and off-farm work. This is due to the fact that the problems of 'self supply and self-consumption' and 'absent market' are relevant almost only for the time resource of the agricultural household members in the developed countries. These problems are not considered to be important in the developed countries because of the highly commercialized and specialized character of agricultural production and the low share of agricultural products in the total expenditure. The time resource of the agricultural household members is an important exception. Non-working home time is an important 'factor' for the 'production' of utility[11]. Farm work time of the household members, which is the main labor input for the agricultural production, is an input which is very difficult to 'buy' from a market because hired labor is only an imperfect substitute for family labor due to differences in education, training level, and in supervisory requirements.[12] On the other hand, the economic development in the non-agricultural sectors make off-farm income opportunities available in rural areas. It means that a market where the agricultural households can 'sell' their time exists. The allocation of time among the three competing alternatives - home time, farm work and off-farm work - is closely related with agricultural product supply and factor demand, agricultural structure, and welfare and income situation of agricultural households. The agricultural household model, which combines the agricultural production and the utility

[10] For example, Huffman (1980) and Sumner (1982)

[11] Becker (1965)

[12] For a theoretical discussion on the second kind of difference between family labor and hired for agricultural production on the base of a transaction cost approach , see Pollak (1985). For empirical evidence from Germany, see Schmitt, Schulz-Greve, and Lee (1996)

maximization, proves to be a useful framework for the analysis of the time allocation in agricultural households.

In the following sections, the basic elements of the agricultural household model will be presented in a simplistic version and the directions of the possible modifications, which are relevant for this dissertation, will be briefly mentioned. As the core of the researches in this dissertation is the off-farm labor supply decision in Germany - a developed country - the model presentation and the discussion will be concentrated on the time allocation aspect.

In the following discussion, ‘part-time farmers’ and ‘full-time farmers’ are defined as following: an agricultural household will be referred to as a ‘part-time farm’ if it has positive farm work time and be referred to as a ‘full-time farm’ if it has no off-farm work time. Although this definition is different from that of official statistics, it is more convenient for the theoretical discussion.

4.2 Elements of the Agricultural Household Model [13]

4.2.1 Basic Structure of the Agricultural Household Model

The agricultural household is assumed to have the optimization problem:

$$\max_{T_h, C, T_f, T_m} U(T_h, C; Z_h) \tag{4-1}$$

subject to:

$$T = T_f + T_h + T_m \tag{4-2}$$

$$C = g(T_f; p, Z_f) + w_m(H_m, Z_m)\, T_m + V \tag{4-3}$$

$$T_m \geq 0, \tag{4-4}$$

where T_h = home time

C = consumption of goods other than home time

Z_h = household characters that affect the preference

T = time endowment

T_f = own farm work time

T_m = off-farm work time

g = farm income function

[13] The discussion in this section is based on Nakajima (1986), Strauss (1986), Kimhi (1989) and Huffman (1991).

p = vector of prices of agricultural outputs and inputs except the farm work labor of the household
Z_f = fixed farm input
w_m = wage rate for off-farm work
H_m = human capital which influences wage level
Z_m = other variables which influence wage level
V = non-labor income

The utility of the household (U) is determined by home time (T_h) and consumption of the goods (C). The utility function is assumed to be quasi-concave in these variables and twice differentiable. For the purpose of this study, which concentrates mainly on the effects of family structure, human capital, and farm income potential on labor decisions, 'other goods' can be considered as one good [14] , whose price is set to one . The preference structure is affected by exogenous (Z_h) and the demographic structure of household is considered to be the most important among these household characteristics. The household faces two restrictions. The first one is the time restriction (4-2): there is a fixed amount of time which is allocated among home time (T_h), own farm work (T_f), and off-farm work (T_h). The other one is the income restriction (4-3): the level of consumption is set by the sum of farm income (g), off-farm income (w_m T_m), and exogenous non-labor income (V). Farm income (g) is the restricted profit function which is defined as the indirect objective function of the maximization problem:

$$\underset{z}{\mathrm{Max}}: \; p' z \tag{4-5}$$

subject to:

$$(z, T_f ; Z_f) \in S \tag{4-6},$$

where z = the vector of the agricultural outputs and inputs except the farm work labor of the household [15]
S is a production possibilities set.

[14] This simplification a theoretical justification due to the composite commodity theorem. See Deaton and Muellbauer (1980) p.120 ff

[15] The elements of this vector take either positive or negative value according to whether the good in question is net output or net input.

In simple words, $g(T_f; p, Z_f)$ is the maximum agricultural income which can be obtained by optimal choice of output and input mix when the farm work time of the household and the prices are set to T_f and p. The farm technological condition is influenced by the fixed inputs (Z_f), which include not only the physical capital but also farm-specific human capital in addition to the natural and locational conditions. The function g is assumed to be strictly concave in T_f. This assumption means that the profit maximization would be possible if labor input is variable.

The model assumes heterogeneity between the farm labor supplied by the agricultural household (T_f) and the hired labor. This means that these two kinds of labor enter the netput vector as two different elements and that off-farm work time (T_m), which is the difference between total work time ($T_f + T_m$) and farm work time (T_f), has a non-negativity restriction (4-4).[16] This heterogeneity assumption is, as mentioned in the beginning of this chapter, due to difference in education, training level, and in supervisory requirements.

Under the assumption of the differentiable utility function, the optimality condition can be expressed with the help of the Lagrangian function:

$$L \equiv U(T_h, C; Z_h) + \tau(T - T_h - T_f - T_m) + \lambda(g(T_f; p, H_f, Z_f) + w_m T_m + V - C) + \theta T_m \tag{4-7}$$

Applying Kuhn-Tucker conditions , we get:

$$\frac{\partial L}{\partial T_h} = U_1 - \tau = 0 \tag{4-8}$$

$$\frac{\partial L}{\partial C} = U_2 - \lambda = 0 \tag{4-9}$$

$$\frac{\partial L}{\partial T_f} = -\tau + \lambda g_1 = 0 \tag{4-10}$$

[16] Singh, Squire, and Strauss (1986) discuss another direction for modeling the difference between the family labor and the hired labor. It is the case when there is a price 'wedge' between the 'sold' labor and 'bought' labor but no quality difference between the hired and family labor. See Singh, Squire and Strauss (1986) p.53ff. For agriculture in the developed countries, where considerable differences in qualification and skill between the two kinds of labor can be observed (See Schmitt, Schulz-Greve and Lee (1996)), the assumption of no quality difference is not appropriate.

$$\frac{\partial L}{\partial T_m} = -\tau + \lambda w_m + \theta = 0 \qquad (4\text{-}11)$$

$$\frac{\partial L}{\partial \theta} = T_m \geq 0,\ \theta \geq 0,\ \frac{\partial L}{\partial \theta} \bullet \theta = 0 \qquad (4\text{-}12)$$

in addition to (4-2) and (4-3),

where U_j and g_j are partial derivatives of U and g with respect to the j-th argument of them.

4.2.2 Economic Decisions in case of positive Off-farm Work

If off-farm work (T_m) is positive at optimum, θ equals zero due to (4-12). It leads to the simplified optimality conditions:

$$g_1\ (T_f) = w_m \qquad (4\text{-}13\text{-}a)$$

$$\frac{U_1(T_h, C)}{U_2(T_h, C)} = w_m \qquad (4\text{-}13\text{-}b)$$

$$C + w_m T_h = w_m T + [g(T_f) - w_m T_f] + V \qquad (4\text{-}13\text{-}c)$$

Note that (4-13-c) is obtained by substituting the time restriction (4-2) into the income restriction (4-3), resulting in the elimination of T_m. The left-hand side of (4-13-c) is the expenditure of the household, which is the sum of the expenditure on consumption (C) and the product of off-farm wage and home time. The right-hand side of (4-13-c) is the '**full income**'[17] which consists of the value of time endowment evaluated with the market wage rate ($w_m T$), farm profit ($g(T_f) - w_m T_f$), and non-labor income (V)[18]. Note that farm profit is defined as the difference between the restricted profit (g) and the value of farm work time of family ($w_m T_f$) that is evaluated using the off-farm wage rate w_m as the price of time. Therefore, the equation (4-13-c) is called 'full income restriction'. It has the same structure as the income restriction in consumer theory. However, unlike in the normal consumption analysis in which the income is fixed, the full income of the agricultural household is a function of farm work time.

[17] This concept was introduced by Becker (1965).

[18] Singh, Squire and Strauss (1986) p.18

Determination of farm work time: The equation (4-13-a) is the familiar optimality condition of profit maximizing. Thus the optimal farm work is the solution of the profit maximization problem:

$$\max_{T_f} \quad \pi \equiv g\,(\,T_f\,;\,p,\,Z_f\,) - w_m\,T_f \tag{4-14}$$

Because T and V are given, maximizing (4-14) is equivalent to maximizing the full income in (4-13-c). As no 'consumption relevant' variables, such as $T_{h,}$ C, T , V, or Z_h, appear in the problem (4-14), the optimal level of T_f is determined solely by 'production-relevant' variables, i.e. p, Z_f, and w_m. Therefore, we can write:

$$T_f{}^* = T_f{}^*\,(w_{m,}\,p,\;Z_f\,) \tag{4-15}$$

Farm work time T_f can be expressed also as a derivative of the profit function which is defined as the indirect objective function of the maximization problem in (4-14) :

$$\pi^*\,(w_{m,}\;p,\;Z_f\,) \equiv g\,(\,T_f{}^*\,;\,p,\,Z_f\,) - w_m\,T_f{}^* \tag{4-16}$$

Using this definition and Hotelling's lemma[19] , the following equation is obtained:

$$T_f{}^* = -\,\pi^*_w\;(w,\,p,\,Z_f\,) \tag{4-17}$$

The optimal levels of other inputs and outputs can be obtained as the first derivatives either of the profit function π^* with respect to the corresponding prices or of the restricted profit function $g(T_f;\,p,\,Z_f\,)$, evaluated with T_f set to the optimal level $T_f{}^*$. Therefore, the optimal farm production output and input variables, including farm work of the household, are determined by production relevant variables only.

Determination of home time and consumption: Substituting (4-16) into the right-hand side of (4-13-c), we get

---

[19] Varian (1978)

$$C + w_m T_h = w_m T + \pi^*(w_{m,} p, Z_f) + V \tag{4-18}$$

The conditions (4-18) and (4-13-b) constitute the optimality condition on the consumption side. The right-hand side of (4-18) is the maximized full income and is expressed as a function of only the exogenous variables. The condition (4-13-b) means that the marginal rate of substitution between home time and consumption is equalized to the price ratio of the two goods. The conditions (4-18) and (4-13-b) are, therefore, in the same form of optimality condition of a utility-maximizing consumer, who allocates his given amount of money to the different goods. Accordingly, the demand for C and T_h can be expressed in forms of Marshallian demand functions:

$$X = X^M (1,w_m , FI), \tag{4-19}$$

where $X = C$ or T_h

$$\text{and } FI \equiv w_m T + \pi^*(w_{m,} p, Z_f) + V \tag{4-20}$$

In (4-19), the first two arguments in X^M play the role of prices and the third one the role of income. It is clear from this expression that not only V and T but also ‘production- relevant’ variables, such as p or Z_f , have influence on C and T_h. The variables p and Z_f exercise, however, their influences only through the profit function π^*, which is a component of the full income. Their effects can be expressed as:

$$\frac{\partial X}{\partial k} = \frac{\partial X^M}{\partial FI}\pi_k , \tag{4-21}$$

where $X = C$ or T_h,

$k =$ p or Z_f

On the other hand, the wage rate (w_m) is both a price variable and a variable which influences the full income. Therefore, w_m affects C and T_h in two different ways. One of the effects of the wage rate is the Marshallian price effect. The other effect comes through the change in the full income, which, in turn, consists of the changes in π^* and in the imputed value of the time endowment ($w_m T$) . Using the property of a Marshallian demand, we can get a more useful expression of these effects [20] .

$$\frac{\partial X}{\partial w_m} = \frac{\partial X^M}{\partial w_m}\Big|_{d(FI)=0} + \frac{\partial X^M}{\partial FI}(T + \pi_{w_m})$$

$$= \frac{\partial X^C}{\partial w_m} - \frac{\partial X^M}{\partial FI} T_h + \frac{\partial X^M}{\partial FI}(T - T_f) \qquad \text{(<-- Slutzky decomposition and (4-17))}$$

$$= \frac{\partial X^C}{\partial w_m} + \frac{\partial X^M}{\partial FI} T_m , \qquad (4\text{-}22)$$

where X^C denotes Hicksian compensated demand function.

The effect of off-farm wage on home time (T_h)and consumption (C) can be decomposed into two parts; a substitution effect and an income effect. The first effect is exactly the same substitution effect from the consumer behavior analysis and the second effect is income effect of full income weighted by the amount of off-farm work.

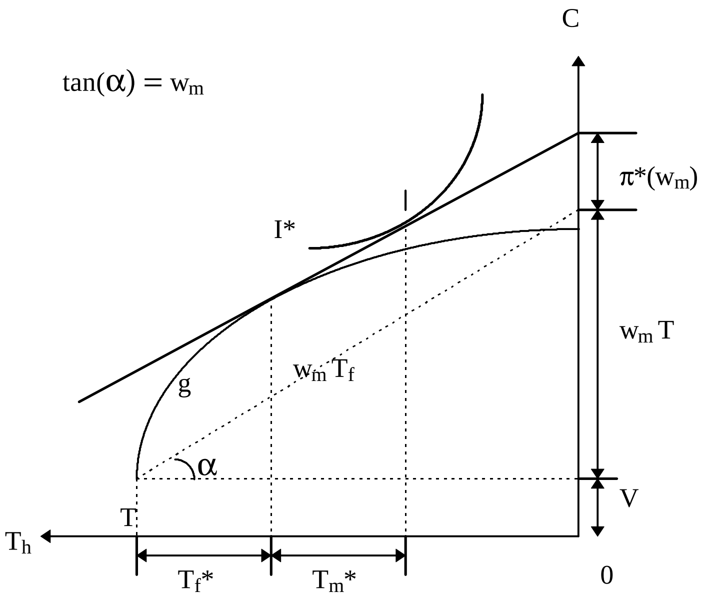
Determination of Off-farm work : From the time restriction (4-2), the optimal off-farm work time is determined as the residual:

$$T_m^* = T - T_h^* - T_f^* = T - T_h^{\,M}(1, w, wT + \pi^*(w, p, Z_f)) + \pi^*_w(w, p, Z_f) \qquad (4\text{-}23)$$

The above discussion can be summarized with Figure 4-1. The economic decision of the agricultural household can be conceptually divided into two stages. In the first stage, the farm work (T_f)is determined so that the economic profit from farm production (the vertical distance between the curve g and the line of imputed wage cost of farm family work ($w_m\ T_f$)) is maximized and therefore, the full income ($V+w_m T + \pi$) is also maximized.

[20] Strauss (1986) p.76

Figure 4-1 Time allocation of the agricultural household with off-farm work



In the second stage, this maximized full income is allocated between home time (T_h) and consumption (C) so that the marginal rate of substitution between the two goods is equal to the price ratio.

4.2.3 Economic Decisions in Case of No Off-farm Work

The discussion in 4.2.2 assumed that off-farm work is positive at the optimum. If off-farm work is zero at the optimum, then the optimum conditions have different structures because, unlike in case of positive T_f , θ in (4-12) cannot be assumed to be zero. In this case the optimality condition can be expressed as:

$$g_1(T_f) = w_0 \qquad \text{(4-24-a)}$$

$$\frac{U_1(T_h, C)}{U_2(T_h, C)} = w_0 \qquad \text{(4-24-b)}$$

$$C + w_0 L = w_0 T + [g(T_f) - w_0 T_f] + V. \qquad \text{(4-24-c)}$$ [21]

$$T = T_h + T_f, \qquad \text{(4-24-d)}$$

where w_0 is defined as $\frac{\tau}{\lambda}$.

[21] Note that it is equivalent to $C = g(T_f) + V$ due to (4-20-d). However, (4-20-c) is more useful.

As it can be clearly seen from the application of envelop theorem[22] to the Lagrangian function (4-7), τ is the marginal utility of time endowment and λ is the marginal utility of non-labor income. Therefore, w_0 is the **shadow price of time endowment** expressed in terms of consumption.

Although the systems (4-13) and (4-24) appear to be similar, the latter differs in some important aspects. First, the shadow price of time endowment w_0 is not exogenously given. Second, unlike in the system (4-13), there is no equation or subsystem in (4-24) which can determine an endogenous variable independently of the other equations. Therefore, the shadow price of time is a function of all exogenous variables except w_m ;i.e.

$$w_0 = w_0 (T, V, Z_h, p, Zf) \qquad (4\text{-}25)$$

However, once the shadow price of time is determined, the behavior of the agricultural household can be understood by the same principle as in the previous subsection 4.2.2.

Determination of farm work: On the production side, the marginal farm income is equal to the shadow price of home time (w_0):

$$g_1 (T_f, p, Z_f) = w_0 \qquad (4\text{-}26)$$

As w_0 is , unlike in case of positive off-farm work, not exogenously given but determined as a function of all exogenous variables of the model, the optimal farm work time is a function of 'household-relevant' variables, such as T, V, and Z_h, as well as of 'production- relevant' variables, such as p, H_f, and Z_f . Thus, we can write:

$$\begin{aligned} T_f^* &= T_f^* (w_0(T, V, Z_h, p, Z_f), p, Z_f) \\ &= T_{f0} (T, V, Z_h, p, Z_f) \qquad (4\text{-}27) \end{aligned}$$

Substituting (4-27) into the definition of farm profit ($g(T_f) - w_0 T_f$) , yields the maximum profit $\pi^* (w_0, p, Z_f)$, where the imputed cost of farm work is given by w_0. Given this definition,

[22] See Varian (1978) p. 276 ff.

$$Tf = - \pi^*_w (w_0, p, Zf) \tag{4-28}$$

Determination of home time and consumption: Substituting the definition of profit function into (4-24-c), we get:

$$\begin{aligned} C + w_0 T_h &= w_0 T + [g(T_{fo}) - w_0 T_{fo}] + V \\ &= w_0 T + \pi^* (w_0) + V \end{aligned} \tag{4-29}$$

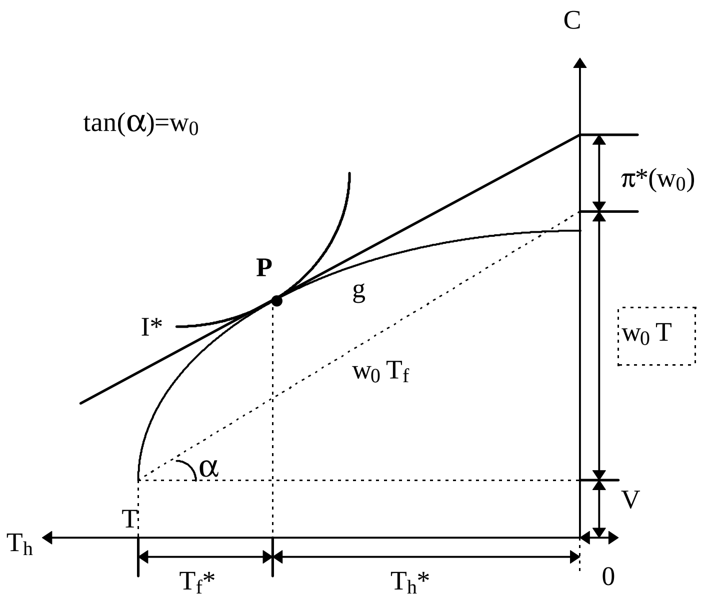
The equations (4-24-b) and (4-29) form the optimality conditions on the consumption side. Therefore, the demand for C and T_h can be expressed as Marshallian demand curve in the same manner as in (4-19).

$$X = X^M (1, w_0, w_0 T + \pi^*(w_0) + V) \text{, where } X = C \text{ or } T_h. \tag{4-30}$$

However, due to the fact that w_0 is a function of all exogenous variables except w_m , every exogenous variable has a two-fold influence on X. The first influence is via the price effect and the second via the income effect.

Figure 4-2 helps to clarify the meaning of the above discussion.

Figure 4-2 Time Allocation of Agricultural Household without Off-farm Work



The maximum utility is obtained at **P**, where the curve of the agricultural income function (g) has the same slope as the indifference curve I* .The shadow price of time is the common slope of two curves at **P**. Once this shadow price is determined, the economic decisions of agricultural household can be described as if they were solutions of, first, theprofit maximizing problem and subsequently, the utility maximizing problem. In both maximizing problems, the endogenously determined shadow price of time (w_0), which is the economic price of farm work in the first problem and the economic price of home time and one of the determinant of full income in the second problem, plays the same role as w_m in Figure 4-1.

4.2.4 Recursivity and Non-recursivity

From the discussions in 4.2.2 and 4.2.3, it is clear that reactions of economic choices of agricultural household to changes in exogenous variables are different, depending on whether the agricultural household has positive off-farm work or not. In case of positive off-farm work, the decision on the agricultural production side, including farm work time, is made independently of the consumption side. The consumption side is affected by the exogenous variables in the production side via changes in full income. This structure is termed 'recursivity' in the literature.

In case of no off-farm work, the recursivity does not hold. Decisions regarding one side cannot be made independently of the other. The optimal choices on the production side as well as on the consumption side are, therefore, functions of all exogenous variables except off-farm wage rate.

The reason why recursivity holds only for the case of positive off-farm work lies in the different mechanisms of determining the economic price of time. In case of positive off-farm work, the off-farm wage rate plays the role of economic price of time whereas in case of no off-farm work, the economic price of time is endogenously determined.

4.2.5 Shadow Price of Time and Participation Decision

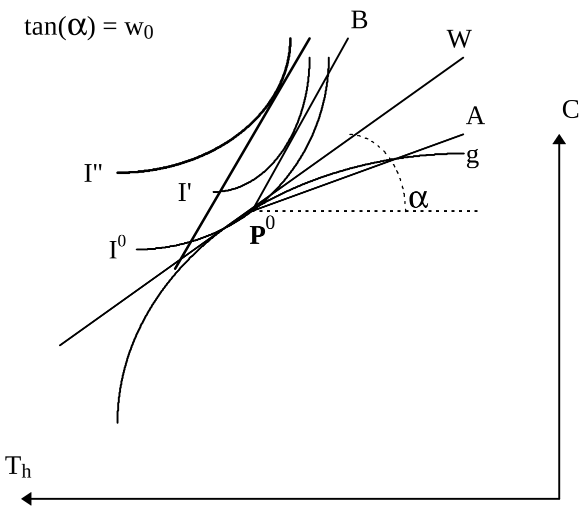
Having seen the differences between the economic behaviors of 'full-time farmers' and 'part-time farmers', one may ask how the decision on the participation in off-farm work is made.

The conditions (4-11) and (4-12) clarify what determines the off-farm work participation decision of agricultural household. If there is no off-farm labor supply(T_m = 0) at optimum, then the expression (4-11) implies

$$w_m \leq w_0 \qquad (4\text{-}31).$$

as θ in (4-12) has non-negativity restriction. The inequality (4-31) means that if the optimal value of T_m is zero, the off-farm wage rate (w_m) does not exceed the shadow price (w_0) of home time, which is determined under the condition of zero off-farm work. By contraposition, if w_m exceeds w_0 , the optimal off-farm work time (T_m) cannot be zero and, therefore, must be positive. Therefore, whether there is positive off-farm labor supply or not (**participation decision**) depends on whether w_m exceeds w_0 . This dependence of participation decision on the inequality (4-31) is depicted in Figure 4-3.

Figure 4-3 Comparison of off-farm wage (w_m) and the shadow price (w_0)



As in Figure 4-2, w_0 is the common slope of agricultural income function (g) and indifference curve I^0 at their tangential point $\mathbf{P^0}$. The curve I^0 corresponds to the maximum utility, attainable under the restriction of zero off-farm work. If the slope of wage line, for example line A, is smaller than w_0 , which is the slope of line W, then there is no possibility of utility improvement through off-farm work. On the other hand, if the slope of wage line, for example line B, does exceed w_0, then the utility level can be enhanced. Even without an adjustment of farm work time, the improvement of utility level I^0 to I' is possible. With such adjustment, the utility level can be raised as high as that represented by the indifference curve I ".

The above discussion can be summarized with:

$$T_m > 0 \quad \text{if} \quad i^*(H_m, Z_m , H_f, p, Z_f, Z_h, T, V) \equiv w_m (H_m, Z_m) - w_0 (H_f, p, Z_f, Z_h, T, V) > 0$$
$$T_m = 0 \quad \text{if} \quad i^*(H_m, Z_m , H_f, p, Z_f, Z_h, T, V) \equiv w_m (H_m, Z_m) - w_0 (H_f, p, Z_f, Z_h, T, V) \leq 0 \tag{4-32}$$

The function i* is usually called '**participation function**' in the literature. Estimation of this function is one of the main objectives of many empirical researches on off-farm work of agricultural households. As it can be seen from (4-32), when variables which raise w_m or lower w_0 are increased, then i* is also increased. Therefore, human capital variables (H_m), such as education and experience, and other variables (Z_m) which characterize labor market situation are expected to influence the participation decision in the same direction as they influence the wage rate. This statement forms the base for a set of hypotheses which can be tested by the estimation of participation function.

On the other hand, the influence of the variables H_f, p, Z_f, Z_h, T, and V on participation decision is always the opposite of the influence of these variables on w_0 . As it is already shown, w_0 is determined from the solution of the system (4-24). One could apply the technique of comparative statics analysis to this system (4-24). However, there is more useful way to see how w_0 is determined and how comparative statics analysis can be carried out. Given that off-farm work (T_m) is zero, the following relation T = $T_h + T_f$ holds trivially. Substituting (4-28) and (4-30) into this expression, we get:

$$T = T_h^{\ M} (1,w_0, w_0T + \pi^*(w_0, p, Z_f) + V) - \pi^*_w (w_0, p, Z_f) \tag{4-33}$$

Comparative statics analysis on the shadow price can be performed based on this equation.[23] Applying implicit function theorem,

$$\frac{\partial w_0}{\partial k} = \frac{-\pi^*_{wk} + \dfrac{\partial (T_h^{\ M} - T)}{\partial k}}{\pi^*_{ww} - \dfrac{\partial T_h^{\ M}}{\partial w}}$$

[23] The following discussion is similar to Strauss (1986) p76.ff and leads to the same conclusion. However, based on mainly on the optimality condition for utility maximization and not on expenditure minimization problem as in Strauss, the properties of Marshallian demand and profit function are more readily utilized.

$$= \frac{-\pi^*_{wk}}{\pi^*_{ww} - e_{ww}} + \frac{\frac{\partial (T_h{}^M - T)}{\partial k}}{\pi^*_{ww} - e_{ww}} \qquad (4\text{-}34)$$

where $k = V, p, Z_f, T, Z_h$

The second line of (4-34) is obtained by noting that, when off-farm work is zero, the following equation holds:

$$\frac{\partial T_h{}^M}{\partial w} = \frac{\partial T_h{}^c}{\partial w} = e_{ww}(1, w, U^*), \qquad (4\text{-}35)$$

because (4-22) always holds. The expenditure function e is the indirect objective function of minimization problem:

$$\underset{C,L}{\text{Min}}\; C + wL \qquad (4\text{-}36)$$

subject to $U^* = U(c, L)$,

where U^* is the utility level attained by the solution to the system (4-24).

First, the effects of V, p and Z_f will be analyzed because they can be expressed using only the income effect of Marshallian demand function and the derivatives of expenditure function and profit function. For the variables V, p,and Z_f, we can write:

$$\frac{\partial w_0}{\partial k} = \frac{-\pi^*_{wk}}{\pi^*_{ww} - e_{ww}} + \frac{\frac{\partial T_h{}^M}{\partial k}}{\pi^*_{ww} - e_{ww}}$$

$$\equiv E_s + E_i \qquad (4\text{-}37)$$

Both E_s and E_i can be interpreted in economic terms. The term E_s is the change in the shadow price that would result if the utility level were kept at U^* by adjusting the non-labor income V because the following holds at the optimum,

$$e_w(1, w, U^*) = T + \pi_w(w, p, Z_f) \qquad (4\text{-}38)$$

as Strauss (1986) pointed out.[24] It is easily seen that E_s is obtained by applying the implicit function theorem to the equation (4-38). On the other hand,

$$E_i = \frac{\frac{\partial T_h{}^M}{\partial(FI)}}{\pi^*_{ww} - e_{ww}} \frac{\partial(FI)}{\partial k} \qquad (4\text{-}39)$$

can be considered to be the effect of full income change on the shadow price weighted by the effect of k on the full income.

The denominators of the terms in the first line of (4-34) is positive due to the convexity of profit function and the concavity of compensated demand. Thus, E_i and E_s have the same signs as the two terms in the numerator on the right hand side of (4-34), i.e. $-\pi^*_{wk}$ and $\frac{\partial T_h{}^M}{\partial(FI)} \frac{\partial(FI)}{\partial k}$, respectively. In the following discussion, therefore, we will concentrate on these two terms. We assume that both home time and consumption are normal goods.

The effects of non-labor income (V): As the numerator is $0 + \frac{\partial T_h{}^M}{\partial FI}$, $\frac{\partial w_0}{\partial V}$ is positive.

The effects of price of agricultural output and input (p): The numerator is $-\pi^*_{wp} + \frac{\partial T_h{}^M}{\partial FI}\pi^*_p$. From the property of profit function[25], $-\pi^*_{wp}$ is the effect of p on labor demand and π^*_p is the output or the input quantity corresponding to p. In case of output, π^*_p is positive because netput is positive, and if labor is a normal input, $-\pi^*_{wp}$ is also positive. In case of input, π^*_p is negative because netput is negative and, if labor is a gross complement of the concerning input, $-\pi^*_{wp}$ is also negative.In general, under the assumptions on labor as mentioned above, an

[24] Strauss (1986) p.78

[25] Chambers (1988) p.271

increase in an output price raises the shadow price of time, whereas an increase in an input price lowers the shadow price of time.

The effects of profit function shifter Z_f : The numerator is $-\pi^*_{w\,Zf} + \frac{\partial T_h^{\,M}}{\partial FI}\pi^*_{Zf}$. If Z_f can be considered to be a fixed input, π^*_{Zf} is trivially positive. In order to clear the meaning of $\pi^*_{w\,Zf}$, it helps to regard π^* (p, Z_f) as a 'short-term ' profit function. Then a 'long-term' profit function can be defined:

$$\pi^{**}(w, p, p_{Z_f}) \equiv \mathrm{Max}_{\,Zf} \quad \pi^*(w,p,Z_f) - p_{Zf} Z_f \tag{4-40}$$

The optimal value of Z_f , denoted as Z_f^*, is a function of w, p, and p_{Zf}. Applying envelope theorem to (4-40), we get:

$$\pi^{**}_w = \pi^*_w (w, p, Z_f^*(w,p,p_{Zf})) \tag{4-41}$$

and, therefore,

$$\pi^{**}_{wp_{Zf}} = \pi^*_{wZ_f} \frac{\partial Z_f^{\,*}}{\partial p_{z_f}} \qquad \text{(4-42)[26]}$$

As $\frac{\partial Z_f^{\,*}}{\partial p_{z_f}}$, being own price effect of an input, is non-positive, $-\pi^*_{w\,Zf}$ has the same sign as $\pi^{**}_{w\,pZf}$. If the family labor and the input in consideration are gross complements, then $-\pi^*_{w\,Zf}$ is non-negative. Therefore, under the assumption of gross complements, an increase in Z_f raises the shadow price.

As it is discussed above, the effects of V, p and Z_f on w_0 can be expressed using the income effect of Marshallian demand function and the derivatives of expenditure and profit functions. On the other hand, the effects of T and Z_h cannot be expressed in the same way. However, their effects can be also analyzed by the equation (4-34). As the denominator in (4-

[26] This is an application of general relationships between restricted and unrestricted profit functions, the detail of which can be found, for example, in Hockmann (1991) p.117 ff.

34) is positive, the directions of the influence of T and Z_h are the same as the sign of numerator in (4-34).

The effects of time endowment (T): The numerator is 0 + ($w\frac{\partial T_h^M}{\partial FI}$ -1) . By differentiating the budget constraint $C + w\,T_h = FI$ with respect to FI, we get:

$$\frac{\partial C}{\partial FI} + w\frac{\partial T_h^M}{\partial FI} = 1 \qquad (4\text{-}43)$$

Therefore, the numerator, $w\frac{\partial T_h^M}{\partial FI}$ -1, is equal to - $\frac{\partial C}{\partial y}$.This means that $\frac{\partial w_0}{\partial T}$ is negative.

The effects of utility shifter Z_h: By including Z_h as an argument of demand function in form of

$$T_h^M(1, w, wT + \pi^*(w, p) + V; Z_h)\ , \qquad (4\text{-}44)$$

we can see that the numerator becomes $\frac{\partial T_h}{\partial Z_h}$. This means that the shadow price of time rises when the preference order changes in favor of home time.

Table 4-1 summarizes the effects of exogenous variables on the off-farm wage, the shadow price of time, and the participation function (i*).

Table 4-1 Effects of exogenous variables on off-farm wage, shadow price and i*

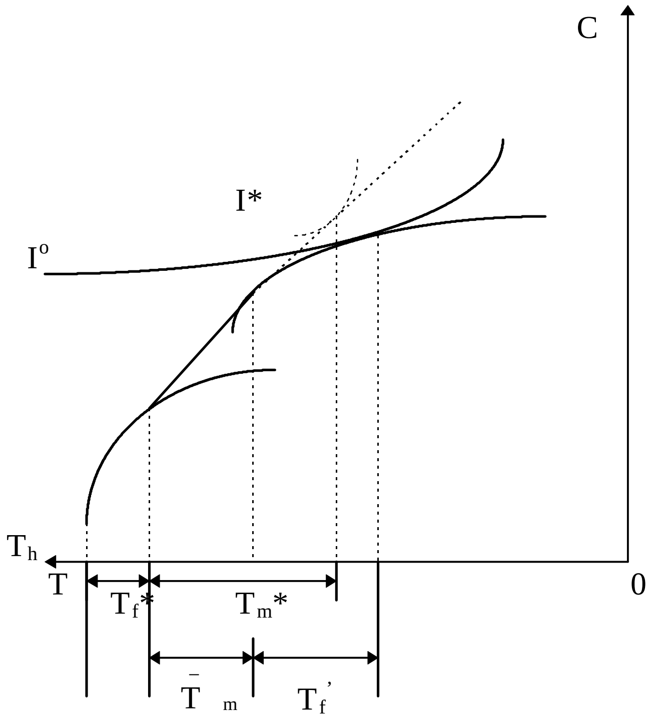
Variable		Wage (w_m)	Shadow Price (w_0)	i* $\equiv w_m - w_0$
human capital for off-farm work	(H_m)	+	0	+
favorable off-farm labor market situation	(Z_m)	+	0	+
time endowment	(T)	0	-	+
unearned income	(V)	0	+	-
preference change in favor of home time	(Z_h)	0	+	-
farm output price (if labor is normal input)	(p)	0	+	-
farm input price (complementary to labor)	(p)	0	-	+
fixed input (complementary to labor)	(Z_f)	0	+	-

4.3 Directions of Extensions

The discussion in the previous section presented the basic elements of agricultural household model, concentrating on the off-farm work participation decision. The basic model can be extended or modified to accommodate various aspects of the reality. The following three following points are relevant for the analysis of the next chapters.

Non-linear Off-farm Income Function: In the simple model, it is assumed that off-farm wage rate is constant so that off-farm income is a linear function of off-farm work time. In reality, off-farm income may be a more complicated function of work time due to the institutional conditions (for example tax system) or the incentive consideration of employers.

Figure 4-4 Time allocation under restriction on off-farm work time



A well-known example of the deviations of off-farm income function from the simplistic version is a restriction of maximum off-farm work time that can be imposed by a political regulation or by a collective bargaining. Figure 4-4 shows how a part-time farmer allocates his time if the maximum off-from work time restriction ($T_m \leq \bar{T}_m$) is binding for him. Without the restriction, his farm and off-farm work time would be T_f* and T_m*, respectively, and the recursivity would hold. If the off-farm work time restriction is binding so that the farmer cannot realize his originally optimal off-farm work time T_m*, then he increases farm work time by Tf ’. In this case, the economic price of his time is endogenously determined in spite of the positive off-farm work, and it is lower than the off-farm wage (w_m). The situation depicted in Figure 4-4 can be considered to be rather restrictive because of the assumption that it is impossible for a farmer to work off-farm longer than a fixed amount of time. As it is theoretically imaginable that the farmer can try to find another off-farm job when he is confronted with such work time restriction in one off-farm job, restrictions on work time can be perhaps better modeled by non-linear off-farm income function. Chapter 5 considers how the implications of the model on the difference of behavior between part-time and full-time farmers are changed by non-linear off-farm income function.

Multiple Persons: A household normally constitutes of more than one person. The one-person model in the previous section does not capture the relationship between the household members. This relationship is the subject of Chapter 6.

Decisions of Agricultural Households in Dynamic Context: The basic model is a static one. Economic choices made in the present often affect economic constraints and preferences in the future. The dynamic aspect is especially important for understanding how part-time farming influences the process of agricultural structural change. In Chapter 7 the influence of part-time farming in dynamic context will be discussed.

5 Farm Work Patterns of Farmers with and without Off-Farm Work

5.1 Introduction

The purpose of this chapter is to compare the farm work pattern of two different groups of farmers; farmers with off-farm work and farmers without off-farm work.

Previous empirical researches on agricultural labor supply can be divided into two groups. The first group applies the model of profit maximizing firm to the farm production, usually including the multiple output and input nature of agricultural production into consideration.[1] Using the production function formulation or duality formulation of profit function, whose usage has been increasing since 70's and now is dominant, the first group estimates the agricultural product supply and the factor demand of farms, including labor. As far as labor and its economic price are concerned, the studies usually use the total farm labor input, i.e. family labor plus hired labor and an average labor wage.

This approach has three potential problems.

First, as mentioned in Chapter 1, in most countries, farms are organized by farm family whose member contributes to the major part of labor input in the farm production. The economics objective of farm family can be better described as utility maximizing than as profit maximizing, where the average labor wage is assumed to be the economic price.

Second, as mentioned also in Chapter 1, although the agricultural profit is the main source of income for many farm families, the significant proportion of workforce farm family is engaged also in off-farm work. The studies in the first group do not analyze this aspect at all.

Third, many studies in the first group do not distinguish between the farm family labor and the hired labor. Possible and widely acknowledged difference between the farm family labor and the hired labor is not considered [2, 3].

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1 For example, Antle (1984), Ball and Chambers (1982), and Shumway (1983). For German agriculture, Grings (1985). The last one treats labor as a fixed factor.

2 For theoretical consideration on the basis of the transaction cost concept, see Polak (1985) and Schmitt, Schulz-Greve and Lee (1996).

3 Another closely related point is that the average price of labor, no matter how it is defined, can be different from the actual opportunity cost of farm family labor due to the difference in education and training level between the farm family workforce and the other kinds of workforce and that, in the industrialized countries like Germany, there might be considerable differences in opportunity cost even

These problems are consequences of unavoidable and, in most cases, even helpful simplification for the studies in the first group because the purpose of these studies is answer the problems which can be or sometimes must be approached from the aggregate level; e.g. the change in technology or productivity. This aggregate character results in that the possible behavioral differences between part-time farmers and full-time farmers are not analyzed. As we will see, the two groups can be different in the determination of relevant economic price of their time and such difference may cause different farm work behavior.

On the other side, the studies in the second group use utility maximizing agricultural household model where farm production, consumption, and labor supply decision are analyzed simultaneously. Nevertheless, as long as econometric analyses are concerned, they have concentrated on the determinants of off-farm work participation decision, wage function, and off-farm labor hour function.[4] Therefore, they answer the question what differences lead to participation or non-participation but do not answer the question whether participation or non-participation leads to differences in the production behavior and if so, then how. It is, however, important to understand the second type of differences because, in many cases, it is how differently farms with and without off-farm labor supply react to changes in the exogenous factors that makes the distinction between the two types of farms useful for the relevant agricultural political discussion rather than what causes the two different types to exist.

The papers by Lopez (Lopez (1984a and b)) are important improvements on both groups of studies in some respect. Using the model of utility maximizing agricultural household, which has the farm profit maximizing problem conditioned on the farm family labor in farm, as a subproblem, and assuming that off-farm work and on-farm work have different utility connotations, Lopez distinguishes between the family and hired labor in farm production and integrates the off-farm labor supply as well as the farm labor supply into the analysis. The papers by Lopez share, however, one formal characteristic of the studies in the first group mentioned before in that all farms are assumed to be 'homogenous'. In his model, all farm families are assumed to have positive off-farm work. This assumption seems to be unavoidable because he uses regionally aggregated data. Consequently, the differences between part-time farmers and full-time farmers are not analyzed.

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among the farmers. (See Schmitt , Schulz-Greve and Lee (1996) for some empirical findings on this point in Germany)

[4] For example, various papers of Huffman and others and of Kimhi.

Using the agricultural household model, this chapter analyzes what differences are to be expected and presents empirical findings on the different patterns of on-farm labor supply as an example of these differences. For this purpose, the participation function and the off-farm labor supply function will be simultaneously estimated.

5.2 Theoretical Model and Its Implications

5.2.1 Model

The agricultural household is assumed to solve the following utility maximization problem.

$$\max_{T_h, C, T_f, T_m} U = U(T_h, C; J) \tag{5-1}$$

subject to:

$$C = g(T_f; p, Z_f) + b(T_m; H_m, Z_m) + V \tag{5-2}$$

$$T = T_h + T_f + T_m \tag{5-3}$$

$$T_m \geq 0, \tag{5-4}$$

where y is off-farm earning function and

other variables are as defined in Chapter 4.

This model differs from the one in Chapter 4 in that it assumes a general off-farm earning function in the form of b (T_m; H_m , Z_m) instead of w_m (H_m, Z_m) T_m. As mentioned in the end of Chapter 4, institutional conditions can make the form of y to differ from the simple form of 'constant wage rate multiplied by work time'($w_m T_m$). Through a general earning function, we can develop a more general analysis about the labor supply and demonstrate what restriction is imposted by the assumption of constant wage rate on the labor supply behavior.

5.2.2 Participation Condition

The optimality conditions can be obtained by constructing Lagrangian function[5]:

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[5] Kuhn-Tucker conditions are sufficient for optimality if the restrictions are quasiconvex in the choice variables. It requires that the off-farm income function is concave or is not 'extremely' convex. See Intriligator (1981), p.70. We assume that this curvature condition is met.

$$L = U(T_h,C) + \tau (T - T_h - T_f - T_m) + \lambda (g (Tf; Z_f) + b(T_m; H_m, Z_m) + V - C) + \theta T_m \quad (5\text{-}5)$$

and applying Kuhn-Tucker condition to it.

$$\frac{\partial L}{\partial T_h} = U_1 - \tau = 0 \quad (5\text{-}6)$$

$$\frac{\partial L}{\partial C} = U_2 - \lambda = 0 \quad (5\text{-}7)$$

$$\frac{\partial L}{\partial T_f} = -\tau + \lambda g_1 = 0 \quad (5\text{-}8)$$

$$\frac{\partial L}{\partial T_{\mathbf{m}}} = -\tau + \lambda b_{\mathbf{1}} + \theta = 0 \quad (5\text{-}9)$$

$$\frac{\partial L}{\partial \theta} = T_m \geq 0,\ \theta \geq 0,\ \frac{\partial L}{\partial \theta} \bullet \theta = 0 \quad (5\text{-}10)$$

in addition to (5-2) and (5-3)

These conditions are exactly the same as the optimality conditions in Chapter 4 except that w_m is replaced with $b_1\ (T_m; H_m, Z_m)$. By applying the same logic as in Chapter 4, we can see that whether off-farm labor supply is positive or not depends on whether $b_1\ (0;H_m,Z_m)$, i.e. b_1 evaluated with $T_m = 0$, is greater than the shadow price of time w_0 or not. As it is shown in Chapter 4, w_0 is obtained from the solution to the maximization problem in which the off-farm work is restricted to zero. In economic terms, the household decides to supply off-farm labor if and only if the initial marginal off-farm income is higher than the shadow price of time from ‘full-time farming’. Therefore,

$$T_m > 0 \text{ if } i^* > 0 \text{ and } T_m = 0 \text{ if } i^* \leq 0, \quad (5\text{-}11)$$

$$\text{where} \quad i^* \equiv b_1\ (0; H_m, Z_m) - w_0\,(V, T, Z_h, p, Z_f) \quad (5\text{-}12)$$

The variables H_m and Z_m would affect the initial marginal off-farm earning in the same way as they were assumed to affect w_m in Chapter 4. Thus, the effects of exogenous variables, summarized in Table 4-1, hold also in this chapter.

5.2.3 Farm Work Decisions in Case of No Off-farm Work

In case of no off-farm work, optimality conditions are simplified to:

$$g_1 \ (T_f \ ) \quad = w_0 \tag{5-13}$$

$$\frac{U_1(T_h, C)}{U_2(T_h, C)} = w_0 \tag{5-14}$$

$$C + w_0 L = w_0 T + [g(T_f) - w_0 T_f] + V. \tag{5-15}$$

$$T = T_h + T_f \tag{5-16}$$

which are identical to the system of (4-24). Therefore, the discussion in Chapter 4 about the 'full-time farmer' holds here, too. The economic price of time (w_0) is a function of all exogenous variables except H_m and Z_m, i.e.;

$$w_0 = w_0 (V, T, Z_h, p, Z_f) \tag{5-17}$$

Thus, the farm work time (T_f) is also a function of all exogenous variables except H_m and Z_m . The reaction of farm work time to the changes in exogenous variables, which is the main concern of this chapter, can be analyzed on the ground of the determination of farm work time as a derivative of profit function:

$$T_f = - \pi^*_w (w_0 (V, T, Z_h, p, Z_f) , p, Z_f) \tag{5-18-a}$$

$$= T_f \ (V,T, Z_h, p, Z_f) \tag{5-18-b}$$

Differentiating (5-18-a) with respect to an exogenous variable, we get:

$$\frac{\partial T_f}{\partial k} = -(\pi^*_{ww} \frac{\partial w_0}{\partial k} + \pi^*_{wk})$$

$$= -\pi^*_{ww}\left(\frac{-\pi^*_{wk}}{\pi^*_{ww}-e_{ww}} + \frac{\frac{\partial(T_h^{\ M}-T)}{\partial k}}{\pi^*_{ww}-e_{ww}}\right) - \pi^*_{wk}$$

$$= \left(\pi^*_{ww}\frac{\pi^*_{wk}}{\pi^*_{ww}-e_{ww}} - \pi^*_{wk}\right) - \pi^*_{ww}\frac{\frac{\partial(T_h^{\ M}-T)}{\partial k}}{\pi^*_{ww}-e_{ww}}$$

$$= \frac{e_{ww}\pi^*_{wk}}{\pi^*_{ww}-e_{ww}} - \pi^*_{ww}\frac{\frac{\partial T_h^{\ M}}{\partial k}}{\pi^*_{ww}-e_{ww}} \qquad (5\text{-}19)$$

where, k = V, T, p or Z_f .

Note that the result of the comparative static analysis on the shadow price of time ($\frac{\partial w_0}{\partial k}$) in (4-34) in the subsection 4.2.5 is used. It was also shown in the same subsection that the first term within the parenthesis in the second line is the compensated change in the shadow price. Thus, the terms within the parenthesis in the third line and, equivalently, the first term in the last line are the compensated change in farm work time. The second term in the last line can be interpreted as the reaction of farm work time to the change in full income which in turn is caused by changes in the exogenous variables k. Applying this general formulation and assuming that both home time and consumption are normal goods and also that farm work time of household is normal input as well as gross complements for other inputs, following results can be obtained.

$$\frac{\partial T_f}{\partial V} = 0 - \pi^*_{ww}\frac{\frac{\partial T_h^{\ M}}{\partial FI}}{\pi^*_{ww}-e_{ww}} < 0 \qquad (5\text{-}20)$$

$$\frac{\partial T_f}{\partial T} = 0 - \pi^*_{ww}\frac{(w\frac{\partial T_h^{\ M}}{\partial FI}-1)}{\pi^*_{ww}-e_{ww}} > 0 \qquad (5\text{-}21)$$

$$\frac{\partial T_f}{\partial Z_h} = 0 - \pi^*_{ww}\frac{\frac{\partial T_h^{\ M}}{\partial Z_h}}{\pi^*_{ww}-e_{ww}} < 0 \qquad (5\text{-}22)$$

$$\frac{\partial T_f}{\partial p} = \frac{e_{ww}\pi^*_{wp}}{\pi^*_{ww} - e_{ww}} - \pi^*_{ww}\frac{\frac{\partial T_h{}^M}{\partial FI}\pi^*_p}{\pi^*_{ww} - e_{ww}} \text{ ; indefinite} \tag{5-23}$$

$$\frac{\partial T_f}{\partial Z_f} = \frac{e_{ww}\pi^*_{wZ_f}}{\pi^*_{ww} - e_{ww}} - \pi^*_{ww}\frac{\frac{\partial T_h{}^M}{\partial FI}\pi^*_{Z_f}}{\pi^*_{ww} - e_{ww}} \text{; indefinite} \tag{5-24}$$

The first terms in (5-20) through (5-24) are compensated changes while the second terms are income effects. Although the signs of (5-23) and (5-24) are indefinite, they show that compensated change effects and income effects themselves have definite signs. An increase in output (input) price has a positive (negative) compensated change effect and a negative (positive) income effect on farm work time. An increase in a fixed factor, which is a complement to family labor, has a positive compensated change effect and a negative income effect on farm work time.

5.2.4 Farm Work Decisions in Case of Positive Off-farm Work

If off-farm work time is positive at the optimum, then the optimality conditions are:

$$g_1(T_f) = w_0 \tag{5-25}$$

$$b_1(T_m) = w_0 \tag{5-26}$$

$$\frac{U_1(T_h, C)}{U_2(T_h, C)} = w_0 \tag{5-27}$$

$$C = [\, g(T_f) + b(T_m) \,] + V. \tag{5-28}$$

$$T = T_h + T_f + T_m \tag{5-29}$$

If b_1 is independent of T_m and exogenously given as in Chapter 4, then, according to (5-26), w_0 is equal to w_m and the system (5-25) through (5-29) becomes identical to the system (4-13) in Chapter 4. In this case, farm work time is a function of production relevant variables (w_m, p, Z_f) only and therefore, recursivity holds. However, if b_1 is a function of T_m, then the equations (5-25) through (5-29) can be solved only simultaneously and, therefore, the recursivity does not hold. In this case, optimal farm work time (T_f*) is a function of all exogenous variables.

$$T_f = T_f\,(w_0\,(V, T, Z_h, p, Z_f, H_m, Z_m), p, Z_f) \qquad (5\text{-}30\text{-}a)$$

$$= T_f\,(w_0\,(V, T, Z_h, p, Z_f, H_m, Z_m), p, Z_f) \qquad (5\text{-}30\text{-}b)$$

In the previous subsection, we applied the duality approach for comparative statics analysis. However, in this section, we employ the more ‘traditional’ approach via total differential of the system (5-25) through (5-29). This is due to the fact that if the off-farm earning function b is not assumed to be concave in off-farm work time (T_m), the condition (5-26) cannot be the first order conditions that characterizes a maximizing behavior.

5.2.4.1 Second Order Condition and Comparative Statics Analysis

If the non-negativity constraint (5-4) on off-farm work time is not binding at the optimum, the maximization problem is reduced to the one with only equality constraints (5-2) and (5-3). Thus, Kuhn-Tucker conditions become identical to the first order conditions and the second order conditions for the maximization problem must hold. The second order conditions,[6] applied to the model in this chapter, require that the sign of the border preserving principal minors of order 3 and 4 from the matrix of the second derivatives of the Lagrangian function (5-5), denoted as $L_{\mathbf{xx}}$, (**x** is the vector of the choice variables and the Lagrange multipliers (T_h, C, T_f, T_m, τ, λ)), be negative and positive, respectively. It means that the two following conditions must hold.

SOC I: $\lambda\,(g_{11} + b_{11}) < 0$ (5-31)

SOC II: $\lambda^2 g_{11}\, b_{11} + \lambda\,(g_{11} + b_{11})\,\left(U_{11} - 2\,\frac{U_1}{U_2}\,U_{12} + \left(\frac{U_1}{U_2}\right)^2 U_{22}\right) > 0$ [7] (5-32)

[6] See Intriligator (1971) p.35

[7] This condition is also presented in Kimhi (1989) to which a great part of the notation in this study is oriented.

It is possible to interpret the conditions SOCI and SOCII if we break down the original maximization problem into two sequential maximization problems as discussed below.

5.2.4.2 Decomposition of the Problem into Two Subproblems

We can decompose the original maximization problem into two steps as following:

Problem 1: Labor Income Maximization Problem

$$\max_{T_f, T_m} J \equiv g(T_f ; p, Z_f) + b(T_m ; H_m, Z_m) \tag{5-33}$$

$$\text{subject to: } T_w \equiv T - T_h = T_f + T_m \tag{5-34}$$

Problem 2: Utility Maximization Problem

$$\max_{T_h, T_w, C} U(T_h, C; Z_h) \tag{5-35}$$

$$\text{subject to: } T = T_h + T_w \tag{5-36}$$

$$C = J^* (T_w, p, Z_f, H_m, Z_m) \tag{5-37}$$

where J* is the indirect objective function of Problem 1.

The first problem is the maximization of total labor income, $J \equiv g + b$, subject to the work-time restriction $T_w = T_f + T_m$. In this problem, total work time (T_w) is given. The indirect objective function of this problem $J^*(T_w, p, Z_f, H_m, Z_m)$ can be called as 'labor income function'. The Second problem is to maximize the utility $U(T_h, C)$, subject to the income restriction ($C = J^*(T_w, \bullet) + V$) and the time restriction ($T = T_h + T_w$).

5.2.4.3 Analysis of Labor Income Maximization Problem

The Lagrangian function for Problem 1 is:

$$L = g (T_f ; A) + b(T_m; B) + l(T_w - T_f - T_m) \tag{5-38}$$

The first order condition is

$$g_1 - l = 0 \tag{5-39}$$

$$b_1 - l = 0 \tag{5-40}$$

$$T_w - T_f - T_m = 0 \tag{5-41}$$

The second order condition is:

$$g_{11} + b_{11} < 0 \quad , \tag{5-42}$$

which is equivalent to the condition SOCI. Therefore, SOCI means that at the optimum, the total work time must be allocated between on-farm and off-farm work in a way that would maximize the total labor income, given the amount of the work time. If the off-farm earning function as well as the farm earning function are concave in off-farm work time and farm work time, respectively ($g_{11}<0$ and $b_{11}<0$) , the condition is automatically satisfied. If the off-farm earning function is convex ($b_{11}>0$), the condition states that the farm work earning function must be concave enough to 'compensate' for the convexity of the off-farm earning function.

Applying the envelope theorem to (5-39), we get:

$$\frac{\partial J^*}{\partial T_w} = l \tag{5-43}$$

where J* is the indirect objective function of the Problem 1.

The Lagrange multiplier *l* is the marginal (total) labor income. The reaction of this marginal labor income to the change in the work time, which shows the curvature of the function $J^*(T_w)$, plays an important role in the interpretation of the second order condition in the original problem. From the comparative statics analysis of the system from (5-40) through (5-42), we get:

$$\frac{\partial \ell}{\partial T_w} = \frac{g_{11} b_{11}}{g_{11} + b_{11}} \tag{5-44}$$

The marginal labor income (*l*) is increasing function of total work time (T_w), i.e. the labor income is a convex function of T_w if the off-farm earning function is convex ($b_{11} > 0$). On the other hand, if the off-farm earning function is concave, then the labor income function is also concave.

5.2.4.4 Analysis of the Utility Maximization Problem

The utility maximization problem (Problem II) is very similar to the household utility maximization problem of full-time farmers discussed in the subsection 4.2.3, where off-farm work. was assumed to be zero. The former differs from the latter in that the labor income function (J*) in the present problem can be either convex, concave, or linear, while the farm earning function of full-time farmers in the subsection 4.2.3 was assumed to be only concave in farm work time.

The Lagrangian function for this problem is:

$$L = U(T_h, C; J) + \tau\ (T - T_h - T_w) + \lambda\ (J^*(T_w\ ; p, Z_f, H_m, Z_m) + V - C) \qquad (5\text{-}45)$$

The first order condition is

$$\frac{\partial L}{\partial T_h} = U_1 - \tau = 0 \qquad (5\text{-}46)$$

$$\frac{\partial L}{\partial C} = U_2 - \lambda = 0 \qquad (5\text{-}47)$$

$$\frac{\partial L}{\partial T_w} = \lambda J^*_1 - \tau = 0 \qquad (5\text{-}48)$$

$$\frac{\partial L}{\partial \tau} = T - T_h - T_w = 0 \qquad (5\text{-}49)$$

$$\frac{\partial L}{\partial \lambda} = J^* + V - C = 0 \qquad (5\text{-}50)$$

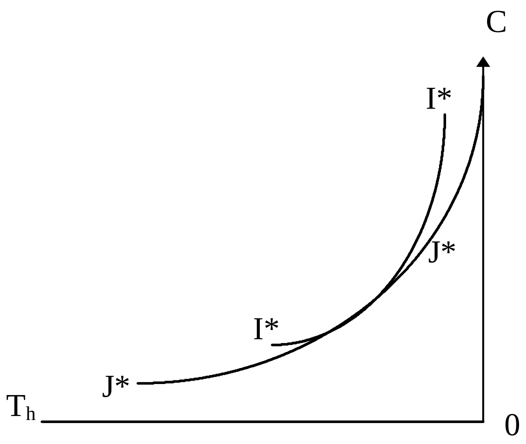
If the labor income function (J*) is concave, which is equivalent to the concavity of off-farm income function, then the analysis of ‘full-time farmer’ in Chapter 4 can be applied directly. Of course, we should keep in mind that in the present problem, total work time (T_w) overtakes the role of farm work time (T_f) of the ‘full-time farmer’ in Chapter 4. Therefore, the second order condition is automatically met and the decision of work time (T_w) can be interpreted as if it were determined from the maximization of $J^*(T_w) - w_0 T_w$, where $w_0 \equiv (\tau/\lambda)$ is the shadow price of time. It is, however, not the case if J* is allowed to be convex.

Therefore, in the following discussion we consider under which circumstances, the second order condition is met.

The second order condition is:

$$D^* \equiv \lambda J^*_{11} + D°$$
$$= \lambda[J^*_{11} + D^0/U_2\ ] < 0 \text{ ,where } D° \equiv (U_{11} - 2\ (U_1/U_2)U_{12} + (U_1/U_2)^2\ U_{22}) \qquad (5\text{-}51)$$

Figure 5.1 The meaning of SOC II



Noting that J^*_{11} ($\equiv \frac{\partial \ell}{\partial T_w}$) is equal to $= \frac{g_{11} b_{11}}{g_{11} + b_{11}}$ at the optimum, (5-51) is necessary and sufficient condition for SOC II to hold because dividing both sides of SOC II by λ (g_{11}+ b_{11}) leads to (5-51). What does the inequality (5-51) mean in economic terms? The term J_{11}* in (5-51) is the derivative of the shadow price of 'total work endowment' (T_w) with respect to T_w . The term D^0/U_2 is the derivative of the marginal rate of substitution between consumption and home time with respect to home time, i.e. $\frac{\partial}{\partial (T_h\ )} \left(\frac{U_1}{U_2} \right)$, which is guaranteed to be negative under the assumption of quasiconcave utility function. Noting

$$\frac{\partial}{\partial T_h} \left(\frac{U_1}{U_2} \right) = - \frac{\partial}{\partial T_w} \left(\frac{U_1}{U_2} \right) \qquad (5\text{-}52)$$

,we can express the sum $J^*_{11} + D^0/U_2$ as:

$$\frac{\partial}{\partial T_w}\left(\frac{\partial\ J^*}{\partial T_w}-\left(\frac{U_1}{U_2}\right)\right)<0. \qquad (5\text{-}53)$$

The Figure 5-1 helps to clarify the meaning of (5-53). In order for a point to satisfy the first order condition to be a maximum, the marginal rate of substitution as a function of work time must increase faster than the marginal labor income. In other words, the indifference curve must be more convex to the origin than the labor income curve. (Note that this condition is automatically met if the labor income curve is concave.)

5.2.4.5 Comparative Static Analysis of the Original Problem

The comparative statics analysis is carried out on the basis of total differentials of the Lagrangian function (5-5) [8]:

$$L_{\mathbf{xx}'}\ d\mathbf{x} = - L_{\mathbf{x}k}\, dk \qquad (5\text{-}54)$$

where $L_{\mathbf{xx}'}$ and $\mathbf{x}$ are as defined before.

k = element from the vector of exogenous variables (V, T, p, Z_f, H_m, Z_m)

$L_{\mathbf{xx}'}$ = matrix of second derivatives of L with respect to $\mathbf{x}$

$L_{\mathbf{x}k}$ = vector of cross derivatives of L with respect to $\mathbf{x}$ and k

The reaction of the choice variables and the Lagrange multipliers to a change in exogenous variable k can be predicted from the sign of the elements of $-L_{\mathbf{xx}'}^{-1} L_{\mathbf{x}k}$. */

With SOC I and SOC II given, the results from the comparative statics analysis of the original problem are as following. We assume, as in Chapter 4, that both home time (T_h) and consumption (C) are normal goods. Let u and v denote a representative element of the vectors (p, Z_f) and (H_m, Z_m), respectively.

$$\frac{\partial Tf^*}{\partial V}=\frac{\lambda b_{11} E}{D} \qquad \text{(same sign as } b_{11}\text{)} \qquad (5\text{-}55)$$

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[8] See Intriligator (1971) p.76 ff

$$\frac{\partial Tf}{\partial T} = \frac{\lambda b_{11} F}{D} \qquad \text{(opposite sign from } b_{11}\text{)} \qquad (5\text{-}56)$$

$$\frac{\partial Tf^*}{\partial u} = \frac{-\lambda g_{1u}(D^0 + \lambda b_{11})}{D} + \frac{\lambda b_{11} E g_u}{D} \qquad \text{(same sign as } g_{1u} \text{ + same sign as } b_{11} g_u\text{)}$$

(5-57)

$$\frac{\partial Tf^*}{\partial v} = \frac{\lambda D^0 b_{1v}}{D} + \frac{\lambda b_{11} E b_v}{D} \qquad \text{(opposite sign from } b_{1v} \text{ + same sign as } b_{11} b_v\text{)}$$

(5-58)

where $D \equiv \lambda^2 \pi_{11} b_{11} + \lambda (\pi_{11} + b_{11}) (U_{11} - 2 (U_1/U_2) U_{12} + (U_1/U_2)^2 U_{22}) > 0$ (SOC II)

$E \equiv U_{12} - (U_1/U_2) U_{22} > 0$

$F \equiv U_{11} - (U_1/U_2) U_{12} < 0$

$D^0 \equiv U_{11} - 2 (U_1/U_2)U_{12} + (U_1/U_2)^2 U_{22} < 0$ (quasiconcavity of the utility function)

Because the sign of $\partial(U_1/U_2)/ \partial C$ is positive, which is equivalent to the assumption of normal home time, the term E is also positive. Because the sign of $\partial(U_1/U_2)/ \partial T_h$ is negative, which is equivalent to the assumption of normal consumption, the term F is negative.

The signs of (5-55) and (5-56) are easy to determine because they depend only on the curvature of off-farm earning function, i.e. sign of b_{11}. The term b_{1v} is the effects of H_m or Z_m on the marginal off-farm earning and b_v is their effects on the level of off-farm earning. By assuming that both b_{1v} and b_v are non-negative, the signs of (5-58) are determined.

To determine the signs of the cases represented by (5-57), we need the sign of b11 as well as the signs of gu (the effects of u on the farm labor income) and g1u (the effects on the marginal farm income). First, if u is an output price, then gu is positive. The term g1u is also positive if family labor is a normal input. Second, if u is an input price, then gu is negative. The term g1u is negative (positive) if the input corresponding to u is a complement (substitute) for farm labor. Finally, if u is a fixed factor, then gu is positive. The term g1u is positive (negative) if the input is a complement (substitute) for farm labor.

From the discussion in the subsections 5.2.3 and 5.2.4, the effects of exogenous variables on the farm work can be summarized as in Table 5-1.

Table 5-1 The results of comparative statics analysis on farm work time

Variable		$T_m = 0$	$T_m>0$		
			$b_{11} = 0$	$b_{11} < 0$	$b_{11} > 0$
		(I)	(II)	(III)	(IV)
unearbed income	(V)	-	0	-	+
time endowment	(T)	+	0	+	-
output price	(p)	? (+)	+	?(+)	+
input price (complementary to labor)	(p)	? (-)	-	-	? (-)
input price (substitute for labor)	(p)	+	+	?(+)	+
fixed input (complementary to labor)	(p)	? (+)	+	?(+)	+
fixed input (substitute for labor)	(p)	-	-	-	? (-)
human capital	(H_m)	0	-	-	? (-)
favorable off-farm labor market situation	(Z_m)	0	-	-	? (-)
factors raising MRS in favor of T_h	(Z_h)	-	0	-	+

Note: MRS= marginal rate of substitution
Signs in parentheses refer to compensated change effects

5.2.5 Summary of theoretical results from the model

From the discussion in the previous sections, following conclusions can be drawn.

(1) The farm work functions (T_f*) vary depending on whether T_m is positive or not. This statement is true regardless whether recursivity holds or not.
(2) When off-farm work is zero, changes in exogenous variables are expected to affect farm work in the direction as shown in the column (I) in Table 5-1. The column (I) is the summary of the discussion in the subsection 5.2.3. In this case, recursivity does not hold.
(3) When off-farm work is positive, changes in exogenous variables are expected to affect farm work in the direction as shown in the column (II), (III) or (IV) depending on whether off-farm earning function is linear, concave, or convex in off-farm work time, respectively. The columns (II), (III), and (IV) are the summary of the discussion in the subsection 5.2.4. Recursivity holds only for the linear off-farm earning function.

Thus, we can carry out the following tests based on an econometric estimation.

(1) To check the general validity of the model, we can test whether farm work (T_f) function of full-time farmers (5-18-b) differs from that of part-time farmers (5-30-b).

(2) To check the recursivity, we can test whether V, T, and Z_h are excluded from the T_f function of part time farmers. If V, T, and Z_h have no influence on the farm-work of 'part-time farmers', the hypothesis that the off-farm wage is linear cannot be rejected.

5.3 Econometric Model

The estimation of the three behavioral functions discussed in the previous section, i.e. the participation function (i.e. the function i* in (5-12)), the farm work time (T_f) function of the 'full-time farmer' (5-18-b), and the farm work time function of the 'part-time farmer' (5-30-b), is the core of the empirical analysis of this chapter. Approximating the three functions with linearized forms and adding corresponding error terms, we get the following econometric system.

$$i^* = x'ß_1 + \varepsilon_1 \qquad (5\text{-}59\text{-a})$$

$$y_2 = x'ß_2 + \varepsilon_2 \qquad (5\text{-}59\text{-b})$$

$$y_3 = x'ß_3 + \varepsilon_3, \qquad (5\text{-}59\text{-c})$$

The vector x contains explanatory variables, ß's are corresponding coefficient vector, and ε's are assumed to have a joint normal distribution with covariance matrix;

$$\Sigma = \begin{pmatrix} \sigma_1^2 & \rho_{12}\sigma_1\sigma_2 & \rho_{13}\sigma_1\sigma_3 \\ \rho_{12}\sigma_1\sigma_2 & \sigma_2^2 & \rho_{23}\sigma_2\sigma_3 \\ \rho_{13}\sigma_1\sigma_3 & \rho_{23}\sigma_2\sigma_3 & \sigma_3^3 \end{pmatrix}. \qquad (5\text{-}60)$$

The value of i^* ($\frac{\partial b}{\partial T_m}(0; p, Z_f) - w_0$) cannot be directly observed. However, the information about its sign is available because, as discussed in 5.2, zero (positive) off-farm work time implies a non-positive (positive) value of i*. When i* is non-positive, the farm work time of full-time farmers (y_2) can be observed. On the other hand, when i* is positive, the farm work time of part-time farmers (y_3) can be observed. (Note that two different dependent varialbes y_2 and y_3 are used instead of the one variable T_f for the notational clarity.) Therefore, according to the sign of i* in (5-59-a), there is a 'switching' between the two regimes (5-59-b) and (5-59-c). According to the terminology of Maddala , the system (5-59) is an 'exogenous switching' regression model if $\rho_{12} = \rho_{13} = 0$, and an 'endogenous switching' regression model otherwise.[9] It is clear that the assumption of zero correlations between the participation function and the two kinds of farm work time functions is too restrictive because it is very probable that there are some unobservable factors which influence the participation function and the farm work functions in a systematically correlated way. As it is well known in the literature, when the correlation coefficients ρ_{12} and ρ_{13} are not zeros, individual regressions of farm work function of full-time or part-time farmers would result in inconsistent estimators.[10]

A maximum-likelihood estimation, which is both consistent and efficient, can be carried out [11], where the individual likelihood contribution is:

$$\frac{1}{(\sqrt{2\pi}\ )^2 \sigma_2 \sqrt{1-\rho_{12}{}^2}} \cdot \int_{-x'ß_1}^{\infty} \exp[-\frac{1}{2}(\varepsilon_1\ \varepsilon_2) \begin{pmatrix} 1 & \rho_{12}\sigma_2 \\ \rho_{12}\sigma_2 & \sigma_2^2 \end{pmatrix}^{-1} \begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \end{pmatrix}] d\varepsilon_1$$

$$= (1/\sigma_2)\ \phi\ (\frac{y - x'ß_2}{\sigma_2})\ \ \Phi\ (\ (x'ß_1 + \rho_{12}\frac{y - x'ß_2}{\sigma_2}\ )/\sqrt{1-\rho_{12}{}^2}\ ) \quad \text{if } i^* \leq 0 \qquad (5\text{-}61)$$

and

$$\frac{1}{(\sqrt{2\pi}\ )^2 \sigma_3 \sqrt{1-\rho_{13}{}^2}} \cdot \int_{-\infty}^{x'ß_1} \exp[-\frac{1}{2}(\varepsilon_1\ \varepsilon_3) \begin{pmatrix} 1 & \rho_{13}\sigma_2 \\ \rho_{13}\sigma_3 & \sigma_3^2 \end{pmatrix}^{-1} \begin{pmatrix} \varepsilon_1 \\ \varepsilon_3 \end{pmatrix}] d\varepsilon_1$$

$$= (1/\sigma_3)\ \phi\ (\frac{y - x'ß_3}{\sigma_3})\ \ [1 - \Phi\ (\ (x'ß_1 + \rho_{13}\frac{y - x'ß_3}{\sigma_3}\ )/\sqrt{1-\rho_{13}{}^2}\ )\ ] \quad \text{if } i^* > 0, \qquad (5\text{-}62)$$

where ϕ and Φ are the density and the cumulative density function of univariate normal distribution, respectively.[12]

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[9] See Maddala (1983), pp 283 - 289

[10] Greene (1993) Chapter 22

[11] A consistent two-stage estimation as in Maddala (1983) Ch.8 is possible but inefficient.

[12] The derivation of this expression is based on the observation that the density function of n-variable normal distribution $\phi_n(\varepsilon\ ; \Sigma)$ can be expressed as

$\phi_{n1}(\varepsilon_1\ ; \Sigma_{11})\ \phi_{n2}(\varepsilon_2 - \Sigma_{21}\Sigma_{11}^{-1}\varepsilon_1\ ; \Sigma_{22} - \Sigma_{21}\Sigma_{11}^{-1}\Sigma_{12}\ )$, We estimate the system (5-59) by maximizing the sum of the log likelihood as defined in (5-61) and (5-62) over the observations. Two points shoud be noted. First, in writing the likehihood, the standard deviation σ_1 in (5-60) is normalized to 1. This normalization is necessary because only the sign of i* and not its absolute magnitude is observable. Second, Because y_2 and y_3 cannot be observed simultaneously, ρ_{23} cannot be estimated. However, the estimation and inference of the model is not inhibited, as we can see from the likelihood function.

5.4 Data and Variables to be Used in Estimation

The data set for our estimation is from a survey that was carried out in Landkreis Emsland in Niedersachsen and Werra-Meißner-Kreis in Hessen in 1991. Using a systematic regional randomizing process for the farms with more than 5 ha of land for agricultural production, 688 sample farms were chosen[13].

Among these 688 farms, 656 farms (95.3%) had a male operator who reported positive farm work time. The estimation was performed using this subsample.

The variables used in the estimation, their definitions, and their counterparts in the theoretical models are listed in Table 5-2.

The farm operators who reported positive off-farm work hours are defined to have positive off-farm labor supply. The farm operators reported their estimation about yearly average of on-farm work time on weekdays weekends separately. The sum of on-farm work on weekdays and weekends are defined as weekly farm work time.

The explanatory variables for the estimation can be categorized into three groups;

(1) individual characteristics of the farm operators: age (**MALTER**), non-agricultural vocational education (**MDANL**), agricultural vocational education (**MDALM**), and general education (**MDASM**)

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where S = $\begin{pmatrix} \Sigma_{11} & \Sigma_{12} \\ \Sigma_{21} & \Sigma_{22} \end{pmatrix}$,

with S_{11} and S_{22} being square matrix with dimension of n_1 and $n_2 \equiv n - n_1$ respectively.

[13] For detailed description of sample selection, see Schulz-Greve (1994), p.72 ff

(2) household characteristics: family size (**FAMGROS**) and transfer and asset income (**EKTUVT**)

(3) farm income potential: standard farm income (Standardbetriebseinkommen; **STBE**)

The variables listed above can be considered to be the operational counterparts of the theoretical variables in the last column of Table 5-2. Thus, based on the results from the theoretical discussion, which are summarized in Table 4-1 and 5-1, we can expect in which direction these variables will affect the off-farm work participation decision and farm work time. However, the correspondence between the operational variables and the theoretical variables is not always obvious. For example, age can especially correspond to many different theoretical variables. Firstly, age influences the labor capacity negatively for older men. Second, the years of experiences have been proved to be important determinants of the income from an occupation[14]. When the information about years of experience is not available, age can

Table 5-2 Variables used in estimation

Variable	Definition	Theoretical Counterpart
DOFF	dummy for positive off-farm work hour	–
MOSTLW	weekly farm work hour (yearly average)	T_f
MALTER	age	T, Z_f, H_m
MDANL	dummy for non-agricultural vocational education finished	H_m
MDALM	dummy for agricultural vocational education on secondary level ('Fachschule') or higher finished	Z_f
MDASM	dummy for general education on junior high school ('Realschule') or higher finished	H_m, Z_f
FAMGROS	number of family members	Z_h
EKTUVT	transfer and asset income of all family members in 1000 DM	V
STBE	'Standardbetriebseinkommen' in 1000 DM	Z_f

Note: The theoretical variables in the third column are as defined in the beginning of the subsection 4.2.1.

[14] Mincer (1974) cited in Gebauer (1987) p.87

be also a proxy variable for the experience, especially so for the agriculture- or farm-specific experiences. Therefore, in most previous studies on the off-farm work participation, age enters the participation function in a quadratic form. Due to these reasons, the same approach is adopted in our estimation in the chapter as well, not only for participation function but also for off-farm work function.

Some explanations about the use of 'standard farm income' are necessary. As no reliable information about the fixed factor for the agricultural production (Z_f) was available, the standard farm income (Standardbetriebseinkommen) was used as a proxy. The standard farm income is an index for 'farm size' calculated from information on land allotment to various crops and stocks of animal and from regionally differentiated benchmark of productivity and estimates of farm overhead cost[15]. The standard farm income was already employed in previous researches on off-farm work in Germany[16].

The descriptive statistics for the variables used in the estimation are reported in Table 5-3. About 25 % and 56 % of the male operators reported positive off-farm work in LEM and WMK, respectively. 'Full-time farmers' worked about 60 hours and 'part-time farmers' about 30 hours on farm in both regions.

Table 5-3 Descriptive Statistics By Region and Off-farm Work Status

Region	LEM		WMK	
Off-farm Work	No	Yes	No	Yes
n	315	107	102	132
MWOSTLW	62.580 (9.624)	33.192 (18.028)	63.015 (14.120)	33.326(19.935)
MALTER	43.820 (12.405)	43.551 (10.811)	49.020 (12.143)	44.561 (9.920)
MDANL	0.0444 (0.206)	0.252 (0.436)	0.137 (0.346)	0.144 (0.352)
MDALM	0.384 (0.487)	0.234 (0.425)	0.324 (0.470)	0.144 (0.352)
MDASM	0.152 (0.360)	0.112 (0.317)	0.245 (0.432)	0.182 (0.387)
FAMGROS	5.260 (1.771)	5.720 (1.700)	4.382 (1.605)	4.492 (1.449)
EKTUVT	5.301 (6.914)	7.798 (8.501)	3.447 (5.254)	2.492 (3.675)
STBE3T	77.249 (45.628)	33.690 (36.319)	77.646 (66.419)	4.923 (26.385)

* Note: Numbers in parentheses are standard deviations

[15] Schulz-Greve (1994) p.112

[16] Gebauer (1987) and Schulz-Greve (1994)

5.5 Estimation Results and Discussions

Table 5-4 and 5-5 show the estimation results of the system (5-59) for LEM and WMK, respectively.[17] First, we should note that for each region there is one correlation coefficient of a considerable magnitude and significance. An inconsistent estimation would result if the sample selection bias were not considered in the estimation. As most variables have common signs in both regions, the results from both regions are discussed together in the following subsections.

5.5.1 Off-farm Work Participation

Age (**MALTER**) shows reverse U-shaped influence on the participation, as it has been reported in many other previous studies[18]. The peak is reached about age of 40. The coefficients of both linear and quadratic terms are significant in both regions. Non-agricultural vocational education (**MDANL**), as expected, raises the participation probability considerably. Agricultural education (**MDALM**), which is expected to affect the participation probability negatively, has the expected sign but its coefficient is not significant. Agricultural education is expected to raise marginal farm labor income. In addition, it might have a 'side-effect' of raising the potential off-farm income. The effect of general education (**MDASM**) is ambiguous. Its coefficient is positive for LEM but negative for WMK and insignificant in both regions. The positive effects of general education on the agricultural and non-agricultural earning functions could compensate for each other. Family size has positive effect in both regions and the coefficient is significant only in LEM. As the number of family member increases, the preference of household might be changed in favor of monetary income ('more mouths need more bread'). Non-labor income (**EKTUVT**), which is expected to have negative effect, has a positive coefficient in LEM and a negative one in WMK, and are statistically insignificant in both regions. The statistical insignificance of the coefficients of EKTUVT might be attributed to bad quality of data on asset income. Agricultural income potential, measured by log of 'Standardbetriebseinkommen+1', which is denoted as **LNST** , affects the participation probability negatively, as expected, and its coefficients are significant in both regions.

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[17] The estimation was carried out using the econometric software Limdep Version 7.0. See Greene (1995) p. 668 ff.

[18] For example, Schulz-Greve, W. (1994), Huffman, W. E. and Lange, M. D. (1989)

Table 5-4 Participation Function and Farm-Labor Supply Function (LEM)

n = 417

	Participation		Farm work time function			
			Farmers without off-farm Work		Farmers with off-farm work	
Constant	0.430	(1.336)	39.204	(10.436) ***	-3.833	(23.006)
MALTER	0.105	(0.0615) *	0.476	(0.421)	0.647	(1.135)
MALTER2S	-0.126	(0.0706) *	-0.469	(0.485)	-0.544	(1.340)
MDANL	0.722	(0.333) **	-0.352	(3.146)	-4.213	(5.113)
MDALM	-0.0674	(0.224)	2.891	(1.534) *	1.068	(3.748)
MDASM	0.0807	(0.319)	-5.491	(1.854)**	-2.165	(6.258)
FAMGROS	0.0996	(0.0492) **	0.256	(0.433)	-1.244	(0.927)
EKTUVT	0.0132	(0.0110)	-0.00589	(0.127)	-0.105	(0.191)
LNST	-1.005	(0.106) ***	2.608	(2.299)	7.440	(3.301) **
σ_2			9.1357	(0.351) ***		
σ_3					13.522	(2.493) ***
ρ_{12}			-0.123	(0.601)		
ρ_{13}					0.552	(0.323) *

Log likelihood function -1720.699

Note: Standard errors in the parentheses

Note: Wald test of 8 linear restrictions (See text)

Chi-squared = 3.62 , Significance level = 0.89

Table 5-5 Participation Function and Farm-Labor Supply Function (WMK)

n = 234

	Participation		Farm Work			
			Farmers without off-farm Work		Farmers with off-farm work	
Constant	-2.0881	(2.887)	25.092	(30.125)	35.944	(29.077)
MALTER	0.324	(0.1305) **	2.249	(1.271) *	-1.453	(1.510)
MALTER2S	-0.424	(0.1427) **	-2.902	(1.277) **	1.664	(1.797)
MDANL	0.579	(0.2997) *	-3.467	(4.003)	-4.138	(3.019)
MDALM	-0.566	(0.4122)	-9.153	(5.077) *	9.673	(3.944) **
MDASM	-0.321	(0.3835)	-4.929	(4.244)	-5.007	(3.390)
FAMGROS	0.0250	(0.1003)	1.598	(0.861) *	-0.0456	(0.905)
EKTUVT	-0.0145	(0.0214)	-0.815	(0.184) ***	-0.551	(0.369)
LNST	-0.924	(0.1793) ***	1.645	(2.181)	10.963	(2.314) ***
σ_2			12.062	(1.623) ***		
σ_3					13.302	(1.150) ***
ρ_{12}			-0.787	(0.254)***		
ρ_{13}					0.263	(0.483)

Log likelihood function -996.1528

Note: Standard errors in the parentheses

Note: Wald test of 8 linear restrictions (See text)

Chi-squared = 21.49, Signifance level = 0.00596

5.5.2 Farm Work Time

Differences in the off-farm work pattern: As noted in the theoretical discussion, an interesting and important question to be answered from the estimation is **whether there are differences in the farm work patterns** between the part-time and full-time farmers. A formal approach is to test the joint hypothesis which states that the coefficients of labor supply functions except constant terms of part-time and full-time farmers are the same. The Wald statistic for this hypothesis, which has a Chi-squared distribution with degree of freedom 8, is 3.62 for LEM and 21.49 for WMK. Therefore, the null hypothesis is rejected for WMK but not for LEM at conventional significance levels.[19] However, it is worthwhile to note that both regions show very similar pattern of differences between the part-time and full-time farmers.

Recursivity: Another interesting question is **whether recursivity holds**. The answer to this question is expected to give information about the curvature of the off-farm earning function (b) with respect to off-farm work time. The effects of the family size (**FAMGROS**) and non-labor income (**EKTUVT**) on farm work of part-time farmers can answer this question. According to the theoretical model, when the off-farm work function is linear, these two variables are determinants of farm labor supply for full-time farmers but not for part-time farmers. The results from WMK confirm this prediction. The two variables FAMGROS and EKTUVT have expected negative and statistically significant coefficients for full-time farmers and the null-hypotheses for part-time farmers are not rejected at conventional significance levels. The fact that the two variables have significant effects neither for part-time farmers nor for full-time farmers in the result from LEM also does not contradict recursivity. Thus, the null-hypothesis of linear off-farm earning function is not rejected. Consequently, we can expect that the explanatory variables affect farm work time of ‘part-time farmers’ in the manner as shown in the column (II) in Table 5-1.

Effects of individual variable on farm work time: Here we will discuss the individual effects of explanatory variables on farm work time of the full-time farmers and part-time farmers.

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[19] The critical value for 5 % significance level is 15.51 in a Chi-squared distribution with degree of freedom 8.

Age (**MALTER**) has a reverse U-shaped influence for full-time farmers in both regions and is statistically significant in WMK, reaching its peak about at the age of 40. However, the effect of age for part-time farmers is not statistically significant in both regions. This fact can be considered to be in accordance with the theoretical model. For full-time farmers, age might affect the determination of subjective value of time through its reverse U-shaped influence on farm experience and on health and labor capacity. For part-time farmers, the effect of experience on off-farm earning can be expected to move approximately in the same direction as on farm earning. Thus, the effects of experience on the allocation of labor among the two income possibilities might compensate for each other.

Although non-agricultural vocational education (**MDANL**), which is expected to raise the off-farm earning and, therefore, to reduce the farm-work of part-time farmers, has negative coefficients in both regions, the coefficients cannot be accounted strongly because they are not statistically significant. Although the effect of agricultural education (**MDALM**) on the farm labor supply of part-time farmers is positive in both regions, it is of great significance only in WMK. **MDALM** has positive, though not significant effect for full-time farmers. These observations suggest that agricultural education raises the marginal farm income considerably and that agriculture-specific human capital has complementary character for farm labor of full-time farmers in LEM.

For full-time farmers in WMK, MDALM has both negative and significant effect. Also the magnitude of the effect is remarkable. It may be reflecting the income effect and may also insinuate that agriculture-specific human capital could have labor-substituting character under certain circumstances. The same principle might hold also for general education (**MDASM**) effect on the farm-work time of full-time farmers in LEM as well.

Family size (**FAMGROS**) has a positive effect for full-time farmers in both regions, as expected from the theoretical model. The coefficient is statistically significant only in WMK. The non-labor income (**EKTUVT**) has negative effect for full-time farmers, which is in accordance with the prediction from the theoretical model. The coefficient is significant only in WMK. The effect of non-labor income for part-time farmers seems to be negligible. It was already mentioned before that the hypothesis of recursivity could be supported by the negligible effect of non-labor income.

Agricultural income potential (**LNST**) has significant positive effect for part-time farmers in both regions, whereas its effect for full-time farmers is not statistically significant and is of small magnitude. This observation can be considered to be in accordance with the theoretical model. For full-time farmers, the negative income effect might be counteracting the positive substitution effect, while for part-time farmers, the increase in marginal farm earning leads to reallocation of labor in favor of farm work unequivocally.

To summarize, the results from WMK provide unambiguous evidence for differences in the farm labor supply pattern between part-time and full-time farmers. Though not so statistically definite as in WMK, the similar patterns of differences are observed also in LEM. The most important finding, which is common to both regions, is that farm work time of part-time farmers is very sensitive to the farm income potential (measured by **LNST**), whereas that of the full-time farmers is not so sensitive to the farm income potential. These results can be interpreted to be consistent with the household model. For the part-time farmers, the comparison between the off-farm wage and the marginal labor income from farm work is important for their labor allocation decision. If the marginal income from off-farm work is not sensitive to off-farm work hours and therefore, if recursivity holds (this was supported by our estimation), then the reaction of the farm work hours to changes in farm income-enhancing variables will be similar to the reaction of a profit maximizing firm because the repercussion from the consumption side is minute. On the other hand, for the full-time farmers, the economic price of farm work is not the anticipated off-farm wage but the subjective value of home time. Changes in the marginal labor income from farm work, caused by the farm income potential or agricultural education, have income effect as well as substitution effect. Both effects can compensate for each other to some degree. In the determination of the subject value of time of full-time farmers, the demographic variables such as age or family size (or family cycle which can be approximated from these variables) might play important roles.

Differences between the two regions: One might ask why the results from LEM do not confirm the differences in the farm labor supply behavior as strongly as those from WMK. One reason might be that the farm families in LEM have, on average, more persons at working age (3.87 persons that are 15 years old and older) than in WMK (3.12 persons). Larger number of persons at working age in the family can widen the discrepancies between the reality and one-person model. Another reason might lie in the fact that in WMK, the agricultural structure has been changing more rapidly than in LEM, as mentioned in section 2.3, widening the farm size difference between the full-time farms and part-time farms more remarkably than in LEM. The greater land endowment of full-time farms in WMK might contribute to accentuate the difference from the part-time farms.

5.6 Summary and Concluding Remarks

In this chapter, differences in farm work behavior between farmers with and without off-farm work are compared. The basic household model in Chapter 4 already showed the difference in determination of economic price of farm labor between the two groups. The theoretical part of this chapter analyzes in detail what differences in farm work behavior are expected. The basic model from Chapter 4 is generalized by allowing concave or convex off-farm earning function. An econometric model in which the participation function and the farm labor supply functions of the two types of farmers are simultaneously estimated is applied to the data set from Emsland and Werra-Meißner-Kreis. The results from WMK support definitely the difference. Farm work time of the part-time farmers is more sensitive to agricultural income potential than that of the full-farmers. It means that part-time farmers are sensitive to price signals in their resource allocation. Age has considerable influence on work time of the full-time farmers, whereas its effect on the part-time farmers is weak. These results can be explained by the household model and human capital theory. Although the evidence from LEM is somewhat weaker, the results from this region also confirms the difference in the effect of farm income potential on the farm labor supply.

These results reveal the potential problem of conventional approach which treats the farms as homogenous subjects that maximize profit using the same prices as resource allocation criteria.

The findings in this chapter have the following implications for policies.

First, it highlights the inappropriateness of structural policies which aim to promote a certain farm size structure that is believed to guarantee a payment at comparable representative wage level of non-agricultural sectors to fully-employed agricultural workforce. Such policy measures presuppose that the opportunity cost of farm family labor can be evaluated with such a representative wage and that it is approximately the same among different farm family members. These presuppositions claim that one can think of one price of farm family labor by which the efficiency of farm resource allocation can be assessed. However, this chapter has shown that the relevant economic price of farm family labor is determined in different ways depending on the off-farm job status. Furthermore, the farm resource allocation, whose representative aspect in this chapter is farm work time, is shown to be considerably sensitive to the changes in the relevant economic prices of labor. Therefore, the efficiency assessment of agricultural production based on a certain 'representative' wage can be misleading. Consequently, certain structure political measures that try to promote a certain size structure of full-time farms, based on such assessment, lack justification from the viewpoint of efficiency and are not expected to be successful. The recent movement of the focal point in German agricultural structural policy from the full-time farms to 'competent and competitive farms in various farm types and sizes' [20] can be considered to be another evidence from a more general context, which supports the theoretical considerations in this chapter.

Second, policy makers are sometimes interested in how sensitive aggregate agricultural output supplies or aggregate input demands react to changes in policy variables. The estimates provided by researchers are usually based on the assumption of homogenous profit maximizing farms. Of course, such approach might be justified as an approximation of the sum of the various reactions from heterogeneous groups. However, given the relatively large availability of the detailed information about the off-farm job status of agricultural households, more differentiated approach which take the different supply and demand patterns of full-time farms and part-time farms into account may produce more accurate prediction at relatively low 'marginal research cost'.

[20] Schmitt (1996)

6 Joint Decisions of Farm Couples on Off-Farm Work

6.1 Introduction

Many studies on labor supply in general and in agricultural households use one-person model as in the previous chapter. As a ‘household’ normally constitutes of more than one person, however, this approach does not capture the interesting aspect of the interdependence in the labor supply decisions. To be specific, the decision of an agricultural household member on off-farm work might have an interdependent relationship with that of other members. Newer studies on off-farm work decision of farm families since Huffman and Lange (1989) take this aspect into account.[1] Most of the newer studies derive the participation condition for each member of the household by generalizing the concept of the shadow price of time in the one-person model and apply multivariate probit models for econometric estimation[2]. It seems that this approach has become conventional in the literature.

The purposes of this chapter are to reconsider the conventional approach critically and to examine the possibility of an alternative approach based on the indirect utility concept. It will be shown that both the conventional and alternative approaches to be suggested here have their own merits and shortcomings. In the empirical section, the estimation results of the econometric models based on the two approaches will be compared and evaluated. The data set from Emsland and Werra-Meißner-Kreis that was used in Chapter 5 will be used for the estimations in this chapter, too.

6.2 Some Preliminary Considerations about Labor Supply Decisions of Families

The extension of analyis on labor supply decision from an individual to a family has some theoretical problems that are briefly discussed in the following subsections before we proceed to the main topic of this chapter.

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[1] Other examples are Tokle and Huffman (1991) , Kimhi (1994) and Kimhi and Lee (1996).

[2] Kimhi and Lee (1996) take somewhat different approach, using the conditional demand concept on the theoretical level and simultaneous tobit equation system for estimation. Although their approach is not directly discussed here, it can be mentioned that it has a problem similar to the one to be discussed in this chapter.

6.2.1 Decision Mechanism

In the production theory (or neoclassical firm theory) or the consumer theory, the extension of the dimensions of input ,output, or consumption space requires no reconsideration of the economic objective of the subject, i.e. profit maximization or utility maximization, respectively. In contrast, the extension of the analysis on labor supply to a multi-person household entails the question of how to model the way the economic decisions of its members are made. According to the typology of Lundberg (1988), there are three groups of models; ‘traditional family’ model, joint utility model, and bargaining models.

‘Traditional Family’ model treats the labor decision of one person (usually the husband) separately from attributes and decisions of the other members (for example, the wife). The decisions of one person are treated as exogenous to the decisions of the other members. This approach is typically chosen in empirical studies on the female labor decision or dynamic economic supply mainly because it helps to simplify analyses which are ‘complicated enough’ by the theoretical or methodological aspects in interest [3] .

Joint utility approach assumes a utility function, which is to be maximized by the household. This utility function is assumed to have attributes and economic behaviors of the members as separate arguments and to have the usual properties of the utility functions from the individual consumer theory. It has been pointed out and criticized that this aggregation approach, from a theoretical point of view, can be justified only under restrictive assumptions[4]. Some studies, which have carried out formal tests on some predictions of the joint utility model, rejected these predictions [5]. However, due to the advantage that well-known theoretical results from one-person utility maximization model can be readily applied, joint utility approach serves as the main theoretical framework for the empirical studies on off-farm labor supply in multiple-person agricultural households.

The studies based on the bargaining model, for example McElroy and Horney(1981) and Browning et al (1994) , conceptualize the resource allocation of the family members as a game theoretical situation. It has theoretical appeal, especially if it is believed that “individuals, not

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[3] For example Eckstein and Wolpin (1989) on the dynamic analysis on female labor participation.

[4] Samuelson (1956) and Becker (1981) explicitly show examples of assumptions under which the joint utility approach can be theoretically justified. In the work of Samuelson it is the existence of consensus on the ‘ethical worth’ of welfare of the members. In the work of Becker it is the existence of a member (‘family head’) who cares about welfare of the other members and, therefore, transfers general purchasing power to other members.

[5] See Lundberg (1988) and the works cited in Browning, Bourguignon, Chiappori and Lechene (1994)

household, are the basic decision units“ [6] The bargaining model has, however, at least two problems. First, there seems to be no standard way to formalize the structure of the ‘game’ of the intrahousehold resource allocation. As it is widely known, the prediction from a game theoretical model is strongly influenced by the structure of the game, which might be termed as ‘institution’. A specific game theoretical modeling of the institution - for example McElroy and Horney (1981) assumes a certain form of ‘utility gain production function’, which is assumed to be maximized by the married couple - can be subject to controversies as much as the joint utility model.[7] Second, the bargaining model approach often requires much more detailed data than are normally available[8] for the empirical implementation.

This chapter employs the joint utility model because it aims to improve the interpretation of this model, which can be still considered to be a useful framework in many empirical researches.

6.2.2 Family Size and Structure

A ‘nuclear family’, i.e. married couple with small number of children that are teenagers or younger, is the dominating image of family or household in economic or social discussions in the developed countries. However, families in reality show a wide spectrum in size and demographic structure. The spectrum can be thought to be wider among farm families because farm familes are, on average, larger in size than the nuclear family [9] and often have more than two generations [10]. Differences in size and demographic structure might lead to differences in decision framework which cannot be captured by mere increase in variables or in the number of arguments in utility functions and restrictions[11]. However, we restrict our discussion to the husband-wife model because this model is the simplest form for the discussion on the

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[6] Browning, Bourguignon, Chiappori, and Lechene (1994)

[7] Chiappori (1988) and Chiappori (1992) are examples of the effort to build a model which is general enough to overcome this problem.

[8] For example, the observability of expense on goods with some special characters in Browning et al (1994)

[9] For example, the average family size in the VW data used for our estimation was 5.4 and 4.5 person in LEM and WMK, respectively, whereas it was, according to the census in 1987, 3.3 and 2.5 for all the households in each region. Schulz-Greve (1994), p.77

[10] For example, about half of the surveyed households in the VW data have 3 or more generations, whereas only 1.3 % of the whole households in Germany have so many generations. See Schulz-Greve (1994) p.79 - 80

[11] For example, Lundberg (1988) reports considerable differences in labor supply pattern of married couples according to the numbers of young children.

intrahousehold interdependence and because the families with married couple are majority in the data set to be used in the empirical section. [12]

6.3 Joint Utility Model and the Problems of Individual Reservation Wage Approach

In this section, the joint utility model for labor supply of two-person agricultural household will be presented and the problem of the conventional way of relating the optimality condition to the econometric models will be discussed.

6.3.1 Model and the Conventional Approach to Construct an Econometric Model

The following model is an extension of the one-person model in Chapter 4 to a two-person case. The household has the following optimization problem.

$$\underset{T_{h1},T_{h2},C,T_{f1},T_{f2},T_{m1},T_{m2}}{\text{Max}} \quad U(T_{h1}, T_{h2}, C; J) \tag{6-1}$$

subject to:

$$C = g(p; T_{f1}, T_{f2}; Z_f) + w_{m1}T_{m1} + w_{m2}T_{m2} + V \tag{6-2}$$

$$T_{hi} + T_{fi} + T_{mi} = T_i, \; i = 1, 2 \tag{6-3}$$

$$T_{mi} \geq 0, \qquad i = 1,2 \tag{6-4}$$

All variables are defined as in the basic model in Chapter 4 and the subscript 1 and 2 denote the husband (1) and wife (2), respectively. The household maximizes its utility which is determined by home time of each member and the ‘pooled’ consumption. The household faces one consumption restriction (6-2) and two time restrictions (6-3), one for husband’s time and the other for wife’s time. The off-farm work time of couple has non-negativity restriction. (6-4). Note that the assumption of the constant wage rate is adopted as in Chapter 4 for the convenience of the following discussion. As we will concentrate only on the participation decision and will not treat off-farm or farm work hour functions, the assumption of the

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[12] c.f. Schulz-Greve (1994) pp79 - 81

constant wage is justifiable. The maximization problem can be solved in the same manner as in Chapter 4 with the Lagrangian function:

$$L = U(T_{h1}, T_{h2}, C; J) + \tau_1 \ (T_1 - T_{h1} - T_{f1} - T_{m1}) + \tau_2 \ (T_2 - T_{h2} - T_{f2} - T_{m2})$$
$$+ \lambda \ [g(p;T_{f1}, T_{f2}; Z_f) + w_{m1}T_{m1} + w_{m2}T_{m2} + V - C] \qquad (6\text{-}5)$$

Kuhn-Tucker conditions for optimality is obtained by setting the first derivatives to zero and by taking the non-negativity restrictions into account. As result, we get:

$$U_1 - \tau_1 = 0 \qquad (6\text{-}6\text{-a})$$

$$U_2 - \tau_2 = 0 \qquad (6\text{-}6\text{-b})$$

$$U_3 - \lambda = 0 \qquad (6\text{-}6\text{-c})$$

$$\lambda g_1 - \tau_1 = 0 \qquad (6\text{-}6\text{-d})$$

$$\lambda g_2 - \tau_2 = 0 \qquad (6\text{-}6\text{-e})$$

$$\lambda w_{m1} - \tau_1 \leq 0 \ , T_{m1} \geq 0, (\lambda w_{m1} - \tau_1) \ T_{m1} = 0 \qquad (6\text{-}6\text{-f})$$

$$\lambda w_{m2} - \tau_2 \leq 0 \ , T_{m2} \geq 0, (\lambda w_{m2} - \tau_2) \ T_{m2} = 0 \qquad (6\text{-}6\text{-g})$$

in addition to the restrictions (6-2) and (6-3)

By defining

$$w_{0i} = \tau_i / \lambda, \qquad (6\text{-}7)$$

the system is simplified into more useful form

$$g_1 - w_{01} = 0 \qquad (6\text{-}8\text{-a})$$

$$g_2 - w_{02} = 0 \qquad (6\text{-}8\text{-b})$$

$$C + w_{01} \ T_{h1} + w_{02} \ T_{h2} = FI \qquad (6\text{-}8\text{-c})$$

$$\text{with } FI \equiv w_{01} \ T_1 + w_{02} \ T_2 \ + \pi^* + V \qquad (6\text{-}8\text{-d})$$

$$\pi^* \equiv [g(p;T_{f1},T_{f2};Z_f) - w_{01}T_{f1} - w_{02}T_{f2}] \tag{6-8-f}$$

$$\textbf{PC1}: \; w_{m1} - w_{01} \le 0 \;, T_{m1} \ge 0, (w_{m1} - w_{01})\, T_{m1} = 0 \tag{6-8-g}$$

$$\textbf{PC2}: \; w_{m2} - w_{02} \le 0 \;, T_{m2} \ge 0, (w_{m2} - w_{02})\, T_{m2} = 0 \tag{6-8-h}$$

The system (6-8) shows that once the economic price of time of each person w_{0i} is determined, the farm work time decision can be explained in terms of the profit maximization behavior. The consumption and home time decision can be explained as the utility maximization behavior for which the 'full income' (**FI**) is given as the sum of imputed value of time endowment of the couple ($w_{01} T_1 + w_{02} T_2$), economic farm profit ($[g(p;T_{f1},T_{f2};Z_f) - w_{01}T_{f1} - w_{02}T_{f2}]$), and non-labor income (V). This interpretation of the system (6-8) is a straight generalization of the principle discussed in detail in Chapter 4. As in Chapter 4, the conditions PC I and PC II help to determine whether the economic price of time becomes equal to the exogenously given off-farm wage or is determined endogenously.

An important step in the research on the off-farm labor supply is to relate the conditions PC1 and PC2 to the participation decision. The conventional way adopted in the previous studies can be summarized as following[13] .

Step1: In case of no male off-farm work, the shadow price of time of husband (w_{10}) is obtained from the optimization problem which is identical to the original one except that T_{m1} is restricted to zero. The shadow price is a function of all exogenous variables except w_{m1}:

$$w_1^* = w_1^*(w_{m2}, \bullet), \tag{6-9}$$

where $\bullet$ denotes all other variables except w_{m1} and w_{m2} .

Because w_{m2} is a function of the human capital variables of wife (Z_{m2}),

[13] This summary follows the line of argument in Kimhi, A (1994), although his description differs in that it begins with the 'interior solution' case in which all decision variables are positive and not with the optimization problem with additional restriction of $Tm_i = 0$.

$$i_1^* \equiv w_{10} = w_1^* (w_{m2}(Z_{m2}), \bullet) \quad (6\text{-}10)$$

The participation in off-farm work by the husband takes place if and only if the following inequality holds:

$$w_{m1}(Z_{m1}) - w_1^* (w_{m2}(Z_{m2}), \bullet) > 0 \quad (6\text{-}11)$$

Therefore, the participation decision of the husband is affected not only by his own off-farm wage in addition to other household and farm variables but also by the off farm wage of the wife.

Step 2: By symmetry, the participation in off-farm work by the wife takes place if and only if the following inequality holds.

$$i_2^* \equiv w_{m2}(Z_{m2}) - w_2^* (w_{m1}(Z_{m1}), \bullet) > 0, \quad (6\text{-}12)$$

where w_2^* is defined by symmetry to w_1^*.

Step 3: Linearizing i_1^* and i_2^* and adding disturbance terms, we get an econometric system

$$i_1 = 1 \text{ if } i_1^* = ß_1' x + \varepsilon_1 > 0 \quad (6\text{-}13\text{-a})$$

$$i_1 = 0 \text{ if } i_1^* = ß_1' x + \varepsilon_1 \leq 0 \quad (6\text{-}13\text{-b})$$

$$i_2 = 1 \text{ if } i_2^* = ß_2' x + \varepsilon_2 > 0 \quad (6\text{-}13\text{-c})$$

$$i_2 = 0 \text{ if } i_2^* = ß_2' x + \varepsilon_2 \leq 0 \quad (6\text{-}13\text{-d})$$

where x is the vector of all exogenous variables from the maximization problem.

The variables i_1 and i_2 are index variables for positive off-farm work by the husband and wife, respectively. The disturbance terms ε_1 and ε_2 have zero expectations and covariance matrix Σ.

Step 4: The coefficient vectors $ß_i$'s and Σ are estimated by a multivariate qualitative dependent model. Almost every study uses the multivariate probit models which assume ε's to have a multivariate normal distribution. In case of two persons it is a bivariate probit model (BVP). The multivariate probit model (MVP) is analogous to the Seemingly Unrelated Regression (SURE) model with quantitative dependent variables [14]. The representative log likelihood is:

$$\log \left[B\left((2\, i_1 -1)\; x'\left(\frac{ß_1}{\sigma_1}\right),\; (2\, i_2 -1)\; x'\left(\frac{ß_2}{\sigma_2}\right),\; (2\, i_1 -1)(2\, i_2 -1)\, \rho \right) \right] \tag{6-14}$$

with i_1 and i_2 as defined in (6-13)

$$B(a,b,r) = \int_{-\infty}^{a}\int_{-\infty}^{b} \frac{1}{(\sqrt{2\pi})^2 \sqrt{1-\rho^2}} \exp\left(-\frac{1}{2}\varepsilon' \Sigma^{-1} \varepsilon\right) d\varepsilon_2\, d\varepsilon_1 \;, \tag{6-15}$$

where $\varepsilon = (\varepsilon_1, \varepsilon_2)'$

$$\Sigma = \begin{pmatrix} 1 & r \\ r & 1 \end{pmatrix}$$

Note that, because only the sign and not the absolute magnitude of the latent variables i_1^* and i_2^* can be observed, not $ß_i$'s themselves and the variance of ε_i's but only ($ß_i/\sigma_i$) and the correlation coefficient ρ can be identified. These coefficients are obtained by maximizing the sum of log likelihood over observations.

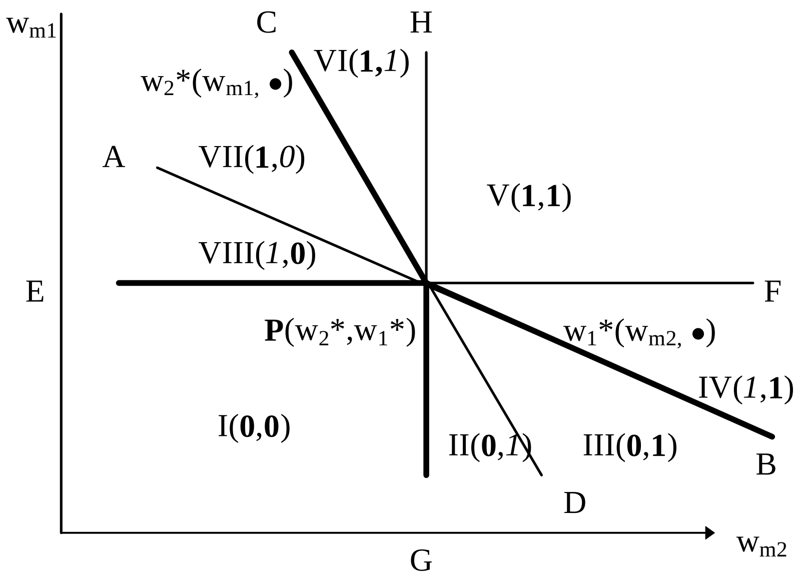
6.3.2 The Problem of the conventional multivariate probit approach

The problem of the approach described in the previous subsection lies in the assumption that the optimal level of off-farm work of one person is positive in the optimization problem where the off-farm work of the other person is restricted to zero. However, this assumption is not guaranteed to be fulfilled. If this assumption is not fulfilled, then the shadow price of one person cannot be described in the fashion of (6-9) because the off-farm wage of the other

[14] For details of MVP and SURE models see, for example, Greene (1993) Chapter 21 and 17, respectively.

person is not a determinant of the shadow price. For example, if the optimal off-farm work of the wife is zero in the optimization problem where T_{m1} is restricted to zero, then the off-farm wage of wife (w_{m2}) plays no role in the determination of the shadow price of husband. Therefore, the function w_1* in (6-9) ,which has w_2 as one of its argmuments, does not represent the relevant shadow price of time of the husband. Figure 6-1 illustrates this point more clearly.

Figure 6-1 Wage combination and Participation Decision



The line AB depicts the function w^*_1 defined in (6-9) in the (w_1 , w_2) space. Thus, it shows the reaction of w^*_1 to the change in w_{m2}. Changes in other variables result in shift of the line. This shadow wage is the solution of w_1 for the equation:

$$T_1 = T_{h1}^{M} (1, w_1, w_{m2}, FI) - \pi^*_1(w_1, w_{m2}, .) \qquad (6\text{-}16)$$

The full income FI and the economic farm profit were defined in the system (6-8). The appearance of the exogenous off-farm wage of wife (w_{m2}) in (6-16) assumes the positive off-farm work of wife. If this condition is met, then the line AB is the threshold line of the participation of husband. Any combination of off-farm wages above the line AB will lead to a positive off-farm work of husband. The slope of this line AB, which can be obtained by the same procedure used for the analysis on the shadow price of time in one person model in Chapter 4 is :

$$\frac{\partial w_1^*}{\partial w_{m2}} = \frac{-\pi^*_{12} + e_{12} + \dfrac{\partial T_{h1}^M}{\partial (FI)} T_{h2}}{\pi^*_{11} - e_{11}} \tag{6-17}$$

Thus, the slope of the line AB cannot be determined a priori. If the farm labor of the husband and wife are gross substitutes in farm production ($-\pi^*_{12} > 0$) and home time of them are Hicksian substitutes ($e_{12}>0$) and home time of the husband is a normal good, then the sign of (6-17) will be definitively positive. However, it is certain that there are many possible combinations of the three terms, $-\pi^*_{12}$, e_{12}, and $\dfrac{\partial T_{h1}^M}{\partial (FI)} T_{h2}$, which lead to the negative slope. The slope of the lines in Figure 6-1 is only for illustrative purpose.

By symmetry, the line CD depicts the shadow price of wife's time on the assumption of the positive off-farm work of husband. The shadow price is the solution to w_2 for the equation:

$$T_2 = T_{h2}^M (1, w_{m1}, w_2, FI) - \pi^*_1(w_{m1}, w_2, \bullet) \tag{6-18}$$

Under the assumption of the positive off-farm work of husband, any combination of the off-farm wages lying on the right side of the line CD will lead to the positive off-farm work of wife.

The role of the lines AB and CD as threshold lines assumes the positive off-farm work of partner. If this assumption is not met, the shadow price of time of the husband and wife are given by the co-ordinates of point **P**. The point **P** $\equiv(w_1^0, w_2^0)$, at which the lines AB and CD intersect, denotes the solution to the simultaneous equations system:

$$T_1 = T_{h1}^M (1,w_1, w_2, FI) - \pi^*_1(w_1, w_2, \bullet) \qquad (6\text{-}19)$$

$$T_2 = T_{h2}^M (1,w_1, w_2, FI) - \pi^*_2(w_1, w_2, \bullet) \qquad (6\text{-}20)$$

Thus, the combination **P** is the shadow price of the husband's and wife's time under the restriction that the off-farm work of both husband and wife is zero. Note that, by definition, w_1^0 and w_2^0 are not influenced by the exogenous off-farm wage rate[15] . Therefore, in case of no off-farm work of the partner, the horizontal line EPF and the vertical line GPH are the threshold lines for the off-farm work of the husband and wife, respectively.

The conventional approach described in the previous section amounts to the claim that given other exogenous variables, the four regions in the ($w_{1,}$ w_2) space, separated by the lines AB and CD, correspond to the four combinations of the off-farm job status of the couple. The falsehood of this claim can be seen if we consider an off-farm wage combination in the region VIII. According to this claim, the combination in the region VIII will lead to the off-farm work by neither the husband nor the wife. However, it is not true. Note that the four lines AB, CD, EF and GH separate the space of the off-farm wages of the husband and wife into eight regions, which are denoted by roman numbers I through VIII. Because the region VIII lies left to both the line CD and GPH, the optimal off-farm work of wife is zero regardless whether the husband has positive off-farm work or not. This fact is expressed by the second co-ordinate, **0** , within the parenthesis after the region number VIII. Given that the optimal-farm work of wife is zero, the threshold line for the off-farm work participation by husband is not AB but EPF. Therefore, the off-farm wage combinations in the region VIII will lead to the positive off-farm work by husband, which is expressed by the italic-typed '*1*' in the first co-ordinate within the parenthesis. By symmetry, the combinations in the region II will lead to zero off-farm work by the husband and positive off-farm work by the wife whereas according to the conventional approach, zero off-farm work of both husband by wife would have been expected.

The off-farm job status of the couple corresponding to the other regions can be determined in similar way. To generalize, in the first step, we determine the off-farm job-status of at least one person in each region by inspecting whether the region lies on the same side of

[15] The comparative statics analysis on w_{01} and w_{02} can be done by applying implicit function theorem to the equations (6-19) and (6-20). This is not pursued here because most of them do not have definite signs, leading to no refutable hypotheses.

the two relevant threshold lines [16]. In the second step, the job status, which remains undecided in the first step, is decided on the basis of the job status of the partner, which is determined in the first step. By this method, we can see that the threshold line for the husband's participation is not the line AB but the kinked line EPB and for the wife's, not the line CD but the kinked line CPG [17]. Thus, the multivariate probit approach, which assumes that the job status of the couple corresponds to the region of the off-farm wage space separated by the two straight lines AB and CD, is not logically consistent with the maximization behavior.

Two possible arguments could arise in order to justify a use of MVP framework. First, the partition of the wage space by two straight lines and the application of the multivariate probit model could be justified if the line AB were very flat and the line CD were very steep so that they would approximate the horizontal line EPF and the vertical line GPH. In such a situation it would mean that the off-farm wage of the partner would play almost no role in the participation decision. However, it cannot be assumed a priori before the estimation. If this situation should be assumed, it would lead to exclusion of an important aspect of intrahousehold interdependence of the off-farm work decision.

Second, a modified version of MVP with partial observability may seem to be applicable as each region from the partition by the kinked lines has two sublines as its border. For example, the region corresponding to the participation of both persons, i.e. the union of I, II and III, is separated from the other by the sublines PB and PC. Therefore, the condition '$i^*_1 > 0$ **and** $i^*_2 > 0$' is the necessary and sufficient condition for 'T_{m1} **and** T_{m2}' to be positive simultaneously, although not respectively. It might seem that a 'partial observability' model, suggested by Poirier (1980), could be estimated and would have the following structure if we concentrate on the case of simultaneous off-farm work participation.

$$\text{Prob}(T_{m1} > 0 \text{ and } T_{m2} > 0) = B(ß_1'x, ß_2'x, \rho), \qquad (6\text{-}21)$$

$$\text{Prob(other cases)} = 1 - B(ß_1'x, ß_2'x, \rho). \qquad (6\text{-}22)$$

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[16] A potential problem in this step is that there might be regions where the off-farm job status of neither the husband nor the wife can be determined. This is the case if the product of the first derivatives of the shadow prices with respect to the partners' off-farm wage is greater than unity. However, under the assumption of the utility maximization, this product is always smaller than unity around the point P. See Appendix for this.

[17] Kimhi (1989) discusses similar separation of a variable space by kinked threshold lines in a context of simultaneous participation decisions in on-farm and off-farm work in a one-person model.

with B defined in (6-15)

Unfortunately, this partial observability model cannot be implemented because the identification condition is not met. For identification of this model, it is required that there must be at least one variable which appear only in either i_1* or i_2* and not simultaneously. Otherwise, we cannot know which of ß's corresponds to which of i*'s.[18] This identification condition is not met in our problem because all exogenous variables appear in both reservation wage functions. For example, exogenous variables in the off-farm earning function of one person appear not only in his own reservation wage function but also in that of the other person.[19]

6.3.3 Indirect Utility and Multinomial Logit Approach

An alternative approach can be found by using the indirect utility function. The maximized utility level G* from the problem (6-1) is a function of the exogenous variables which appear as: (1) utility shifters (Z_h)or a profit function shifters (p, Z_f) or as (2) determinants of off-farm wage (H_{mi}) of the persons with off-farm work.

Let j be the index for the choice of the household among the four possible combinations concerning the positiveness of off-farm work. To be specific,

j=0 ; no off-farm work
j=1; only the husband has off-farm work
j=2; only the wife has off-farm work
j=3; both persons have off-farm work

Then we can write the indirect utility level of the household i in the form of

$$G^*_{ij} = ß_j' x_i + \varepsilon_{ij} \qquad (6\text{-}23)$$

[18] See Maddala (1983) p.280.

[19] If we concentrate on asymmetric cases such as 'only husband with off-farm work' or 'only wife with off-farm work', then we might be able to impose such conditions. However, this approach does not give us a general picture of interdependency.

Some elements of $ß_j$ can be set to zero. For example, an exogenous variable, which affects the off-farm wage of the wife only, have zero coefficient in $ß_0$ and $ß_1$. These restrictions can be also tested in standard way. Note that it is not possible in the conventional bivariate probit approach.

With this framework given, we can apply one of the multinomial qualitative response models. The probability that household i chooses alternative j is:

$$P_{ij} \equiv P \left(ß_j ' x_i + \varepsilon_{ij} > \mathrm{Max}_{k \neq j} [G_{ik}^*] \right) \tag{6-24}$$

The concrete functional form of the probability, therefore, depends on the specification of the random variables ε_{ij}'s.

The most widely used multinomial qualitative response model is the multinomial logit (MNL). It is known that, if ε's are independent and all ε's have the same distribution functions:

$$P(\varepsilon_j < a) = \exp(-\exp(-a)) , \tag{6-25}$$

then the representative probability is given by

$$P_{ij} = \exp(ß_j ' x) / \Sigma_k \exp(ß_k ' x) \text{ [20]}. \tag{6-26}$$

The parameters of this model is estimated by maximizing the log-likelihood function, $\sum_i \sum_j y_{ij} \log(P_{ij})$, where y_{ij} equals 1 if the household i chooses the alternative j,and zero otherwise. The likelihood is easy to maximize because it is globally concave in the coefficients[21, 22].

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[20] McFadden, D (1974) cited in Amemiya (1985)

[21] See Maddala (1983) p.37

The signs of the elements of difference vector ($ß_j$ - $ß_0$) have interesting economic interpretation. Let us take $ß_1$ and $ß_3$, which were set to null vector for normalization. The probability for the wife to have off-farm work on the condition that the husband has off-farm work is:

$$\frac{P_3}{P_1 + P_3} = \frac{\exp(ß_3\text{'x})}{\exp(ß_1\text{'x}) + \exp(ß_3\text{'x})} = \frac{\exp((ß_3 - ß_1)\text{'x})}{1 + \exp((ß_3 - ß_1)\text{'x})} \tag{6-27}$$

Differentiating with respect to the vector x, we get:

$$\frac{\partial}{\partial x}\left(\frac{P_3}{P_1 + P_3}\right) = (ß_3 - ß_1)\frac{P_1 P_3}{(P_1 + P_3)^2} \tag{6-28}$$

The expression (6-28) shows that an exogenous variable affects the conditional probability in the same direction as the sign of the corresponding element in the vector ($ß_3$-$ß_1$). For example, if the coefficient of male non-agricultural education in $ß_3$ is greater than its counterpart in $ß_1$, then male non-agricultural education increases the possibility of female off-farm work on the condition that there is male off-farm work. Thus, by comparing ($ß_2$-$ß_0$) and ($ß_3$-$ß_1$), we can see how the exogenous variable affects the probability of femal off--farm work participation differently depending on whether the husband has off-farm job or not. Even though this information, expressed in conditional probability context, does not seem to correspond directly to the reservation wage formulation discussed in 6.3.1 and 6.3.2, it provides a useful framework for describing the interpersonal dependence in the joint decision on off-farm work. Note that a simple expression like (6-28) is not possible in BVP.

Whereas MNL model has the merit that it conforms to the utility maximizing behavior and that it makes useful conditional probability formulation like (6-28) possible, the assumption of identical and independent distribution of the random variables can be considered to be too

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[22] As, for any given vector ($ß_0$, $ß_1$, $ß_2$, $ß_3$), a new set ($ß_0$+d, $ß_1$+d, $ß_2$+d , $ß_3$+d) , where d is a vector all elements of which are one and the same arbitrary constant, a normalization is necessary. The vector $ß_0$ is set to zero in the application for this purpose.

restrictive. For example, the random part in the off-farm wage of the husband is a part of both random variable ε_{i2} and ε_{i4}. In addition, the variances of ε's might be of different magnitudes. Multinomial Probit model (MNP), which allows for the correlations among the random variables and for the heteroskedasticity of the random variables, might be an attractive alternative. However, Keane (1992) has pointed out a difficult problem in practical identification of this model. He showed that although, theoretically, only the trivial normalization of coefficient vectors and the variances of random variables are needed for the identification of MNP models, the practical identification is very difficult, unless at least one exclusion restriction is imposed on each of the difference vectors ($ß_j$-$ß_0$). This problem is called 'fragile identification'. Keane (1992) also showed that, without such restrictions, the likelihood function is very difficult to maximize with available iteration algorithms and that, even when one gets convergence, the estimates often have very large standard errors so that meaningful inferences cannot be drawn. In accordance with his prediction, the iteration for finding the maximum of likelihood would not converge in some provisional MNP estimation based on the VW data. However, the imposition of exclusion restrictions does not seem to be justifiable for our model, especially for the coefficient vector $ß_3$. Therefore, no results based on MNP is available.

As both of the practicable models have problems at different levels - the multivariate probit model at the theoretical level, as pointed out the previous subsection, and the multinomial model at the level of random variable specification -, an a priori choice for one of the models cannot be made. In the empirical part of this chapter, the results of a multivariate (in our case bivariate) probit model and of a multinomial logit model will be presented and discussed.

6.4 Data

For the estimations of the models discussed above, the same data set from Landkreis Emsland and Werra-Meißner-Kreis that was used in Chapter 5 is used again. The general economic situation and the agricultural structure of the two regions were described in Chapter 2 already. Among 667 households in the sample, 531 households with operator couple were used. Table 6-1 is the crosstable of off-farm work participation of these couples in each region.

Table 6-1 Off-Farm Work Participation of Farm Operator Couples

Emsland

Wife / Husband	No	Yes	Total
No	212 (65.6%)	28 (8.7 %)	240 (74.3%)
Yes	73 (22.6%)	10 (3.1%)	83 (25.7%)
Total	285 (88.2%)	38 (11.8%)	323 (100 %)

Werra-Meißner-Kreis

Wife / Husband	No	Yes	Total
No	94 (45.2%)	9 (4.3%)	103 (49.5%)
Yes	68 (32.7%)	37 (17.8%)	105 (50.5%)
Total	162 (77.9%)	46 (22.1%)	208(100 %)

In both regions, the male participation rate is about twice as high as the female participation rate. However, the female participation rate is not negligible. There are some considerable regional differences. Whereas about only one third of the couples have off-farm work in Emsland, 55% of the couples have off-farm work in Werra-Meißner-Kreis. The participation rates of both the husbands and wives in Werra-Meißner-Kreis are twice as high as in Emsland. Another interesting regional difference can be found in the off-farm work participation rates of the wives whose husbands have off-farm work. In LEM, it is only 12 % (10/83) , whereas it is about 35 % (37/105) in Werra- Meißner-Kreis. On the other hand, the participation rates of wives with husbands that do not have off-farm work do not differ much from each other in both regions.

Table 6-2 shows the descriptive statistics of the variable used in the estimations. They can be categorized into four groups:

(1) human capital variable of the husband [23]: age (MALTER), dummy for non-agricultural vocational education (MDANL), dummy for agricultural education at secondary ('Fachschule') or higher level (MDALM) and dummy for general education at junior high school ('Realschule') or higher level (MDASM)

[23] These variables were used in the estimation in Chapter 3

Table 6-2 Descriptive Statistics of the Four Groups

Emsland

Group	total	0	1	2	3
n	323	212	73	28	10
MALTER	46.925	48.953	45.781	36.643	41.100
	(10.389)	(10.141)	(9.393)	(8.207)	(8.293)
MDANL	0.0836	0.0377	0.178	0.0357	0.500
	(0.277)	(0.191)	(0.385)	(0.189)	(0.527)
MDALM	0.297	0.283	0.233	0.571	0.300
	(0.458)	(0.452)	(0.426)	(0.504)	(0.483)
MDASM	0.0991	0.0802	0.0959	0.214	0.200
	(0.299)	(0.272)	(0.297)	(0.418)	(0.422)
FALTER	43.028	44.962	41.863	33.464	37.300
	(10.656)	(10.572)	(9.943)	(7.530)	(7.832)
FDANL	0.331	0.250	0.343	0.750	0.800
	(0.471)	(0.434)	(0.478)	(0.441)	(0.422)
FDALM	0.0155	0.0142	0.0137	0.000	0.100
	(0.124)	(0.118)	(0.117)	(0.000)	(0.316)
FDASM	0.245	0.222	0.137	0.643	0.400
	(0.431)	(0.416)	(0.346)	(0.488)	(0.516)
FAMGROS	6.375	6.316	6.671	6.000	6.500
	(1.900)	(1.875)	(2.115)	(1.515)	(1.650)
KIDZAHL	1.257	1.231	1.288	1.179	1.800
	(1.311)	(1.397)	(1.184)	(0.983)	(1.135)
EKTUVT	6.841	6.771	8.031	4.153	7.164
	(7.714)	(7.655)	(8.726)	(5.074)	(5.867)
STBET	66.271	80.449	32.015	62.842	25.372
	(50.836)	(52.288)	(33.254)	(30.457)	(24.216)

Table 6-2 Descriptive Statistics of the Four Groups (Continued)

Werra-Meißner-Kreis

Group	Total	0	1	2	3
n	208	94	68	9	37
MALTER	47.774	50.096	48.088	40.222	43.135
	(10.515)	(11.433)	(9.439)	(7.173)	(8.377)
MDANL	0.414	0.149	0.632	0.000	0.784
	(0.494)	(0.358)	(0.486)	(0.000)	(0.417))
MDALM	0.216	0.287	0.0441	0.667	0.243
	(0.413)	(0.455)	(0.207)	(0.500)	(0.435)
MDASM	0.188	0.181	0.118	0.556	0.243
	(0.391)	(0.387)	(0.325)	(0.527)	(0.435)
FALTER	44.039	46.830	43.632	36.556	39.514
	(10.979)	(11.808)	(10.177)	(7.418)	(8.494)
FDANL	0.337	0.181	0.368	0.556	0.622
	(0.474)	(0.387)	(0.486)	(0.527)	(0.492)
FDALM	0.0192	0.0319	0.000	0.111	0.000
	(0.138)	(0.177)	(0.000)	(0.333)	(0.000)
FDASM	0.284	0.298	0.191	0.667	0.324
	(0.452)	(0.460)	(0.396)	(0.500)	(0.475)
FAMGROS	4.894	4.851	4.927	5.111	4.892
	(1.699)	(1.820)	(1.687)	(1.692)	(1.449)
KIDZAHL	0.726	0.745	0.794	0.778	0.541
	(0.981)	(1.026)	(1.001)	(0.833)	(0.869)
EKTUVT	3.078	3.515	2.133	5.691	3.069
	(4.529)	(5.124)	(2.773)	(8.283)	(4.086)
STBET	48.165	78.106	23.238	51.747	17.036
	(50.836)	(52.288)	(33.254)	(30.457)	(24.216)

(2) human capital variable of the wife : age (FALTER), dummy for non-agricultural vocational education (FDANL), dummy for agricultural education at secondary or higher level (FDALM) and dummy for general education at junior high school or higher level (FDASM). As the numbers of the wives with agricultural education are very small (under 2% in both regions), causing heavy multicollinearity, FDALM is not included in the estimations.

(3) household relevant variables: family size (FAMGROS), number of children under 14 (KIDZAHL), transfer or asset income in 1000 DM(EKTUVT)

(4) farm income potential: standard farm income in DM (STBET). In the estimation, after performing some specification experiments, the form of log(STBET+1) was chosen. This transformed variable is denoted as LNST.

Some facts can be observed in both regions. When only the husband has off-farm work, then the couple has lower farm income potential than average. The couples with only female off-farm work are younger than other couples. These couples are characterized by higher levels of male agricultural education, male general education, female non-agricultural vocational education, and female general education than average. However, the average of their farm income potential is almost the same as the average of whole sample. When both wives and husbands have off-farm work, then the couples have much lower farm income potential and higher level of male and female non-agricultural vocational education than average.

6.5 Estimation Results and Discussions

In this section, the estimation results from the bivariate probit model and multinomial logit model are presented and compared.

6.5.1 Bivariate Probit

Table 6-3 shows the estimation results from the bivariate probit model.[24]

Own age (MALTER, MALTER^2/100, FALTER, FALTER^2/100) has reverse U-shaped effects, which reach their peaks at the age of late 40's for husbands and around the age of 40 for wives. The coefficients are significant only for the husbands. The age of spouse seems to have negative effects generally but the coefficients are statistically insignificant.

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[24] The estimation was carried out with Limdep Version 7.0. See Greene (1995) Chatper 22 and 24.

Table 6-3 Participation Function Estimation Results by Bivariate Probit Model

Variable	LEM		WMK	
	Husband	Wife	Husband	Wife
Constant	-2.658	-1.964	-4.026	-8.518
	(2.827)	(3.603)	(3.471)	(4.605)*
MALTER	0.445	-0.127	0.334	0.308
	(0.222)**	(0.225)	(0.190)*	(0.240)
MALTER2S	-0.478	0.708E-01	-0.344	-0.393
	(0.235)**	(0.254)	(0.192)*	(0.264)
MDANL	0.671	-0.254	1.042	0.547
	(0.415)	(0.416)	(0.319)***	(0.386)
MDALM	0.163	-0.263	-0.618	0.915
	(0.290)	(0.292)	(0.535)	(0.494)*
MDASM	0.831	0.307	0.251E-01	0.238
	(0.389)**	(0.369)	(0.427)	(0.470)
FALTER	-0.150	0.273	-0.505E-01	0.1251
	(0.169)	(0.238)	(0.210)	(0.211)
FALTER2S	0.136	-0.328	-0.267E-02	-0.144
	(0.185)	(0.286)	(0.220)	(0.245)
FDANL	-0.147	0.733	0.500	0.320
	(0.290)	(0.330)**	(0.492)	(0.368)
FDASM	-0.907	0.625	-0.357	0.238
	(0.344)***	(0.315)**	(0.499)	(0.379)
FAMGROS	0.260E-02	0.907E-01	0.436E-01	0.785E-01
	(0.641E-01)	(0.112)	(0.132)	(0.148)
KIDZAHL	-0.900E-01	-0.318	-0.101	-0.653
	(0.125)	(0.169)*	(0.225)	(0.242)***
EKTUVT	0.199E-01	-0.514E-01	-0.204E-01	0.236E-01
	(0.120E-01)*	(0.295E-01)*	(0.300E-01)	(0.221E-01)
LNST	-1.089	-0.197	-0.546	-0.332
	(0.145)***	(0.162)	(0.122)***	(0.145)**
ρ	-0.328E-01 (0.251)		0.483 (0.220)**	
n	323		208	
log(L)	-194.364		-149.359	

Own non-agricultural vocational education (MDANL, FDANL) has positive effects and the coefficients are significant for the wives in Emsland and for the husbands in Werra-Meißner-Kreis. The cross-person effects (MDANL in the second and the fourth columns and FDANL in the first and the third columns) are statistically not significant. However, it is worthwhile to note that the coefficient of the cross-person effect is negative in Emsland, whereas it is positive in Werra-Meißner-Kreis. It might imply that the influence of the off-farm wage of one person on the reservation wage of spouse could be different from region to region, depending on the production conditions. However, we should bear in mind that this kind of reservation wage interpretation has the problem which was already discussed in section 6.3 The husband's agricultural education (MDALM) has positive and significant effect on the wife's participation in Werra-Meißner-Kreis. It suggests that the agriculture specific human capital of husband is substitutive for the farm work of wife. In other cases, the effects are statistically not significant. The effects of general education of the husband (MDASM) are positive both on his own participation and on his partner's, the only significant case being for the husband in Emsland. The effects of general education of the wife (FDASM) are positive on her own participation and negative on the husband's and are significant only in Emsland.

The effects of the family size (FAMGROS) are not significant in any of the cases. The number of the children has significant negative effect on the participation of wife in both regions. This fact is widely observed also in other studies and can imply that the children raises the value of home time of the wife. The effects of non-labor (transfer and asset) income (EKTUVT) income are significant only in Emsland and are positive on the participation of husband but negative on the participation of wife. It might suggest that home time of the husband could be an inferior good for the family. However, we should note that the magnitude of the coefficient is very small. The farm income potential (LNST) has negative, in most cases significant, effects on off-farm work participation of both husband and wife. This observation is in accordance with the theory.

The correlation coefficient between the two participation functions is positive and significant in Werra-Meißner-Kreis. The correlation coefficient in Emsland is negative and statistically not significant.

6.5.2 Multinomial Logit (MNL)

Table 6-4 shows the estimation results of a MNL model. By the interpretation of this table, we should keep in mind that the coefficients are the elements of ($ß_j$ - $ß_0$). Thus, the natural interpretation of the coefficients is; how the relative ‘attractiveness’ of the choice j, in comparison with choice of no off-farm work, is affected by an increase in the corresponding variables by one unit’. By the cross-row comparison of coefficients, we can also tell which choice is most favored by an increase in a variable.

The husband’s age (MALTER, $MALTER^2/100$) has reverse U-shaped influence on the case of ‘husband only’ and ‘simultaneous participation’. In Werra-Meißner-Kreis, the influence of husband’s age on both case is significant, whereas in Emsland, it is significant for ‘husband only’ case. The influence of the wifes’ age(FALTER, $FALTER^2/100$) is statistically insignificant for all cases except for the case of ‘wife only’ in Emsland.

Non-agricultural vocational education of the husband (MDANL) has positive effect on the cases of ‘husband only’ and ‘simultaneous participation’ in both regions and their coefficients are significant only in Werra-Meißner-Kreis. We should note that MDANL favors ‘simultaneous participation’ case to ‘husband only’ case in both regions. It suggests that on the condition of positive off-farm work by the husband, an increase in the off-farm wage of husband encourages the off-farm work participation by wife. It is in accordance with what we would expect, given the results from BVP for WMK, although BVP has the problem of being unable to distinguish between the participation decisions of the wife in case of no male off-farm work and in case of positive male off-farm work. This kind of ‘conformity’ between BVP and MNL is not observed in LEM. The results from BVP suggest negative effect of male non-agricultural education on the participation decision of wife, although the coefficient is not statistically significant. Similar ‘contradiction’ is also observed in the cross-person effect of non-agricultural education of the wife (FDANL) in LEM. Of course, the comparison of the cross-person effect in BVP with that in MNL is problematic because the coefficients have marginal probability interpretation in BVP whereas they have conditional probability interpretation in MNL. However, such ‘contradiction’ can be considered, at least, as an indication of the potential problem of referring the results of BVP to the reservation wage.

Non-agricultural education of the husband (MDANL) has negative effect on the ‘wife only’ case in both regions but is significant only in Emsland. It seems, at first, to contradict

Table 6-4 Estimation Results of Multinomial Logit

Variable	LEM			WMK		
	husband only	wife only	both	husband only	wife only	both
Constant	-1.672	-2.915	-13.200	-9.695	-24.258	-18.892
	(4.780)	(7.273)	(11.303)	(5.967)	(15.907)	(7.073)***
MALTER	0.667	-0.336	0.785	0.759	0.983	0.807
	(0.347)*	(0.460)	(0.708)	(0.348)**	(1.017)	(0.448)*
MALTER2S	-0.734	0.210	-0.905	-0.775	-1.241	-0.911
	(0.359)**	(0.523)	(0.766)	(0.349)**	(1.258)	(0.492)*
MDANL	0.734	-2.260	1.631	1.124	-20.228	2.340
	(0.675)	(1.374)*	(1.031)	(0.499)**	(14558.)	(0.734)***
MDALM	0.0529	-0.940	0.365	-1.685	1.379	0.963
	(0.518)	(0.662)	(1.049)	(0.846)**	(1.283)	(0.943)
MDASM	1.617	1.128	1.515	0.246	1.132	0.250
	(0.662)**	(0.760)	(1.248)	(0.675)	(1.025)	(0.826)
FALTER	-0.219	0.798	0.0377	-0.103	0.370	0.303
	(0.260)	(0.459)*	(0.622)	(0.317)	(0.802)	(0.421)
FALTER2S	0.180	-1.015	-0.0431	0.196E-02	-0.477	-0.461
	(0.275)	(0.576)*	(0.714)	(0.340)	(1.100)	(0.488)
FDANL	-0.228	1.220	1.657	0.737	0.061	1.225
	(0.476)	(0.596)**	(1.103)	(0.684)	(1.043)	(0.771)
FDASM	-1.561	0.950	-0.166	-0.420	1.435	0.203
	(0.562)***	(0.585)	(0.971)	(0.720)	(1.086)	(0.784)
FAMGROS	0.0137	0.246	0.0152	0.106	0.308	0.206
	(0.130)	(0.212)	(0.316)	(0.213)	(0.397)	(0.273)
KIDZAHL	-0.246	-0.717	-0.0813	-0.0678	-1.707	-1.204
	(0.216)	(0.348)**	(0.470)	(0.353)	(0.774)**	(0.455)***
EKTUVT	0.0240	-0.157	-0.0227	-0.0805	0.0422	-0.0101
	(0.0242)	(0.0698)**	(0.519)	(0.0615)	(0.0882)	(0.0647)
LNST	-2.049	-0.963	-2.199	-1.250	-1.223	-1.486
	(0.279)***	(0.403)**	(0.459)**	(0.303)***	(0.655)***	(0.354)***
n	323			208		
log(L)	-187.723			-142.428		
log(L_0)	-301.054			-242.838		

the theoretical model. Based on the theoretical model, one would expect that MDANL would exercise no influence on the utility differentials between the case of ‘no off-farm work’ and the case of ‘wife only’. The negative effect of MDANL on the ‘wife only’ case implies that husband’s non-agricultural education has some general income- enhancing effect which works positively on agricultural production as well as on off-farm earning and the positive effect on agricultural production increases relative attractiveness the ‘no-off work’ case in comparison to the ‘wife only’ case.

The effect of the wives’ non-agricultural education (FDANL) is positive on the ‘wife only’ case and the ‘simultaneous participation’ case in both regions but significant only in Emsland, whereas it is negligible for the ‘husband only’ case. It is in accordance with what is expected from the indirect utility model.

Agricultural education of the husband (MDAL) has negative and significant effect on the ‘husband only’ case in Werra-Meißner-Kreis. General education of the husband and the wife (MDASM, FDASM) has significant effects only on the ‘husband only’ case in Emsland, the effect of MDASM being positive and the effect of FDASM being negative. It may suggest that husband’s own general education enhances his off-farm wage more than his on-farm productivity and that the human capital of wife increases the on-farm productivity, which in turn raises the reservation wage of husband.

The effect of the family size (FAMGROS) is negligible in all cases, whereas the effect of number of children (KIDZAHL) is negative on both ‘wife only’ and ‘simultaneous participation’ cases. The effect of non-labor income (EKTUVT) is negative for all forms of off-farm work participation but significant only for the ‘wife only’ case in Emsland.

Although the farm income potential (LNST) has negative effects on all forms of off-farm work, its effect is smaller for the ‘wife only’ case in comparison to the other cases. It might be interpreted to mean that the complementary relationship between the wife’s farm labor and other factors are weaker.

6.5.3 Evaluation of Models by scalar criteria

As BVP and MNL have their own merits and drawbacks at theoretical or model specification level, as discussed before, a natural question arises; which model is the ‘better’ one for explaining the given data? Table 6-5 and Table 6-6 give general impression about the accuracy of the prediction of the two models in LEM and WMK, repectively.

Table 6-5 Frequencies of actual & predicted outcomes of j : Emsland

BVP

Predicted / Actual	0	1	2	3	TOTAL
0	200	9	3	0	212
1	33	37	0	3	73
2	17	2	9	0	28
3	2	8	0	0	10
TOTAL	252	56	12	3	323

MNL

Predicted / Actual	0	1	2	3	TOTAL
0	198	9	5	0	212
1	31	40	0	2	73
2	15	2	11	0	28
3	2	6	0	2	10
TOTAL	246	57	16	4	323

Note: Outcome is j that is defined in 6.3.3.

Table 6-6 Frequencies of actual & predicted outcomes of j : Werra-Meißner-Kreis

BVP

Predicted / Actual	0	1	2	3	TOTAL
0	81	12	0	1	94
1	17	43	0	8	68
2	6	1	2	0	9
3	4	12	0	21	37
TOTAL	108	68	2	30	208

MNL

Predicted / Actual	0	1	2	3	TOTAL
0	83	10	0	1	94
1	14	49	1	4	68
2	4	2	3	0	9
3	4	14	1	18	37
TOTAL	105	75	5	23	208

Note: Outcome is j that is defined in 6.3.3.

In both tables, the predicted outcome for couple i is defined as the alternative k, whose predicted probability is the greates among P_{ij} (j=0,1,2 and 3). From the numbers in the diagonal cells of the two tables (the 'correct' prediction), we can see that MNL outperforms BVP in both regions: the former has 5 and 6 more correct predictions than BVP in Emsland and Werra-Meißner-Kreis, receptively.

In Table 6-7, three criteria are used to compare the two models.

Table 6-7 Scalar criteria to measure the 'goodness' of multinomial choice models

Criterion	Definition	LEM		WMK	
		BVP	MNL	BVP	MNL
log of likelihood ratio	$2 (L^* - L^0)$	213.3812	226.6624	186.9564	200.8202
pseudo R^2	$1 - L^*/L^0$	0.3544	0.3764	0.3849	0.4135
Hauser's statistic	See text	0.9667e-1	0.1699e-5	0.59345e-1	0.1303e-5

Note: L^* = maximized log likelihood
L^0 = log likelihood under the null hypothesis
(for BVP the correlation coefficient is not restricted to zero)

The first criterion is log-likelihood chi-square test statistic which is used for the test of null hypothesis that states: all explanatory variables except constant terms have zero coefficients. In both regions, both BVP and MNL have statistics which are well above the critical value[25]. Although we can be sure from this statistic that the variables are relevant, "it does not provide an indication of how accurate the predictions are". (Judge et al (1985), p.774)

The second criterion is McFadden's pseudo R^2. It has the merit that it lies between 0 and 1, like the familiar R^2, and intuitive appeal that it will approach 1 as the model approaches to "perfect fit". Here, the 'perfect fit' means that a model attaches probability 1 to the realized choice. According to McFadden's pseudo R^2, MNL explains the outcomes better than BVP. Of course, we should not forget that MNL has more coefficients and the increase in pseudo R^2 value can be a mere reflection of this fact. However, the higher pseudo R^2 value of MNL may at least imply that MNL explains the data no worse than BVP. The second criterion also has

[25] Critical value at 1 % is 45.642 for BVP with degree of freedom 26 and 62.428 for MNL with degree of freedom 39.

the same problem as the first criterion because it does not provide an intuitive indication of how accurate the prediction of each model is. In addition, the appropriateness of evaluating the merits of competing models based on these criteria might be questioned when the models belong to different likelihood familes.

The third criterion in Table 6-7, Hauser statistic, is based on 'information theory' (Hauser (1978)) and is recommended in Judge et al (1985) as an approach to alleviate the problems of the first two criteria mentioned before[26]. (As Hauser statistic is seldom used in the economic literature, some basic concepts of information theory based on the discussion in Judge et al (1985) and Theil (1967) and the rationale of Hauser statistic will be explained in the digression after this subsection.) One is to reject a model as inappropriate for the explanation of the data if Hauser statistic is greater than a critical value from a standard normal distribution table.

We can see that both models cannot be rejected as inappropriate. However, MNL can be considered to perform extremely well when judged by Hauser statistic.

Digression: Basic Concepts of Information Theory and the Rationale for Hauser's statistic

Theil (1967) defines the 'information' of a message concerning an event as

$\log (P_1 / P_o)$,

where P_1 = probability of the event after the message is received

P_0 = probability of the event before the message is received[27] .

The definition can be understood intuitively if we see that the greater P_1 / P_0 is, the more reduction in uncertainty of whether the event in question will eventually happen is achieved. [28] 'Expected information' is an extension of the information concept to a situation in which a

[26] Judge et al (1985), p. 774

[27] Theil (1967) p.10

[28] The choice of log as the functional form might seem to be arbitrary at first look. Theil(1967) supplies axiomatic justification of this choice (pp. 5-7).

message changes a probability distribution of J, mutually exclusive events **y** = ($y_{1,...,}$ y_J). Let the probability distribution before and after the reception of a message be $\mathbf{P_0}$ = ($P_{01,}$ ... , P_{0J}) and $\mathbf{P_1}$ = ($P_{11,}$ ..., P_{1J}), respectively. Then the expected information is

$$\sum_{j=1}^{J} P_{1j} \log(P_{1j} / P_{0j}) \qquad (6\text{-}29)$$

In a multinomial choice model context, the message that an observation unit i has the characteristic x_i changes the probability of observing the unit choosing alternative j from a prior one P(y_j) to posterior one P(y_j | x_i). Therefore, the expected information of the model is:

$$EI(y;X) = .\frac{1}{n}\sum_{i=1}^{n}\ \sum_{j=1}^{J} P(y_j|x_i)\log(P(y_j|x_i) / P(y_j)) \qquad (6\text{-}30)$$

Sample share of the alternative j is a natural choice for P(y_j).

Building on these concepts, Hauser (1978) proposes a measure of accuracy of a multinomial choice model. The multinomial choice model, given the message x_i , makes the prediction $\hat{P}_{ij}$ about P(y_j | x_i). Thus it provides ‘empirical information’ :

$$I(y:X) = \quad \frac{1}{n}\sum_{i=1}^{n}\ \sum_{j=1}^{J} \ {}_{ij} \log(\hat{P}_{ij} / P(y_j)), \qquad (6\text{-}31)$$

where δ_{ij} is 1 when i chooses j and 0 otherwise.

Hauser observes that if the model is accurate, then $\sqrt{n}$ (I(y;X) - EI(y; X)) is asymptotically normally distributed with mean EI(y;X) and variance [29]

[29] Judge el al ((1985), p.777) writes „ I(y;X) is asymptotically normally distributed with mean EI(y;X) and variance V(y;X)“. Hauser ((1978), pp. 413 ff) writes also in similar way. It is, however, clear from the context that they mean the expression in the text.

$$V(y;X) = \frac{1}{n}\sum_{i=1}^{n} \{\sum_{j=1}^{J} P(y_j|x_i)[\log(P(y_j|x_i)/P(y_j))]^2 - [\sum_{j=1}^{J} P(y_j|x_i)[\log(P(y_j|x_i)/P(y_j))]^2\}$$

(6-32)

Therefore, we can carry out a test, referring $z = \sqrt{n}\,(I(y;X) - E\hat{I}(y;X))/\hat{V}(y;X)$ to the standard normal distribution table, where $E\hat{I}$ and $\hat{V}$ are the estimates of EI and V, obtained by substituting $\hat{P}_{ij}$ for P_{ij}.

6.5.4 The Predicted Effects of Changes in Explanatory Variables.

From a political point of view, it is important to obtain predictions about 'marginal effects', i.e. the changes in the relevant economic variables that will be caused by the marginal changes in explanatory variables from the econometric models. Having seen that MNL is better in prediction and has very low Hauser statistic, we concentrate our discussion on MNL in this subsection.

In many studies, marginal effects are presented in elasticity forms, which are calculated using the value of the first derivatives, and are evaluated just at one point. In most cases, this point is the average of the explanatory variables. This approach could be improved by considering the following. First, the average point might not be a representative point for the population. Second, because in the qualitative choice models, the choice probabilities are generally non-linear functions of explanatory variables, the marginal effects depend on the reference level of the explanatory variables as well as on the coefficients. To be specific, in the MNL, used in this chapter, the derivative of the probability for a couple to choose the alternative j with respect to a variable x_s is:

$$\frac{\partial P_j}{\partial x_s} = P_j(\beta_{js} - \sum_{k=1}^{3}\beta_{ks}P_k)$$

(6-33)[30]

[30] Greene (1993), p.666

where $ß_{ks}$ is the coefficient corresponding to x_s in the vector $ß_k$.

Thus, it is more helpful to evaluate the probabilities at multiple representative points. Third, for the dummy explanatory variables, many of which appear in the estimation in this chapter, the difference P(j is chosen with the dummy 1) - P(j is chosen with the dummy 0) is more meaningful than the derivative expression.

Considering the points mentioned above, we calculate the predicted effect of discrete chanes in explanatory variables for three size groups. The farms are divided into three size groups according to the classification in annual agricultural report of the federal government for the economic year 1990/91 [31]: small (Standardbetriebseinkommen (STBE) under 40,000 DM), middle (STBE between 40,000 and 60,000), and large (STBE over 60,000 DM).[32]

The averages of explanatory variables for the three groups are in Table 6-8. For each group, a 'model farm' was built by taking the group average for the continuous variables (MALTER, FALTER, EKTUVT, STBE) , zero for the dichotomous dummy variables (MDANL, MDALM, MDASM, FDANL, FDASM), and the rounded number of the averages for the other discrete variables (FAMGROS, KIDZAHL).

Table 6-9 and 6-10 show the predicted changes in the possibilities for the 'model farm' of each group to choose each alternative concerning off-farm work status of the couples. The 'reference level' is the predicted probability for the 'model farm' to choose each alternative. The lines below 'reference level' in Table 6-9 and 6-10 show how the probabilities change when the explanatory variables of each 'model farm' change their levels as following: age of the couple increases by 5 simultaneously, the discrete variables by one, and the continuous variables by one (i.e. 1,000 DM).

From Table 6-9 for Emsland, we can see that when age increases from middle of the forties to the fifties, then the probabilities of all off-farm work participation cases are reduced and that the effect of increased age is stronger for the husband than for the wife. The effect of age on the participation of husband is the strongest for the middle size group. The effect of age on the participation of wife is not so size-sensitive as on the participation of the husband.

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[31] Bundesministerium für Ernährung, Landwirtschaft und Forsten (1992)

[32] This grouping, based only on farm income potential, is admittedly ad hoc. Some experimental cluster analyses, however, showed that the farm income potential is the only meaningful variable in cluster building.

Table 6-8 Average of Explanatory Variables by Size Group

Emsland

Farm Size STBE (in 1000DM)	under 20	40 - 60	over 60
n	96	66	161
MALTER	47.4	48.9	45.8
MDANL	0.19	0.09	0.02
MDALM	0.19	0.27	0.37
MDASM	0.05	0.06	0.14
FALTER	43.7	44.7	41.98
FDANL	0.38	0.27	0.33
FDASM	0.21	0.26	0.26
FAMGROS	6.45	6.05	6.45
KIDZAHL	1.16	0.91	1.46
EKTUVT	6.79	6.91	6.84
STBE(1000;DM)	19.3	50.4	100.1

Werra-Meißner-Kreis

Farm Size STBE (in 1000 DM)	under 40	40 - 60	over 60
n	96	66	161
MALTER	48.99	44.31	47.21
MDANL	0.63	0.34	0.08
MDALM	0.09	0.28	0.41
MDASM	0.15	0.21	0.24
FALTER	45.27	39.90	43.76
FDANL	0.42	0.21	0.26
FDASM	0.19	0.17	0.48
FAMGROS	4.51	5.41	5.32
KIDZAHL	0.50	0.97	1.02
EKTUVT	2.55	2.58	4.20
STBE	13.74	49.94	106.33

Table 6-9 Effects of Changes in Explanatory variables on Probabilities of Off-farm Work (in %):

Emsland, STBE under 40,000 DM

Off-farm Work	None	Husband only	Wife only	Both
reference level	22.78	71.10	3.75	2.36
(M,F)ALTER	12.67	-10.12	-2.19	-0.35
MDANL	-10.36	9.68	-3.54	4.22
MDALM	-0.58	1.95	-2.32	0.95
MDASM	-17.13	17.71	-0.88	0.30
FDANL	-0.98	-16.93	8.41	9.50
FDASM	23.33	-40.90	15.88	1.69
FAMGROS	-0.46	-0.48	0.95	-0.01
KIDZAHL	4.87	-3.62	-1.53	0.28
EKTUVT	-0.25	0.91	-0.58	-0.08
STBE	1.82	-1.85	0.11	-0.08
Emsland, STBE 40,000 - 60,000 DM				
reference level	67.84	28.04	3.33	0.80
(M,F)ALTER	13.75	-11.08	-2.33	-0.34
MDANL	-15.92	16.66	-3.06	2.32
MDALM	0.10	1.57	-2.03	0.35
MDASM	-37.41	35.29	1.28	0.83
FDANL	-3.61	-6.90	7.35	3.17
FDASM	13.89	-20.95	7.04	0.02
FAMGROS	-0.89	0.01	0.87	0.00
KIDZAHL	5.80	-4.24	-1.56	0.00
EKTUVT	-0.12	0.63	-0.49	-0.02
STBE	0.83	-0.78	-0.02	-0.02
Emsland, STBE over 60,000 DM				
reference level	84.44	11.15	4.13	0.28
(M,F)ALTER	6.75	-3.90	-2.77	-0.09
MDANL	-7.34	10.06	-3.74	1.02
MDALM	1.54	0.82	-2.49	0.13
MDASM	-29.83	25.16	4.12	0.54
FDANL	-6.81	-2.99	8.73	1.06
FDASM	1.99	-8.75	6.80	-0.04
FAMGROS	-1.09	0.01	1.09	0.00
KIDZAHL	4.04	-2.01	-2.02	-0.01
EKTUVT	0.28	0.31	-0.59	-0.01
STBE	0.23	-0.19	-0.03	-0.01

Table 6-10 Effects of Changes in Explanatory variables on Probabilities of Off-farm Work (in %):

Werra-Meißner-Kreis, STBE under 40,000 DM

Off-farm Work	None	Husband only	Wife only	Both
reference level	16.25	56.38	9.45	17.92
(M,F)ALTER	16.03	-0.82	-6.65	-8.56
MDANL	-11.93	-10.21	-9.45	31.59
MDALM	-1.64	-46.97	24.31	24.30
MDASM	-4.70	-5.13	11.39	-1.56
FDANL	-8.33	1.07	-4.56	11.82
FDASM	-2.11	-24.15	25.08	1.18
FAMGROS	-1.97	-1.30	1.85	1.43
KIDZAHL	5.13	12.92	-7.19	-10.85
EKTUVT	0.70	-2.12	0.83	0.58
STBE	1.28	-0.68	-0.10	-0.51

Werra-Meißner-Kreis, STBE 40,000 - 60,000 DM

reference level	46.18	46.12	2.95	4.75
(M,F)ALTER	9.79	-6.29	-1.72	-1.78
MDANL	-26.74	13.65	-2.95	16.03
MDALM	12.36	-35.27	11.88	11.03
MDASM	-7.82	2.86	4.64	0.32
FDANL	-17.66	13.43	-1.01	5.24
FDASM	2.60	-14.11	10.12	1.40
FAMGROS	-3.15	1.67	0.79	0.69
KIDZAHL	4.43	1.12	-2.36	-3.19
EKTUVT	1.67	-2.03	0.24	0.12
STBE	0.63	-0.52	-0.03	-0.08

Werra-Meißner-Kreis, STBE over 60,000 DM

reference level	76.43	20.64	1.20	1.73
(M,F)ALTER	9.45	-7.44	-0.93	-1.08
MDANL	-28.02	19.60	-1.20	9.63
MDALM	8.91	-16.37	4.14	3.32
MDASM	-6.16	3.62	2.23	0.31
FDANL	-16.12	13.41	-0.19	2.91
FDASM	2.23	-6.68	4.00	0.45
FAMGROS	-2.33	1.61	0.38	0.33
KIDZAHL	2.81	-0.64	-0.98	-1.19
EKTUVT	1.21	-1.29	0.07	0.01
STBE	0.21	-0.18	-0.01	-0.02

Non-agricultural and general education (MDANL, MIAS, FDANL, FDASM) have strong effect on the job status of the couple. For example, higher level of non-agricultural education of husband (wife) raises the probability of the 'husband only' (the 'wife only') case and lowers the probability of the 'wife only'(the 'husband only') case. In general, the 'husband only' case is the most sensitive to the changes in these variables. The variables have relatively little influence on the probability of simultaneous participation. Non-agricultural education of the wife is, however, an exception. By comparing the different size groups, we can see that theeffects of these variables are the strongest for the middle-sized group. The increase in family size (FAMSGROS) generally increases and the number of children in family (KIDZAHL) decreases the probabilities of all three participation cases but the changes in probabilities are small for all size groups. It applies to the case of non-labor income (EKTUVT) as well, which has negative effect on both cases that involve female participation. The increase in farm income potential raises the probability of 'no off-farm work'. However, the effects seem to be of the secondary importance in comparison to the non-agricultural education variables.

The importance of age, non-agricultural vocational education, and general education is observed also in Werra-Meißner-Kreis (WMK) (Table 6-10). However, there are two important regional differences. First, increases in education level raise the probability of simultaneous participation in WMK much more strongly than in LEM. Second, the effects of age and education are generally less farm-size-sensitive in WMK than in LEM. In WMK, age and education level affect the couples with large size farm considerably as well as the couples with small and middle size farm. To summarize, the effect of human capital is important in determining which off-farm work combination is chosen and its effect takes different pattern according to the farm income potential and region.

6.6 Summary and Concluding Remarks

In this chapter, the off-farm work decision of agricultural household is analyzed on the basis of the two-person joint utility model. Previous studies on this theme have explained the participation decision of each person in the household using the concept of the reservation wage, which is based on the condition that the other members of the household have positive off-farm work. Based on this approach at the theoretical level, those previous studies used multivariate probit models (in two person case bivariate probit model (BVP)) for the econometric estimation of the participation decision.

This approach is problematic because it does not take into account that the reservation wage of one member cannot be defined independently of the job status of the other members. Indirect utility formulation circumvents this problem and enables us to employ multinomial logit (MNL) model. MNL has its own limit because the assumption about the covariance structure of random part in indirect utility is restrictive. Therefore, a judgment in favor of either BVP or MNP cannot be made a priori. Estimation results on the data set from Emsland and Werra-Meißner-Kreis ('VW data') show that MNL predicts the choice possibility, measured by Hauser test, more accurately than MVP.

Because of the genuine non-linearity in the qualitative choice model, the marginal effects of explanatory variables on the job status choice probability are evaluated for the 'model farms' of three different size groups categorized by potential farm income in each region. Evaluation results on three representative points show that age and education level have important effects on the joint decision about the off-farm work status and that the concrete magnitudes of the effects are influenced by the potential farm income considerably. There are also important regional differences. In Emsland, general and non-agricultural education of the husband (the wife) increases mainly the probability of the 'husband only' ('wife only') case, whereas in Werra-Meißner-Kreis, it increases mainly the probability of the 'simultaneous participation' case. The marginal effects are more farm-size-sensitive in Emsland than in Werra-Meißner-Kreis.

The results of this chapter underline the importance of the household as the relevant decision unit of the agricultural resource allocation. Even when policy measures or changes in labor market situation affect only certain group of agricultural household members directly (for example, young men) in terms of anticipated wage levels, job availability, or economic value of home time, such policy changes can influence time allocation of the other members in the households as well and therefore, the agricultural resource allocation in general, too. Furthermore, the results of this chapter show that the directions and the magnitudes of such intrahousehold cross-effects depend on the farm size and the regional agricultural production conditions. This insight may be important for the design and coordination of economic policies which affect the rural regions because it can help to improve conformity both between political goals and measures and among various measures with different political objectives.

Appendix: The product of the slope of reservation wage line AB and CD around the point P.

This appendix shows that the product of the slope of reservation wage line AB and CD around the point P is always smaller than unity so that the off-farm job status of the couple can be determined unequivocally by the steps described in subsection 6.3.2.

Due to (6-17), the slope of AB around the point **P** is

$$\frac{\partial w_1^*}{\partial w_{m2}} = \frac{-\pi^*_{12} + e_{12}}{\pi^*_{11} - e_{11}} \qquad (6\text{-}34)$$

Note that T_{h2} is zero at **P**. By symmetry, we get:

$$\frac{\partial w_2^*}{\partial w_{m1}} = \frac{-\pi^*_{21} + e_{21}}{\pi^*_{22} - e_{22}} \qquad (6\text{-}35)$$

The denominators in both (6-34) and (6-35) are positive, due to the convexity of the profit function and the concavity of the expenditure function. Therefore, the condition:

$$\frac{\partial w_1^*}{\partial w_{m2}} \frac{\partial w_2^*}{\partial w_{m1}} < 1 \qquad (6\text{-}36)$$

is equivalent to

$$(\pi_{11} - e_{11})(\pi_{22} - e_{22}) - (\pi_{12} - e_{12})^2 > 0. \qquad (6\text{-}37)$$

The inequality (6-37) is in turn equivalent to positiveness of the determinant the matrix:

$$A \equiv \begin{pmatrix} \pi_{11} - e_{11} & \pi_{12} - e_{12} \\ \pi_{12} - e_{12} & \pi_{22} - e_{22} \end{pmatrix}$$

$$= \begin{pmatrix} \pi_{11} & \pi_{12} \\ \pi_{12} & \pi_{22} \end{pmatrix} - \begin{pmatrix} e_{11} & e_{12} \\ e_{12} & e_{22} \end{pmatrix} \tag{6-38}$$

The matrix A is positive definite because the matrix of the second derivatives of the profit function (the first term in the second line of (6-38)) is positive definite and the substitution matrix (the second term in the second line of (6-38)) is negative definite. Thus the determinant of A is positive.

7 Dynamic Aspects of Off-Farm Labor Supply Decision

7.1 Introduction [1]

This chapter deals with the dynamic aspects of off-farm labor supply of farmers in the context of agricultural structural change and regional labor market. As mentioned in Chapter 1, reduction in the agricultural workforce and number of farms and increase in significance of part-time farms have been important elements which characterize the structural changes in agriculture in the industrialized countries.

These elements are well documented on the aggregate level in official statistics. These statistics, combined with the price (opportunity cost) of input and output variables for agricultural production, enable researchers to explain the general tendency of the agricultural structural change process.[2]

An important aspect in the dynamic context of structural change which cannot be satisfactorily addressed by this aggregate level approach is the role of the part-time farming in the process of reduction in agricultural workforce and farms. Figure 7-1 helps to articulate the problem more concretely. The change in agricultural structure is determined by the individual occupational decisions of younger members in agricultural households and of active farmers among the various occupational alternatives, which can be categorized into full-time farming, part-time farming, full-time non-agricultural working and retirement. An aspect of such occupational decisions, which is important especially in the dynamic context of structural change, is the influence of past off-farm work status on the decisions in the subsequent periods. It is of political importance because, depending on whether the past off-farm work status has genuine effects on the decisions to have off-farm work or to exit entirely from agriculture in the future or not, the effects of policy measures that influence the relative advantages of full-time farming and part-time farming will differ. Thus, whether such effect exists has been an important subject of agricultural political debate.

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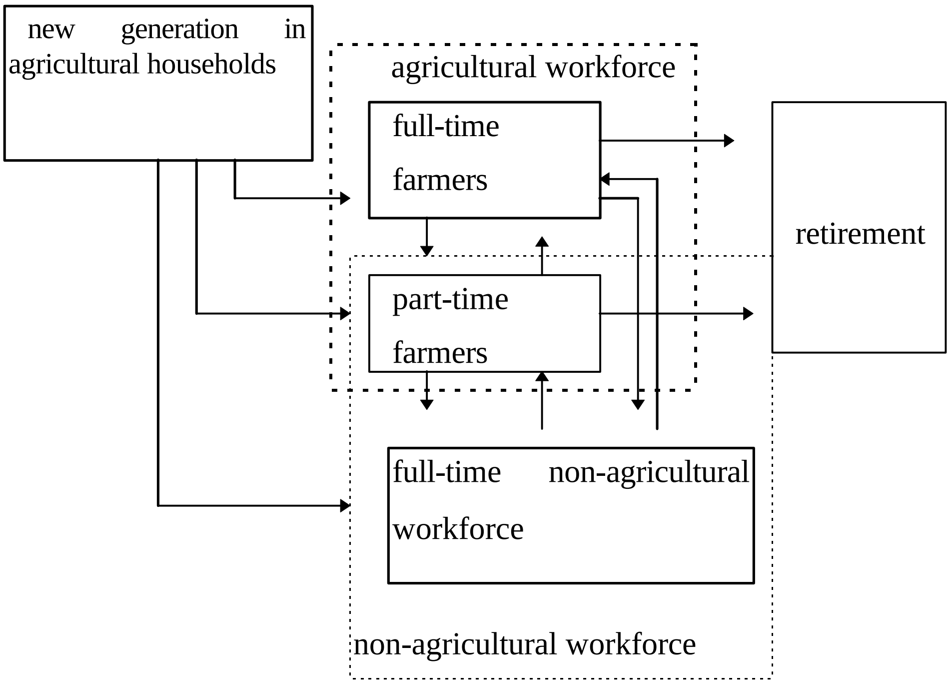
[1] This chapter is the result from the German side in the Israeli-German joint project 'Time Allocation of Farmers over the Life Cycle: The Role of Part-Time Farming in the Process of Structural Change', which was financially supported by Volkswagen Foundation.

[2] See, for example, Andermann, G. und Schmitt, G (1996)

Figure 7-1 Agricultural Workforce and Job Status Change



However, there seem to be relatively few researches on this topic. The main reason for the rarity of the researches on this question is that the panel data which provide information about the job status history of individual farmers are often unavailable. And the few previous studies that had access to such data treat the influence of the past off-farm job status either on the exit behavior or on the off-farm labor supply in the subsequent period but not the two influences simultaneously. Pfeffer (1989), using a survey in Germany in which the farmers were asked prospective questions about the survival and viability of their farms - therefore, not a genuine panel data based on the real occurrence -, found that part-time farmers had lower expectation of the family continuing to farm. Weiss(1996), using an Austrian panel data, found that the off-farm work participation and the amount of off-farm work time had positive effects on the exit from agriculture. Pfeffer and Weiss treated the off-farm work decision as exogenous and concentrate only on its effect on the exit behavior. They did not consider the effect of the present job status on the decision about the off-farm work in the subsequent periods. On the other hand, Gould and Saupe(1989) and Weiss(1997) analyzed the panel data from southwestern Wisconsin in the U.S. and upper Austria, respectively, using a framework that endogenized the off-farm work decision in the first period and investigated the asymmetry between the entry into and exit from the off-farm labor market in the second period. They compared the two participation functions of the first-period off-farm work participant group on the one hand and the first period non-participant group on the other hand, correcting for sample selection bias. Their studies were, therefore, restricted to how the off-farm work status in one period affects the off-farm work status in the next and did not treat its effect on the exit behavior.

The main purpose of this chapter is to improve on the previous studies, taking both aspects into account , i.e. the dynamic effects of off-farm work experience on the exit and off-farm work in the subsequent periods. A panel data set from Nordrhein-Westfalen (**NRW**), which will be referred to as 'NRW-data' , will be used for the empirical analysis.

Another aspect that is taken into account in this chapter is the effects of regional labor market situation on the occupational choice of farmers. The regional labor market situation, which is expressed in variables such as unemployment rate, employment growth rate, and sectoral composition of employment, is believed to influence the off-farm work participation because it influences off-farm wage level, off-farm job availability, and compatibility of off-farm work with farm work. Many of such variables are taken into the estimation of the participation and wage function in static framework[3]. However, most of previous researches on the dynamic aspect of off-farm work participation tried to measure the effect of regional economy by using regional dummy variables. It is meaningful to examine how the various dimensions of local labor market influence farmers' decisions on job status in a dynamic context. Collected from a large geographical unit with much regional differentiation in labor markets, the NRW data set enables the measurement of the effects of regional labor market situation.

This chapter is organized as following. In section 2, the structure of the panel data set will be presented and a casual observation about the correlation between the job status in 1979 and 1991 will be made. Section 3 discusses the conceptual distinction between the structural state dependence and spurious dependence, which is important for the extraction of the genuine structural effect from the observed correlation. Section 4 presents the econometric model to be used for the empirical analysis of the data. The estimation results are presented and discussed in Section 5. The final section summarizes this chapter.

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[3] For example, Gunter and McNamara (1990), Tokle and Huffman (1991), Hearn, McNamara and Gunter (1996)

7.2 Data Structure for Estimation and Some Preliminary Observations

Official aggregate data do not provide information about the dynamic aspects of off-farm work experiences at the individual level. To study such aspects empirically, we need data which enable the identifications of the same persons and farm units over the time periods. A data set provided by the statistics office of state (‘Land’) NRW (Landesamt für Datenverarbeitung und Statistik NRW), which we refer to as NRW data enables such identifications.

7.2.1 Data Structure

The data set is obtained from the agricultural census and the accompanying representative surveys in Nordrhein-Westfalen in 1979 and 1991. The agricultural censuses themselves cover the whole number of farms above minimum criteria. The whole number was 94,917 in 1979 and 69,977 in 1991[4]. Part of the population, about 14,000 farms in 1979 and about 12,000 in 1991, was chosen for the ‘representative survey’ in which more detailed questions in addition to the census questionnaire were asked. Only part of the farms from the representative survey in 1979 was included in the representative survey in 1991. However, the information about the farms that were included in the 1979’s representative survey but were omitted in the 1991’s representative survey can be obtained from the population census in 1991 as long as the farms did not exit between the two survey years because each farm had the same identification number in the two census years.

For this study, a data set with the information about the farms from 1979’s representative survey was available. It comprises:

(1) information from the representative survey in 1979

(2) information from the representative survey in 1991 about the farms which were also in the representative survey in 1979.

(3) information from the agricultural census in 1991 about the farms which were included in the representative survey in 1979 but omitted in the representative survey in 1991, as long as they were included in the census in 1991.

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[4] These are the numbers of the farms which were classified as to be in ‘agricultural production sector’ (Betriebsbereich Landwirtschaft) and whose operator were natural persons.

We can follow up changes or exit of the farms by the farm identification number as mentioned before. Unfortunately, it is not possible for individuals. To identify the individuals over the two survey years, we assume that if the individuals who registered in each survey year are in the same farm, have the same sex, and have age differential 12, then they are one and the same person [5] .

7.2.2 Job Status Transition between 1979 and 1991

Based on the above assumption, Table 7-1, which concentrates on the male operators in 1979, suggests notable influence of off-farm work experience in 1979 on the off-farm work decision in 1991 and on the stay-exit decision between the two survey years.

Table 7-1 Job Status Changes of Male Operators

1991 Farm stayed ?	Yes			No	Total
Person stayed?	Yes		No		
Off-farm Work?	No	Yes			
Off-farm Work in 1979					
No	5723(56.0)	429(4.2)	2991(29.3)	1075(10.5)	10218(100)
Yes	493(21.2)	828(35.6)	587(25.3)	414(17.8)	2322(100)
Total	6216(49.6)	1257(10.0)	3578(28.5)	1489(11.9)	12540(100)

Note: Numbers in parentheses are percent with the row-wise sums as bases.

The ‘farm-based’ exit rates differential is considerably big. About 18% of the farms where male operators were engaged in off-farm work in 1979 disappeared during the two survey years, whereas only 10 % of the other group of farms disappeared. The difference in the ‘person-based’ exit rates is not so high as that in the ‘farm-based’ exit rates but is also in favor of the farmers with off-farm work experiences. About 43 % of the male operators who had off-farm work in 1979 were not found in 1991, whereas about 40 % of the male operators who had no off-farm work in 1979 were not found in 1991.

The difference between the chance for the farmers with off-farm work in 1979 to have off-farm work in 1991 and the chance for the farmers without off-farm work in 1979 to have off-

[5] There were 8 cases for farm operator couples in 1979 that had one but two „matching“ persons in 1991. They were excluded from the sample for the following estimations.

farm work in 1991 is rather large. More than one third of the farmers who had off-farm work in 1979 retained the same job status, whereas only about 4% of the farmers who had no off-farm work in 1979 participated in off-farm work in 1991.

These observations provide motivations for more precise consideration about the effect of off-farm work experiences on the job status choice in the subsequent periods.

7.3 Structural State Dependence and Spurious Dependence

A theoretically and politically interesting question is whether the correlation between the past and the future job status, as observed in the previous section 7.2, is - to use the terminology of Heckman (1981) - due to the 'structural state dependence' or due to the 'spurious dependence'. In the following, Heckman's distinction between the two types of dependence will be summarized and the implication for agricultural structural changes and policies will be discussed.

Spurious dependence means that there might be some persistent unobservable differences among the decision makers in terms of preference or economic constraints that make a certain choice more attractive for a certain decision maker than for others throughout the relevant period. In this case,

> previous experience may appear to be a determinant of future experience solely because it is a proxy for such temporally persistent unobservable. (Heckman(1981) p.92)

On the other hand, structural state dependence means that the experience from a status causes changes in preferences or constraints that in turn 'bias' the decision in the subsequent periods in favor of certain status.

> In this case past experience has a genuine behavioral effect in the sense that an otherwise identical individual who did not experience the event would behave differently in the future than an individual who experienced the event. (Heckmann(1981) p.91)

Translated into the context of the occupational choice of farmers, spurious dependence is at work , for example, if a farm has lower productivity than other farms which appear identical judged by the observable variables, and if this productivity differential is known to the farmer but not to the researcher, and if the low productivity lasts through the concerning period. In this case, the farmer operating the farm with lower productivity **is** more likely to have off-farm work than other farmers who appear identical in terms of observable variables throughout the whole period. The same principle applies also to differentials in off-farm income earning power or in the preference. On the other hand, for example, if the off-farm work experience of a farmer in the present, by way of human capital accumulation, raises his off-farm income earning potential, and if he **becomes**, therefore, more likely to have off-farm work in the following periods than others who are identical in other respects, then we have structural state dependence.

For further sources of such structural state dependence, we can think of (a) changes in the preferences in favor of off-farm work, (b) farm work specific human capital accumulation which enhances the farm income possibilities, and (c) fixed cost entailed by changes in occupational changes.

The distinction between the structural and spurious state dependence is of political interest because the influence of present economic conditions or policies which encourage or discourage off-farm work on the agricultural structure will vary according to how strong the structural state dependence is. If the structural dependence is absent, a policy measure which lowers the income from agricultural production for a given period will raise the probability for the farmers to have off-farm work during that period but the effect will disappear when the policy is not implemented any more. On the contrary, if the structural dependence is present, such policy measures will have enduring effects on the structural change even after they cease to be implemented.

7.4 Model

7.4.1 Theoretical Model

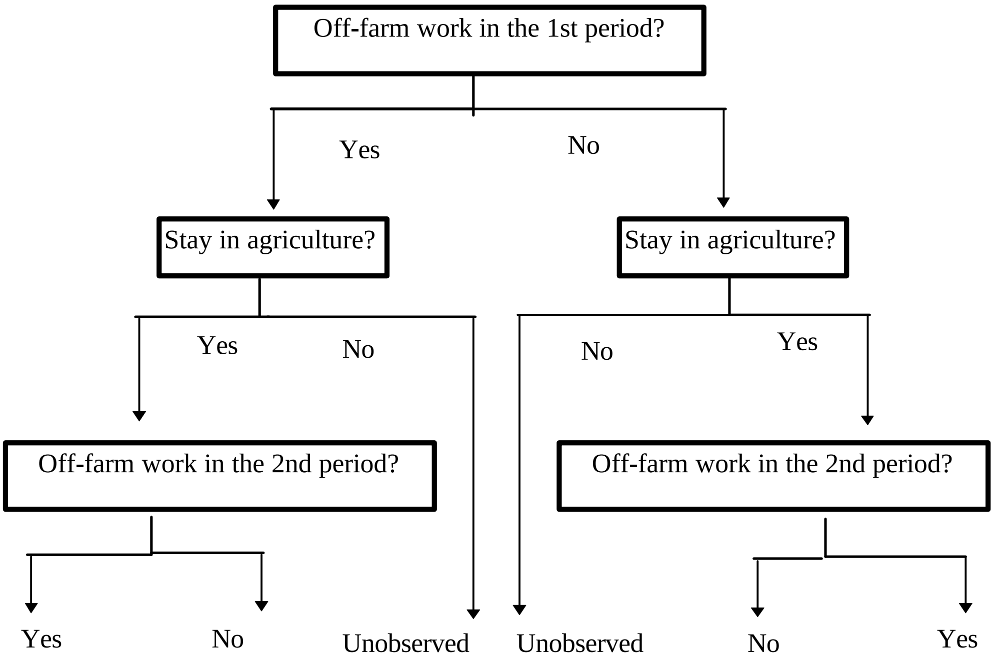
The farmers are assumed to face three stages of decision as depicted in Fig 7-2.

In the first stage, he chooses between the participation and non-participation in off-farm work, referring to

$$y_1^* \equiv G_{11}^*(x_1) - G_{10}^*(x_1) \quad , \tag{7-1}$$

where G_{11} and G_{10} denotes the maximum utility level attainable on the condition of off-farm work participation and non-participation, repectively, given the current exogenous variables (x_1). The farmer decides for positive off-farm work if and only if y_1* is positive.

Figure 7-2 the Structure of the Model



In the second stage[6] , he decides whether to stay in or exit from the agricultural production, referring to

$$y_2^* \equiv G_{21}^* (x_2, y_1) - G_{20}^* (x_2, y_1) \qquad (7\text{-}2)$$

where G_{21}* and G_{20}* denote the maximum utility level attainable on the condition of stay in and exit from agriculture, respectively, given the current exogenous variables (x_2) and the index variable y_1, which stands for the off-farm job status chosen in the first stage. The variable y_1 is one if y_1* is positive and is zero otherwise.

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[6] The distinction between 'stage' and 'period' should be noted. Although there are only two 'periods' of observation, we have conceptually three decision 'stages'

If the farmer exits, his behavior cannot be observed in the third stage. If he stays, then in the third stage, he decides whether to have off-farm work in the second period, referring to

$$y_3^* \equiv G_{31}^*(x_3, y_1) - G_{30}^*(x_3, y_1), \qquad (7\text{-}3)$$

where G_{31}^* and G_{30}^*denote the maximum utility level attainable in the third stage on the condition of participation and non-participation, respectively, given the current exogenous variables (x_3) and the job status in the first stage, denoted by the dichotomous variable y_1.

The vectors of exogenous variables (x_t's) contain the same kinds of variables as used in the previous chapters. To iterate, they are human capital variables (age, education level), household characteristics (family size, non-labor income), and farm income potential. It can be expected that these variables affect the participation decision in the first and third stage in the same direction as they do in the static model discussed in Chapter 4. Their effects on the 'stay or exit' decision in the second stage can be expected to be similar.

In addition to these variables mentioned above, x_t's contain also the variables which represent the local labor market situation. As Gunter and McNamara (1990) noted, regional labor market conditions that decrease the off-farm employment availability or result in a low wage structure are expected to affect the off-farm work participation negatively. Under the same conditions, exit from agriculture can be affected also negatively. However, the exit decision can be expected to be less sensitive to regional labor market situations because it can be combined with emigration from economically unfavorable regions, whereas the choice for off-farm work by the agricultural household members is locally restricted due to their residences.

Dynamic Optimization Aspect: The presentation of the model might give the impression that we are adopting the assumption that the farmer's behavior is myoptical. It might seem so because the model does not explicitly reflect the fact that an economic subject in a dynamic context makes the decision at a given stage on the ground not only of current utility but also of the effects of present decision on the utility in the future. The forward-looking behavior is generally modeled in the dynamic programming framework in labor economics literature. Eckstein and Wolpin (1989) and Berkovec and Stern (1991) present good examples of the empirical researches based on this framework. This approach has the merit of being able to measure the effect of the past job status on the wage. It is, however, not pursued in this chapter due to the following reasons. First, the data set used for this study provides no information about the off-farm labor income of usable quality. It only provides total off-farm work income of the operator couples, which makes no differentiation between labor and non-labor (transfer or asset) income. Even if one can be sure that there is no non-labor income, attribution to the husband or the wife is impossible when both of the couple participate in off-farm work. Second, another data problem is that the time interval between the two observation periods is very long (12 years) and that the farmers who exited from agricultural production are not observed in 1991. Thus, there are very many missing values for the application of structural dynamic programming framework. Third, our model can be considered as a reduction form. The utility V_{t1}'s and V_{t0}'s can be considered as the sum of the current utilities and discounted expected utility conditional on the choice of the alternative s_{t1} or s_{t0}.

7.4.2 Econometric Model

For the empirical implementation of the theoretical models discussed before, we employ the following econometric model suggested by Kimhi [7] .

$$y_1^* = ß_1' x_1 + \varepsilon_1 \qquad (7\text{-}4\text{-}a)$$

$$y_2^* = ß_2' x_2 + \gamma_2 y_1 + \varepsilon_2 \qquad (7\text{-}4\text{-}b)$$

$$y_3^* = ß_3' x_3 + \gamma_3 y_1 + \varepsilon_3 \quad , \qquad (7\text{-}4\text{-}c)$$

where y_i'*s are not directly observed,

y_i's are observable binary variables with

y_i= 1 if y_i^* >0 and y_i= 0 otherwise.

x_i = exogenous variables observed in the i-th stage.

ε_i 's are assumed to have trivariate standard normal distribution.

[7] This model was suggested by Kimhi for the Israeli-German joint project 'Time Allocation of Farmers over the Life Cycle: The Role of Part-Time Farming in the Process of Structural Change'. This chapter is the result of the joint project on the German side.

Off-farm work participation in the first period, stay in the agricultural production, and the off-farm work participation in the second period are represented by $y_1 = 1$, $y_2 = 1$, and $y_3 = 1$, respectively. The opposite cases are indexed with zero.

There are some important points to be discussed about the formulation of this econometric model.

Measurement of Structural Dependence and Spurious Dependence: The main interest of this model lies in the structural influence of off-farm work experience on the stay decision and on the off-farm work decision in the next period. The coefficients γ_2 and γ_3 express the magnitude of the structural dependence. However, in order to estimate the structural parameters properly, we should pay attention to the effect of possible spurious dependence.

Unobserved differences among the farmers in productivity, anticipated off-farm wage and preference lead to the correlations between choice probability in the three stages. To repeat the example in section 7.3, a farmer with lower farm-productivity, which is not explained by the observed variables but is persistent over time, will have higher possibility to have off-farm work in the first and third stage and lower possibility to stay in agriculture in the second stage than other farmers with the same conditions as long as the observed variables are concerned. It will lead to a negative correlation between ε_1 and ε_2 , a negative one between ε_2 and ε_3 , and a positive one between ε_1 and ε_3 .

If the correlations between the disturbance terms are not zero, then separate estimations of the second and third equation or simultaneous estimation of these two equations is inconsistent. It should be noted that Pfeffer (1989) and Weiss (1996), who treat the off-farm work experience as exogenous in estimating the 'exit' function, might have this problem of inconsistency.

Therefore, a maximum likelihood estimation which allows for the correlations between the decision equations of the three stages is needed. Under the assumption of a joint normal distribution of random variables, it amounts to the estimation of trivariate probit model.

Partial Observability Due to Exit: The system (7-4) is distinguished from a usual multivariate probit model by one element. It is the fact that the farmers who exited in the second stage are not observed in the third stage. Bearing this fact in mind, we can build a qualitative dependent model analogy of the attrition bias model of Hausman and Wise (1979). Their model have three equations [8],

$$y_1 \quad = ß' x_1 + \varepsilon_1 \tag{7-5-a}$$

$$y_2^* \ = ß_2 ' x_2 + \varepsilon_2 \tag{7-5-b}$$

$$y_3 \quad = ß' x_3 + \varepsilon_3 \tag{7-5-c}$$

with the observation mechanism that y_3 is observed if and only if $y_2^* > 0$.

where y_1 , y_3 = quantitative dependent variables in period 1 and 2

y_2^* = latent variable which determines whether y_3 is observed.

ε_i 's are assumed to have a joint normal distribution.

If there exist non-zero correlations between ε_i's, then usual estimation method applied only to the units observed in both periods produces inconsistent estimators. To overcome this problem, Hausman and Wise suggest the maximum likelihood estimation where ε_3 for the units unobserved in the second period is integrated out[9] .

Although the system (7-4) differs from the system (7-5) in some respects [10], the problem of inconsistency of estimation restricted only to the units, which are observed in the both periods, applies to the system (7-4), too. The approach of maximum likelihood estimation where ε_3 is integrated out for the units unobserved in the second period can be also applied to the system (7-4), yielding representative likelihood function;

$$\Phi_2(q_1 z_1, -(z_2 + \gamma_2 y_1), -q_1 \rho_{12}) \ \text{ if } y_2 = 0 \tag{7-6}$$

where $$\Phi_2(a, b, r) = \int_{-\infty}^{b}\int_{-\infty}^{a} \frac{1}{(\sqrt{2\pi})^2 \sqrt{1-r^2}} \exp[-\frac{1}{2}(\varepsilon_1 \quad \varepsilon_2)\begin{pmatrix} 1 & r \\ r & 1 \end{pmatrix}^{-1}\begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \end{pmatrix}] d\varepsilon_1 d\varepsilon_2 \tag{7-7}$$

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[8] Notations are changed for conformity with the text.

[9] For the exact form of their likelihood, which we do not present here to concentrate on the system (7-4),see p.459 of Hausman and Wise (1989).

[10] The differences are (i) that (7-4) has qualitative dependent variable not only in the second equation but also in the first and the third equations, (ii) that ß is assumed to be the same in the first and the third equation in (7-5), and (iii) that (7-5) has no endogenous variable on the right hand side of the equations whereas y_1 appears on the right hand side of the second and the third equations of (7-4).

i.e. cumulative density function of the standard bivariate normal distribution

and

$$\Phi_3(q_1 z_1, z_2 + \gamma_2 y_1, q_3(z_3 + \gamma_3 y_1), q_1\rho_{12}, q_3\rho_{23}, q_3 q_1 \rho_{31}) \text{ if } y_2 = 1, \qquad (7\text{-}8)$$

where $\Phi_3(a, b, c, r_{12}, r_{23}, r_{31})$

$$= \int_{-\infty}^{c}\int_{-\infty}^{b}\int_{-\infty}^{a} \frac{1}{(\sqrt{2\pi})^3 |\Sigma|^{\frac{1}{2}}} \exp[-\frac{1}{2}(\varepsilon_1 \quad \varepsilon_2 \quad \varepsilon_3)\Sigma^{-1}\begin{pmatrix}\varepsilon_1\\ \varepsilon_2\\ \varepsilon_3\end{pmatrix}]d\varepsilon_1 d\varepsilon_2 d\varepsilon_3 \qquad (7\text{-}9)$$

with $\Sigma = \begin{pmatrix} 1 & r_{12} & r_{31} \\ r_{12} & 1 & r_{23} \\ r_{31} & r_{23} & 1 \end{pmatrix}$,

i.e. cumulative density function of the standard trivariate normal distribution

$q_i = 2\, y_i - 1$ (y_i's are defined under (7-4))

$z_i = ß_i x_i$, i = 1,2,3.

We should note that, seen from another point of view, this model can be considered to be a three-variable extension of the partial observability model of bivariate probit as discussed by Meng and Schmidt (1985). In their bivariate model, y_2 is observable only when y_1*is positive. Therefore, ε_2 is integrated out in the likelihood function for the observations with $y_1 = 0$, simplifying the likelihood into a univariate normal distribution function. In our model, y_1 and y_2 are always observable, whereas y_3 is observable only when y_2* is positive, i.e. the endogenous dummy variable y_2 is unity. Therefore, ε_2 is integrated out in the likelihood function for the observations with $y_2 = 0$, simplifying the likelihood into a bivariate normal distribution function.

7.5 Estimation and Results

7.5.1 Variables Used in the Estimation

Table 7-2 shows the descriptive statistics of the variables used in the estimation of system (7-4).[11] The first three variables are endogenous. The farmers were asked how many hours they worked off-farm in April 1979 and 1991, repectively. The Farmers who reported positive work time are coded to have dummies DOFF79 and DOFF91 equal to 1. The dummy DSTAY is one if the farmer who was male operator in 1979 could be identified also in 1991 according to the assumption mentioned in subsection 7.2.1. Age is a proxy variable for general work ability and experiences. The dummy DAL2, which represents agriculture-specific human capital, is one if the farmer reported in 1979 to have diplomas from middle-level agricultural vocational schools („Landwirtschaftsschule“ or „höhere Landbaus-, Technikschule“). The dummy DANL shows whether the farmer had any non-agricultural vocational qualification.

LSIZE is log of ‘standard farm income’ (Standardbetriebseinkommen) which represents the farm income potential according to the German agricultural statistic scheme.

Table 7-2 Descriptive Statistics of Variables

Variable	Definition	Mean	Standard Deviation
DOFF79	dummy for off-farm work in 1979	0.185	0.388
DSTAY	dummy for stay in agriculture	0.596	0.491
DOFF91	dummy for off-farm work in 1991	0.168	0.374
AGE79	age in 1979	46.010	11.125
DAL2	agricultural training or education	0.604	0.489
DANL	non-agricultural training or education	0.142	0.349
LSIZE79	log of standard farm income in 1979	3.454	1.158
FAMILY79	number of family members in 1979	4.683	1.9053
LSIZE91*	log of standard farm income in 1991	3.453	1.416
FAMILY91*	number of family members in 1979	4.340	1.700

n=12540

Note: * - based on the farms of the farmers who were observed in 1991

[11] The estimation was carried out with MAXLIK Version 4, an application module written in the matrix language GAUSS.

To capture the effects of regional market situation as discussed in the theoretical section, previous empirical studies used variables such as regional unemployment, labor market size (measured by size of labor force), employment growth rates, and shares or growth rate of shares of industries that provide relatively more part-time jobs in the employment.[12] This approach is followed also in this study, using three kinds of regional labor market variables: unemployment rate (ALQ79,ALQLT,ALQ91), increase in the share of private service sectors in employment (DSHPRI79, DSHPRILT, DSHPRI91), and growth of total employment (JOBGR79, JOBGRLT, JOBGR91). Unemployment rate, decreasing the off-farm job availability and generally having negative effect on the wage level, is expected to affect the off-farm work participation and exit from agriculture negatively. The growth of total employment is an indicator of favorable dynamism in the regional labor market and thus is expected to encourage off-farm work and exit from agriculture. Generally in the developed countries, in West Germany, and in NRW as well, the service sector grows faster than the other sectors and is important for creating new jobs. In addition to this general effect, the service sector is usually believed to have more flexible work hour requirements which would enable farmers to combine off-farm job with farm work more easily. Therefore, an increase in the share of service sector in the regional economy is considered to affect off-farm work and exit from agriculture positively.

Their descriptive statistics by 54 'Kreis's are in Table 7-3. ALQ79 and ALQ91 are unemployment rates of each survey year. As the unemployment rates in 1979 were not available by Kreis but only by bureau of labor (Arbeitsamt), the number of regional unit is not 54 but 33. DSHPRI79 and DSHPRI91 are the percent differentials between the shares of private service sectors in whole employment between 1978 and 1979 and between 1990 and 1991. JOBGR79 and JOBGR91 are the rate of increase (in percent) in the whole employment. These variables are used as the explanatory variables for the participation functions of each observation year. DSHPRILT and JOBGRLT are defined in the similar way as their short-run counterparts except that they are defined from the differentials between 1979 and 1991. ALQLT is defined as the average of the yearly unemployment rates not from 1979 but from 1984 until 1991. There are two reasons for this definition of ALQLT. First, the yearly

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[12] Gunter, L and McNamara (1990), Tokle and Huffman (1991) and Hearn, McNamara and Gunter (1996)

unemployment rates by Kreis are available only from 1984. Second, the unemployment rates in the early 80's are not representative for this decade because there was a jump in unemployment rate around 1983 in the whole Germany as already shown in Table 3-2 in Chapter 3.

Table 7-3 Descriptive Statistics of Regional Labor Market Variables

Variable	N	Mean	Std. Dev.	Minimum	Maximum
ALQ79	33	4.0	1.08	2.3	6.3
DSHPRI79	54	0.67	0.47	-0.72	2.60
JOBGR79	54	1.63	1.08	-1.29	3.73
ALQLT	54	10.2	2.33	6.9	15.6
DSHPRILT	54	3.96	2.79	-3.14	10.40
JOBGRLT	54	11.76	12.19	-13.47	39.40
ALQ91	54	7.3	2.05	4.3	12.6
DSHPRI91	54	0.88	0.46	-0.044	2.41
JOBGR91	54	2.33	1.16	-0.12	4.81

7.5.2 Estimation Results and Discussions

Table 7-4 is the result of the trivariate probit model with partial observability. The estimation was done over 12540 male farmers who were reported as farm operators in 1979. The first and the third columns present estimates of the off-farm work participation function in 1979 and 1991. The second column presents the estimate of ß's in the equation (7-4-b) i.e. the propensity to stay in agriculture, which will be refereed to as 'stay function' in the following discussion.

Age is important for all three functions. As usual in the literature about off-farm work of farmers, the age effect is in reverse U-shaped form, reaching the peak at the age of middle thirties and at about the age of forty for the first and second participation functions, respectively. For the stay function, the peak of the age effect is reached already at the age of early twenties. This observation implies that the exit from the agriculture of the male farm operators takes place mainly in the form of retirement.

Table 7-4 Parameter Estimation Results of Trivariate Probit Model with Partial Observability

	Participation 79 (DOFF79)		Stay (DSTAY)		Participation 91 (DOFF91)	
CONSTANT	-0.879	(0.254)***	-0.814	(0.213)***	-4.222	(0.923)***
AGE (1)	0.109	(0.0102)***	0.035	(0.0083)***	0.245	(0.0348)***
$AGE^2/100$ (1)	-0.143	(0.0110)***	-0.077	(0.0092)***	-0.296	(0.0367)***
DAL2 (2)	-0.238	(0.0331)***	0.163	(0.0273)***	0.0348	(0.0561)
DANL (2)	0.709	(0.0381)***	-0.074	(0.0446)**	0.280	(0.0627)***
LSIZE (1)	-0.659	(0.0123)***	0.163	(0.0256)***	-0.357	(0.0191)***
FAMILY (1)	0.0772	(0.0084)***	0.0742	(0.0071)***	0.0035	(0.0151)
DOFF79	-	-	0.285	(0.141)**	1.270	(0.131)***
ALQ (3)	-0.0570	(0.0196)***	0.0037	(0.0087)	-0.0562	(0.0246)**
DSHPRI (4)	0.149	(0.0518)***	-0.0112	(0.0050)**	-0.0223	(0.0479)
JOBGR (5)	-0.0210	(0.0181)	0.0063	(0.0013)***	-0.0288	(0.0266)
ρ_{12}	-0.125	(0.0780)*				
ρ_{23}	-0.259	(0.220)				
ρ_{31}	0.165	(0.0721)**				

n = 12540

-2 Log likelihood ratio = 56045

Note: The numbers in the parentheses are standard errors.

Note:

(1) For the first two columns the values are as of 1979 and for the last column as of 1991.

(2) For all three columns the values are as of 1979

(3) ALQ79, ALQLT and ALQ91 for the first, the second, and the third column, respectively.

(4) DSHPRI79, DSHJPRILT and DSHPRI91 for the first, the second, and the third column, respectively.

(5) JOBGR79, JOBGRLT and JOBGR91 for the first, the second, and the third column, respectively.

Agricultural education(DAL2) has a negative and significant effect on the 1979 participation function and a positive and significant effect on the stay decision, as expected. Its influence on the participation decision in 1991 is positive and seems to contradict the theory, but is statistically not significant. This insignificance suggests that a depreciation of the human capital which had been accumulated from the agricultural vocational education before 1979 took place. Non-agricultural vocational qualification (DANL) has, as expected, statistically significant positive influences of considerable magnitudes on the participation in both survey years. Its effect on the stay decision has also the expected negative sign and is statistically significant.

The coefficients of family size (FAMILY) have positive signs in both participation functions but only the coefficient in participation function in 1979 is significant. Its positive signs are in accordance with the theoretical considerations in Chapter 4 according to which a larger family size lowers reservation wage by changing the marginal rate of substitution between home time and income in favor of income (‘more mouths need more bread’). FAMILY has a positive and significant coefficient in stay function. Large family size might at least indicate the higher availability of family labor, which can raise farm productivity evaluated around the point of zero farm work labor (i.e. exit from agriculture). Consequently, the stay in agriculture might be more attractive in a large-sized family than in a small-sized family.

The farm income potential (LSIZE) has expected signs and is important in all three functions. However, the influence on stay decisions does not seem to be as strong as on participation decisions.

The main focus of this chapter is on the structural dependence effect of off-farm work experience (DOFF79) on the stay and participation decision. In the participation function from 1991, DOFF79 has a positive, statistically significant coefficient of a great magnitude, which overwhelms those of agricultural education and non-agricultural qualification. It suggests that the off-farm work experience changes the preference or economic restriction (off-farm and on-farm earning potential) in favor of job-combination over ‘full-time farming’. A more interesting result is the effect of DOFF79 on the decision to stay in agriculture. In contradiction to what one would expect from a simple cross tabulation in Table 7-1, off-farm work experience does not have a negative but a positive sign in the stay function and the null hypothesis cannot be rejected at the conventional significance levels. Therefore, job combination, *ceteris paribus*, raises the advantage of staying in the agriculture. As no structural model is specified for the exit decision, it is difficult to deliver a clear economic reason for the above observation. However, some plausible, even though not rigorous, conjectures could be made. They are discussed at the end of this section (7.5.3).

Another important aspect is the effect of the variables which describe the development in regional labor markets. A higher current regional unemployment rate (ALQ) reduces the participation probabilities in both survey years. Regional average unemployment rate of the years from 1979 to 1991 has a positive sign in the stay function, as expected. However, the estimate is not statistically significant. The increase in the share of private service sectors in employment (DSHPRI) is significant and has a positive coefficient in the first participation function and a negative coefficient in the stay function. It corresponds to the expectation that growing importance of service sectors encourages job-combination and eases the exit from agriculture. DSHPRI has, however, a negative sign in the participation function in 1991 but its coefficient is not statistically significant. This result might reflect the changes in the quality of workforce that the service sectors demand. The proportion of 'simple' jobs in service sectors which could be easily combined with farm-work could have been reduced. However, a decisive conclusion is not possible without further detailed researches. Total employment growth in the region (JOBGR) has negative and insignificant coefficients in the two participation functions. It is probably due to the aggregate character of the variable and suggests that overall employment growth itself is not a sufficient condition for the farmers' off-farm work participation and there are some matching conditions to be fulfilled. (The result on the effect of the growth in the private service sectors discussed above supports this idea.) Surprisingly, JOBGR has a positive and significant sign in the stay function. It might, again, suggest the inappropriateness of the aggregate variable as an indicator for the availability of 'relevant' occupational alternatives to farming.

The estimates of the three correlation coefficients have expected signs. The correlation coefficient between the participation function in 1979 and the stay function is negative and statistically significant. It means that the negative correlation between off-farm work and stay in agriculture observed in Table 7-1 is partly due to the spurious dependence. The correlation coefficient between the two participation functions are statistically significant. Thus, the positive serial correlation of the off-farm work participation is attributable not only to the state dependence but also to the spurious dependence.

7.5.3 Possible Reasons for Positive Effect of Off-farm Work Experience on Stay Decision

As mentioned in 7.5.2 the estimation result shows positive and statistically significant effect of off-farm work experience on stay decision. Because the econometric model used is not in structural form, one cannot deliver definite explanation for this observation. However, some plausible sources of this phenomenon can be named.

First, if the exit from agriculture means an occupational change into a full-time non-agricultural job, it will often mean a discontinuous jump in time allocation and not a result of continuous expansion of off-farm work time. It implies that the full-time non-agricultural job and the off-farm work that was and is available to the farmer are different in their work hour flexibility. Then, it is possible that a farmer A who had an off-farm job and can still keep the job finds the job-combination option better than the full-time non-agricultural job option, whereas another farmer B who had the same characteristics as the B but did not have an off-farm job in the previous period due to some random factor, and therefore, has difficulties finding off-farm job finds better to choose the full-time non-agricultural job option.

Figure 7-3 Choice between job combination, full-time farming and full-time off-farm job

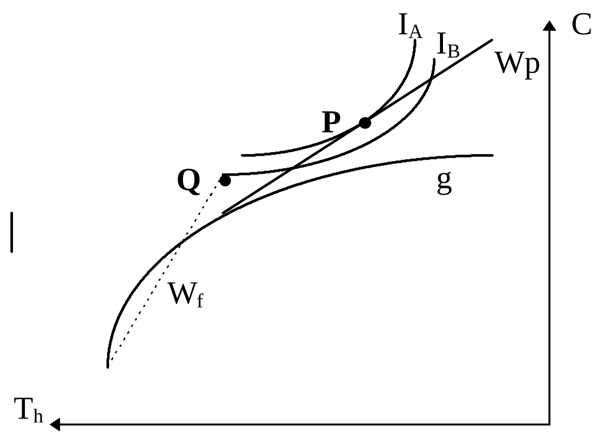

Figure 7-3 shows a drastically simple example of such situation with farmer A and farmer B. Point **P** is the choice of the farmer A who could and can still combine his farm work with an off-farm job, represented by the wage line W_p. For farmer A, **P** is a better choice than **Q** which means exit from farm production and a job with a higher average wage represented by the wage line W_f and fixed work time. However, for another farmer B, **Q** is a better choice if , for example, the part-time off-farm job represented by W_p is not available to him hypothetically because he did not have off-farm job in the previous period. This example is extreme in assuming that the availability of part-time off-farm job totally depends on the off-farm job experience in the previous period. However, under more realistic assumption such as positive effect of job experience on the wage or on the possibility of retaining the same job, the main point of argument still holds.

Second, the exit from farm or farm work can be related to the residential change. It is another source of discontinuous jump in the choice space and therefore the same logic as above is also valid here. If two farmers are identical in other respects, but if one of them, A, has off-farm work experience and therefore has some advantage over B in wage or job availability in the current period, then the stay in agriculture is more attractive for A than for B.

Third, the job-combination can have the effect of risk-dispersion, raising the financial stability of the farm. It can make the choice of stay in the agriculture more probable.

7.6 Summary and Concluding Remarks

This chapter deals with the effects of past off-farm work participation experience on the off-farm work participation and exit decisions. The correlations between past off-farm work experiences and present off-farm work participation and exit from agriculture can result both from the structural state dependence due to the genuine changes in preferences and economics constraints and from the spurious dependence due to the unobserved heterogeneity among farms and farmers.

A trivariate probit model which consists of the participation function for the first period, stay function for the time between the first and the second period, and the participation function for the second period is estimated. The effects of state dependence are measured by the coefficients of the first period off-farm work dummy variable in the stay function and in the second period participation function. The spurious effects are taken into account by allowing non-zero correlation between the three functions. In addition, partial observability caused by exits of significant portion of farmers is also taken into account.

The estimation results from the NRW data set show that there exists considerable positive structural dependence concerning the effect of the previous off-farm work experience on the off-farm work decision in subsequent periods and that the stay decision is not negatively but positively affected by the off-farm work experience. In addition, the estimation results show that the regional labor market situation plays an important role in the off-farm work decision of farmers and suggests that the availability of jobs with high work time flexibility might be important for the off-farm work participation of farmers.

The results of this chapter have the following implications for policy.

First, even policy measures whose implementation is timely limited can have enduring effects on the occupational decisions of farmers. The same principle can hold also for the labor market situation. Therefore, if policy makers regard the off-farm labor supply of agricultural households as a desirable political goal, for example in economically disadvantageous areas, then the policy measures with the character of 'start help' can be meaningful.

Second, the discussions on relative stability or instability of part-time farms in comparison to full-time farms could be misleading if the structural state dependence with genuine behavioral effect is not conceptually distinguished from spurious dependence which reflects the correlations among unobserved variables. One could observe the serial correlations between the past off-farm job status and the exit from agriculture. Such observation is important as the description of tendency. However, political recommendation either for or against part-time farming in order to achieve certain policy goals (for example, preserving regional agriculture) cannot be made directly based on such observation if the structural state dependence are not correctly extracted from the correlations.

Third, the positive effect of past off-farm experience on stay decision in farm, which is shown by the estimation results, may be an indication that part-time farming can play a positive role in the structurally weak rural areas which are losing population because of the disadvantageous economic conditions. Of course, we should keep in mind that the estimation result is based on the observation about personal exit from agriculture and not about the exit of farm from the agricultural production or emigration persons from a region. However, occupational decisions and residential decisions may be related with each other in some degree. If it is the case, part-time farming can be a contributing factor to preservation of sound settlement and economic structure in rural areas [13], which is among the important goals of economic policy in the developed countries.

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[13] 'Sicherung ländlicher Gebiete als funktionsfähige Siedlungs- und Wirstschaftsstruktur'. See Bundesministerium für Ernährung, Landwirtschaft und Forsten (Federal Ministry of Nutrition and Agriculture) (1989)

8. Summary

This dissertation deals with off-farm labor supply of agricultural households in three different contexts of resource allocation; the farm labor supply behavior, the intrahousehold interdependence in time allocation, and the occupational choice in the context of dynamic agricultural structural change.

Due to the difficulties in constructing and estimating a 'grand' model which could encompass all of the three aspects and the unavailability of a data set which would make implementation of such model possible, the three aspects are treated separately. However, all of them are analyzed within the framework of the agricultural household model.

The agricultural household model provides a unifying microeconomic framework for the understanding of decision of agricultural households on consumption, production, and time allocation. This 'unification' is important because agricultural household in most countries is complex of farm firm, supplier of agricultural production factors, and consumer. In the analysis of behavior of the agricultural households in the developed countries, the agricultural household model is especially useful for understanding their time allocation decision. Based on a simple model, it is shown that the off-farm work participation decision can be explained by combining human capital theory and the concept of the shadow price of time.

The agricultural household model shows that the difference between the determination of the economically relevant price of time of the 'full-time farmers' and of the 'part-time farmers' will lead to the different reaction patterns of farm work supply to changes in the economic variables. The estimation results of from an econometric model, which integrates the qualitative participation decision and the quantitative farm labor supply based on a data set from Emsland and Werra-Meißner-Kreis, seem to support the prediction of the theory. Part-time farmer's farm work time is much more sensitive to farm income potential than full-time farmer's. On the other hand, farm work time of full-time farmers is more sensitive to age and household relevant variables. This finding highlights the potential problem of assessing the farm productivity or of predicting the production reaction to the changing economic situations under the assumption of homogenous farmers as profit maximizers.

Interdependence in the off-farm work participation decision of the agricultural household members is a relatively new research topic. Many of the previous researches try to generalize the concept of the reservation wage in the one-person model and apply multivariate probit model (MVP) for econometric estimation. This approach has the problem that it does not take

into consideration that the reservation wage of one member cannot be defined independently of the off-farm job status of the other members. Indirect utility formulation circumvents this problem and enables application of employ multinomial logit model (MNL). The Estimation results on the data set from Emsland and Werra-Meißner-Kreis show that MNL predicts the choice possibility more accurately than MVP, judged by Hauser's statistic. The concrete evaluation of the predicted probabilities shows that age and education level have important effects on the joint decision about the off-farm work status and the concrete magnitudes of the effects are considerably influenced by farm size and region. The interdependence in off-farm work decision underlines the importance of the household as the relevant decision unit of agricultural resource allocation. Policy measures or changes in the labor market situation, which affect only certain group of the agricultural household members directly in terms of anticipated wage levels, job availability or the economic value of home time, can influence time allocation of the other members in households and therefore, agricultural resource allocation in general, too.

The widely observed correlations between the past off-farm work experiences and the present off-farm work participation and the exit from agriculture can result not only from the structural state dependence due to the genuine changes in preferences and economics constraints but also from the spurious dependence due to the unobserved heterogeneity among farms and farmers. Using a panel data with 12 year interval from Nordrhein-Westfalen, the trivariate probit model which consists of the participation function for the first period, the stay function for the time between the first and the second period, and the participation function for the second period is estimated. The model takes the partial observability caused by exits of significant portion of farmers from agriculture into account. The estimation results show that there exists considerable positive structural dependence regarding the effect of past off-farm work experience on the off-farm work decision in the subsequent periods and that the off-farm work experience does not reduce but increases the possibility for a farmer to stay in agriculture. These results suggest that even policy measures whose implementation is timely limited can have enduring effects on the occupational decisions of farmers on the participation in the off-farm labor market. Another important point to be drawn from the results is that a discussion on the effect of part-time farming on the stability or instability could be misleading if the correlations between the job status in different time periods are confused with the genuine behavioral effect of a past experience on the decision in the subsequent periods. Finally, the results on the stay decision indicate that part-time farming can contribute to the preservation of settlement and economic structure in rural areas.

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