An Economic Analysis of the Farmland Market and Farmland Abandonment in Japan

by

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No portion of this work referred to in this thesis has been submitted in support of an application for any other degree or qualification from this or any other university or institutes of learning

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Abstract

With the advent of globalisation, Japanese agriculture is under strong pressure to reform. Despite highly protectionist policies, Japanese agriculture has declined significantly and now faces problems relating to sustainability and the livelihood of rural communities. The failure of Japan to develop its agricultural structure, especially the enlargement of farming units, has been a key factor. This thesis analyses the farmland market in Japan, testing its efficiency against theoretical models and examining farmland policy and structural change. Using time series data, test results support the theoretical model, with the possibility of structural breaks also recognised in some regions in 1967 and 1980, when the regulation of farmland market changed drastically. Results also indicate that the market is not as efficient as in the UK or US.

The thesis also examines the recent increase of abandoned farmland in Japan. A theoretical model is developed to include the effect of ageing of the agricultural population. The results imply that farmland abandonment is mainly caused by the rapid increase of farmland supply and ageing of the agricultural population, but that the level of cash rent (i.e., profitability of land) is of little or no importance. The protective agricultural policy and strong regulations on agricultural land transactions helped small-scale farmers to remain in agriculture until the 1980s. However, these farmers face difficulty in surviving due to the serious fall in producers' prices (especially rice) and the high rate of ageing in the agricultural population. Moreover, in these circumstances, farmers are not motivated to extend their scale.

Small-scale family farming system played a major role in Japanese agriculture after post-war period, but the recent increase of farmland abandonment shows the limit of this type of farming system. Farmland policy needs to be reformed in order to achieve an agricultural structure that is more competitive. In the past this has failed due to the strong regulations on farmland transactions. However, the development of an agricultural policy framework is necessary to support agriculture's multifunctionality. Finally, farmland abandonment is also a problem in other parts of the world, for example the mountainous areas of Europe, and the Japanese experience may provide an interesting insight for other countries.

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Chapter 1. Introduction

"We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect".

(Aldo Leopold (1886-1948), quoted in *The Quiet Crisis* by Stewart L. Udall, 1963)

1-1. Japanese Agriculture under Globalisation

With the advent of globalisation, Japanese agriculture is under strong pressure to reform, as is the case in many countries. The World Trade Organisation (WTO) is insisting that countries open-up their domestic markets to imports of agricultural commodities and food products. Japan's bilateral Free Trade Agreements (FTAs)[1] also require the elimination of trade barriers, including those in the agricultural sector.

Modernisation and development of the farming structure has been an important aim of Japanese agricultural policy. Several policy instruments have been applied to encourage the enlargement of the scale of farming. Nevertheless, the increase in average size of farm has been minimal (e.g., from 0.99 ha in 1960 to 1.79 ha in 2000[2]), and far from that achieved in other OECD[3] countries. Besides, the status of agriculture in the national economy has rapidly declined. For example, the share of agricultural production in gross domestic production decreased from 9.0 % in 1960

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[1] FTAs with Singapore in 2001, and with Mexico in 2004. Future agreements are expected with Korea, ASEAN and Thailand.

[2] MAFF, Japan, '*Report of Farm Economy Survey*' in 1960, and '*Survey on Farm Management Trend*' in 2000. Non-commercial farms are not included in the data for 2000.

[3] Or ganisation for Economic Co-operation and Development.

to 1.2 % in 1998[4]. The proportion of farm households in total households was 29.0 % in 1960 and 7.2 % in 1999, while the share of the agricultural workforce in the total workforce was 26.8 % in 1960, dropping to 4.6 % in 1999[5]. Depopulation and ageing of the agricultural population is widely evident in many farming areas, and the need of rural development and an increase in the number of farming successors have been stressed at the grass root level and by policy makers.

Meanwhile, the area of farmland abandonment in Japan has increased dramatically, particularly in both urban farming areas and hilly and mountainous areas, more than doubling from 99,000 ha in 1975 to 210,000 ha in 2000. This issue is considered very important in terms of loss of multifunctionality: landscape degradation, loss of biodiversity and water ecosystem, and in some cases is linked to natural disasters such as flooding and landslides which may block community roads. It is also noted that farmland abandonment in rural areas invites production damage due to the invasion of wild animals, which also often leads to a chain reaction of further abandonment (Ohe, 2001). Japan introduced in 2000 a new direct payment to support farmers in hilly and mountainous areas in order to prevent further increases of farmland abandonment. This is categorised as falling in the Green box[6] in WTO terminology.

There is also a concern expressed in some quarters about Japan's low self-sufficiency

[4] Ministry of Finance, Japan, '*National Economic Accounting*'.
[5] Min istry of Public Management, Home Affairs, Posts and Telecommunications, Japan, '*Labour Force Survey*' and '*Population Census*'.
[6] WT O distinguishes the type of domestic support into three categories; amber, blue and green boxes. All domestic support measures considered to distort production and trade (with some exceptions) fall into the 'amber box'. Conversely, a subsidy which would not distort trade, or at most cause minimal distortion, is categorised in the 'green box'. Subsidy relating to production control such as production quota and set aside, which is said to distort trade less than alternative amber box subsidies, falls in the 'blue box' (see also, http://www.wto.org/).

rate, although over production of rice has been a serious problem.

1-2. Rational or Irrational?

As in many countries, agricultural policy in Japan has mainly targeted improvements in production and farmers' income. However, responding to a series of domestic agricultural problems and international trends, a new agricultural policy framework aims at four main pillars: to achieve a stable food supply based on an increase of domestic production; enhancement of multifunctionality subject to agricultural production; sustainable agricultural development; and rural development.

Thus, the concept of 'development' in Japanese agricultural policy has changed dramatically. Development as defined by neo-classical economists tends to be evaluated by financial success. This is because, conventionally, it is assumed that economic suppliers (or producers) are profit (or income) maximisers; and economic demanders (or consumers) are utility (or satisfaction) maximisers (Brockway, 1995). Thus, man in the neo-classical economic theory is a 'rational' animal, maximising both profit and utility. However, what is rationality? Hahn and Hollis (1979) claim that rationality can be interpreted as an 'egoism' if a person's choice is all explained as the choosing of 'most preferred' alternatives. However, to examine actual choices of people is the only way to understand their real preferences, and those actual choices are not always explained by their most preferred choice. Sen (1979) aims to depart from the 'unsympathetic isolation abstractly assumed in Economics', which is based on the word of Edgeworth (1881), in order to explain these phenomena, and claims that it is important to distinguish between two separate concepts: 'sympathy' and 'commitment'. In the case of 'sympathy', a person's concern for others directly affects that person's welfare. In other words, the knowledge of torture of others makes a person sick, which is sympathy. Thus, in this case well-being is psychologically dependent on someone else's welfare. Meanwhile, 'commitment' is that the knowledge of others' pain does not make one feel personally worse off, but he/she thinks it is wrong and is ready to do something to stop it. Thus, the behaviour based on sympathy is in a sense egoistic, and commitment is a sense of duty. Sen also defines that in the terminology of modern economic theory, 'sympathy' is a case of 'externality'[7] (e.g., pollution, loss of the natural environment), and 'commitment' is close to 'moral', which of course may cover a very broad spectrum (from religion to politics). The government often applies law or regulations in order to prevent the events brought by a sum of egoistic behaviours. However, the world market distortion by some government interventions has been highlighted especially in recent international trade negotiations, and the free market system has been favoured. It is believed that a free market system induces 'rational' behaviours, while a regulated market system encourages 'irrational' behaviour, in the neo-classical economics use of these terms.

Now, a question is raised: is farmland abandonment the result of rational behaviour of Japanese farmers, or irrational behaviour stemming from the distorted market system? However, it needs to be noted that the area of abandoned farmland in Japan is increasing even though the farmland market system has become less and less regulated. Godo (1998) stresses that the farmland market system in Japan is heavily distorted, and it is a failure of policy that even inefficient farmers can own land as a source of wealth-seeking benefit (e.g., capital gain or tax preference). He also claims that farmland abandonment would not have appeared if the farmland market was

[7] Sen claims that many economic models (e.g., a Pareto optimum) rule out 'externality'.

efficient. This thesis examines these issues from both aspects; policy and the farmland market system.

1-3. Objectives and Methods of the Study

1-3-1. Objectives

Research into the farmland market is very important for the further structural reform of agriculture in Japan. However, farmland issues in Japan have been conducted mainly in the areas of sociology, geography and agricultural engineering, and not much in the area of economics. A lot of aspects are considered as factors leading to farmland problems (e.g., financial, geographical and family). Nevertheless, there is a belief that the Japanese farmland market is inefficient in economic terms, but at present there is not enough evidence to support this claim. In this study, the main interest is to analyse the Japanese farmland market; how the farmland market structure influences farmers' behaviour to land, namely decisions of selling, letting or abandoning.

First, it is necessary to understand farmland policy and its background, to identify what factors influence the farmland market. It is also of interest to test if the Japanese farmland market is inefficient as is believed. Has there been policy impact on the farmland market throughout the observed period (from 1955 to 2000)? It is also of interest to find out how the farmland market system is associated with today's farmland problems, which may provide useful insights for strategies of farmland policy reform as a part of future agricultural structural reform. In addition, this study may also provide meaningful insights for the enlarged EU in which some new member countries have experienced rapid change in terms of their farmland market system, and are already facing a high rate of farmland abandonment.

1-3-2. Research methods

1-3-2-1. Farmland valuation theory

In order to understand the farmland market, farmland valuation theory has been well researched in the UK, US and Canada. Shi *et al.* (1997) divide the literature on agricultural land price into two categories; studies which use asset-pricing or capitalisation models, and studies which use hedonic pricing models. The former implies that the value of an asset is equal to the discounted value of all future expected earnings, the Present Valuation Model (PVM), and the latter uses non-farm factors to explain variation in agricultural land prices, ranging from the valuation of urbanisation and urban fringes, to soil and site characteristics, and erosion control and soil conservation (Oltmer and Florax, 2001). In order to understand the impact of farmland policy on the farmland market over time, the former method is applied in this thesis.

1-3-2-2. Testing farmland valuation theory

If the farmland market functions efficiently, then land prices should be determined by market fundamentals, e.g., agricultural land profitability. In order to test the market efficiency, the PVM has been widely applied in studies assuming that there is a consistent relationship between asset prices and returns. However, the farmland market has some unique characteristics – high transaction costs, immobility and differences in farming conditions, etc. Since the late 1980s, it has been pointed out that farmland price movements cannot be explained well by the asset-pricing model, although this model embodies economic theory (e.g., Burt, 1986; Featherstone and

Baker, 1987). Meantime, the issue is raised that if time series data are not integrated by the same order, then the traditional time series regressions may show a spurious relationship (Engle and Granger, 1987). Responding to this, unit root tests and cointegration analysis have been applied in more recent studies in order to test the PVM in farmland price formation. In this study, unit root tests and cointegration analysis are applied to Japanese time series data on farmland prices and rent.

1-3-2-3. Building a model for farmland abandonment

The next point of interest is to understand the increase of farmland abandonment within the theoretical framework. A model is constructed for this purpose based on the PVM. Due to the limitation of time series data on farmland abandonment, a panel data set. Recently, unit root tests and cointegration have been developed for panel data (e.g., Levin and Lin, 1992; 1993; Im *et al.*, 1997; Harris and Tzavalis, 1999; Harris and Sollis, 2003). Some of these tests are applied in the present study.

1.4. Organisation of the Study

This thesis consists of eight chapters. Organisation of the remaining seven chapters is as follows, with a summary in Figure 1-1.

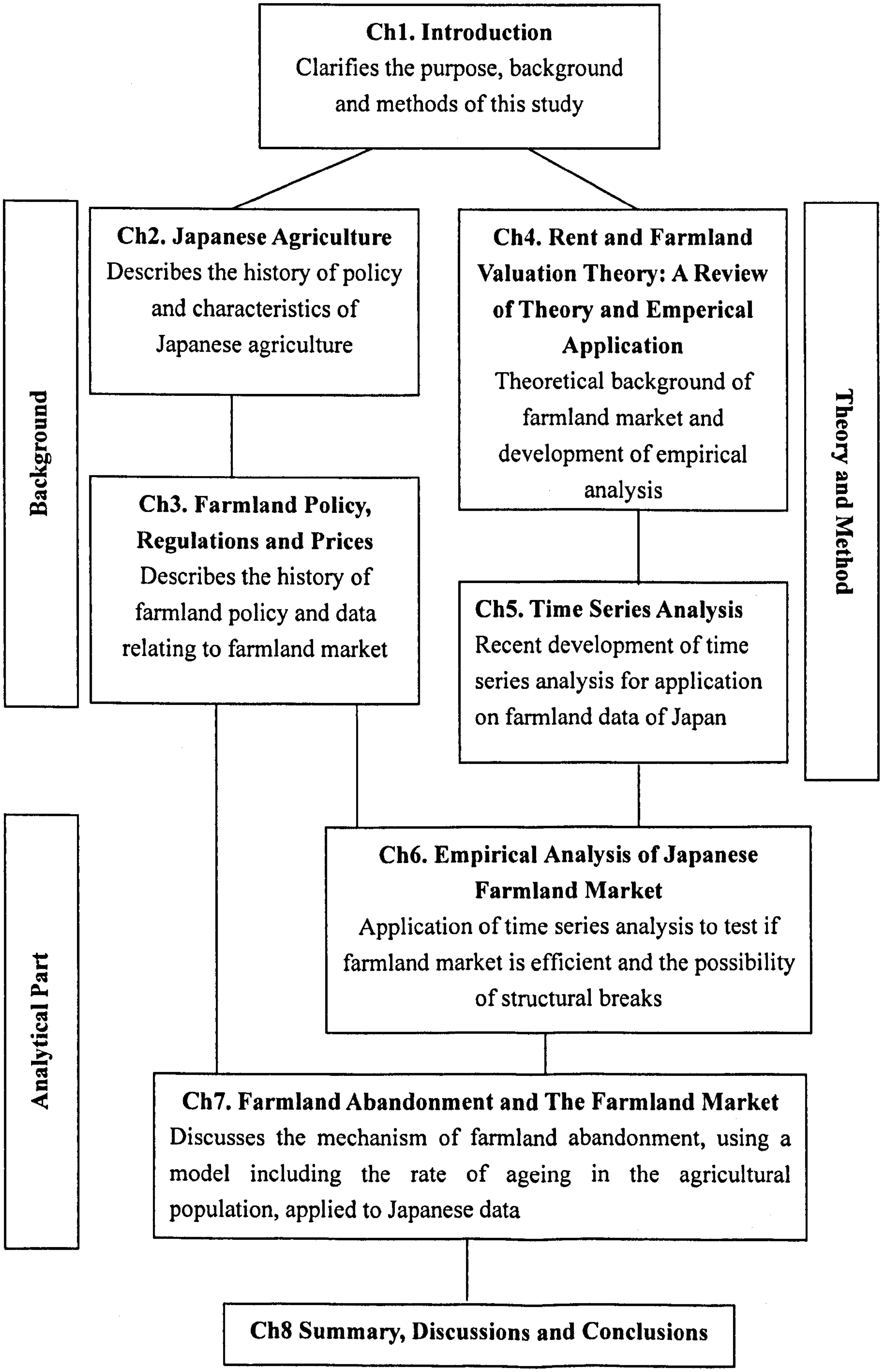
Chapters 2 and 3 provide an understanding to the policy background. Chapter 2 describes the history of agricultural policy and characteristics of the Japanese farming system. The problems that Japanese agriculture has faced, mainly relating to farmland issues, are also outlined in this chapter. In Chapter 3, the development of farmland policy is overviewed since the basic framework of agricultural land policy should have strongly influenced land use and farmland transactions. As well as detailing the characteristics of the Japanese agricultural policy framework, the impacts of regulations on farmland market are also discussed.

Chapters 4 and 5 are theoretical and methodological reviews. Chapter 4 tracks the theoretical development relating to land from Ricardian rent theory to recent PVM models. Due to land being a unique commodity compared to the normal agricultural products, the theoretical concept of the farmland market (e.g., the stock and flow concept) and price determination in the land market are carefully reviewed. Recent developments in time-series analysis, i.e., the concept of unit root and cointegration analysis, as well as testing procedures, are reviewed in Chapter 5.

Chapter 6 and Chapter 7 contain the empirical analysis. Chapter 6 tests if the Japanese farmland market follows the theoretical price determination. First, a simple unit root test is applied, and subsequently the possibility of a structural break in the tested period is also considered. After applying a test for a cointegration relationship, the presence of a rational bubble in farmland prices is tested. Chapter 7 studies the mechanism of recent increases of farmland abandonment. First, the mechanisms of the farmland market and farmland abandonment are discussed. A model for farmland abandonment is constructed, based on the PVM model, including the rate of ageing in the agricultural population, and tested.

Chapter 8 is a concluding chapter which consists of a summary of each chapter, and discussion of the results, providing implications for farmland policy reform and possible future research.

Figure 1-1 Thesis organisation



Chapter 2. Japanese Agriculture

2-1. Introduction

Japanese agriculture is unique compared to European agriculture in terms of land use and agricultural policy. In order to understand Japanese agricultural land issues, it is also important to understand the history and basic principle of agricultural policy, and characteristics of the Japanese farming system. Japanese agricultural policy can be characterised into four time periods; the post-war period, the rapid economic growth period, the production surplus period, and the policy reform period. The aim of this chapter is to overview the development of agricultural policy in Japan first, and then outline the problems which Japanese agriculture has faced, highlighting characteristics of the farming system.

2-2. Development of Agricultural Policy in Japan

2-2-1. Post -war period

From the end of World War II to the mid 1950s was the period of economic recovery and social reconstruction from feudalism to democracy. Providing the staple food supply was one of the most important objectives in order to underpin the stability of the national economy. Staple foods (rice, wheat and barley) were controlled and distributed by the Food Agency of the Ministry of Agriculture, Forestry and Fisheries (MAFF) under the Food Control Law enacted during the war (1942). That basic system lasted until 1995 when the New Food Policy was introduced. Under the new policy framework, the government controls only stockpiled rice[1] and minimum access rice[2], and the price determination of rice has shifted to the market system since then.

2-2-2. Rapid economic growth period

From the mid 1950s until the early 1970s, Japan achieved rapid economic growth. In this phase, the focal agricultural problem was how to adjust to the growing Japanese economy. The Agricultural Basic Law, enacted in 1961, reflected the central issues of Japanese agriculture at that time. The main policy objectives addressed were to diminish the productivity gap between the agricultural sector and the non-agricultural sector, and to equalise the living standards between them. The Japanese government tried to speed up the growth in agricultural productivity through the improvement of the agricultural structure (Hayami, 1990). The major task had been to expand farm size to enable farms to utilize modern labour-saving technologies efficiently, while shifting production from commodities such as rice to commodities such as meat and milk, which are more income elastic and in which Japan is not at so great a comparative disadvantage as in field crops (Hayami, 1990).

Price support policy reinforced by border protection was the main policy instrument for achieving income parity with other sectors. Before the Agricultural Basic Law in 1961, the only products covered by agricultural pricing policies were rice, wheat, raw silk, feedstuffs, and potatoes for industrial use. However, since then, pricing policies

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[1] As Japan faced a serious shortage of rice in 1993 due to the poor harvest of rice, stockpile of rice was institutionalised in this new policy framework.

[2] The minimum amount of imported rice, which is agreed at the Uruguay Round of multilateral trade negotiations (General Agreement on Tariffs and Trade, GATT) in 1994.

have been extended to cover livestock products, vegetables, fruit, soybeans, rapeseed, sugar beet and sugar cane. The prices received by producers for most commodities covered by price support are based on production costs and some concept of income parity[3](Australian Bureau of Agricultural and Resource Economics, 1988). Import quotas were used to protect domestic producers and maintain price stability. In addition to the import quota restrictions, imports of several agricultural commodities were controlled by governmental or semi-governmental agencies. For example, rice, wheat, and barley imports were regulated by the Food Agency; imports of beef, butter, and powdered milk were controlled by the Livestock Industry Promotion Corporation; sugar and silk imports were controlled by the Silk and Sugar Price Stabilization Corporation; and leaf tobacco imports were regulated by the Japanese Tobacco Corporation (Hayami, 1990). Deficiency payments from the government were applied to a limited number of products such as soybeans, rapeseed, and milk for processing.

The other objective for Japanese agricultural policy after 1961 was to attain higher productivity through improving the structure by enlarging farm size. A large percentage of capital formation was financed by government subsidies, especially in the case of investment in land infrastructure (e.g., improvement in the size and congruence of farmlands, and improvement of irrigation systems). As for other measures, farmers have received preferential treatment in the taxation system in terms of their income and properties. These preferential treatments became obstacles to overcome in the development of an efficient agricultural sector in Japan because

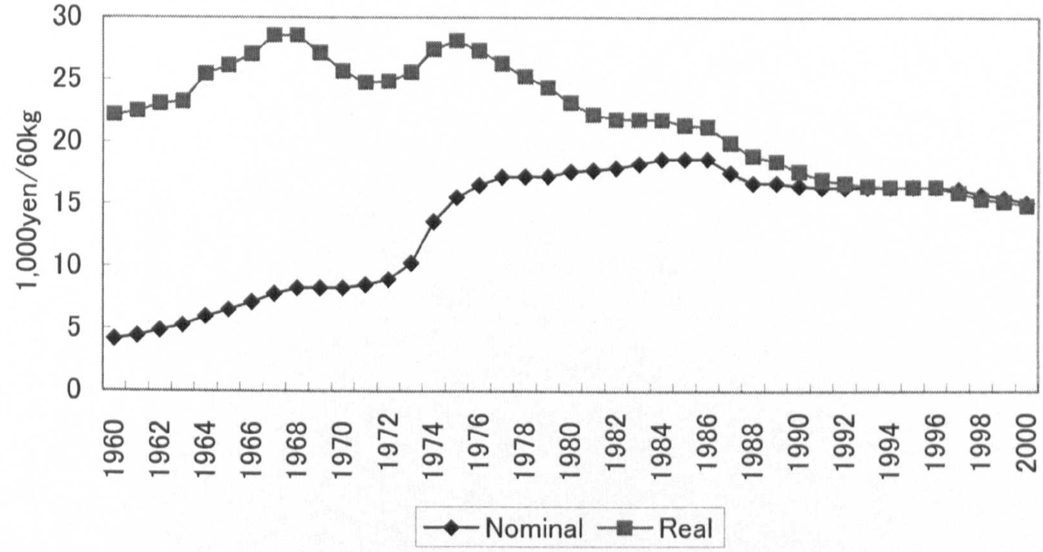
3 For example, as to rice, the government buying-up (producers') price was based on a 'price parity system' which reflects the producers' purchase index such as production materials and daily commodity until 1960. The price determination system was changed to a 'production cost and income compensation system' in 1960, and stronger producer protectionism had been reflected on the rice price since then (Kusakari, 1998).

they were a disincentive to inefficient small-scale farmers to move out of agriculture (Australian Bureau of Agricultural and Resource Economics, 1988).

2-2-3. Production surplus period

As the result of price support, increases in the price of rice stimulated domestic production, although domestic demand of rice declined steadily after the peak in 1963. An accumulation of surplus rice in government storage increased, and the fiscal burden from the rice control programme escalated to the level of about 40 % of the agricultural budget at the end of the 1960s (Hayami, 1990). In response to this, the government introduced a production control programme from 1971, which encouraged farmers to convert from rice into other production, as well as implementation of set-aside with compensational subsidies. Faced in 1987 with the prospect of surplus accumulation for the third time, the government reduced the producer price of rice by 5.95 percent (see Figure 2-1), the first reduction in 31 years (Hayami, 1990). Table 2-1 shows the implementation of rice production control since 1971. The targeted area has been increased year by year. This has also brought some conflicts in local communities between farmers who do not want to follow the production control and administrators who must allocate it equally in regions, although the 'achievement ratio' has not been worsened visibly.

Figure 2-1 Producer price of rice (Government buying-up price)[4]



Source: Food Agency, Japan, *Document on Producer Price of Rice* (1960-72), MAFF Japan, *Annual Statistical Report of Food Supply* (1973-)

[4] Th e price is for unpolished rice. As the rice price is strongly controlled by the government buying-up price until the introduction of the market pricing system in 1995 under the New Food Policy, producer price of rice is close to the government buying-up price.

Table 2-1 Implementation of production control for rice

Year	Targeted Area (1,000ha)	Achievement Ratio (%)	Name of Programme	
1971	547	98	Measures for conversion of rice	
1972	520	108		
1973	498	112		
1974	325	98		
1975	244	111		
1976	215	91	Measures for multi-utilisation of paddy field	
1977	215	99		
1978	391	112	Stage I	Measures for restructuring of paddy field utilisation
1979	391	121		
1980	535	109		
1981	631	106	Stage II	
1982	631	107		
1983	600	106		
1984	600	103	Stage III	
1985	574	103		
1986	600	103		
1987	770	102	First Stage	Measures for establishment of paddy agriculture
1988	770	103		
1989	770	103		
1990	830	103	Late Stage	
1991	830	103		
1992	700	108		
1993	676	106	Measures for development of paddy farming	
1994	600	102		
1995	680	101		
1996	787	100	Measures for promotion of new production control	
1997	787	102		
1998	963	99.5	Measures for promotion of urgent production control	
1999	963	100.0		
2000	963	100.9	Measures for establishment of paddy agricultural operation	
2001	1,010	100.2		
2002	1,010	100.5		
2003	1,060	-		

Source: MAFF, Japan

2-2-4. Policy reform period

The Japanese high protection system of domestic production has prevented the achievement of one of the most important objectives, that of improvement of agricultural structure. Moreover, international pressure on Japanese protectionism has become stronger because the price of products such as beef, oranges and rice were so far out of line with international prices (Hayami, 1990). Thus, the structure of Japanese agriculture has not been competitive with world markets. Low self-sufficiency, except for rice, also became a major concern in terms of food security (see Table 2-2), as well as rural community sustainability due to ageing in the agricultural population and the decline of agriculture in general. Beginning with the report released by MAFF in 1992, entitled The Basic Direction of New Policies for Food, Agriculture and Rural Areas, the new policy system has been introduced gradually. The biggest change was that the Food Control Law was abolished, and the New Food Policy implemented in 1995. Under the new policy, the government controls only rice for national stock and minimum access rice from abroad; the direct intervention in the rice market was abolished and the price of rice has become determined under the market system. In 1999 The Basic Law on Food, Agriculture and Rural Areas was enacted in order to establish a new policy structure aiming to harmonise producers and consumers, and urban areas and rural areas:

"The objective of this Law is to stabilise and improve people's lifestyle and to develop the national economy through comprehensively and systematically implementing policies on food, agriculture and rural areas by means of establishing basic principles and basic matters for realising them and clarifying the responsibilities of the state and local governments. (Objective, Article 1)"

This basic law has four principles: 1) Securing a stable food supply, 2) Fulfilment of multifunctional roles, 3) Sustainable agricultural development, 4) Development of rural areas. The change of policy objectives and targets is overviewed in Figure 2-2. In achieving a stable food supply, the self-sufficiency rate is targeted at 45 per cent for example in 2010, which is a 5 per cent point increase in 2000 in calorie base (Table 2-2). Furthermore, under this new policy framework, bringing to the end the price support policy, direct payments for farmers in less-favoured areas were introduced in 2000. A workshop on production control has been established by the MAFF from 2002 to discuss the future system, evolving towards a system whereby farmers can chose either acceptance with compensation, or rejection without subsidy from the authorities which allocate the quota.

Table 2-2 Self-sufficiency of major products in Japan

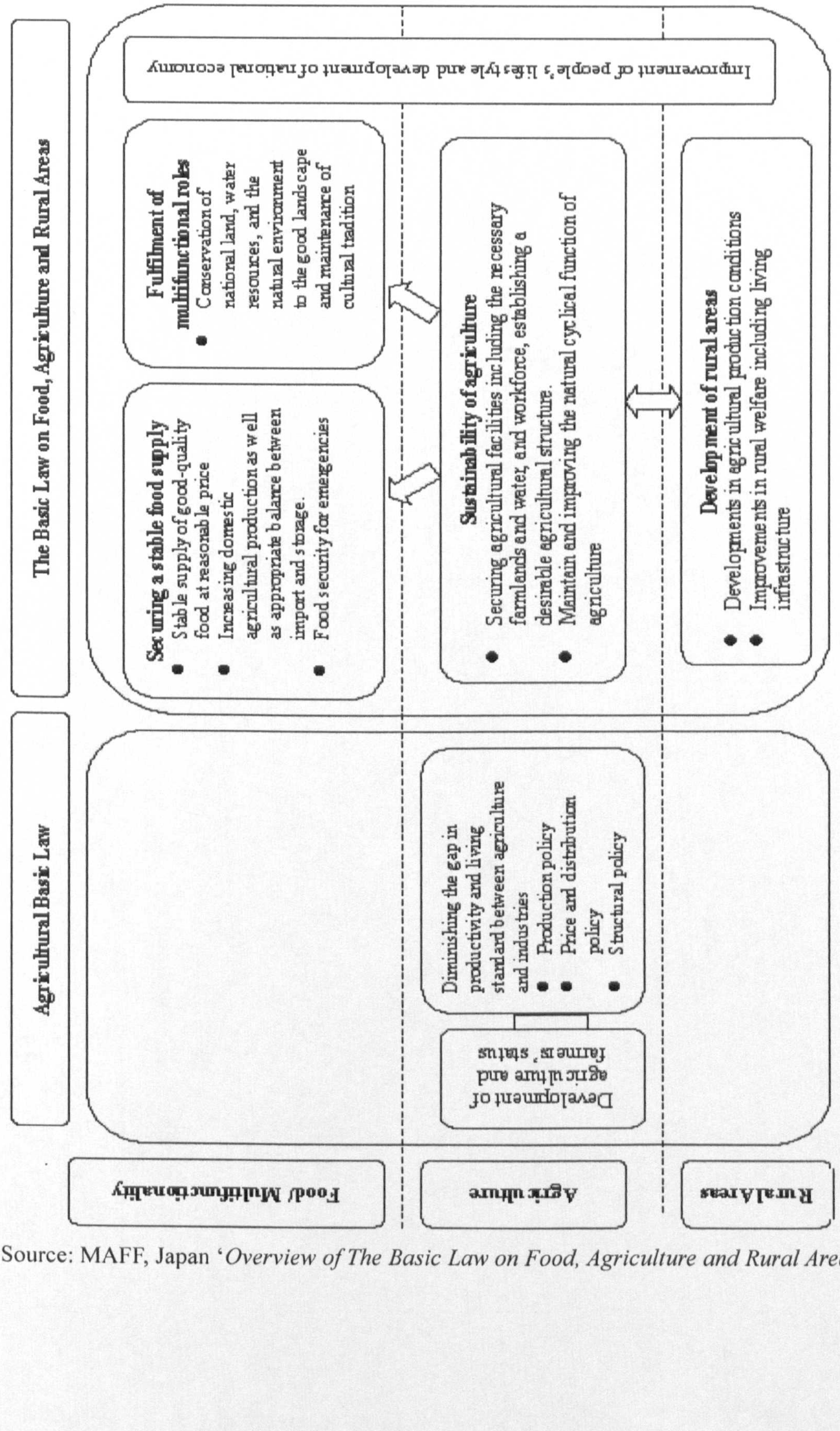
Unit: %

Year	Rice	Wheat	Barley	Potatoes	Soybean	Vegetables	Fruits	Beef	Pork	Poultry	Sugar	Feeding stuffs	Self-sufficiency rate in calorie base (Total)
1965	95	28	73	100	11	100	90	95	100	97	31	55	73
1975	110	4	10	99	4	99	84	81	86	97	15	34	54
1985	107	14	15	96	5	95	77	72	86	92	33	27	53
1990	100	15	13	93	5	91	63	51	74	82	32	26	48
1995	103	7	8	87	2	85	49	39	62	69	31	26	43
2000	95	11	7	83	5	82	44	33	57	64	29	26	40
(2010)	(96)	(12)	(14)	(84)	(5)	(87)	(51)	(38)	(73)	(73)	(98)	(35)	(45)

Source: MAFF, Japan, '*Report of Self-Sufficiency in Food and Food Balance Sheets*', (2000), '*Basic Plan for Food, Agriculture and Rural Areas*'

Note: The rate of self-sufficiency of feeding stuffs is determined by using the amount converted into total digestible nutrients (TDN). The amount of 2010 is targeted self-sufficiency rate set by government. Self-sufficiency rate = domestic production / domestic consumption supply *100. Self-sufficiency rate (calorie base) = domestic production supply in calorie / total domestic supply in calorie *100.

Figure 2-2 Policy target of the Basic Law on Food, Agriculture and Rural Areas



Source: MAFF, Japan '*Overview of The Basic Law on Food, Agriculture and Rural Areas*'

2-3. Agricultural Land

Agricultural land is defined as land which is used for agricultural production. Arable land is only used for agricultural crop production, not including pasture. However in Japan extensive livestock production based on pasturing which is dominant especially in less-favoured areas in European countries is still rare. Grassland and orchard are often included in 'vegetable fields' in the official data, as the amount is very small. Therefore, it is noted that the analysis of agricultural land in this section is focused on arable land use.

2-3-1. Area of arable land

The area of arable land has decreased gradually as can be seen in Figure 2-3. For example, total area of arable land was about 6 million ha in Japan (excluding Okinawa prefecture) in 1962, but 4,830,000 ha in 2000. This large reduction of farmland area is caused mainly through natural disaster and artificial farmland conversion into non-arable use[5]. Figure 2-4 shows that a lot of farmland was lost during 1960s and 70s. As seen by the breakdown of ruined land[6] into 'conversion for non-arable use', 'farm or forest road / afforestration', and 'abandonment etc.[7]', farmland conversion to non-agricultural use is outstanding during this period, because of the strong demand for non-agricultural land following rapid urbanisation. During this period, a conflict became clear between urban planning, which tried to enclose a lot of farmland for urban use, and agricultural policy, which tried to keep as

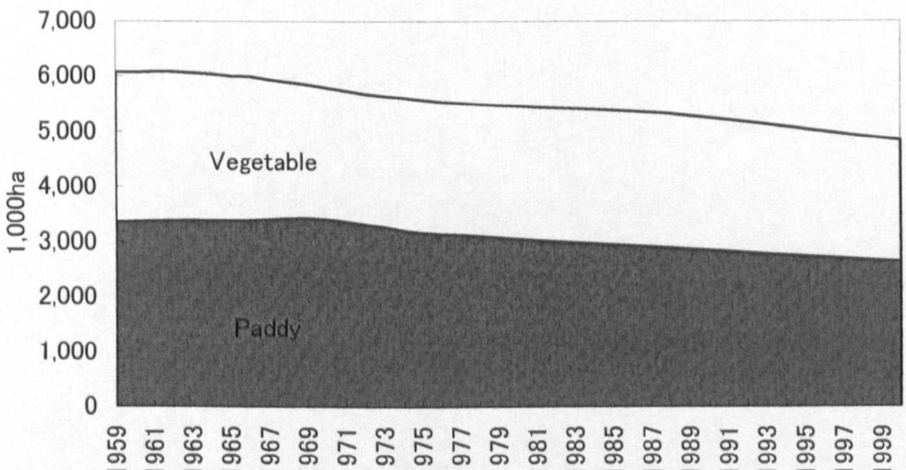
[5] Here, non-agricultural use means converting to woods, wasteland, pasture and ponds as well as building industrial factories, roads or railways, and residential houses. The definition is from MAFF *Survey on Area of Arable Land and Area under Cultivation.*

[6] Land ruined by natural disasters is excluded.

[7] Altho ugh most of land is abandoned, this category includes lands that have sunk under the water, and used for river site. Converted land for 'uncertain reason' was added here as well.

much farmland as possible, even in urban or suburban areas. The decade from 1966 was the peak of the reduction of farmland; from 80,000 to 100,000 ha of farmland disappeared every year. This was also attributed to 'Farmland abandonment, etc' categorised in Figure 2-4. This was the first big phase of farm retirement, because of labour demand in non-agricultural industries and the clear gap between agriculture and non-agricultural sectors in terms of productivity and living standards. Although the rapid urbanisation which invaded farming areas slowed down, the farmland loss through abandonment etc. has continued due to the ageing of farmers and the shortage of successors.

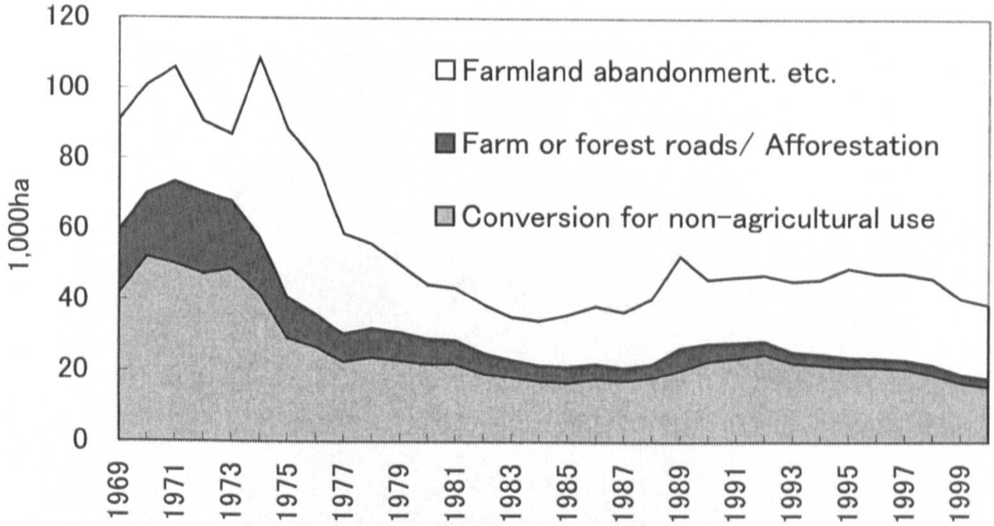
Figure 2-3 Total arable land



Source: MAFF Japan, *Survey on Area of Arable Land and Area under Cultivation*

Note: Orchard and grassland are contained in 'vegetable'.

Figure 2-4 Breakdown of non-natural ruined agricultural land



Source: MAFF Japan, *Survey on Area of Arable Land and Area under Cultivation*
Note: The data breakdown is only available from 1969.

2-3-2. Land use

Table 2-3 shows the state of land use of Japan, Hokkaido, and the prefectures[8]. The area of paddy field in 2000 is 2,641,000ha which is 54.7% of total arable land in Japan, while vegetable land is reported at 2,189,000ha (45.3%). As seen in the breakdown of non-paddy fields, land for vegetables is 1,188ha (24.6%), orchard is 356ha (7.4%), and grassland is 645ha (13.4%). However, Hokkaido has a very different land use from other prefectures. In Hokkaido, the ratio of paddy field is about one fifth of total area of arable land, whilst the percentage of grassland is larger than that of vegetable fields. Conversely, the ratio of paddy field is almost two-thirds of total arable land in the prefectures. With regards to non-paddy field, the rate of vegetable fields is largest and that of grassland is quite small. The area of orchard is 9.7 % of all land use.

[8] Hokkaido is excluded from this data.

The land use in classified farming areas[9] is seen in Table 2-4. Paddy field is mostly dominant in the urban farming area; 65% of total arable land in this area. However, in other faming areas - flat, hilly and mountainous - more than half of arable land is paddy field. In terms of orchard and grassland, all farming areas have very small percentages. Considering that the flat farming area tends to have large-scale physically favoured farms, while less-favoured areas (LFAs) tend to be located in hilly and mountainous areas, the land use is not obviously different with regard to the condition of farming area.

Table 2-3 The state of arable land (2000)

Unit: 1,000ha (%)

	Total	Paddy	Non-Paddy			
			Total	Vegetables	Orchard	Grassland
Whole Japan	4,830	2,641 (54.7)	2,189 (45.3)	1,188 (24.6)	356 (7.4)	645 (13.4)
Hokkaido	1,185	235 (19.8)	950 (80.2)	414 (34.9)	4 (0.3)	532 (44.9)
Prefectures	3,646	2,406 (66.0)	1,239 (34.0)	774 (21.2)	353 (9.7)	112 (3.1)

Source: MAFF Japan, '*Survey on Area of Arable Land and Area under Cultivation*'

[9] As to definition of farming areas, see Appendix 2-1.

Table 2-4 Land use in classified faming area (1995/2000)

Unit: %

Area	Paddy field		Vegetable field (Grassland)		Orchard	
	1995	2000	1995	2000	1995	2000
Urban	63	65	24 (4)	25 (2)	9	8
Flat farming	58	59	34 (2)	36 (1)	5	5
Hilly farming	50	52	35 (5)	36 (2)	10	9
Mountainous farming	53	55	35 (6)	36 (3)	6	6

Source: MAFF, Japan, *Agricultural Census* 2000

Note: Grassland is the area which is used for pasture or grazing in addition to arable land.

2-4. Problems of Japanese Agriculture

2-4-1. Agricultural population and change in farming structure

Depopulation has been serious in rural areas since the mid-1950s. Particularly, young labour flowed from rural areas to urban and industrialised areas seeking job opportunities. Table 2-5 shows the number of farm households and the agricultural population. The number of farm households was 6,057 in 1960, which was 29.0% of the total number of households, however it declined rapidly and halved to 3,120 (6.7%) in 2000. The Japanese MAFF has been involved actively in rural development programmes mainly through agricultural supports, because agriculture has been still the main industry in the majority of rural areas (OECD, 1995). Since first establishment of the Rural Community Integrated Development Project in 1973, projects for the improvement of rural living conditions have been implemented in many ways. Besides, the establishment of non-agricultural industries was also encouraged in rural areas based on the Rural Industry Promotion Act, enacted in 1971, in order to create new employment opportunities.

Table 2-5 Farm household and farm population

Unit: 1,000 (% of total)

	1960	1970	1980	1990	2000
Farm household	6,057	5,342	4,661	3,835	3,120
	(29.0)	(19.7)	(12.9)	(9.3)	(6.7)
Farm Population	344,110	265,950	213,660	172,960	134,600
	(36.5)	(25.4)	(18.3)	(14.0)	(10.6)

Source: MAFF Japan, *Agricultural Censes* and Ministry of Public Management, Home Affairs, Posts and Telecommunications, Japan, *National Census*

Note: Farm population is total number of farm household members. The numbers in the brackets are the rate of farm households out of total households and the rate of agricultural population out of total population respectively.

This kind of policy movement also induced a particular farming type in Japan: small-scale part-time farming operated by senior farmers. Table 2-6 shows that the ratio of part-time agricultural households is quite high, especially for type II, which mostly engages in off-farm work increased from 1960 to 1975. A lot of farmers have been able to find full-time or part-time job opportunities whose payment is relatively high within their commuting area, accompanying the development of infrastructure and cars. In addition, Table 2-7 shows the farm population according to age category, with the ratio for the whole agricultural population. It is noted that members of farm households who are less than 40 year-old decreased as well as the proportion of total farm household members, while senior members have increased. Especially, members who are over 65 years old notably increased in the last decade.

As rice is a staple food and a key production for the majority of farmers in Japan, government stressed the price stability of rice through the price support system as well as the improvement of technology, including breeding. The Japan Agricultural Cooperatives (*Nokyo*) have taken important roles not only to spread new technology and new breeding, but also to collect regional agricultural production and distribute it to wholesale markets. Therefore even with scale inefficiencies and lower intensity of cultivation, a part-time farmer is guaranteed a fairly good return (Hillman and Rothenberg, 1988), and it is even possible to farm by spending only weekends due to a quite well-organised rice production support system by the government and the *Nokyo* (Kusakari, 1998). These support systems enabled a lot of small-scale part-time farm households to maintain themselves financially and physically even for aged farmers. Actually, they have attained a higher average income than that of other households[10], mostly because of increases in off-farm income (Figure 2-5).

[10] Hil lman and Rothenberg (1988) mention one reason for the rise in farm household income was commodity price supports. However, according to Figure 2-5, the main reason is due to off-farm income increase.

Table 2-6 The type of farm household

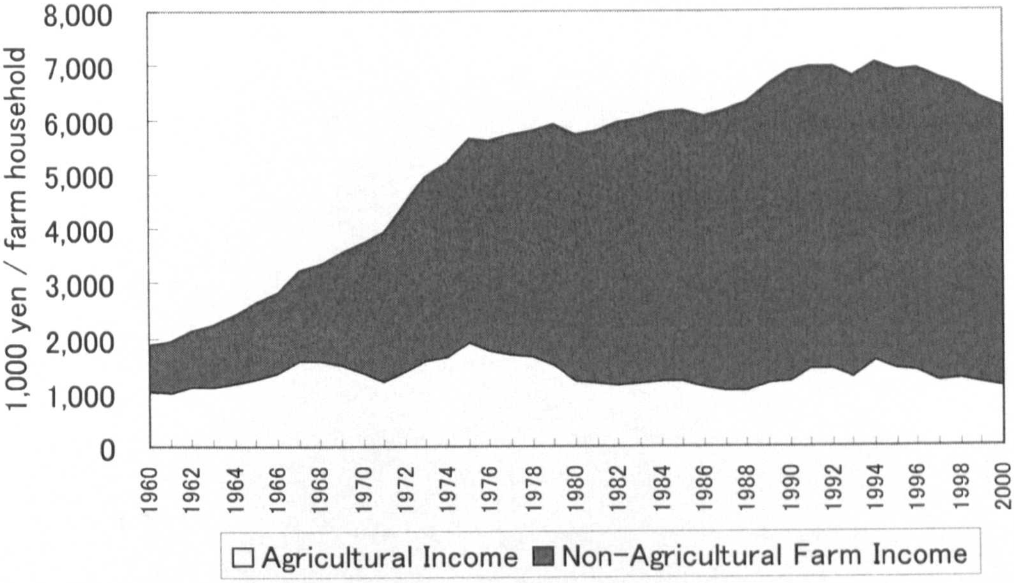
Unit: 1,000 households (%)

	Number of Farm Households		
	Full-time Farm households	Part-time farm households	
		Type I	Type II
1960	2,078 (34.3)	2,036 (33.6)	1,942 (32.1)
1965	1,219 (21.5)	2,081 (36.7)	2,365 (41.8)
1970	831 (15.6)	1,802 (33.7)	2,709 (50.7)
1975	616 (12.4)	1,259 (25.4)	3,078 (62.1)
1980	623 (13.4)	1,002 (21.5)	3,036 (65.1)
1985	626 (14.3)	775 (17.7)	2,975 (68.0)
1990	473 (15.5)	521 (17.1)	2,058 (67.4)
1995	428 (17.7)	498 (17.2)	1,977 (68.1)
2000	426 (18.2)	350 (15.0)	1,561 (66.8)

Source: MAFF Japan, *Agricultural Census*

Note: Type I is farm households which engage mostly in agriculture, and Type II is farm households which engage mostly in off-farm work (see Appendix 2-2).

Figure 2-5 Real agricultural income and non-agricultural farm income of one farm household (Prefectures)



Source: MAFF Japan, *Farm Household Economy Survey* (1960-1994), *Farm Management Statistical Survey* (*Farm Management Trend Survey*) (1995-)

Note: The data from 1991 is the average for one commercial farm household[11]. Data is deflated by GDP deflator (1995=100).

[11] As to the definition of commercial farm household and non-commercial farm household, see Appendix 2-2.

Table 2-7 Ageing of agricultural population

Unit: 1,000 (%)

age	1960	1970	1980	1990	2000
< 19	14,273 (41.5)	8,834 (33.2)	5,451 (25.5)	4,003 (23.1)	2,573 (19.1)
20 – 29	4,945 (14.4)	3,375 (12.7)	2,867 (13.4)	1,664 (9.6)	1,308 (9.7)
30 – 39	4,329 (12.6)	3,314 (12.5)	2,378 (11.1)	2,185 (12.6)	1,202 (8.9)
40 – 49	3,427 (10.0)	3,733 (14.0)	2,933 (13.7)	2,043 (11.8)	1,863 (13.8)
50 – 59	3,218 (9.4)	2,894 (10.9)	3,206 (15.0)	2,478 (14.3)	1,710 (12.7)
60 – 64	1,383 (4.0)	1,332 (5.0)	1,201 (5.6)	1,470 (8.5)	951 (7.1)
> 65	2,835 (8.2)	3,111 (11.7)	3,330 (15.6)	3,452 (20.0)	3,851 (28.6)

Source: MAFF, Japan, *Agricultural Census*

Note: The numbers in the brackets show the proportion of total agricultural population.

Table 2-8 shows the farm economy of one farm household in real terms from 1960 to 2000. Although the average farm size has almost doubled, from 0.98 to 1.79, this farm scale is too small not only to have international competitiveness but also to diminish the productivity gap between agriculture and non-agricultural sectors, as the government has aimed to achieve since 1960 when the Agricultural Basic Law was enacted. Agricultural gross return reached 3 million yen in the late 1970s, and then has kept at that level. However, since the operation cost has increased, agricultural income has decreased: the deterioration in agricultural income in the last decade is serious. 'Farm economy surplus', which also takes into account non-agricultural income, had two peaks, in the early 1970s and early 1990s. Since 1990, farm economy surplus has been dropping gradually. Regarding the profitability of agricultural land, Table 2-9 shows the farm economy in real terms per 10 are (0.1 ha) of agricultural land. Agricultural gross return and agricultural income have decreased steadily after the peak of around 1975, while operation cost kept increasing until the middle of the 1980s.

Table 2-8 Farm economy of one farm household (in real terms)

Unit: 1,000yen / household

	Farm size (ha)	Agricultural Gross Return	Farm operation cost	Agricultural Income	Farm Economy Surplus
1960	0.98	1,628.5	606.1	1,022.4	230.2
1965	1.03	2,210.1	946.6	1,263.5	417.2
1970	1.09	2,637.0	1,276.4	1,360.5	598.9
1975	1.13	3,440.6	1,545.5	1,895.1	1,523.0
1980	1.18	3,063.9	1,858.7	1,205.2	1,105.1
1985	1.26	3,243.6	2,050.6	1,193.1	1,180.6
1990	1.33	3,140.3	1,923.7	1,216.6	1,794.6
1995	1.70	3,791.4	2,349.3	1,442.1	1,769.6
2000	1.79	3,507.6	2,483.0	1,110.9	1,520.5

Source: MAFF Japan, Farm Household Economy Survey (1960- 1994), Farm Management Statistical Survey (Farm Management Trend Survey) (1995-)

Note: The data from 1991 does not include non-commercial farm household. Data is deflated by GDP deflator (1995=100). Farm economy surplus is disposable income of farm household (including off-farm income) minus family expenses.

Table 2-9 Farm economy per 10 are agricultural land under operation

Unit: 1,000yen/10 are

	Agricultural Gross Return	Farm operation cost	Agricultural Income (Real)
1960	165.8	61.7	104.1
1965	214.2	91.7	122.4
1970	242.6	117.4	125.2
1975	304.2	136.6	167.6
1980	260.1	157.8	102.3
1985	257.4	162.7	94.7
1990	236.8	145.1	91.8
1995	223.0	138.2	84.8
2000	201.0	135.5	62.1

Source: MAFF Japan, *Farm Household Economy Survey* (1960-1994), *Farm Management Statistical Survey* (*Farm Management Trend Survey*) (1995-)

Note: The data from 1991 does not include non-commercial farm households. Data is deflated by GDP deflator (1995=100). 1 ha = 100 are.

2-4-2. The scale of farming

Although policy objectives were aimed at the development of a competitive agricultural structure, farmland scale has not enlarged enough, although a lot of policy effort has been implemented since 1961 with the enactment of the Agricultural Basic Law. Table 2-10 shows the average farmland size owned by one farm household in Hokkaido and at prefecture level, from which Hokkaido is excluded. Hokkaido has a much bigger scale of farm than those in the prefectures. The average size of farmland under agricultural operation by one farm household in the prefectures has increased barely between 1960 and 1990, but since 1990 the rate of increase has speeded up[12]. In order to see the trend in farm scales respectively, the rate of households in each farm scale to total households is displayed in Figure 2-6. Although the small-scale farm which operates less than 1.0 ha is still dominant, the larger scale of farm (over 2 ha) has been increasing. The rate of farm scale by the classification of agricultural area in Figure 2-7 shows that the flat farming area has almost 20% of farms which have more than 2 ha, being about 50% if more than 1 ha farms are included. To see the detail of agricultural land enlargement, Table 2-11 shows the rate of agricultural land leasing in each scale of farm. The small farm holding of less than 1 ha of land tends not to lease land much; the bigger the farm scale is the more percentage of households tend to lease land, reaching 56.3 % of area leased in more than 10 ha farm households. The average area leased by one farm household also rises following the increase in scale of farm; farm households which hold more than 10.0 ha tend to lease 10.14 ha on average.

Three types of farms are typically considered for Japanese agriculture. First, the small scale farm individually operated, where the farmer is willing to diminish the scale gradually and likely to retire in the near future due to ageing. This is labelled 'potentially retiring farm'. Secondly, the average scale of farm which tends to keep the current scale as long as it can, and labelled as 'maintaining farm'. The last type of farm, to which the second type of farm may shift, is active farm (i.e., developing farm) operated sometimes by a group such as an agricultural production corporation. In Figure 2-8, the vertical axis shows profitability of farm, and horizontal axis shows time which also shows the ageing process of farms. Because of the chronic drop in

[12] A part of the reason is assumed to be that the data has excluded non-commercial farms which normally keep only small-scale farmland since 1995.

agricultural profitability and ageing of the agricultural population, the scale of farm has polarised between high profitability farms with high productivity, and low profitability farms with low productivity. Farmland abandonment has increased rapidly, especially from the latter farm type following the process of ageing when farmers have to diminish the scale of operation or retire without anybody to take over the running of all, or a part, of the farm.

Table 2-10 Average farm size

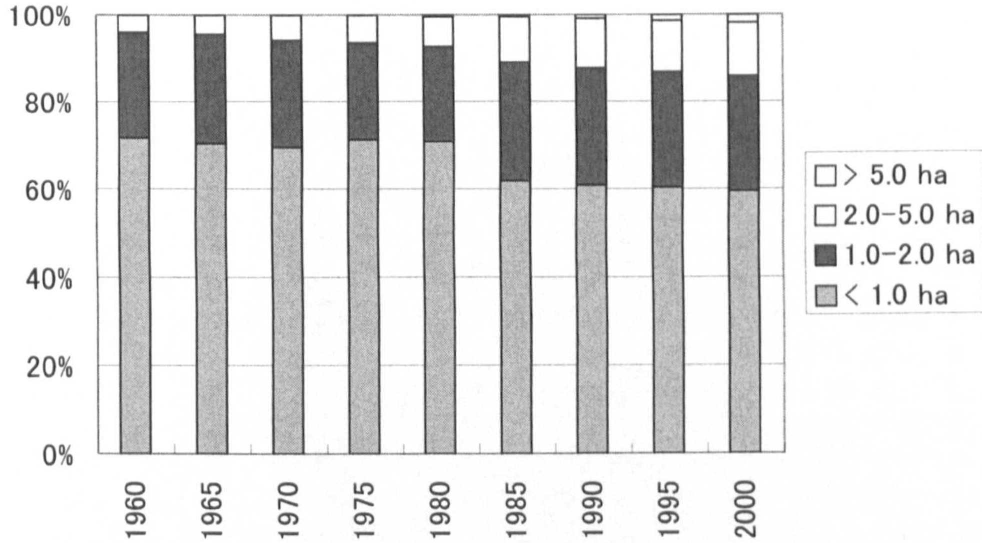
Unit: ha / household

	1960	1965	1970	1975	1980	1985	1990	1995	2000
Hokkaido	6.63	7.14	9.08	10.53	11.05	12.54	14.02	18.15	17.77
Prefectures	0.87	0.90	0.92	0.93	0.97	1.02	1.06	1.35	1.45

Source: MAFF, *Report of Farm Economy Survey* (till 1995), and *Survey on Farm Management Trend* (form 1995)

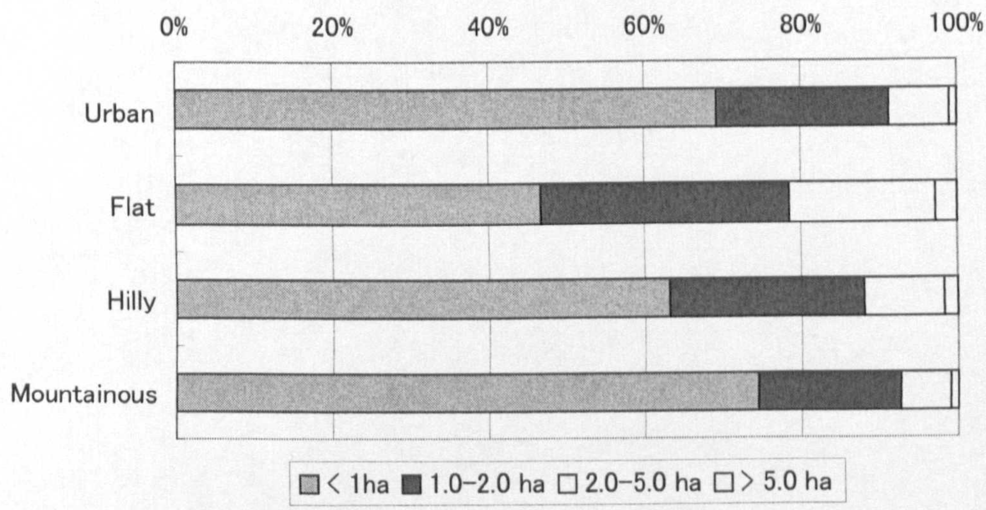
Note: The data from 1995 is the average size of agricultural land owned by one commercial farm, not including non-commercial farms.

Figure 2-6 Distribution of farm size (Prefecture level)



Source: MAFF Japan, *Agricultural Census*

Figure 2-7 Distribution of farm size by agricultural area (2000)



Source: MAFF Japan, *Agricultural Census*, 2000

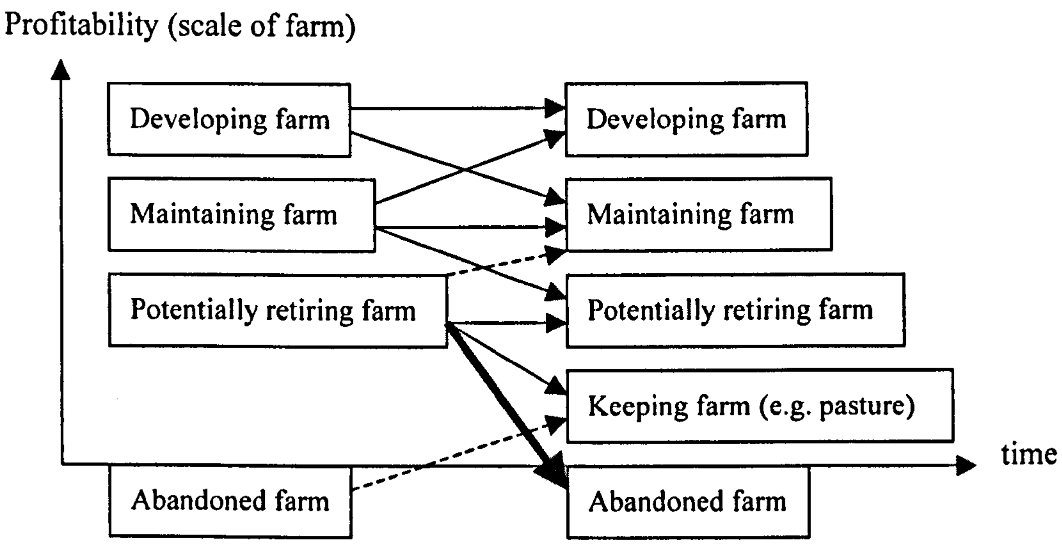
Table 2-11 Agricultural land lease (Prefectures, commercial farm household)

Scale of farm	The ratio of leasing area out of total arable land (%)		The leasing area per farm household (ha)	
	1995	2000	1995	2000
< 0.5 ha	5.3	6.0	0.13	0.13
0.5-1.0	6.1	7.2	0.21	0.21
1.0-2.0	8.7	10.3	0.39	0.40
2.0-3.0	13.2	15.8	0.73	0.77
3.0-4.0	19.0	22.9	1.18	1.24
4.0-5.0	25.2	30.0	1.69	1.80
5.0-10.0	35.7	41.7	2.96	3.21
10.0 ha<	47.2	56.3	9.38	10.14

Source: MAFF Japan, *Agricultural Census*, 2000

Note: Commercial farm households are farm households which have more than 30 are of operating farm, or the amount sold of agricultural products is over 500,000 yen (around £2,631 when £1 = ¥190).

Figure 2-8 The change in farm structure



Note: Drawn by the author

2-4-3. Farmland abandonment

Recently, the amount of abandoned farmland[13] in Japan has been increasing quite dramatically, especially in hilly, mountainous and urban areas[14] (see Table 2-12). The issue is considered important in terms of loss of multifunctionality – landscape degradation, and loss of biodiversity and water ecosystem – and in some cases is linked to natural disasters such as flooding and landslides. Under the urgent need for the further agricultural policy reform, the increase of farmland abandonment is one of the serious concerns for the sustainability of Japanese agriculture. Farmland abandonment occurs when agricultural profitability reaches a minimum threshold and alternative productive uses for land cannot be found, and nobody takes over the land. The deterioration of agricultural profitability and the elimination of price support have seriously affected the increase of farmland abandonment in Japan recently.

The proportion of terraced paddy field is often high in LFAs. Farming activities on the terraced paddy field are still labour intensive, because modern machines cannot be introduced to such physically disadvantaged areas. For example, it is claimed that labour requirements on such fields are 3-5 times more than that of normal paddy fields (Shigeto and Hubbard, 2004). While Japanese rice production has become more capital-intensive with the increase of part-time farmers, production on terraced paddy fields has remained labour-intensive. Furthermore, an ageing farm population (Table 2-7) and a lack of successors have led to an oversupply of farmland, especially that which has disadvantages in terms of its location and physical

[13] That is, farmland which is possible to cultivate again after being kept idle with some treatments; it does not include land diverted for housing and afforestation, or wasted lands (Definition in Agricultural Census, Japan).

[14] Farming in urban areas is not uncommon in Japan.

condition (Kashiwagi, 1994; Odagiri, 1994). Coupled with a low demand (Tanimoto, 1994), this has brought about farmland abandonment.

Table 2-12 The area and proportion of abandoned farmland in Japan

Unit: ha (%)

	Urban Farming Areas	Flat Farming Areas	Hilly Farming Areas	Mountainous Farming Areas
1990	21,472 (2.04)	18,156 (1.06)	36,349 (2.52)	16,694 (3.62)
1995	27,324 (4.15)	42,182 (2.22)	65,450 (5.23)	24,515 (5.59)
2000	35,225 (5.76)	58,171 (3.15)	83,501 (7.00)	31,088 (7.55)

Source: MAFF Japan, *Agricultural Census*

Note: The figure in the brackets shows the proportion of abandoned farmland[15].

[15] (Proportion of abandoned farmland) = (the area of abandoned farmland) / {(the area of abandoned farmland) + (arable land under operation)}*100

2-5. Summary

Japanese agricultural policy has changed subject to the social situation. In the post-war period, to assure the staple food supply (rice, wheat and barley) was a very important policy aim. However, a productivity gap became visible between the agricultural sector and non-agricultural sector. The policy instruments were targeted mainly to diminish that gap. The structure of strong agricultural protectionism has been framed since then, which is often criticised by other nations. Meanwhile, Japan has faced over-supply mainly of rice since the end of 1960s, due to high price support on rice and diversification of food culture. Since 1971, the production control system has been applied continuously in order to reduce the amount of production of rice and to give incentives for farmers to switch into other crops which are not over-supplied. Since the end of the 1980s, Japan has experienced drastic agricultural policy reform responding not only to international trade pressure, but also to address modern agricultural problems systematically. Policy objectives extended to four points: food security, enhancement of agricultural multifunctionality, sustainable agricultural development, and rural development.

Japanese agriculture has declined rapidly. The first turning point was the end of the 1970s. Agricultural land decreased drastically due to high demand for non-agricultural use and abandonment. An important characteristic of agricultural land use in Japan is that there is no obvious difference between urban farming areas and mountainous farming areas. As the main land use is paddy field all over Japan, except for Hokkaido, high government support was placed on rice production, which enabled small-scale farmers to remain in agriculture. Meanwhile, the government introduced several policy instruments which might support enhancement of farming scale in order to improve the efficiency of agriculture. Nevertheless, the increase has been minimal.

In discussing Japanese agricultural problems such as depopulation in rural areas, ageing of the agricultural population, minimal increase of farming scale, and increase of abandoned farmlands, one of the key aspects is the failure in development of the farming structure. It is of interest to focus on agricultural land policy and market structure here, because those should have strongly influenced the development of the farming structure. In the next chapter, Japanese agricultural land policy and prices are outlined.

Appendix 2-1 Definition of farming areas in Japan

MAFF statistics define four types of areas, taking account of farming condition (OECD, 1995).

1) **Urban area**: municipalities whose proportion of densely inhabited districts (DIDs) in liveable area (total land except lake or forest) is 5 per cent or more, and population density is 500 inhabitants/ km^2 or more (or population in DIDs is 20,000 inhabitants or more), or municipalities whose proportion of cultivated land in the liveable area is less than 40 per cent, and population density is 500 inhabitants/ km^2 or more except those whose proportion of forest land and grazing land in total land is 80 per cent or more.
2) **Flat farming area**: municipalities whose proportion of cultivated land in total land is 20 per cent or more, and the proportion of forest land and grazing land in total land is less than 50 per cent, except those whose paddy field of inclination tangent is 1/20 or more and upland field of inclination angle is 8 degrees or more, exceed 90 per cent of the total land. Or municipalities whose proportion of cultivable land in total land is 20 percent or more, whose proportion of forest land and grazing land in total land is 50 per cent or more, and whose paddy field of inclination tangent is 1/20 or more and upland field of inclination angle is 8 degrees or more, is less than 10 per cent of the total land.
3) **Hilly farming area**: municipals whose proportion of cultivated land in total land is less than 20 per cent except those which are classified as "Urban area" and "Mountainous farming area". Or municipalities whose proportion of cultivated land in total land is 20 per cent or more except those which are classified as "Urban area" and "Flat farming area".
4) **Mountainous area**: municipalities whose proportion of forest land and grazing land is 80 per cent or more, and the proportion of cultivated land in total land is

less than 10 per cent.

Appendix 2-2 Definition of farm household (OECD, 1995)

Farm household: Farming households whose area of cultivated land is 0.1 ha or more after census in 1990, whereas it was 0.05 ha or more in Western Japan in earlier censuses. Even if a farm's area of cultivated land is less than this, it is included if its sales of agricultural products amount to or exceed ¥150,000 after 1990 (¥20,000 in 1960, and ¥50,000 in 1970, and ¥100,000 in 1980).

1) **Full-time farm household:** farm household which has no household member engaged in non-farm employment.
2) **Part-time farm household:** farming household which has one or more household members engaged in jobs other than farming and where they have been employed for 30 days or more, or engaged in their own non-farm business from which they have earned ¥ 100,000 after 1990 (¥ 70,000 in 1980) or more, during a year before the survey year
3) **Part-time farm household type I:** farm household where at least 50 per cent of income was earned in farming.
4) **Part-time farm household type II:** farm household where more than 50 per cent of income was earned from non-farm jobs.
5) **Commercial farm household:** farm household whose area of cultivated land is 0.3 ha or more, or whose annual sales of agricultural products amount to ¥500,000 or more. This new classification was introduced in 1990.
6) **Non-commercial farm household:** farm household other than commercial farm household.

Farm household as policy target

i) Self-supporting management farm household:

This farm household was advocated as the basic farm unit in the Agricultural Basic Law and was defined as a household which earns total agricultural income comparable to the income of a salaried worker's household. More specifically, agricultural income per household member was used for making this comparison.

ii) Core farm household:

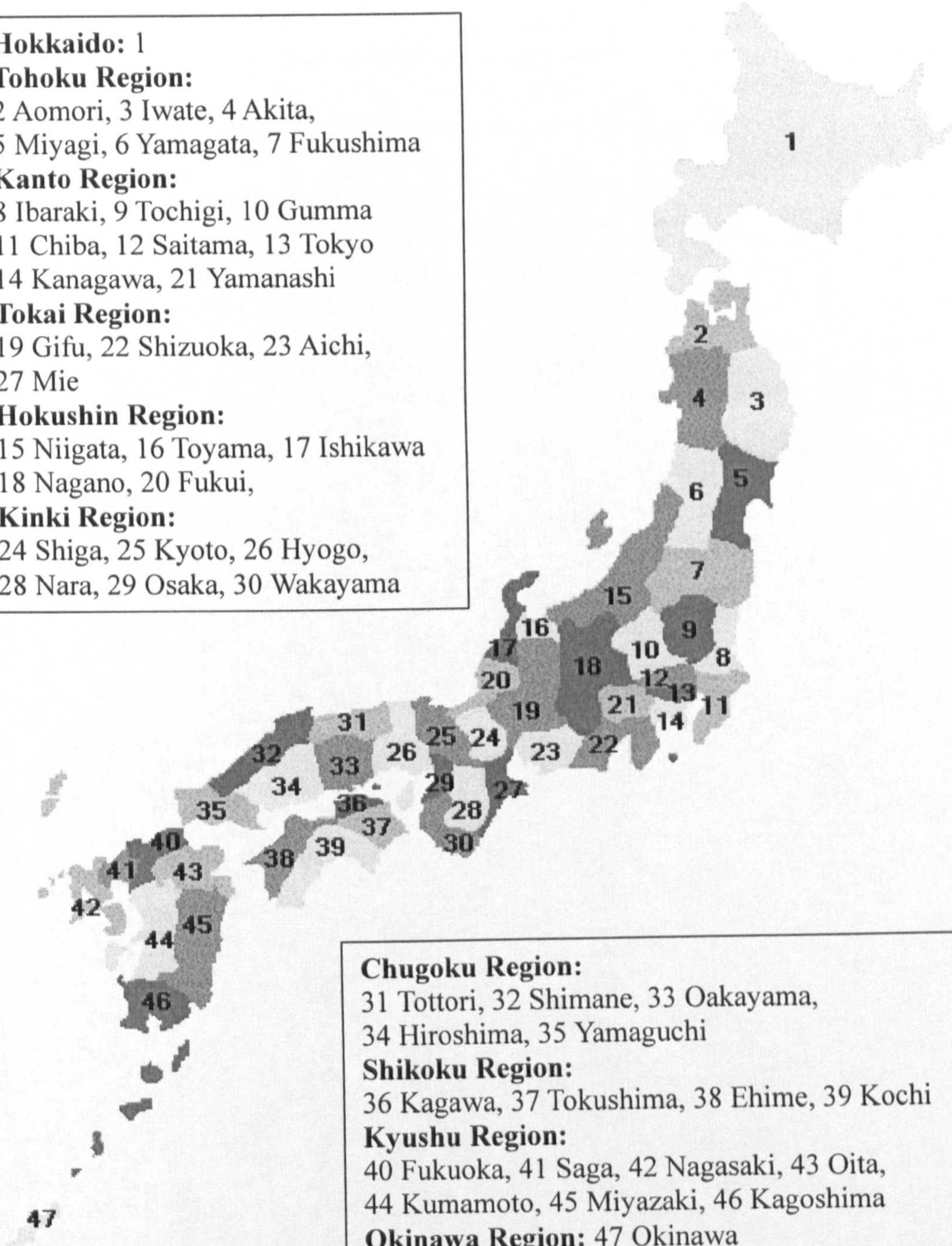
This notion of the core farm household was introduced in the MAFF Annual Report on the State of Japan's Agriculture in 1973, for the first time as an alternative to the previous self-supporting management farm household. As the active engagement in farming is the key element for this type of farm household, this is defined as a farm household with males of 16-59 years of age who are engaged in farming for more than 150 days per year. This category includes a broader range of farm households than the previous target.

iii) Individual farm management body

This notion was introduced in the New Policy Direction in 1992. Comparable working hours and life-time income to those of workers in other industries are the main elements of this new policy target. Unlike the core farm household, the individual management body could include those farms run by women or elderly persons. Furthermore, this farm unit could also be involved in food processing, sales or other non-farm business. The notion of full-time and part-time farm households was not used because these definitions cannot explain the whole farm household situation in Japan.

Appendix 2-3 Map of Japan

Hokkaido: 1
Tohoku Region:
2 Aomori, 3 Iwate, 4 Akita,
5 Miyagi, 6 Yamagata, 7 Fukushima
Kanto Region:
8 Ibaraki, 9 Tochigi, 10 Gumma
11 Chiba, 12 Saitama, 13 Tokyo
14 Kanagawa, 21 Yamanashi
Tokai Region:
19 Gifu, 22 Shizuoka, 23 Aichi,
27 Mie
Hokushin Region:
15 Niigata, 16 Toyama, 17 Ishikawa
18 Nagano, 20 Fukui,
Kinki Region:
24 Shiga, 25 Kyoto, 26 Hyogo,
28 Nara, 29 Osaka, 30 Wakayama



Chugoku Region:
31 Tottori, 32 Shimane, 33 Oakayama,
34 Hiroshima, 35 Yamaguchi
Shikoku Region:
36 Kagawa, 37 Tokushima, 38 Ehime, 39 Kochi
Kyushu Region:
40 Fukuoka, 41 Saga, 42 Nagasaki, 43 Oita,
44 Kumamoto, 45 Miyazaki, 46 Kagoshima
Okinawa Region: 47 Okinawa

Source: http://www.japan-guide.com/list/e1002.html

Appendix 2-4 Destroyed or converted farmland

Unit: ha

	Destroyed or Converted Farmland					
			Artificial Destroyed Land			
	Total	Natural Disaster	Total	Conversion into non-agricultural use	Farm or forestry roads/ Afforestation	Farmland abandonment. etc. (Farmland Abandonment)
1960	34,300	10,500	23,800	n.a.	n.a.	n.a.
1961	36,100	8,720	27,400	n.a.	n.a.	n.a.
1962	34,000	4,580	29,400	n.a.	n.a.	n.a.
1963	48,600	2,080	46,500	n.a.	n.a.	n.a.
1964	49,400	2,040	47,400	28,400	19,000	n.a.
1965	70,100	1,110	69,000	31,200	37,800	n.a.
1966	49,600	3,230	46,400	26,500	19,900	n.a.
1967	85,800	2,670	83,100	34,400	48,700	n.a.
1968	80,100	5,640	74,500	33,100	41,400	n.a.
1969	94,400	3,450	90,900	41,900	17,700	31,400
1970	103,000	2,020	101,000	52,000	18,000	31,000
1971	112,500	1,450	111,000	50,200	23,100	32,600
1972	99,400	8,830	90,600	47,400	22,900	20,300
1973	88,200	1,160	87,000	48,700	19,200	19,100
1974	110,500	1,890	108,600	41,900	15,800	50,900
1975	89,100	457	88,600	29,200	11,600	47,800
1976	80,800	1,890	78,900	26,800	9,220	42,800
1977	60,300	1,450	58,800	22,700	7,730	28,400
1978	57,000	1,060	55,900	23,900	8,260	23,800
1979	50,400	337	50,100	23,000	7,890	19,200
1980	45,000	476	44,500	22,000	7,090	15,400
1981	43,800	308	43,500	22,000	6,690	14,800
1982	39,800	958	38,800	19,300	5,880	13,700
1983	37,300	1,890	35,400	18,300	4,960	12,100
1984	35,500	1,140	34,400	17,200	4,550	12,600
1985	36,300	252	36,000	16,800	4,560	14,600
1986	38,500	66	38,400	17,800	4,320	16,300
1987	37,000	212	36,800	17,300	3,780	15,700

1988	40,900	422	40,500	18,200	3,840	18,400
1989	52,600	156	52,500	20,300	6,240	25,900
1990	47,100	1,050	46,000	22,900	4,880	18,200
1991	47,000	315	46,700	23,800	4,310	18,600
1992	47,500	117	47,400	25,000	3,620	18,700
1993	47,200	1,530	45,700	22,600	2,980	20,000 (18,400)
1994	48,700	1,470	47,300	22,000	2,930	21,100 (21,100)
1995	50,300	1,110	49,200	21,300	2,740	25,100 (23,900)
1996	47,900	81	47,800	21,300	2,510	23,900 (22,500)
1997	47,800	121	47,700	20,800	2,480	24,400 (23,100)
1998	46,400	53	46,400	19,100	2,800	24,400 (23,200)
1999	43,100	2,530	40,500	16,800	2,500	21,300 (20,000)
2000	39,700	974	38,700	15,660	2,306	20,800 (20,800)

Source: MAFF, *Survey on Area of Arable Land and Area under Cultivation*

Note:

1) Data shows the change from August to the following July.
2) The data in Okinawa prefecture is excluded until 1974.
3) Non-agricultural Use is for building factories, roads and rails, housing, and so on.
4) Farmland abandonment implies farmlands whose owners are not willing to keep it under cultivation, or rough lands which used to be farmlands and are impossible to restore.
5) The data of Farm or forestry roads/ Afforestation between 1964 and 1968 includes the area of farmland abandonment etc.
6) Abandoned farmland is land which was used for agriculture, but is verified to be unable to restore for agricultural use anymore.

Chapter 3. Farmland Policy, Regulations and Prices

3-1. Introduction

In the previous chapter, Japanese agricultural policy and the farming system were overviewed. In order to analyse farmland problems in Japan, it is important to understand the development of farmland policy and regulations as well as aspects of the social structure, such as land ownership and social customs in rural communities, because they are very distinctive due to historical reasons and, of course, have affected farmers' behaviour to land use. Post-war farmland policy was formed on the strong principle of 'owner-cultivators', which has been interpreted more recently as 'cultivators' protection' (Sekiya, 2002). This principle has influenced Japanese farming structures strongly. The aim of this chapter is to focus on policies relating to agricultural land, to understand the nature of Japanese farmland policy and to overview farmland price movements.

3-2. Development of Agricultural Land Policy

The foundation of Japanese agricultural land policy and ownership structure was formed after the World War II as one of the important social transformations towards a democratic society in order to prevent the centralisation of wealth and authority. The decomposition of large landowner farms and reinforcement and protection of the cultivators' right was the first priority for this reform. Small-scale farming has become a characteristic of Japanese agriculture since then. However, the rapid economic growth in Japan highlighted the gap in living standards between city and rural areas, and policy developed to achieve productivity increases and modernisation of agriculture but within the constraint of the strong protection on cultivators' rights. Therefore, the farming environment was very protective, even for small-scale or part-time farmers. Meanwhile, the government-dependent farming system has brought domestic and international pressure for fundamental reform in terms of the farming structure in Japan, especially after 1980s. However, due to the strong regulation and protectionism on cultivators' right, the government has struggled to reform farming structure towards greater efficiency through the enlargement of farming scale. In this section, the policy development is followed in order to highlight the struggle of Japanese farmland policy to transform the farming structure within the owner cultivators' principle. Policy development is divided into three periods according to the social situation; post-war period (1945-55), rapid economic growth period (1955-1980), and after 1980.

3-2-1. Post -war period: Land reform and "owner-cultivators" principle

Land reform was carried out from 1945 to 1950 as a part of the social structure transformation from feudalism to democracy. The abolishment of the landlord system was a high priority. The main pillars of land reform were: (1) the reduction of rent and the conversion of rent in-kind to money rent; (2) the creation of 'owner-cultivators'; and (3) the democratisation of the agricultural land committees (Koppel and Kim, 1993). As it was a serious social problem that the status of tenant farmers were oppressed before the war, land reform was considered as an essential action in order to remove feudalism in rural society. Land reform was undertaken between 1946-50; government bought out tenant farms compulsorily from landlords and sold them to tenant farmers. In this period, approximately a third of the ownership of all farmland passed to tenants under the agricultural land reforms (OECD, 1995). Table 3-1 shows the area of owner-cultivated land and tenanted land in 1945 and 1950. The area of owner-cultivated land increased to 4,685ha in 1950 from 2,787ha in 1945, and accounted for 90% of all agricultural land, while tenanted land decreased to 10%. Through the process of passing land to tenants, the scale of farm diminished (see Table 3-2). In 1941, 8% of farms operated more than 2.0 ha agricultural land, which decreased to 3.5% in 1950. Meanwhile small farms of less than 0.5 ha and 0.5-1.0 ha increased from 34% to 42% and from 31% to 33%, respectively. The agricultural Land Law enacted in 1952 was formed on the principle that owner-cultivators should take a central role to improve agricultural productivity. Under the law, the maximum size one farmer could own was 3 ha (12 ha in Hokkaido), and the level of rent was also controlled to protect the tenant. The original form of post-war farmland control was established during this period through land reform and formulation of the Agricultural Land Law (Sekiya, 2002). Tabata (1990) claims that this has been important in the post-war agricultural protection system in Japan.

Table 3-1 Owner cultivated land and tenanted land

	Total ha	Owner cultivated ha (%)	Tenanted ha (%)
1945	5,156	2,787 (54)	2,368 (46)
1950	5,200	4,685 (90)	515 (10)

Source: Sekiya (2002) (Original source is "*The report on performance of emancipation of agricultural land etc.*")

Note: The data of Okinawa prefecture is excluded.

Table 3-2 The scale of farm

Unit: 1,000 farm households, (%)

	Total	< 0.5ha	0.5-1.0ha	1.0-1.5ha	1.5-2.0-ha	2.0-3.0ha	> 3.0ha
1941	5,226	1,752	1,610	1,446		313	83
		(34.0)	(31.0)	(28.0)		(6.0)	(2.0)
1950	5,931	2,461	1,952	945	363	176	27
		(42.0)	(33.0)	(16.0)	(6.0)	(3.0)	(0.5)

Source: Sekiya (2002). (Original source is MAFF Japan, *Agricultural Census*)
Note: The data of Okinawa prefecture is excluded.

3-2-2. Agricultural land law under rapid economic growth

As Japan achieved rapid economic growth after 1955, the modernisation and development of agricultural structures became an important target of agricultural policy. The Agricultural Basic Law was enacted in 1961 in order to clarify the basic policy goals. As the main policy objectives were to diminish the productivity gap between the agricultural sector and non-agricultural sector, and to attain the equalisation of living standards with people engaged in other sectors, the following projects were set up: the expansion of farm size to enable farms to utilise modern labour-saving technologies efficiently, and the shifting of production from commodities such as rice to commodities such as meat and milk, which are more income elastic and in which Japan is not at so great a comparative disadvantage as in field crops (Hayami, 1990). The first revision of the Agricultural Land Law in 1962 was undertaken following the establishment of the Agricultural Basic Law, as the Land Law had to be adjusted to meet new policy objectives. The details of the first revision were to enlarge the maximum size of farmland which one farmer could own, to allow Agricultural Production Corporations[1] to acquire farmlands, and the establishment of a farmland trust system. To protect tenant status, more priority was put on tenancy rights under this law.

By the end of the 1960s, the speed of economic growth became rapid, and the strong demand for land from the non-agricultural sector boosted farmland prices above the fundamental prices based on agricultural earnings, and encouraged housing development and speculative land possession. Around this period there were two concerns for agricultural policy-makers; first, it became difficult to encourage farmland transaction by the transference of property rights, which was the targeted policy method until this period, due to booming farmland prices, and second, the area of farmland rapidly decreased because of high demand for non-agricultural use. Therefore new policy directions were sought. One was to switch the strategy for enlargement of farm scale from property right transfer (i.e., sales transaction) to cropping right transfer (i.e., rental transaction), which required further mitigation of farmland regulation based on the Agricultural Land Law (Ishii, 1982). Responding to a high demand for non-agricultural use, urban planning tried to enclose a certain area of farmland in urban areas. This movement led to the establishment of the New City Planning Law (1968) which created zones between urbanization promoting area and urbanization control area[2]. The former area enclosed a large area (300,000 ha) of farmland which was no longer under farmland control and therefore free to convert into non-agricultural use (Tabata, 1990). Meanwhile, in order to cope with the rapid

[1] Agricul tural Production Corporation is a general name for a corporate body, with several members, which operates a farm. The scale and formation of these corporate bodies varies. Before this revision, only an individual could hold land.

[2] Urbanization promoting area is where an urban area is already formed, or an area where urbanization should be planned preferentially within the next ten years. These areas are excluded from the agricultural improvement plan, besides farmland is allowed to convert into non-agricultural use with a simple procedure.

decrease of farmland, a certain area of farmland was also enclosed under the Land Use Planning Law, which led to the Agricultural Land Use Promoting Law in 1969 as a response to the New City Planning Law. This law designated 4,360,000 ha of farming area (79 per cent of all agricultural land at that time), and policy measures for agricultural promotion such as infrastructure development were selectively implemented (Tabata, 1990). Since then the Agricultural Land Use Promoting Law has complemented the Agricultural Land Law. The implementation of the new policy framework required a further revision of the Agricultural Land Law in 1970. This revision can be interpreted as a very important transition in terms of agricultural land policy from the conventional owner-cultivator principle, under the Agricultural Land Law since the end of the world war, to the encouragement of leasing transactions rather than sales transactions in order to achieve enlargement of farm scale. The main pillars of this revision were mitigation of regulations mainly on property right[3] and establishment of some projects for promoting farmland transactions[4] mediated by public institutions or the Japan Agricultural Cooperative (*Nokyo*). Under the previous policy framework, it was said that once farmland was leased, it was almost impossible to receive it back due to the preferential system on tenancy right. Nevertheless, the policy method for enlargement of farmland scale was focused on encouragement of rental transactions. Until then, cash rent was totally controlled at a maximum level. However, this control was abolished in the second revision of the Agricultural Land Law, which introduced the standard cash rent system[5], regarded as

[3] Th is includes the abolishment of the limitation in the farm size one farmer can own, mitigation of the regulation on cancellation of leasing contract, and abolishment of the direct control on the level of maximum rent level.
[4] "The project for promoting rationalisation of farmland holdings" and "the project for entrusting operation to Japan Agricultural Cooperative". These projects have not performed well in encouraging farmland transactions.
[5] Th is system is that the local Chamber of Agriculture sets the standard level of cash rent in the region, and then has a role to advise on the reduction of the rent to the standard level when the rent is notably high.

an important change in the history of the farmland control system since rents are the core part of farmland leasing relationships (Sekiya, 2002). In 1975, the Agricultural Land Use Promoting Law was revised to encourage further farmland leasing, establishing a new project, the objective of which was to legitimise farmland transactions undertaken on the black market. Sekiya (2002) notes that farmland was strictly controlled by the Agricultural Land Law until 1970. Since then, the policy direction has moved to deregulation on property right and farm rent.

3-2-3. Agricultural land policy after 1980

In 1980, the Encouragement of Agricultural Land Use Law, which started as a project in 1975, was enacted with three projects in order to encourage further farmland leasing: the project to promote the right to use transfers; the project to improve agricultural land use; and the project to promote commissions of farming operations. Following the enactment of this law, the Agricultural Committee Law was revised, and the third revision of the Agricultural Land Law was carried out in the same year. Farmland policy in the 1980s was developed to target farmland preservation and management, and the effective use of farmland, further mobilisation of farmland through leasing transactions, and the expansion of farm scale with policy frameworks and projects established in 1980 (Tabata, 1990). The 'Basic Direction of Agricultural Policy Towards the 21st Century' was released in 1986 by the Agricultural Policy Council (APC). Suggested themes by the end of the 1980s were the need for basic restructuring in the agricultural sector and improving market access for imported agricultural products, and further agricultural structural improvement combined with agricultural pricing policy[6]. Following these policy targets, the Encouragement of

[6] Agricul tural structural reform became an urgent policy aim because of the cut in price support under international trade pressure from the GATT Uruguay Round.

Agricultural Land Use Law was revised in 1989. The details of this revision were to improve the prior adjustment procedure for the smoother and more efficient implementation of the agricultural land-use promoting project, especially on 'core' farmers[7] who were expected to expand their scale, and to provide a new structure for promoting utilisation of idled farmland. Tabata (1990) claims that this reform is notable in the sense that targeted farmers for farm scale expansion were clarified for the first time in the policy statement, and that the policy instruments were also applied to support those farmers at the same time.

The fourth revision of the Agricultural Land Law was at the same time as the enactment of the Law for Promoting Reinforcement of Agricultural Management Bases in 1993. The requirements to be registered as an Agricultural Production Corporation were loosened to a large extent. Being very different from this revision, the fifth revision was motivated by the move to decentralise the authorities in 1998. Through this revision, the authority to give permission for farmland conversion into non-agricultural use was transferred from the MAFF to governors of prefectures. The most recent revision (6^{th}) of the Agricultural Land Law was in 2000 (implemented in 2001) and is characterised as a further moderation of the requirements in terms of Agricultural Production Corporations, which was an extension of the fourth revision of the Agricultural Land Law. Under these revisions, it was accepted for people who are neither directly engaged in farming activities nor farmland owners, but receiving goods or services from corporate bodies regularly, to be members of Agricultural Production Corporations. However, it should be noted that the principle of "owner-cultivators" is still dominant in the Japanese farmland system. Moreover, the

[7] 'Core' farmers are defined by the local authorities as those under 60 years old and working on farms more than 150 days each year. They are seen as having and important role in achieving greater efficiency in agriculture. (Also see Appendix 2-2 in Chapter 2.)

central issue of the discussion for this revision was the possibility for business corporations to own farmlands in order to operate agriculture, because it was a concern that such business corporations may possess farmland expecting speculation or land laundering, and that those businesses may disrupt the regional agricultural operation system, water management, and land use, etc. Of course, there were also positive expectations such as an increase in employment opportunities in rural areas. The discussion, however, reached the agreement that business corporations are permitted only as a special case of Agricultural Production Corporations. Besides, through the revision of the Law for Promoting Reinforcement of Agricultural Management Bases in 2003, community farming[8] was added as an encouraged farming style in the marginal areas. The Law of Structural Development in Special Zones was established in the same year for encouraging the further entry of corporate bodies, other than Agricultural Production Corporations, in agriculture.

Table 3-3 shows a summary of all policy movements relating to agricultural land, listed by chronological order. The characteristics of Japanese farmland policy movement are mainly summed up in two points. Firstly, each time the law has been revised the regulations have been loosened in terms of farmland ownership and rent control. There is an expectation behind that various corporation bodies, such as Agricultural Production Corporations, will bring more competitive agriculture in Japan with more efficient land use and agricultural production systems than conventional small-scale family farms. Secondly, the principle of 'owner-cultivators'

[8] Com munity farming is a farming system which has been encouraged in marginal communities which face a serious shortage of successors and an increase of farmland abandonment. As the system varies from community to community, some communities own farming equipment and let each farm household use if the majority of farmers do not have money to invest in new machines, and others have operators who help farmers when more labour is required.

still underlies the farmland policy.

Table 3-3. The history of agricultural land policy

Year	Establishment of Law or Policy	Purpose or *comments*
1951	Enactment of "Agricultural Committee Law"	To deal with agricultural land administration at the local authority level. Committee members are elected by local farmers.
1952	**Enactment of "Agricultural Land Law"**	To persist and protect the right of owner-cultivators for improving agricultural productivity.
1954	Revision of "Agricultural Committee Law"	Establishment of National Chamber of Agriculture
1957	Revision of "Agricultural Committee Law"	Expansion of work with which the committee can deal
1961	Enactment of "Agriculture Basic Law"	To improve agricultural structure and encourage farmland transactions.
1962	**Revision of "Agricultural Land Law"** (First Revision)	Mitigation of regulations following the enactment of "Agricultural Basic Law"
1968	Enactment of "New City Planning Law"	To enclose a certain area of farmland especially in urban areas (urban planning side)
1969	Enactment of "**Agricultural Land Use Promoting Law**"	To establish zoning area and the plan for land use promotion (agricultural policy side)
1970	Revision of "**Agricultural Land Law**" (Second Revision) Enactment of "Farmers' Pension Fund Law" Project for promoting moderate farmland mobility Establishment of the project for promoting rationalisation of farmland holdings	Mitigation of regulations on leasing transactions to encourage the enlargement of farming scale and establish new projects for that purpose. *Towards promotion of farmland mobilisation by leasing transaction* Abolition of control on

		maximum amount of farm rent, and establishment of standard rent system
1972	Introduction of residential-type taxation on farmland in urbanisation promotion areas	
1974	Enactment of "Act for Planning the Utilisation of the National Land"	
1975	Revision of **"Agricultural Land Use Promoting Law"** Beginning of the project for promotion of agricultural land utilisation	For the further encouragement of farmland mobilisation through leasing transactions.
1978	Establishment of actions to restructure the use of paddy fields	
1979	Enactment of " Act for Promoting advanced agricultural land use" (subsidising to mobilise farmlands)	
1980	Enactment of **"Encouragement of Agricultural Land Use Law"** Revision of **"Agricultural Land Law"** (Third Revision) and "Agricultural Committee Law"	Mitigation of regulations
1987	Beginning of actions to establish paddy field farming	
1989	Revision of **"Encouragement of Agricultural Land Use Law"** Enactment of "Act for special cases in Agriculture Land Law in terms of leasing certain farmlands" Revision of "Criteria for Farmland Conversion Permission"	For encouraging leading farmers to expand their farm scale
1993	Enactment of **"Law for Promoting Reinforcement of Agricultural Management Bases"** Revision of **"Agricultural Land Law"** (Forth Revision) Beginning of Production Green Areas System	Drastic mitigation of criterion to be registered as an agricultural production cooperative

1998	Revision of "**Agricultural Land Law**" (Fifth Revision)	For decentralisation of authority
1999	Enactment of "The Basic Law on Food, Agriculture and Rural Areas"	
2000	Revision of "**Agricultural Land Law**" (Sixth Revision)	Further mitigation of criterion to be registered as an Agricultural Production Corporation (the possibility of farmland acquisition by business corporations)
2003	Revision of "**Law for Promoting Reinforcement of Agricultural Management Bases**" Enactment of "**Law of Structural Development in Special Zones**"	To encourage various corporate bodies, not only Agricultural Production Corporations but also business corporations, to enter agriculture.

Note: Arranged by the author. The law in bold is the law directly relating to regulations on agricultural land.

3-3. Farmland Regulations

Following the process of development of agricultural land policy in the previous section, this section focuses on the details of the four main farmland regulations which may have strongly influenced farmland transactions. Firstly, the purpose of the Agricultural Land Law is reported:

"*The law shall reinforce the stability of cultivators' status and agricultural productivity through approving the basic principle that farmland should be owned by its cultivator, encouraging cultivators to own lands, protecting their property right and adjusting for the application of those right in order to achieve the efficient use of lands for agriculture.*" (Article 1)

This article implies the principle of "owner cultivator", and is often criticised as a policy anachronism (Sekiya, 2002). As the actual state, Sekiya (2002) says that it is appropriate to call "cultivator protectionism" nowadays as the policy target is not on 'owner cultivator' anymore. In order to protect cultivators' rights, there are three pillars of regulation framework: property right transaction, cultivators' right protection and farmland conversion. These were formed as an integrated regulation system mainly to prevent anticipated asset-holdings of agricultural land and to retain good lands for agriculture. As regulations on property right and farmland conversion have played important roles for the above purpose, the strong restriction on tenancy contract has been recognised as an obstacle for smoother transactions in the rental market, although the regulations loosened gradually, as stated in the previous section (Sekiya, 2002). Here the details of the regulations are overviewed.

3-3-1. Regulation on property right transfer and land ownership

The transfer of farmland property right is strongly regulated under Article 3 of the Agricultural Land Law. Under this law, permission is required when farmers want to transfer property right (i.e., sales transaction) or use right (i.e., rental transaction). There are several rules for property right transfer. Firstly, it has to be guaranteed that buyers or tenants use those lands for agriculture. In terms of possession of land by corporation bodies, only Agricultural Production Corporations are permitted, though business corporations are also allowed as a special case of Agricultural Production Corporations from 2003. In addition, it is required that owners of property or use right or family members of those owners have to engage in agriculture at the regular base[9]. There is also a minimum possession of land after the property right transfer; more than 2.0 ha for Hokkaido and 0.5 ha for prefectures. It is also examined if new owners of property right are able to farm effectively in light of the distance from the place they live and their financial status. This regulation has played a central role to prevent asset-holding acquisition of agricultural land.

The especially strong restriction on possession of tenant farms was built under Articles 6 to 14 of the Agricultural Land Law, which has been argued as the obstacle to smooth transaction of the rental agreement. For example, farmers are not allowed to obtain tenant farms out of their residential areas. There is also the maximum area which they can own as a tenant farmer; 4 ha for Hokkaido, and from 0.5 ha to 1.5 ha according to the rule that each prefecture defines.

The area of farmland for which land right has been transferred is shown in Table 3-4.

[9] The definition of "regular base" is considered the working on agriculture for over 150 days during the year, or the necessary duration of days for the particular farming style.

The increase in the area of transactions means an improvement of mobility of farmland use which has been targeted by the government since the enactment of the Agricultural Basic Law in 1961. The area of use right transfer has been increasing, especially under the Law for Promoting Reinforcement of Agricultural Management Bases, and reached 99,610 ha in 1999, while the area for which property right has been transferred is decreasing. The total transferred area peaked in the 1970s with more than 70,000 ha, but recently dropped below 30,000 ha. Sekiya (2002) explains the reasons for the decrease in the number of sales transactions as: (1) the number of sales due to agricultural retirement decreased, (2) the demand for alternative farmland acquisition in agricultural areas became rare because farmland conversion to non-agricultural use in urban areas was almost completed, and (3) the high agricultural land prices and slump in agriculture were a disincentive to purchase land (see 3-4 in terms of farmland prices). In addition, about 46 per cent of farmland in Hokkaido and 32 per cent of farmland in the prefectures was handed over, for example when farmers retire, when farmers shift to part-time farming, and when farmers are too old to handle the existing scale of farmland[10] (Sekiya, 2002).

[10] This resu lt is from a survey in 1999.

Table 3-4 The area of farmland for which land right is transferred

Unit: ha

	Agricultural Land Law		Law for Promoting Reinforcement of Agricultural Management Bases	Total area of land right transferred (% of total arable land)
	Property right	Use right		
1960	56,729	2,690	-	59,419 (0.98)
1965	73,947	2,462	-	76,409 (1.27)
1970	71,211	1,838	-	73,049 (1.26)
1975	47,568	5,909	11	53,488 (0.96)
1980	40,496	10,185	27,397	78,079 (1.43)
1985	38,098	5,818	41,405	85,321 (1.59)
1990	34,435	5,396	51,880	91,711 (1.75)
1995	27,079	4,129	63,868	95,079 (1.89)
1999	29,110	4,094	99,610	132,814 (2.73)

Source: MAFF, Japan '*Survey on Collective Analysis of Land Management Information*', '*Survey on Area of Arable Land and Area under Cultivation*'

3-3-2. Protection of cultivator's right

Besides the restriction on possession of property right, strong protectionism has been applied for tenant farmers, discouraging landowners to lease their lands. Until 1970 it had been very difficult to cancel or dissolve the tenancy contracts once the landowner had made an agreement with tenant farmers, as it required the permission from the governor of the prefecture (Article 20). In order to encourage rental transaction for the enlargement of farming scale, the policy reform in 1970 removed the requirement of permission from the local governor when farmers want to cancel a tenancy contract. If landlords do not want to renew the contract, it is permitted only when more than 10 years tenancy contract was expired. This reform was essential because farmers had strong fears that once they leased land it would never come back due to the strong cultivators' rights protection.

Cultivators' right was also protected through strong regulation on the level of farm rent, which would have affected the amount of farmland transactions. Under the Agricultural Land Law enacted in 1952, the maximum level of farm rent was controlled. Through the revision of implementation in 1955, a different level of maximum farm rent was introduced following farmland rating based on the productivity. The rent level is determined by estimating the net profit of land; producers' income minus operation cost which is including own labour cost, capital interest, tax and public dues, and producer returns. As the level of rent should be negotiated between farmers, it should not exceed the maximum level the local authority specified. In 1967, the maximum level of farm rent was increased 4 times for paddy fields and 2.5 times for vegetable fields, following the improvement in agricultural profitability. A reason for the maximum level of farm rent being low was that the city equivalent labour cost was used as own labour cost before 1970. However, direct control on rent was abolished in 1970, and replaced with a standard rent system. Officially, farmers can negotiate the farm rent freely under the new system. However, the agricultural committee sets the standard level of rent in the region and can advise a reduction when a high rent case is reported. Nevertheless, the previous control system still applied for 10 years (until 1980) to ongoing tenanted land as a transitional measure. Initially, a standard rent level was expected to be revised every three years, but the law has changed to allow rents to be revised every time when required.

3-3-3. Regulation on farmland conversion

Regulation on farmland conversion is prescribed in Articles 4 and 5 of the Agricultural Land Law. Permission for farmland conversion is required under the following conditions; first, that agricultural land is converted for non-agricultural use without transfer of property right or use right, and second, that the transfer of property rights or use rights is required in order to convert agricultural land into non-agricultural land. The permission for farmland conversion is examined by the Minister of Agriculture, Forestry and Fisheries when the area is more than 4 ha, and by governors of prefectures in the case of less than 4 ha[11]. The cases which do not require permission are: (1) when the main administrative body of farmland conversion project is the government or prefectures, (2) when the conversion is undertaken for a public purpose, for example building a public school or compulsory purchase such as under Land Expropriation Law, (3) land conversion in urbanisation promotion area designated under City Planning Law, and (4) when the project body and conversion purpose is specified under implementation rules of Agricultural Land Law.

In addition to the City Planning Law, the Agricultural Land Use Promoting Law plays an important role in order to regulate farmland conversion. Agricultural areas under the two laws are classified in Table 3-5 which is also drawn visually in Figure 3-3. The City Planning Law firstly drew a borderline between urbanisation promotion area, urbanisation control area, and others. Urbanisation promotion areas which are numbered (1) in Table 3-5 and Figure 3-3 are those which should be urbanised preferentially in the following 10 years, and whereby there is no need for

[11] There are some exceptions that governors can give permission for conversion of more than 4 ha farmland under some law. In addition, all authority passed to governors of prefectures in 1998, which is also mentioned in 3-2-3.

permission in the case of farmland conversion, as well as being excluded from the long-run agricultural land-use promoting plans. Conversely, the Agricultural Land Use Promoting Law designated agricultural land use promoting areas, and farming areas where agricultural land use is specified. In the latter area, agricultural structural improvement is preferentially planned through activities which mainly improve production infrastructure[12]. Thus farming areas designated under Agricultural Land Use Promoting Law, which are (2), (4) and (6) in Table 3-5 and Figure 3-3, are not allowed to convert agricultural land, barring exception[13].

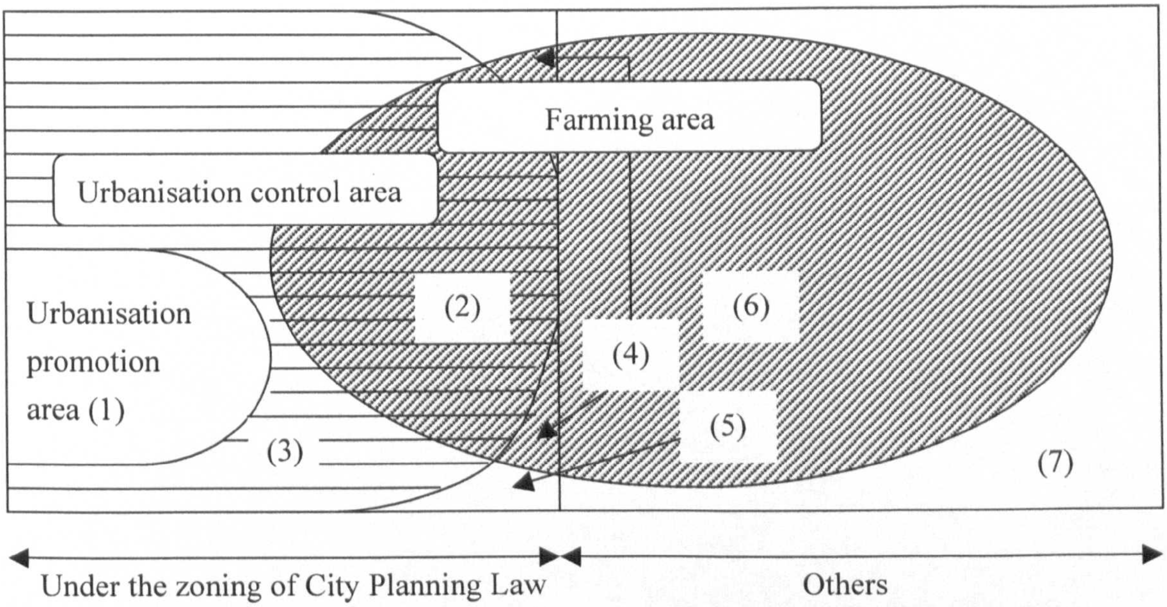
Table 3-5 Classification of land use in Japan

		Under the zoning of Agricultural Land Use Promoting Law
Under the zoning of City Planning Law	Urbanisation promotion area (1)	None
	Urbanisation control area	Farming Area (2)
		Others (3)
	Others	Farming Area (4)
		Others (5)
Others		Farming Area (6)
		Others (7)

Source: National Chamber of Agriculture "*The Result of Survey on Farmland Prices*", 2001
Note: Farmlands in farming area classified under Agricultural Land Use Promoting Law should not be converted into non-agricultural land use in principle.

[12] Agricultural land use promoting area is 17,197,000 ha (agricultural land is 5,275,000 ha), and farming area is 5,028,000 ha in 1999 (agricultural land is 4,510, 000 ha) (Sekiya, 2002).
[13] Land conversion is exceptionally permitted when there is a project under the Compulsory Purchase of Land Law etc., when land is offered for land use which is designed by agricultural land use plan under Agricultural Land Use Promoting Law, or when the land is temporarily offered within the conditions.

Figure 3-3 Classification of land use in Japan



Source: National Chamber of Agriculture "*The Result of Survey on Farmland Prices*" 1990

Note: the numbers in brackets match those in Table 3-5.

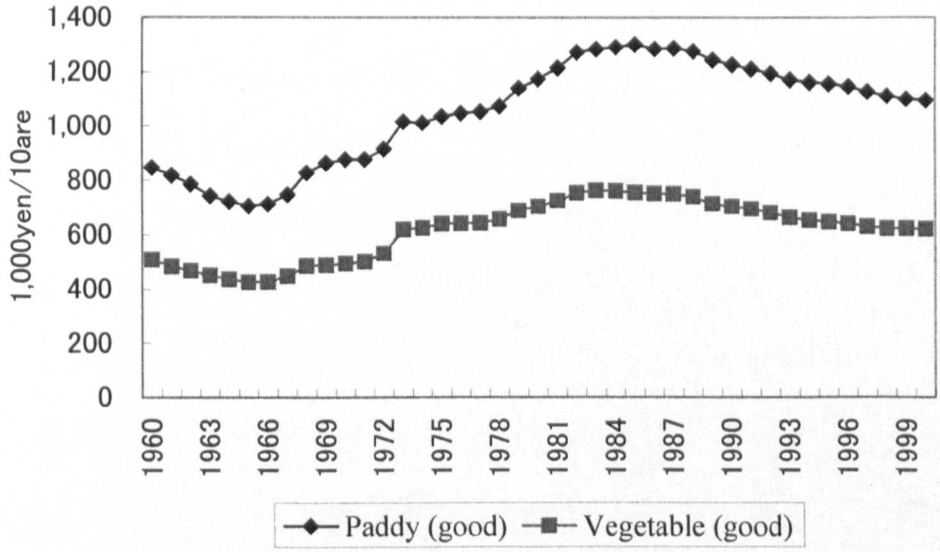
3-4. Regulation and Prices: Discussion

(a) Sales market

Although farmland was strictly regulated through property right, rent determination and farmland conversion, farmland prices themselves have not been regulated directly. Therefore, it is said that those are influenced by non-agricultural factors such as urbanisation or infrastructures. However, level of influence from non-agricultural factors should be different depending on the classification of land use which was specified in Table 3-5 and Figure 3-3. It is of interest here to discuss the farmland price movement, considering the impact of regulations on land use.

There are two data sources of agricultural land prices: "*The Result of Survey on Farmland Prices*" of the National Chamber of Agriculture (NCA), and "*The Survey on Farmland Prices and Farm Rents*" of the Japan Real Estate Institute (JREI). The NCA offers agricultural land price data of the area on which farmland conversion is not allowed (e.g., (2) and (6) in Table 3-5). Conversely, with the JREI, problematic data which may show unrealistic prices due to expectation for non-agricultural use is removed, in order to avoid distortion of the farmland price data. However, Ishii (1991) points out the possibility of data distortion through too much data manipulation. Figure 3-4 displays the farmland price movement of paddy and vegetable field land based on the data of JREI. The NCA data gives more details in the sense of the areas designated by the New City Planning Law and the Agricultural Land Use Promoting Law (see Table 3-5 and Figure 3-3) as well as farmland conversion prices. However, it should be noted that both data sets are collected through surveys which ask the 'average' transaction price in each region every year from the regional chamber of agriculture[14]. Thus, no pooled data of every transaction case is available in Japan.

Figure 3-4 Farmland price data of Japan Real Estate Institute



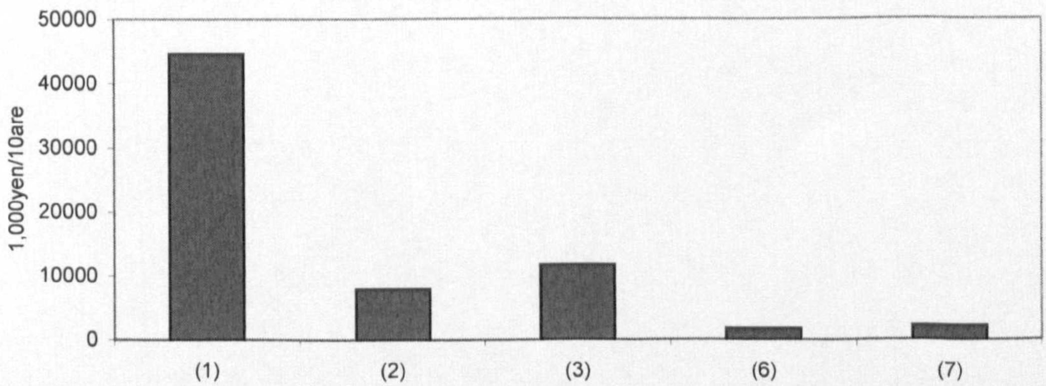
Source: Japan Real Estate Institution '*The Survey on Farmland Prices and Farm Rents*'
Note: The data is deflated by GDP deflator.

The survey of NCA offers the following agricultural land price data[15]: (1) agricultural land in urbanisation promotion area, (2) agricultural land in 'farming area' in urbanisation control area, (3) agricultural land which is not designated as 'farming area' in urbanisation control area, (6) agricultural land in 'farming area' which is not covered by New City Planning Law, (7) agricultural land neither in 'farming area' nor area covered by New City Planning Law. Moreover, it also provides sales price for housing (see Appendix 3-3). The price level is very different in five classified areas as seen in Figure 3-5. The price of farmland located in urbanisation promotion

[14] The data is not the actual transaction price, nevertheless it is said that the data is quite close to the real transaction price, as all farmland transaction cases should be reported to the chamber of agriculture.
[15] The numbers match those in Table 3-5 and Figure 3-3.

area (1) is extremely high, reflecting directly commercial land prices. The price level is high in the area which is not classified as 'farming area' under Agricultural Land Use Promoting Law in urbanisation control area (3), although still much lower than that in urbanisation promotion area. In this survey, farmland prices in the farming area out of the zoning of City Planning Law (6) is regarded as a representative farmland price of rural Japan, and named 'purely farming area'. These farmland prices are supposed to closely reflect the level of farming profit, as the farmland conversion for non-agricultural use is strongly regulated. Meanwhile the prices categorised in farming area (2) in Table 3-5 in the urbanising control areas under the City Planning Law are named the prices of 'urban farming area', which is also strongly regulated solely for agricultural use.

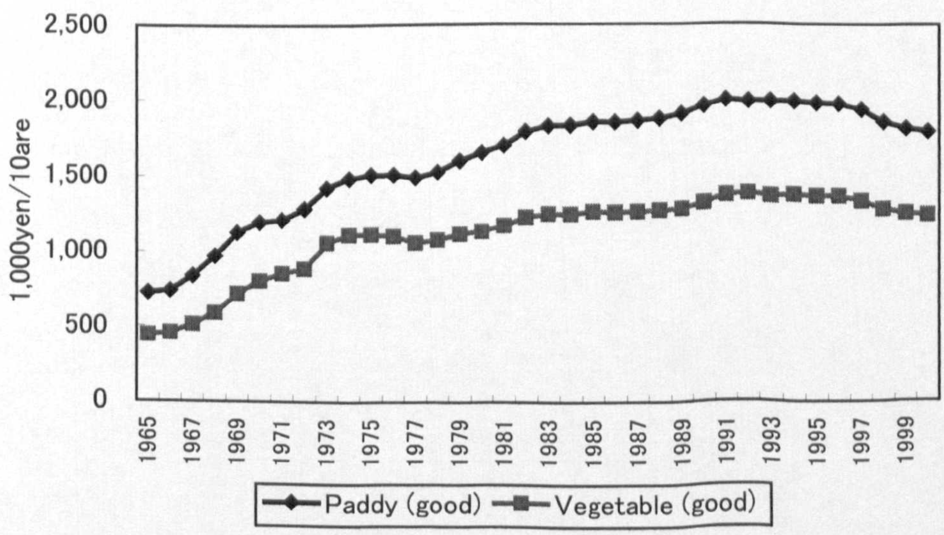
Figure 3-5 The farmland price level in 5 areas, 2000



Source: National Chamber of Agriculture "*The Result of Survey on Farmland Prices*" 2001
Note: The numbers (1) - (5) match those in Table 3-5 and Figure 3-3.
(2) is 'urban faming area' and (6) is 'purely farming area'.

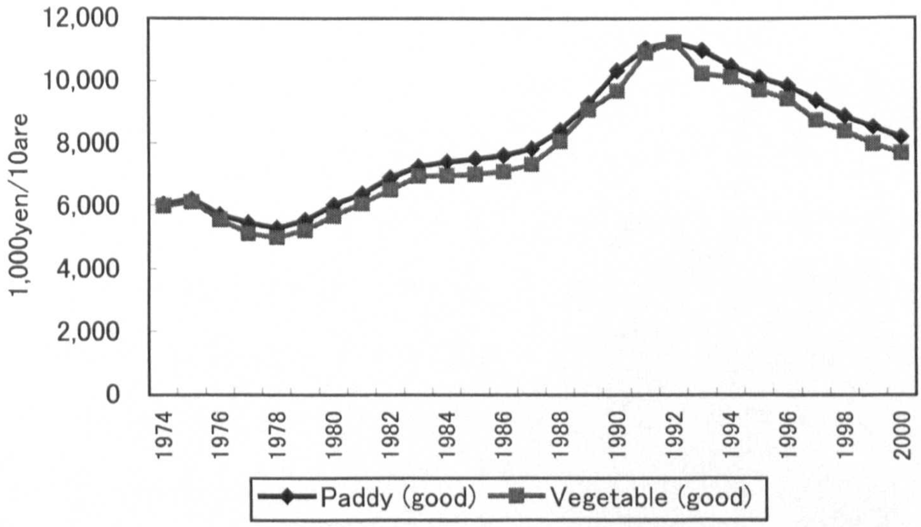
Figure 3-6 and Figure 3-7 show the movement of farmland prices in the purely farming area (1965-2000) and the urban farming area (1974-2000) respectively. As can be seen, the price level of land in the urban farming area is six to eight times higher than that in the purely farming area, although farmland conversion to non-agricultural use is banned in both areas. This indicates that farmland prices in urban farming areas seem to be strongly influenced by the price of non-agricultural land, for housing, roads and public buildings, etc. The sharp rise in price from 1988 to 1992 is most likely a reflection of the so called 'bubble economy' in Japan. Farmland prices in purely farming areas had been increasing until 1992, but have since declined as a result of deterioration in farmland profitability due to a chronic fall in product prices. Paddy prices and vegetable field prices have followed similar trends, but the price level of vegetable fields is almost half (Figure 3-4) or 60-80 % (Figure 3-6) of that of paddy fields in the purely farming areas. In the urban farming area, they are almost the same (Figure 3-7).

Figure 3-6 Farmland prices in the purely farming area, 1965-2000



Source: National Chamber of Agriculture "*The Result of Survey on Farmland Prices*" 2001
Note: The data is deflated by GDP deflator.

Figure 3-7 Farmland prices in the urban farming area, 1974-2000



Source: National Chamber of Agriculture "*The Result of Survey on Farmland Prices*" 2001
Note: Data is available only from 1974.

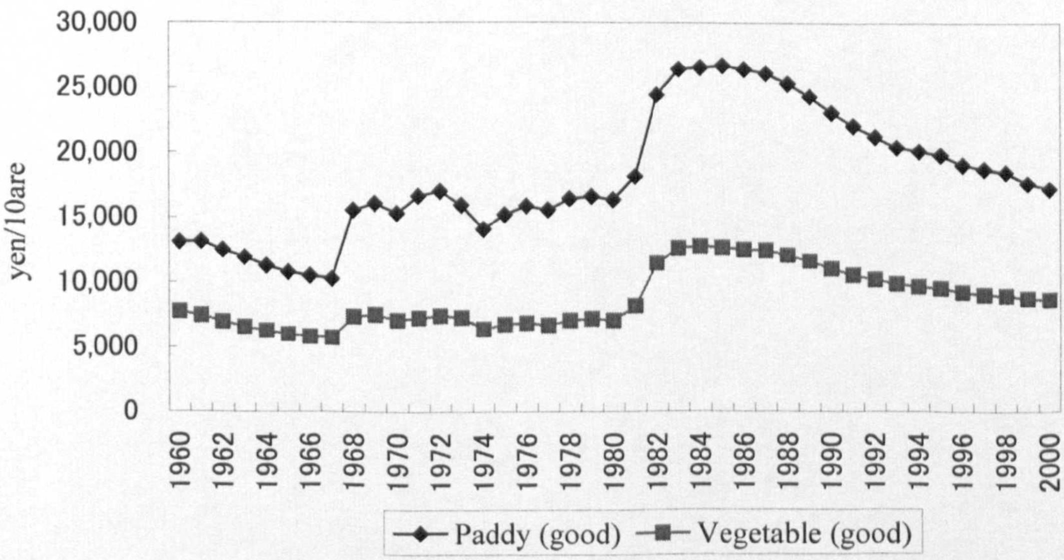
Thus, it is clear that land use regulations failed to limit farmland prices in urban farming areas within the existing regulation framework. However, farmland prices in the areas which have less urbanisation pressure are expected to reflect agricultural productivity rather than non-agricultural factors. The data of JREI (Figure 3-4) and of NCA (Figure 3-6) show that farmland price constantly increased till the early 1980s and the late 1980s, respectively, but then started falling. As seen in Table 3-4, there is serious decrease in the amount of property right transaction. It is often argued that this is due to the high level of farmland prices.

(b) Rental market

As explained in 3-3, farm rent was directly controlled until 1980, and therefore the change in farm rent is not smooth. Figure 3-8 displays the rent in Japan from 1960 to 2000. The rent of paddy fields has a higher level than that of vegetable fields, although both of them have similar trends, with a bigger fluctuation in paddy fields.

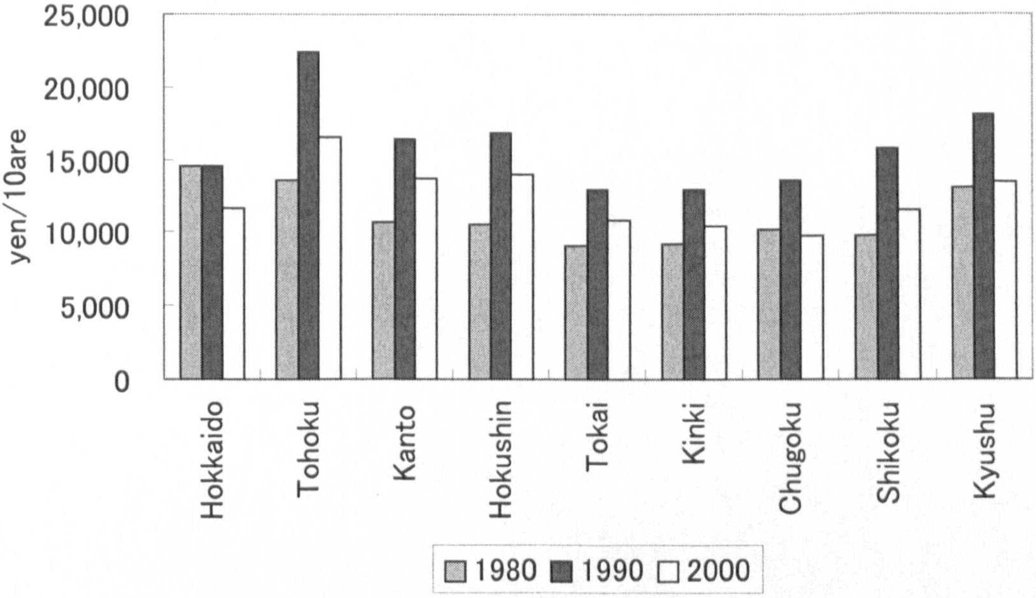
The big jump in rent around 1980 underlines that farm rent was controlled until then in many areas. Sekiya (2002) says that after introduction of the standard rent system the rent level was not 'controlled' by the government anymore, rather being monitored as not to rise above the standard level. Thus, it can be concluded that rent control was virtually abolished after 1980. Figure 3-9 shows the rent level after 1980 by region. Hokkaido had highest rent level in 1980, however the abolishment of rent control caused a very big jump in rent level in all regions except for Hokkaido: the biggest increase was in Tohoku, which also shows the largest decrease in the rent level during 1990-2000.

Figure 3-8 Real farm rent, 1960-2000 (Good land)



Source: Japan Real Estate Institute "*The Survey on Farmland Prices and Farm Rent*"
Note: The data is deflated by the GDP deflator.

Figure 3-9 Real farm rent trend from 1980 to 2000 by regions



Source: Japan Real Estate Institute "*The Survey on Farmland Prices and Farm Rent*" and author's calculation

Note: The data is deflated by the GDP deflator.

(c) Establishment of intermediate agency for farmland transaction

An overview of the farmland market in Japan suggests that farmland transactions, as well as price or farm rent determination, are not as efficient as normal commodities, not only because of strong regulations, but also because of land-specific characteristics such as location preference or condition of land (e.g., quality of land, facilities such as irrigation). In order to reduce these obstacles and to achieve smoother reallocation of land, government policy focused on the establishment of an intermediate agency to process negotiations of land sales or rents instead of negotiations between individual farmers. The development of this system means a reduction in transaction cost for seeking appropriate farms or tenant farmers. The Agricultural Land Holding Rationalisation System was firstly established in 1970, and public corporations and agricultural cooperatives have mainly taken on this role.

There are 613 corporations nationwide in 2004[16]. Farmland is not only an input in agriculture, but also is considered as an important asset for the family which should succeed from generation to generation. Especially in rural areas, the attachment to family farming and agricultural land is still strong. Besides, they tend to have a strong sense of duty to maintain those lands for the memory of ancestors and the regional environment. The establishment of an intermediate agency has been also expected to reduce the emotional uneasiness for farmers to negotiate for sales or rents with neighbours. There are also strong needs from farmers to lease agricultural lands until one of the young family members becomes ready to engage in agriculture (e.g., return migration, retirement or career change). The intermediate agency system would give more flexible contracts for farmers to sell or lease their farms. However, the strong restriction of property right transfer and tenancy contract remains, and is often criticized as 'small-farmers protectionism'. In this context, it is often argued that fundamental reform of basic agricultural law is needed. However, if there were not enough buyers or potential tenant farmers for lands, due to regulations, the efficient reallocation of land would not be achieved. Nevertheless, the problem of inefficient land transaction is not only regulations, but also that the financial struggle and ageing of the population which have been especially serious since the end of the 1980s have made it difficult to encourage farmers to enlarge their scale. Thus, it is assumed that the recent increase in farmland abandonment is due to the increase in supply of land and shortage of active farmers who can farm them.

[16] Sour ce is "Revision of Agricultural Land Policy" (September, 2005), MAFF, Japan

3-5. Summary

Japanese farmland policy has been developed on the basic principle of 'owner-cultivators' established in the post-war period, although it has been interpreted as 'cultivators' protectionism' according to the policy change. As a part of strategies for social structural transformation, the first policy target was set to encourage owner-cultivators and to protect tenancy right and farmland. However, since the rapid economic growth period, farmland policy has struggled with the need of enlargement of farming scale to achieve more competitive agricultural units and the strong protectionism of property and tenancy right. Meanwhile, the strong urbanising pressure inflated farmland prices, and it became difficult for the government to encourage farmers to enlarge farm scale through sales transactions. Therefore, their policy strategy shifted to encourage rental transactions.

The Japanese agricultural land policy has been characterised by three regulation aspects since the post-war period: property right transaction, cultivators' right protection and farmland conversion. Generally, only farmers who engage in agriculture are allowed to own farmland, and in terms of possession of land by corporate bodies, only Agricultural Production Corporations are permitted. It is strictly checked if the owner or property or use right engage in agriculture at the 'regular base'. Regarding restriction on farmland conversion, according to the zoning applied in 1969 under Agricultural Land Use Promoting Law, farmland designated as 'farming areas' are not allowed to convert to non-agricultural land. The above two regulations play important roles to prevent asset-holding possession of farmland and to retain good lands for agriculture. However, the protection of cultivators' right through the priority on tenant farmers and farm rent control is an obstacle for enlargement of farming scale by encouraging tenancy agreement.

Although there was not direct control on farmland prices, it is of interest to study the movement of farmland prices and the influence of farmland policy on them. There are two main data sources in terms of farmland price: the National Chamber of Agriculture (NCA) and the Japan Real Estate Institute (JREI). The data from JREI shows that prices increased until the end of the 1980s and since then have declined steadily, whilst the data from NCA show prices rising until the beginning of the 1990s. As NCA provides details of price according to farming areas, we can see a big difference in terms of price level between rural agricultural areas and urban agricultural areas. It is obvious that land use regulations failed to control the farmland prices in urban farming areas, as seen by the influence of urbanisation and the general land price trend. However, it is too early to conclude that Japanese farmland prices do not reflect agricultural productivity. Farmland prices started falling in 1980s, probably reflecting the slump of agriculture in Japan. Nevertheless, the farmland market may not be efficient due to the strong regulations on farmland transaction and land-specific characteristics (i.e., immobility of land and location preference, etc).

In order to reduce those obstacles, an intermediate agency for farmland transaction has been established. This processes negotiation of land sales or rental instead of individual farmers. This system is expected to reduce emotional uneasiness of farmers' selling or leasing their land, in small community and to give more flexibility to tenancy contracts. However, in order to achieve efficient reallocation of land the reinforcement of demand side is also required. Recent increases of farmland abandonment are assumed as the result of imbalance between demand and supply.

There is still a basic regulation framework (e.g., strong restriction on property right transfer), and it is often argued that there is a need for fundamental reform of agricultural land policy through the entry of a wide range of farming bodies in agricultural production, for encouraging a more active transaction of land.

In the next chapter, the theoretical aspects relating to farm rent and farmland prices are reviewed

Appendix 3-1 Farm rent and farmland prices by Japan Real Estate Institute

Unit: yen/10are

Year	Farm Rent		Farmland Prices		GDP Deflator
	Nominal	Real	Nominal	Real	(1995=100)
1960	2297.5	10430.9	149.3	677.8	22.03
1961	2444.5	10297.0	154.6	651.0	23.74
1962	2410.5	9744.5	155.2	627.2	24.74
1963	2415.0	9252.5	155.8	596.7	26.10
1964	2413.5	8779.2	159.3	579.5	27.49
1965	2426.5	8395.0	163.6	565.8	28.90
1966	2475.5	8158.9	172.9	569.9	30.34
1967	2563.5	8008.9	191.5	598.1	32.01
1968	3846.0	11452.6	220.7	657.2	33.58
1969	4137.5	11797.5	237.2	676.2	35.07
1970	4184.0	11205.7	256.1	685.8	37.34
1971	4689.0	11949.8	270.5	689.4	39.24
1972	5057.5	12205.0	300.1	724.1	41.44
1973	5413.0	11590.3	382.1	818.0	46.70
1974	5763.0	10214.1	462.1	818.9	56.42
1975	6610.0	10930.7	507.0	838.3	60.47
1976	7397.0	11325.3	552.0	845.1	65.31
1977	7725.0	11079.7	591.6	848.5	69.72
1978	8529.5	11695.1	631.2	865.4	72.93
1979	8877.5	11846.3	685.4	914.6	74.94
1980	9211.5	11658.1	742.2	939.3	79.01
1981	10797.5	13126.4	797.8	969.9	82.26
1982	15011.5	17928.9	848.5	1013.3	83.73
1983	16618.5	19504.4	872.7	1024.2	85.20
1984	17188.0	19653.3	897.7	1026.5	87.46
1985	17579.5	19684.3	918.2	1028.1	89.31
1986	17679.0	19455.9	925.5	1018.5	90.87
1987	17542.5	19286.2	926.8	1019.0	90.96
1988	17116.0	18689.3	923.2	1008.1	91.58
1989	16791.0	17969.6	914.4	978.6	93.44
1990	16300.5	17050.9	922.8	965.2	95.60
1991	16003.5	16304.6	934.9	952.4	98.15
1992	15685.5	15708.0	936.1	937.4	99.86
1993	15209.5	15138.3	921.4	917.0	100.47
1994	14978.0	14882.8	913.5	907.6	100.64
1995	14672.0	14672.0	902.2	902.2	100.00
1996	13951.0	14155.0	881.7	894.6	98.56
1997	13714.0	13877.3	868.8	879.1	98.82
1998	13602.5	13719.3	860.6	868.0	99.15
1999	12950.0	13176.4	847.1	861.9	98.28
2000	12602.5	12912.4	837.5	858.0	97.6

Source: Japan Real Estate Institute, The Survey on Farmland Prices and Farm Rents

Appendix 3-2 Farmland prices of National Chamber of Agriculture

Unit: 1,000yen/10are

Year	Purely Farming		Urban Farming	
	Nominal	Real	Nominal	Real
1965	169	584.7	N.A.	N.A.
1966	182	599.8	N.A.	N.A.
1967	217	678.0	N.A.	N.A.
1968	263	783.2	N.A.	N.A.
1969	324.5	925.3	N.A.	N.A.
1970	374.5	1003.0	N.A.	N.A.
1971	406.5	1036.0	N.A.	N.A.
1972	451	1088.4	N.A.	N.A.
1973	581.5	1245.1	N.A.	N.A.
1974	735	1302.7	3397.5	6021.6
1975	795.5	1315.5	3728.0	6164.8
1976	856	1310.6	3681.0	5635.9
1977	891.5	1278.6	3692.0	5295.3
1978	952.5	1306.0	3754.0	5147.3
1979	1021	1362.4	4035.0	5384.4
1980	1104.5	1397.9	4620.5	5847.7
1981	1184	1439.4	5121.5	6226.1
1982	1265.5	1511.4	5612.5	6703.3
1983	1312.5	1540.4	6058.0	7110.0
1984	1347	1540.2	6282.0	7183.0
1985	1393.5	1560.3	6479.0	7254.8
1986	1414	1556.1	6686.5	7358.6
1987	1421	1562.2	6894.5	7579.8
1988	1441	1573.5	7542.0	8235.2
1989	1488.5	1593.0	8574.5	9176.4
1990	1566.5	1638.6	9567.0	10007.4
1991	1650.5	1681.6	10764.0	10966.6
1992	1679	1681.4	11217.0	11233.1
1993	1681	1673.1	10654.5	10604.7
1994	1690	1679.3	10373.5	10307.5
1995	1669	1669.0	9909.5	9909.5
1996	1642	1666.0	9498.5	9637.4
1997	1613	1632.2	1613	9048.0
1998	1552	1565.3	1552	8623.4
1999	1505	1531.3	1505	8247.2
2000	1479	1515.4	1479	7934.9

Source: National Chamber of Agriculture "*The Result of Survey on Farmland Prices*" 2001

Appendix 3-3 Farmland sales prices for housing

Unit: 1,000yen/10are

		Under the zoning of Agricultural Land Use Promoting Law	1990	1995	2000
Under the zoning of City Planning Law	Urbanisation promotion area (1)	Paddy	88,217	91,756	76,157
		Vegetable	100,848	98,899	81,788
	Urbanisation control area	Paddy	29,966	32,227	29,009
		Vegetable	31,522	33,185	29,558
Others		Paddy	14,919	16,857	16,781
		Vegetable	13,946	16,003	16,091

Source: National Chamber of Agriculture "*The Result of Survey on Farmland Prices*" 2001 and authors calculation.

Chapter 4. Rent and Farmland Valuation Theory: A Review of Theory and Empirical Application

4-1. Introduction

Olmer and Florax (2001) review the main reasons for the recent increasing interest in the determinants of agricultural land prices. For example, in the US there was an explosive increase in farmland prices in the 1970s followed by an equally rapid decrease in the 1980s, and in England and Wales farmland prices jumped after the entry into the EC, and started decreasing in the 1980s. Meanwhile, Japanese farmland prices increased rapidly (see Figure 3-4, 3-6 and 3-7) from the end of the 1960s till the 1980s because a lot of farmland had converted to non-agricultural use, and the farmland price included a conversion expectation. Moreover, at the end of the 1960s and the beginning of 1970s, the demands of farmers who lost their agricultural lands in urbanising areas even pushed farmland prices up in rural areas. It is believed by some in Japan that price formation is no longer based on agricultural returns and that all farmland prices include an expectation for farmland conversion into non-agricultural use (e.g., Kaiji, 1973; Ito, 1984; Godo, 1998). The purpose of this chapter is to review the theoretical development of rent, land and farmland prices and the empirical research.

Land and rent occupied a critical position in Classical Economics (Currie, 1981), although it didn't regard agriculture as the origin of wealth like the Physiocrats[1]. The economic system envisaged by the Classical Economists was based on three socio-economic groups – landowners, capitalist tenant farmers and landless labourers,

[1] Th e Physiocrats believed that agriculture was unique in that the new wealth created by agricultural production exceeded the wealth destroyed in the process of production (Currie, 1981).

and Adam Smith (1723-1790) distinguishes three factors of production – land, labour and capital (or stock) which were implied in his *Wealth of Nations* (1776). In Classical Economics, labour produced the wealth, not agriculture itself. However, it also distinguished between 'circulating capital[2]' and 'fixed capital[3]'. In Classical Economics, land is treated as a factor of production and the production function takes the form:

$$Y = f(A, K, L) \tag{4-1}$$

where Y= aggregate output, A = land, K= capital, and L= labour. Land was broadly defined as synonymous with the "natural endowment", and was treated as fundamentally fixed in availability, while the supplies of capital and labour were more elastic (Randall and Castle, 1985).

With the development of neoclassical economics in the last decades of the nineteenth century, mainstream economic theory abandoned the idea that land rent needed a separate set of theories (Ball *et al.*, 1998), because in developed countries the issues of land and its ownership had declined considerably in political, social and economic significance (Currie, 1981). Even prior to the emergence of neoclassical economics, Marx had abandoned the tripartite division of society in classical economics and had grouped the owners of land and capital together. Land became another factor of production, rather than the belonging to a particular social grouping with subsequent economic consequences (Ball *et al.*, 1998). Following technological development in agriculture, and increase in the importance of industries in economies, the fixity of land and diminishing marginal productivity of the other factors were no longer the dominant matter to neoclassical economists. They tended to give land no special

[2] This is the capital which was used up in the process of production.
[3] This me ans the capital which could be used for several acts of production.

place in their model (Randall and Castle, 1985), and the aggregate production function could be simplified from the classical function (4-1) to,

$$Y=f(K, L) \tag{4-2}$$

Neoclassical economists (Schultz, 1980), also pointed out that:

"*the share of national income that accrues as land rent and the associated social and political importance of landlords have declined markedly over time in high-income countries, and they are also declining in low-income countries.*" (p642)

The modernisation of agriculture and research transformed land into a more productive resource, and changed poor productive land into high quality land. Thus, Ricardian rent theory based on fertility of land was recognised as being no longer adequate, and the profitability of land became a central part of the determination of rent. As Harvey (1974) remarked, therefore, the modern explanations (on the concept of the land market) have been extremely brief and do not discuss the nature or role of transactions in any details. However, it is still essential to detail the mechanism of the farmland market and transactions, especially for this study focusing on the farmland market structure as the main analytical instrument.

The purpose of this chapter is to provide the theoretical and empirical framework of this study; firstly we begin with the basic concept of the rent, detailing the recent development of the theory by Currie (1981) and Lloyd (1993) followed by recent empirical modelling.

4-2. Nature of Rent in Classical Economics

For the classical economists, the nature of rent became an important notion to develop commencing with a conceptual explanation by Smith in the context of the generation of wealth. He described rent as 'the produce of those powers of nature, the use of which the landlord lends to the farmer'(Currie, 1981):

"*Rent, considered as the price paid for the use of land, is naturally the highest which the tenant can afford to pay in the actual circumstances of the land. In adjusting the terms of the lease, the landlord endeavours to leave him no greater share of the produce than what is sufficient to keep up the stock from which he furnishes the seed, pays the labour, and purchases and maintains the cattle and other instruments of husbandry, together with the ordinary profits of farming stock in the neighbourhood.*" (Smith, 1970, p247)

Smith's basic theory of rent, which is based on 'natural' or 'normal' rent level or profit, did not give a clear explanation of the decomposition of the surplus into rent and profit (Currie, 1981). On the other hand, David Ricardo (1772-1823) focused on the exchange value driven by commodities from two sources: from their scarcity, and from the quantity of labour required to obtain them. Ricardo is regarded as the first to develop a rent theory in the sense that he explained the determination of profits and the source of rent focusing on the agricultural sector, in 'An Essay on the Influence of a Low Price of Corn on the Profit of Stock' originally printed in 1815. Currie (1981, p12) briefly reviewed the rent theory of Ricardo as follows:

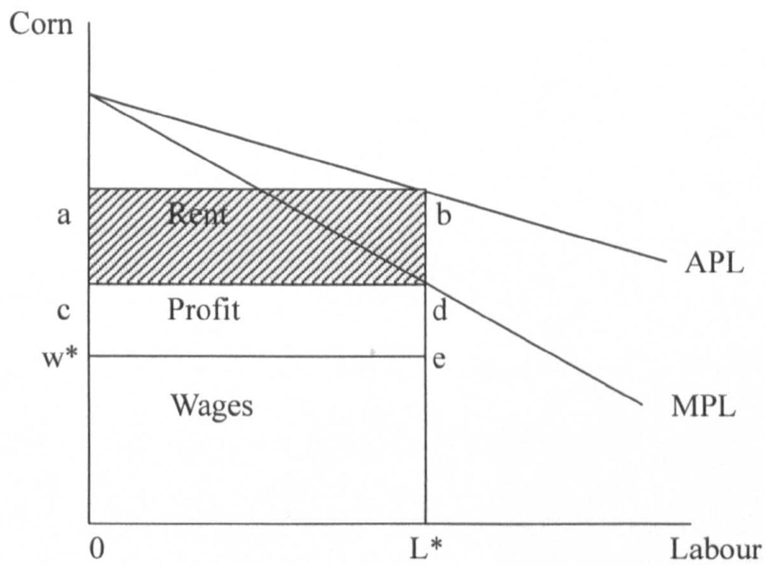
"*In the first settling of a country with sufficient fertile land for the initial population, the entire surplus of output over the outgoings necessary for cultivation would accrue to the owners of capital as profits. Thus if the individual employed capital to the value of 200 quarters of wheat and if, after replacing the capital, the value of the remaining produce – the surplus – was 100 quarters of wheat, the rate of profit to the* *capitalist would be 50 per cent. At first increased food requirements consequent upon population growth might be met by bringing into cultivation land equally fertile and equally well situated. However, with yet further increase in population, it might be necessary to resort to land less fertile or less advantageously situated. On such land more capital would have to be employed in order to obtain the same output. Thus the equivalent of 210 quarters of wheat might be required to obtain a total output of 300 and a surplus of 90. The rate of profit would therefore be 43 per cent. Now the rate of profit on this grade of land would constitute the 'normal' rate of profit. Competition would ensure that the same rate of profit of 43 per cent would be earned on the most fertile land. The remaining 7 per cent would accrue to the owners of that land in the form of rent. If the growth of population required the cultivation of land even less fertile or even less advantageously situated then the profit rate would be determined by the surplus on that land. The profit on the first and second grades of land would fall accordingly. The rent of the most fertile land would rise. Rent would also be paid for the land of the second grade. The convenient feature of this hypothesis of the emergence of differential rents was that the rate of profit earned on the marginal no-rent land defined the normal rate of profit. On intra-marginal land anything in excess of the normal rate of profit would be appropriated by landlords in the form of rent. This explanation in terms of marginal no-rent land permitted a remarkably simple explanation of a very complicated phenomenon."*

The phrase 'economic rent' was used by Ricardo to indicate the price paid for 'the original and indestructible qualities of the soil'. Hallett (1960) comments, however, that Ricardo probably realised a difference between 'economic rent' and 'the cash rent' which is actually paid to a landlord. He notes that the popular writers who followed Ricardo ignored this distinction, and that they even argued that the landlord had stolen the land from the people and was receiving money for which he did nothing.

4-2-1. Ricardian corn model

According to Ricardo, rent is that portion of the product of the earth which is paid to the landlord for the use of the original and indestructible power of soil. However, rent forms no part of the price of agricultural products as understood from Ricardo's famous sentence: "Corn is not high because a rent is paid, but a rent is paid because corn is high". Modern interpretation of Ricardo's rent theory can be explained by the so-called Ricardian Corn model (Currie, 1981) assuming that there is a given total amount of unimproved land available for use in the production of a single commodity, corn. It is not required that all the land necessarily be cultivated. It is assumed that, at any point in time, the wages fund is predetermined as a result of past developments and, that the total labour force is predetermined by the population level. The simplest explanation of the definition of rent is displayed in Figure 4-1. Regarding the agriculture sector as one large farm, APL represents the average product of labour and MPL represents the marginal product of labour. As a result of competition for and among hired workers the market wage rate is given by the total wages fund divided by the fixed supply of labour. The market wage rate is shown as w* in Figure 4-1, and the labour force, L*, determines the marginal product of labour. Profit is then obtained as a residual: profit per worker is the difference between the marginal product of labour and the wage rate (i.e., the rectangle, cdew*). Rent is also determined as a residual: it is the surplus on intra-marginal units of labour (equivalent to the rectangle, abdc).

Figure 4-1 The Ricardian corn model



Source: Currie (1981).

The growth of population required the cultivation of land less fertile or less advantageously situated, and then the scarcity of fertile land raises the level of rent. The emergence of differential rents represents the difference of productivity defined by land fertility. To simplify, land quality is expressed in a single dimension F ($0 \leq F < \infty$), where larger values for F indicate higher levels of soil fertility (Randall and Castle, 1985). The output of a single crop (z_i) is written as a function of labour, land and soil fertility,

$$z_i = f(L, A, F) \tag{4-3}$$

$\partial^2 f / \partial L \cdot \partial F > 0$ and $\partial^2 f / \partial A \cdot \partial F > 0$ which imply that increasing fertility has a positive influence on the marginal productivities of both labour and land. Then the production function in per acre terms can be expressed by using unit productivity, $q_i = z_i / A$, and unit labour input, $l = L / A$:

$$q_i = a_i f(l, F), \qquad \partial f / \partial l > 0, \partial^2 f / \partial^2 l > 0 \tag{4-4}$$

where a_i is a proportionality factor ($a_i > 0$ for all i) for crop i. The profit for the crop i per acre, π, may be expressed as follows:

$$\pi = p_i \cdot a_i f(l, F) - wl - p_r(F) \tag{4-5}$$

where p_i is the price for crop i, and w is the wage paid. Besides, p_r shows the unit land rent. As labour use per acre is optimised at the level l^*,

$$p_r(F) = p_i \cdot a_i f(l^*, F) - wl^* \tag{4-6}$$

Restricting the rent to be non-negative, there is some land for which $p_r(F_{\min}) = 0$, and $p_i \cdot a_i f(l^*, F_{\min}) = wl^*$. Randall and Castle (1985) conclude that land rents are positive and increase with soil fertility for $F > F_{\min}$, and that land with $F < F_{\min}$ is abandoned and output there would be zero because the revenue is less than labour cost at the optimal factor combination.

4-3. Land in Neoclassical Economic Theory: Supply and Demand Approach

4-3-1. The stock and flow concept of the land market

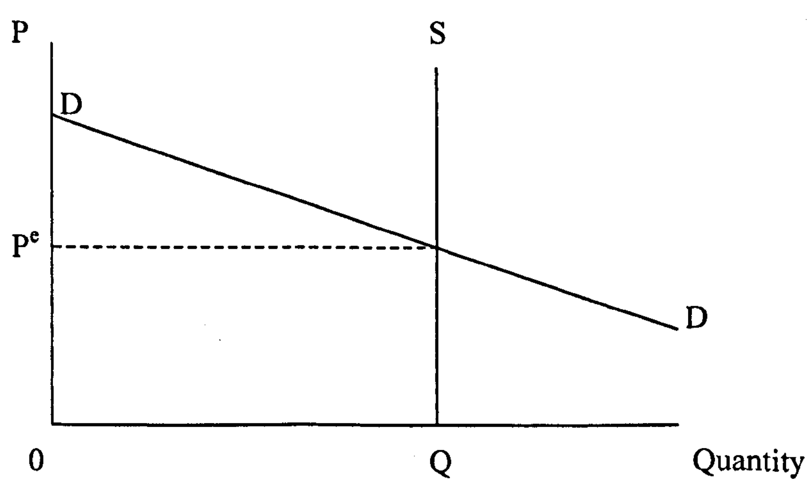
Within the neoclassical economics which developed in the last decades of the nineteenth century, like other economic commodities it is assumed that the price of land is determined by the concept of demand and supply (Harvey, 1974; Lloyd, 1993). However, as Lloyd (1993) remarks, special attention needs to be paid to the actual definition of 'supply' and 'demand' in the case of land. The term 'supply' does not have the conventional meaning of 'the amount entering the market in the certain time period, rather it refers the accumulated stock of commodities, not the amount of land which is on sale in the given period. The demand for the stock of land may also be interpreted similarly; all agents who hold land are considered to have a demand curve, and not simply those who are wishing to purchase land. Therefore, the demand for the stock of land originates from both prospective purchasers and current owners of land. Lloyd (1993) cites the concept of stock demand clarified by Wicksteed

(1910) using the concept of *reservation price* and *offer price*.

"*Given that each agent has a valuation of land determined by its net present value, the stock demand curve represents a ranking of those valuations in descending order, irrespective of whether the individual is seeking to purchase at a particular price or an owner registering the worth he attaches to the unit he currently owns. Thus we can define the valuation of a current owner (his reservation price) as the minimum sum he would be prepared to accept in exchange for his land. Conversely, the valuation of a prospective purchaser (his offer price) represents the maximum sum he would be prepared to buy land for.*" (p III7)

Figure 4-2 illustrates a stock concept of the equilibrium land price determination. The line QS denotes a fixed quantity of land available in the given period, and demand curve DD shows a ranking of valuations of reservation price. The interception of these curves represents and equilibrium market price (P^e) based on the demand to hold the stock of land.

Figure 4-2 Equilibrium price determination in the stock market

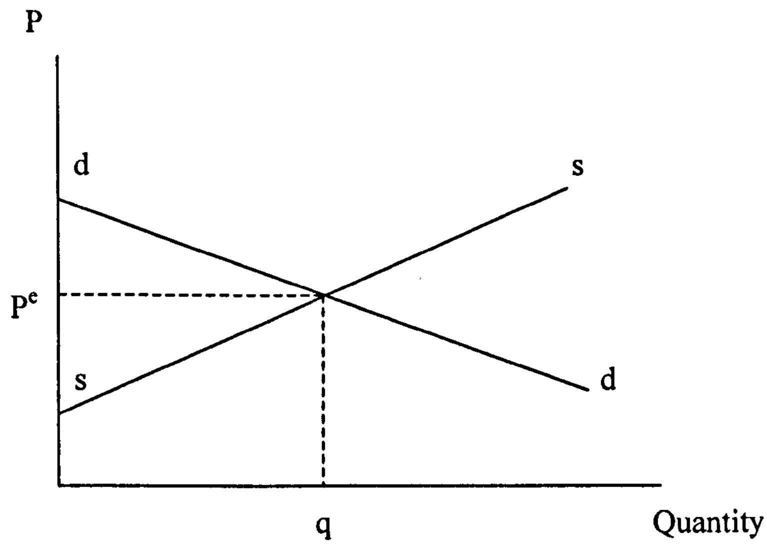


The flow concept of the land market which is detailed in Harvey (1974) and Lloyd (1993) is important to understand the mechanism of farmland transactions. It is important to note that the level of transactions is independent of the equilibrium price of land which is determined by fixed supply and accumulated demand curves in such circumstances. The equilibrium price reflects a valuation of land such that all individuals (collectively) are prepared to hold the existing stock at a point in time, but is nothing regarding the allocation of land among individuals. Conversely in the flow market as shown in Figure 4-3, at the equilibrium price there will be some individuals who own land but wish to sell (i.e., $P_{it} < P^{e}$) when we assume there are $i = 1, 2, \ldots, n$ agents in the market at time t, and some individuals who wish to buy land at the current price (i.e., $P_{it} > P^{e}$). Thus, it is assumed that at the market equilibrium price, there exist individuals who are not in equilibrium. The trade of land will take place at the equilibrium price to resolve "an *intra-market disequilibrium*" (Lloyd, 1993, pIII9). Lloyd (1993) explains this mechanism: demand and supply of land in the *flow* concept as follows:

" *The 'supply of transactions' during a given period, (i.e., the number of units of land that owners wish to sell in a particular period), will depend on the extent of the misallocation of land amongst owners in the market. The transactions supply schedule will thus comprise reservation prices only and ceteris paribus, the higher the price, the more land will be offered for sale. Thus the transaction supply curves will have a positive gradient as depicted in Figure III.2 (Figure 4-3 in this study). The quantity of land that owners collectively wish to sell at any given price will be determined by the number of owners whose valuation of land is less than that given price. 'Transaction demand' can be thought of in a similar way, in that, it represents the valuations of agents in the market that wish to purchase land at given prices. ········· The quantity of land that prospective purchasers will wish to buy during any period will be determined by the number of valuations of prospective owners equal or greater than the current market price.* " (pIII.9)

Thus, both price and the volume of trade of land in equilibrium are derived using more familiar flow concept of demand and supply, and should not be confused with the concept of stock of land.

Figure 4-3 Transaction of land (flow market)



In order to clarify the link between the stock market and flow market concept, now we assume that at time t, there are n agents, which is equivalent to the number of agents holding land at time t, in a land market. Each agent possesses an initial stock of land Q_i for $i = 1, \ldots, n$, and each agent also has a downward sloping demand curve in relation to land price, P_t, for the ownership of land. The demand curve is $D_{it} = D_{it}(P_t)$ for $i = 1, \ldots, n$. The equilibrium price of land, P_t^e reflects the intersection of the aggregate downward demand curve for land with the perfectly inelastic stock supply curve (Phipps, 1984) as shown in Figure 4-2.

$$\sum_{i=0}^{n} D_{it}(P_t^e) = \sum_{i=0}^{n} Q_{it} \tag{4-7}$$

Describing the flow market of land by using the concept of the excess demand or excess supply, it is assumed that m agents (where $m \leq n$) have non-negative excess demand;

$$ED_{it}(\overline{P}_t) = D_{it}(\overline{P}_t) - Q_{it} \geq 0 \quad \text{for } i = 1, \ldots, m \tag{4-8}$$

and the remaining $n\text{–}m$ agents have non-negative excess supply;

$$ES_{it}(\overline{P}_t) = Q_{it} - D_{it}(\overline{P}_t) \geq 0 \quad \text{for } i = m+1, \ldots, n \tag{4-9}$$

The m agents with a non-negative excess demand are potential purchasers of land, and $n-m$ agents are potential sellers of land. At lower prices, aggregate excess demand increases partly because the number of prospective purchasers can increase and partly because the demand for land ownership increases. Conversely, aggregate excess supply diminishes with lower price. The intersection of the aggregate excess supply curve and excess demand curve will be the equilibrium price, P_t^e.

$$0 < \sum_{i=1}^{h} ED_{it}(P_t^e) = \sum_{i=h+1}^{n} ES_{it}(P_t^e) > 0 \tag{4-10}$$

where h agents have non-negative excess demand and $(n-h)$ agents have non-negative excess supply. Those agents are considered as individuals who are not in equilibrium at the equilibrium price. However, considering the land-specific characteristics such as transaction costs and location problem[4], the actual amount of land traded will be smaller than the above;

$$0 < \sum_{i=1}^{h} ED_{it}(P_t^e) = \sum_{i=1}^{g} ES_{it}(P_t^e) > 0 \tag{4-11}$$

where k ($< h$) agents are actual purchasers of land, g ($< n-k$) being actual vendors of land. Therefore (n–g–k) agents are content to hold the land they currently own. The government often introduces some policy instruments in order to resolve those barriers for the smooth transaction[5]. Meanwhile, as the owners gain nothing by holding land idle, it is better for them to let the land to farmers as they can receive the returns from the land, except psychic benefit from land ownership (Harvey, 1974).

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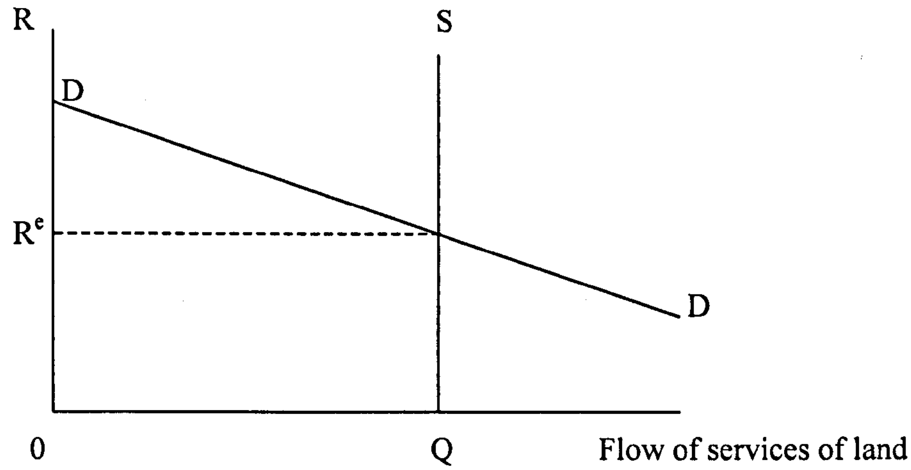
[4] Lloyd *et al.* (1991) explains that the transaction cost includes (a) the searching cost, and negotiation cost, and (b) costs of implementing final contracts. As to location problem, it often happens that potential buyers of land may not trade because of mismatching the location preference.

[5] For example, see the establishment of intermediate agency for farmland transaction in Japan (3-4 in Chapter 3).

The rent of land is simply determined by the demand for the service flow, represented by the curve *D*, and perfectly inelastic supply curve *S* as seen in Figure 4-4. This is based on the similar concept to the determination of equilibrium price of land. This is defined as 'equilibrium rent' by Harvey (1974) under the assumption of the market being perfectly competitive in rationing the total available supply of services in each period among the competing agricultural users. In this sense, 'equilibrium rent' is rather conceptual rent than actual rent as this circumstance unlikely happens in practice. Harvey (1974) also outlines the definition of 'observed rent', which is actually paid rent (i.e., cash rent) by tenant farmers to landowners. However, the level of rent is not renegotiated each year, but of the end of the tenancy contract, usually every 2 – 10 years in Japan. Therefore rents are determined in the market by the new entry of tenants with prospective landowners and renegotiation of the tenancy contract. Thus, Harvey (1994) notes that the concept of 'market rents' is defined as either i) the result in each period of new tendered rents or ii) the result of renegotiations between sitting tenants and landlords in each period, the newly negotiated rents. In practice in Japan, as outlined in Chapter 3, the rent level had been directly controlled to reflect agricultural profitability until 1980. Even since 1980, all rent is observed not to exceed the 'standard rents' by the regional chamber of agriculture[6]. Therefore, we can assume that 'market rents' would be close to the 'standard rent', and 'observed rents' may contain some gap from 'market rent', although subject to the duration of the contract period.

[6] Th e standard rent is determined by the regional chamber of agriculture to reflect agricultural profitability in that region. It was revised every three years initially, but it would be revised every time when required under the new law.

Figure 4-4 Determination of rent



4-3-2. Price determination in land market

As the determination of the land market at the aggregated level is explained above, Currie (1981) concentrates on the interaction between landowners and prospective tenant farmers, and stipulates the process of rental contracts agreement from the simplest cases. Based on the analysis of Currie (1981), Lloyd (1993) interprets the model for the sales market and explains the price determination from the case of two market participants (current landowner and a prospective purchaser) to the case which includes a large number of agents. We concentrate on the sales market as Lloyd (1993) does, and detail here.

(a) Case 1

Firstly, the market which consists of one unit of land and two agents is assumed: a current landowner and a prospective purchaser. It is also assumed that a current owner has an offer price, P_{o1}, and a prospective purchaser (agent 1) has a reservation price, $P_{r,o}$. If $P_{o1} > P_{r,o}$, trade between agent 1 and the current owner will occur. However, the equilibrium price (P^e) is indeterminate although it should be in the range of $P_{o1} \geq P^e \geq P_{r,o}$, which is called 'core' by Currie (1981, p87) or if the valuation of the two agents are exactly same, the equilibrium price will be determined as $P^e = P_{o,1} = P_{r,o}$. However, it is not clear if the transaction is proceeded or not in this case. Lloyd (1993) describes, "trade is an ongoing phenomenon, ownership constantly switching between the two agents" (pIII.15).

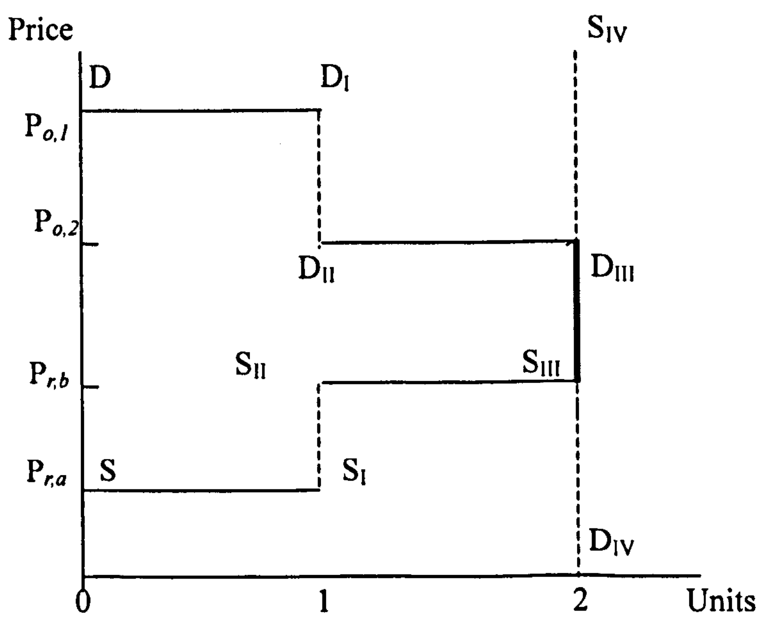
(b) Case 2

Now we consider the third agent as a prospective purchaser in the market. Therefore, there are one unit of farm and two prospective purchasers in the market. Agent 2 has the offer price, $P_{o,2}$, which is $P_{o,1} > P_{o,2} > P_{r,o}$. In this case, the unit will be still sold to Agent 1, however, Agent 2 plays an important role in the sense that its offer price narrows the range of 'core' in which the equilibrium price lies because the final agreed price cannot be less than Agent 2's offer price. Therefore, the equilibrium price lies in the range of $P_{o,1} \geq P^e \geq P_{o,2}$. Similar to case 1, if $P_{o,1} = P_{o,2} > P_{r,o}$, it is not certain which prospective purchaser will obtain ownership. Again, trade will be an ongoing phenomenon.

(c) Case 3

In the next case, there are two homogeneous units of land and four agents in the market; two current landowners (Agent A, B) and two prospective land purchasers (Agent 1, 2). The reservation land prices of current owners for Agent A and B are $P_{r,a}$ and $P_{r,b}$, and the offer prices of prospective land purchasers for Agent 1 and 2 are $P_{o,1}$ and $P_{o,2}$, respectively. It is assumed that $P_{o,1} > P_{o,2} > P_{r,b} > P_{r,a}$. In this case, all unit for sales will be traded at the same price (i.e., the equilibrium price), because the lowest offer price, $P_{o,2}$, exceeds the highest reservation price, $P_{r,b}$. The transaction will occur within the range of the core between $P_{o,2}$ and $P_{r,b}$ because at price above $P_{o,2}$ Agent 2 would not wish to purchase the second unit of land, and at price below $P_{r,b}$ Agent B would not wish to sell the second unit of land. All units will be traded at one price since the prospective owner who pays the higher price and the current owner who receives the lower price would negotiate until both units of land were traded at the same price. Therefore, the equilibrium price lies in the range of $P_{o,2} \geq P^e \geq P_{r,b}$. This is illustrated with supply and demand curves of the four agents in Figure 4-5. The demand curve and the supply curve are represented by $DD_ID_{II}D_{III}D_{IV}$ and $SS_IS_{II}S_{III}S_{IV}$. As explained above, the intersection of the transaction function occurs at 2 units, and the equilibrium price lies between $P_{r,b}$ and $P_{o,2}$.

Figure 4-5 Determination of the equilibrium price with two owners and two prospective purchasers: The case of $P_{o,1} > P_{o,2} > P_{r,b} > P_{r,a}$



(d) Case 4

Using the above concepts, we now examine the case where there is a number of agents in the market in order to allow us to consider the continuous function as used in the previous section. Similarly, it is assumed that there are *m* prospective owners and *n* current owners of land in the market. In this definition, there are *n* homogeneous units of land. $P_{r,i}$ and $P_{o,j}$ are denoted as the reservation price of the *i*th owner ($i = 1, 2, ..., n$) and the offer price of the *j*th prospective purchasers ($j = 1, 2, ..., m$), respectively. Now we define the transactions demand and supply curves by assuming the rank such as:

$$P_{o,1} \geq P_{o,2} \geq \ldots \geq P_{o,m}$$

$$P_{r,1} \geq P_{r,2} \geq \ldots \geq P_{r,,n}$$

It is also assumed that $P_{o,1} \geq P_{r,1}$ as the basic condition for the transaction between these agents. Following the rule as explained above, all transactions will occur at the same equilibrium price. If *k* units of lands are agreed for trade in the given period, the equilibrium price must lie in a range between the offer price of the 'marginal' prospective purchaser and the reservation price of the 'marginal' owner, which is given by:

$$\min(P_{o,k}, P_{r,k+1}) \geq P^e \geq \max(P_{r,k}, P_{o,k+1})$$

This is explained by assuming the simple case where two prospective owners and two landowners exist in the market with $P_{o,1} > P_{r,b} > P_{o,2} > P_{r,a}$. This case is illustrated in Figure 4-6; the supply curve and demand curve are $DD_ID_{II}D_{III}D_{IV}$ and $SS_IS_{II}S_{III}S_{IV}$, respectively. It is recognised that the equilibrium price lies in the range such that:

$$\min(P_{o,1}, P_{r,2}) \geq P^e \geq \max(P_{r,1}, P_{o,2})$$

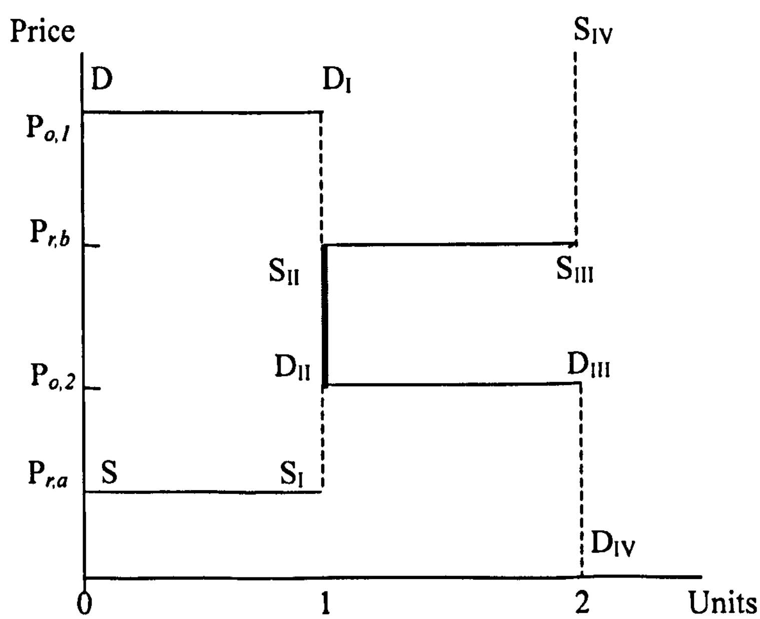
and then, $P_{r,2} \geq P^e \geq P_{o,2}$.

As explained in this analysis, it is implied that the equilibrium price is determined by the valuation of the prospective purchaser and the valuation of the current owner at the margin. However, the concept of the 'stable equilibrium' is also a significant point to be discussed. Currie (1981) states as follows;

"*By construction, equilibrium is necessarily stable. Notice, however, that* *indeterminacy of some sort is inevitable. This indeterminacy may relate to the contract rent [this case, agreed transaction price], the number of transactions or the identities of the final farmers. This indeterminacy is attributable to the indivisibility of operating units. It does not disappear however large the number of participants. However, it may well become of less practical significance as the number of participants increases.*" (p89)

Only after trade has occurred and a stable equilibrium attained, will the 'marginal' vender and 'marginal' prospective purchasers determine the range the equilibrium price falls in. Lloyd (1993) develops further discussion about this point in Appendix III.A (pIII.32-III38).

Figure 4-6 Determination of the equilibrium price with two owners and two prospective purchasers: The case of $P_{o,1} > P_{r,b} > P_{o,2} > P_{r,a}$



4-4. The Empirical Limit ation of the Supply and Demand Approach

Although the simple capitalisation formula, which assumes that farmland prices are discounted residual earnings, was used in early studies, the divergence of asset values from farm income led to the need of alternative explanations, such as productivity increases, government programmes, and urbanising pressures[7]. In the 1960s, these variables were introduced in land pricing through a supply-demand framework for empirical studies (e.g., Herdt and Cochrane, 1966; Tweenten and Martin, 1966; Cowling *et al.*, 1970). Harvey (1974) points out the theoretical pitfalls in the above approaches; firstly there is unlikely to exist a stable relationship between supply and demand, and secondly factors which may affect the supply and demand curves also could cause shifts in both demand and supply curves, which means that the separate influences cannot be identified. Nevertheless, these supply and demand models explained farmland price movement reasonably well during estimated periods (e.g., Harvey, 1974). However, Burt (1986) explains that a classic supply function for agricultural land does not exist, because farmland supply is highly influenced by governmental land use planning or policy, and is not reasonably elastic to land prices. Traill (1979) also mentions the possibility of farmers' speculative behaviour; farmers contemplating retirement may postpone to do so when they anticipate a sharp rise in land prices, or may retire early if they foresee a fall in land prices. Thus, due to a number of unresolved theoretical and empirical questions surrounding the supply-demand approaches to the farmland market, most recent empirical studies of farmland price movements have been focused exclusively on demand side forces

[7] Robins on, *et al* (1985) developed an aggregate two-sector land market model (see Appendix 4-1 for details). However, as is the case in many countries, land use regulations such as zoning are applied, responding to the rapid loss of agricultural land due to strong urbanising pressure.

(e.g., Weersink *et al.*, 1999), although there are exceptions (e.g., Lopez *et al.*, 1994)[8]. Thus, there is general agreement that the demand side of the market, potential buyers, determine a value of land based on their anticipated future net returns. This present valuation theory is widely applied for the empirical study.

4-5. Agricultural Land Valuation in Modern Economics

The study of agricultural land price determination has been developed under two broad model categories: models using the concept of farmland returns and models using non-farm factors.

The theoretical framework of the first category is mostly based on the asset-pricing or capitalisation model, implying that the value of an asset is equal to discounted land rent and prices. The asset-pricing model has been largely developed in finance and real estate theory, but is also related to the net present value model used in natural resource economics (Randall and Castle, 1985).

The second category of studies uses mainly non-farm factors to explain the variation in agricultural land prices. These studies are based on the hedonic pricing model, and frequently use variables such as the distance to urban centres or highways, population density, the attractiveness for recreational activities, and/or land and soil characteristics. Oltmer and Florax (2001) comment that the focus of these studies ranges from the valuation of urbanisation and urban fringes (e.g., Chicoine, 1981; Dunford *et al.*, 1985; Shonkwhiler and Reynolds, 1986; Shi *et al.*, 1997), to soil and

[8] Lopez *et al.* (1994) develop a supply-demand model of the amount of land in agriculture to find the optimal allocation of agricultural land.

site characteristics (e.g., Miranowski and Hammes, 1984; Xu *et al.*, 1993; Elad *et al.*, 1994), and erosion control and soil conservation (e.g., Ervin and Mill, 1985; King and Sinden, 1988; Palmquist and Danielson, 1989).

The former model category can consider the influence of agricultural policy (e.g., agricultural product prices and farmers' income) because the returns of land, as the main constituent of land prices, are likely to reflect the policy. On the other hand, the latter model category is suitable to evaluate the effect of land use regulations in the short period, but not the effect of agricultural policy change on the farmland market in the long run. As this thesis is interested in economic analysis of farmland market structure in the long run, using time series data, this section focuses on a review of the first category of model.

4-5-1. Assumptions for analysis of land

For analysing the land market in the present valuation theory, we need to conceive a number of homogeneous units of land which comprise the immutable stock of land (Lloyd, 1993). We also assume that this stock of land is to be allocated among individuals via the price system in the perfectly competitive market. It is further assumed that each market participant forms a valuation of land on the basis of a subjective expectation of the discounted net returns from land acquisition over the period of ownership. Each agent behaves economically rational as maximising its wealth and utility. The decision is made as described by Lloyd (1993); if the individual's price valuation of land exceeds the prevailing market price that agent will wish to purchase land; conversely, if the valuation is below the market price the individual will not wish to buy (if he does not already own land) and will with to sell (if he does).

With regards to the above assumptions, Lloyd (1993) emphasises the following four points to be made concerning valuations. Firstly, as valuations are based on the concept of present value, in practice, individuals may use some other method of valuation, or even no method at all. In other words, the valuation may be the outcome from a purely random generating process and represents no more than a guess. Second, the any particular valuation is assumed to hold irrespective of whether the agent currently owns land or not. Therefore, in this framework, no transaction cost is considered. As the third point, an agent's valuation will be revised in light of new information but will hold in the absence of any new information. Consequently, the valuation encapsulates all information pertinent to the individual about the future and in an expectation that the individual believes will materialise. Therefore, under this assumption, each agent acts as if he has perfect foresight. Fourth, valuations are assumed to vary across agents. Despite the assumption of homogeneous units of land and perfect information, it is still assumed that individuals act on past information differently. Net returns to land ownership are unlikely to be the same for all owners due to, as Lloyd (1993) notes:

"*Varying importance individuals attach to non-pecuniary returns of landownership, differences in farming ability and the discount rate that each participant uses to convert expected future returns to an equivalent present value.*" (pIII.3)

Lloyd (1993) also mentions the importance to make the distinction between income derived from land ownership and that derived from farming in the precise nature of the net present value concept. Nevertheless the importance of this distinction would vary depending on the ownership structure in each country. For example, in England, there are three types of farmers focusing on the source of labour; capitalist farmers who rely entirely on hired labour for farming, owner cultivate farmers who own the land they farm and use mainly family labour, and tenant farmers who rent farms mainly from capitalist farmers. Conversely, in Japan, as reviewed in the previous chapter, the owner of land needs to be the cultivator (i.e., owner-cultivator). Therefore, we can dismiss the capitalist concept in this analysis (i.e., wealth maximising just from the ownership of land). Rather, it is assumed that the demand for land, like any other factor of production, strongly links to the demand for the agricultural production. Of course, as Lloyd (1993) points out, the present value of a stream of net rents may not be the only determinant of land price. Individuals may attach some importance to the ownership of land itself[9] and hence may purchase land for the subjective satisfaction that owning land bestows, as well as its input value for production.

4-5-2. Pr esent valuation model (PVM)

As discussed above, the present value theory, in which a stream of future income is an equivalent sum of money which is available for current consumption, is widely applied to study farmland prices in many countries. For this analytical framework, the following points are assumed as Lloyd (1993) listed:

"*1. There is a large number of homogeneous ownership units in the land market.*
2. There are sufficient agents in the land market to own all ownership units at a non-zero price, i.e., there is excess demand for land at a price of zero.
3. Each participating agent wishes to hold only one unit of land.
4. There are no transaction costs in transfer of ownership or any other barriers to ownership.
5. Input and output markets are perfectly competitive.
6. Any non-pecuniary benefit to land ownership is quantifiable.

[9] In Japan, the attachment to the ownership of the land often stem from the duty to ancestors who acquired and maintained the land (i.e., sentimental value), as well as financial security or future expectation from owing the property.

7. *Individuals aim to maximise their income (pecuniary or otherwise).*
8. *No government regulation of any kind.*
9. *The decision to purchase land is based solely on an individuals' net present valuation of land.*
10. *Individuals act with perfect knowledge of the present period and subjective certainty of future periods.*
11. *There is a perfect capital market in which the supply of credit is perfectly elastic for any individual at the prevailing rate of interest.*" (p III.5-6)

Under the above assumptions, the value of land is the capitalised value of the current and future stream of earnings from owning that land,

$$P_t = \sum_{i=0}^{\infty} \frac{E(R_{t+i})}{(1+r_{t+1})(1+r_{t+2})\cdots(1+r_{t+i})} \tag{4-12}$$

where P_t is the equilibrium land price at the beginning of time period t; R_t is the residual real return generated from owning the land measured at the end of time period t; r_t is the time varying real discount rate for year t; and E is the expectation on returns conditional on information in period t. If it is assumed that the discount rate is constant, agents are risk neutral, and differential tax treatments of capital gains and rental income are ignored (Hamilton and Whiteman, 1985), then the asset valuation model given by equation (4-12) becomes:

$$P_t = (1+r)^{-1} \sum_{i=0}^{\infty} \frac{E(R_{t+i})}{(1+r)^i}. \tag{4-13}$$

When $\delta = 1 / (1 + r)$:

$$P_t = \delta \sum_{j=0}^{\infty} \delta^j E_t\left[R_{t+j}\right] \tag{4-14}$$

Furthermore, assuming the residual earnings are constant in each period, R^*, equation (4-14) simplifies further to the traditional capitalisation formula:

$$P_t = \frac{R^*}{r} \tag{4-14'}$$

The capitalisation formula of equation (4-14)' has formed the foundation for most studies on asset values with residual returns measured by, for example, net farm income or net rent. If the land were sold at $t = 0$ and R_{t+j} represents the anticipated stream of residual earnings at all subsequent times, using (4-14)', the market value of this land would be

$$P_0 = \frac{R_0}{r}. \tag{4-15}$$

Farmland prices are influenced by the future possibility of it being used for non-agricultural purposes, because the residual returns from land would be different. Randall and Castle (1985) discuss the farmland prices which expect future sales of land for agricultural use, and Phipps (1984) added the case of urban fringe agricultural land which has the possibility of conversion to non-agricultural use.

(a) Farmland prices with sales plan for agricultural use at time *T*

If land is owned by a farmer who plans to sell it at some future time, *T*, its present value will be,

$$P_0^A = \delta \sum_{j=0}^{T} \delta^j E_t \left[R_{t+j}\right] + P_T^A \tag{4-16}$$

P_0^A is the market price of agricultural land at time 0. If there is no unexpected capital gains, P_T^A, which is the market price at time *T*, must be equal to the present value at *T* of the anticipated stream of residual returns from agricultural land use: $P_T^A = \delta \sum_{j=T}^{\infty} \delta^j E_t \left[R_{t+j}\right]$. Therefore, there is no difference between holding land for a finite time period and selling the land at time *T* when there is no change in land use (Randall and Castle, 1985).

(b) Farmland prices with sales plan for non-agricultural use at time T

However, if there is a plan to convert the land use in the future, for example to commercial use or housing, at time T, farmland prices can be distorted as the residual earnings from non-agricultural use can be higher than those from agricultural use in general. Assuming that a farmland owner knows that the land will convert to non-agricultural use at time T, and anticipated residual returns are also assumed to be perfectly known, then the market value of agricultural land which is going to be converted will be,

$$P_0^{NA} = \delta \sum_{j=0}^{T} \delta^j E_t\left[R_{t+j}\right] + \delta \sum_{j=T}^{\infty} \delta^j E_t\left[R'_{t+j}\right] \tag{4-17}$$

where P_0^{NA} is the market price of agricultural land the use of which may change to non-agricultural at time T. R' shows the anticipated residual returns from non-agricultural uses. When a farmer sells land for non-agricultural use, the price must be equal to the future sequent streams of earnings from the land: $P_T^{NA} = \delta \sum_{j=T}^{\infty} \delta^j E_t\left[R'_{t+j}\right]$. Therefore, the market price at time t can be also written as

$$P_0^{NA} = \delta \sum_{j=0}^{T} \delta^j E_t\left[R_{t+j}\right] + P_T^{NA} \qquad \text{(4-17)'}$$

Generally, the residual returns from non-agricultural use are larger than those from agricultural use (i.e., $R < R'$). Therefore, in the farmland market, prices in fringe areas are often much higher than those in rural areas (i.e., $P_0^A < P_0^{NA}$) in many countries. This theory explains the price differences in terms of agricultural land especially between rural agricultural areas and urban fringe areas.

4-5-3. The measurement of returns to land

As outlined above, the present value of farmland is a function of the 'net returns' to land. Recently, the majority of papers on farmland prices using PVM have used cash rents as a measure of returns to land, while early studies often used net farm income (e.g., Harvey, 1974; Trail, 1979). Lloyd (1993) points out the problem of using net farm income as the measurement of returns to land as:

" *Net farm income, as defined in official statistics actually represents the total return to the farmers' labour, management and working capital, such as machinery and livestock purchase and not the return of capital invested in land*[10]. *As a measure of the return to land, net farm income is therefore clearly inappropriate to the extent that its choice as a land income measure seems quite puzzling in retrospect.*" (pIV.14)

Thus, the residual income is a return to entrepreneurship not land. Scofield (1965) calls the reinforced use of net farm income as the return to land a 'seeming paradox' observing the case of rising land prices whilst stagnating or declining net farm income in the US and UK since the Second World War. In order to explain this paradox, there are several papers published investigating the influence of factors such as non-agricultural demand for farmland, technological change and locations. However, more recently, the use of cash rent has become a more accurate measure of farming returns as Alston (1986) explains:

"*This distinction [the residual income is a return to entrepreneurship not land] is particularly clear in the land rental market where the landowner obtains rent, contracted in advance, and the land-user claims any pure profit from the land. The same distinction should apply whether the landowner rents the land to himself or to someone else.*" (p5)

[10] Indeed, net farming income as defined in official statistics explicitly excludes the return to land paid in the form of rent.

Using cash rents as a measure of farm returns is also favoured from the conceptual point of view; the model is developed in the framework of present valuation theory. Thus, the PVM using cash rent is the mostly used model in recent studies on farmland prices.

4-5-4. Testing PVM

Since the late 1980s, while the popularity of the PVM has been based on the assumption that there is a consistent relationship between asset prices and returns, the failure of this model has been pointed out: farmland price movement cannot be explained well by the asset-pricing model, although it embodies economic theory (e.g., Burt, 1986; Featherstone and Baker, 1987). Several models have been considered and tested, including not only agricultural returns, (e.g., Phipps, 1984; Alston, 1986; Burt, 1986), but also the influence of inflation and real interest rates (e.g., Feldstein, 1980; AES, 1989; Just and Miranowski, 1993; Lloyd, 1994) and capital gains (e.g., Melichar, 1979; Castle and Hoch, 1982). Lloyd *et al.* (1991) examine three expectation models: adaptive expectations, naive expectations, and rational expectations. Subtracting $E_t[P_{t+1}]$ and $\delta E_t[P_{t+1}]$ from (4-14) which shows long-run PV rule, Lloyd *et al.* (1991) form the short-run decision rule as;

$$P_t = \delta E_t[R_t + P_{t+1}] + u_t \tag{4-18}$$

Under adaptive expectations, (4-18) may be written as,

$$E_t[R_t + P_{t+1}] = \frac{\alpha(R_{t-1} + P_t) + v_t}{1 - (1 - \alpha)L} \tag{4-19}$$

where α is the expectations coefficient, L is the lag operator and v_t is a random error term which is uncorrelated with u_t. Substituting (4-19) into (4-18) and rearranging,

$$P_t = \frac{1}{1 - \delta\alpha}(1 - \alpha)P_{t-1} + \frac{\delta\alpha}{1 - \delta\alpha}R_{t-1} + \frac{1}{1 - \delta\alpha}(\delta v_t + u_t - (1 - \alpha)u_{t-1}) \tag{4-20}$$

The naive expectations model is a special case of (4-20) where $\alpha = 1$;

$$P_t = \frac{\delta}{1-\delta}(R_{t-1} + v_t) + \frac{u_t}{1-\delta}$$

This is rewritten as,

$$P_t = \frac{1}{r} R_{t-1} + \varepsilon_t \tag{4-21}$$

In order to formulate the rational expectations model, it is assumed that expected percentage rate of return on land as an asset, stemming from expected capital gains and expected income flow, is equal to the (constant) real rate of discount,

$$\frac{E_t[P_{t+1}] - P_t + E_t[R_t]}{P_t} = r \tag{4-22}$$

Furthermore, under this assumption of rational expectations,

$$P_{t+1} - E_t[P_{t+1}] = e_{t+1}$$

where e_{t+1} are serially uncorrelated. Using (4-22) and reducing the subscripts by one gives;

$$P_t = \delta^{-1} P_{t-1} + e_t - E_{t-1}[R_{t-1}] \tag{4-23}$$

Further, if it assumed that rents are modelled by the extrapolative, weakly-rational predictive model[11],

$$R_t = \phi + \sum_{i=1}^{n} \beta_i R_{t-i} \tag{4-24}$$

then, $E_{t-1}[R_t\text{-}1]$ in (4-23) can be replaced by the OLS estimate of R_{t-1} from (4-24), $\hat{R}_{t-1}$, and then,

$$P_t = \delta^{-1} P_{t-1} - \hat{R}_{t-1} + \eta_t \tag{4-25}$$

where η_t are also serially uncorrelated. Applying the all expectation models to England and Wales data from 1971 to 1987, Lloyd *et al.* (1991) conclude that only the adaptive expectations model is acceptable, and that real rate of interest has no

[11] This model forming process is based on the discussion in Rayner and Young (1980).

discernible effect on real land prices. The possibility of short-run cash-flow effect on the land market is also pointed out as a further consideration.

Meantime, the issue has been raised that if time series data are not integrated by the same order, the traditional time series regressions may show a spurious relationship (Engle and Granger, 1987). In the context of 'cointegration theory', testing PVM in farmland price formation is of interest to researchers. Campbell and Shiller (1987) test the PVM using financial markets data (i.e., stock prices and dividends data). This technique can be also applied in the case of farmland valuation theory. If the PVM is correct, then, (a) net rents and land prices should have the same time series properties; and (b) past values of the spread between land prices and rents add useful information in forecasting future changes in net returns. Unit root tests and cointegration analysis are applied in some studies of farmland market analysis.

Using Campbell and Shiller (1987) procedures, Falk (1991) found that price movements are more volatile than rent movements, although farmland prices and rent movements in Iowa are highly correlated. This suggested the possibility of a rational bubble as one possible explanation of the model's failure. Tegene and Kuchler (1991) show that farmland prices and rents are cointegrated using data from five corn belt States in the US, and also estimate the Error Correction Model. Hallam, *et al.* (1992) applied cointegarion analysis to the regression models used in previous studies using British data, concluding that the simplest model using only cash rent as an independent variable in a regression model (e.g., Lloyd *et al.*, 1991) is not suitable to apply for the empirical analysis of the land market in England and Wales. Tegene and Kuchler (1993) investigate the time-series properties of land prices and rents with unit root and cointegration tests using data from three farm production regions -

the Corn Belt, the Northern Plains, and the Lake States. The result shows that there is little evidence to reject the hypothesis that market fundamentals determine farmland prices. Engsted (1998) re-tested the hypothesis of farmland market theory using the same data of Tangne and Kuchler but the vector autoregressive (VAR) methodology, and shows the strong possibility of a speculative bubble in farmland determination in these regions.

Being mindful of unit root test results of farmland prices and rents in the U.S., Clark, *et al.* (1993) also refer to the possibility that the simple capital asset model is not enough to induce clear policy implications. Lloyd (1994) applied cointegration analysis on an inflation-augmented PVM of land price determination using England and Wales data in a VAR framework in order to examine the effect of inflation rate on real price of land. The result suggested that inflation is important in land price determination. Weliwita and Govindasamy (1997) applied cointegration analysis on north-eastern United States data, and found that a cointegrating relationship between land prices and real rent and rate of inflation was not identified as specified in the Lloyd (1994) model using England and Wales data. Nevertheless Weliwita and Govindasamy (1997) found that there is an equilibrium relationship between land prices and real gross farm income, inflation rate, nominal interest rate, and area under crops, grass, and pasture.

Falk and Lee (1998) applied the methodology which decomposes farmland price movements into components driven by fundamental forces and non-fundamental forces, in order to identify if the derivation between farmland prices and rents are caused by overreaction (temporary fundamental shock) of rents (Burt, 1986) or a speculative bubble (Featherstone and Baker, 1987) in Iowa farmland prices[12]. The result shows that fads and overreaction play important roles in explaining short-run farmland price behaviour; however, the long-run movements are mostly explained by permanent fundamental shocks. Roche and McQuinn (2001) test the speculation behaviour in agricultural land prices of Ireland by estimating a general regime-switching model, assuming that if there are bubbles, they eventually burst. The result supports the notion that the boom in the late 1970s and early 1980s was caused by a bubble.

The details of the testing procedure of PVM using unit root tests and cointegration analysis are reviewed in the next chapter.

[12] This decomposition method is developed in financial economics for analysing stock market movement. See Campbell (1991), Lee (1995) and Falk and Lee (1998).

4-6. Summary

This chapter is a review of rent and farmland valuation theory and its empirical application. Rent theory has a long history. In classical economics, land was an important factor of production, and the nature of rent was discussed in the light of the generation of wealth and value. David Ricardo developed a rent theory with a famous corn model. This theory also refers to the concept of land abandonment; too infertile land is abandoned. Meanwhile, with the development of neoclassical economic theory, supply and demand became dominant as an analytical framework. The mechanism of the farmland market is carefully reviewed, focusing on the stock and flow concept.

Farmland valuation theory was then reviewed. Given the marked movement of farmland prices in the US and the UK, agricultural land valuation theory has developed, especially in these countries. A recent development is the model based on the assumption that the value of an asset is the current and future stream of returns from owning the land. This is called the Present Value Model (PVM). The measurement of returns between farm income and cash rent is also discussed. The PVM using cash rent is the most widely applied model in recent studies. However, through empirical applications in several countries, the shortcomings of this model have also been pointed out. The interest of researchers moved on to test the PVM using recently developed time series analysis (i.e., unit root and cointegraion analysis).

In the next chapter, the development of time series analysis and the details of the methodology applied in this study are reviewed.

Appendix 4-1. Agricultural land market with non-agricultural use demand

Nowadays agricultural lands are facing strong demands for non-agricultural use, especially in urban areas. Assuming the free competition of land, Robinson *et al.* (1985) developed an aggregate two-sector land market model; agricultural and non-agricultural use. Firstly, a simple capitalisation formula is written as,

$$P_t = R_t / r_t \qquad \text{(i)}$$

where P_t is the value of land at time t, R_t is net returns of land at time t, and r_t is interest rate at time t. Since rent is expected to be inversely related to quantity demanded of land, Q, reflecting diminishing returns, they are related by a downward-sloping function. Let the aggregate demand for land used in agriculture be

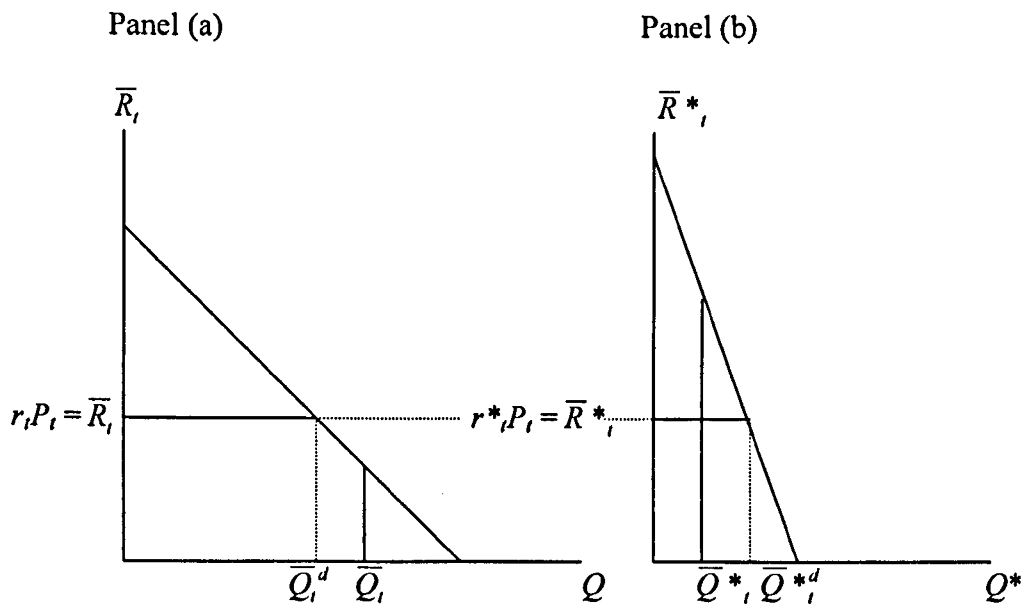
$$\overline{R}_t = \overline{\alpha}_t^0 - \alpha_t^1 Q_t \qquad \text{(ii)}$$

where $\overline{R}_t$ is agricultural rent, and $\overline{\alpha}_t^0$ and α_t^1 are coefficients which are unique to this land for agricultural use. Similarly, let the aggregate demand for non-agricultural purposes be

$$\overline{R}*_t = \overline{\beta}_t^0 - \beta_t^1 Q_t \qquad \text{(iii)}$$

where $\overline{R}*_t$ is non-agricultural rent, and $\overline{\beta}_t^0$ and β_t^1 are coefficients which are unique to this market for non-agricultural land. Vertical lines $\overline{Q}_t$ and $\overline{Q}*_t$ in Figure 4-7 indicate land currently used for agricultural and non-agricultural uses respectively. The equilibrium price P_t equates the excess supply of land ($\overline{Q}_t - \overline{Q}_t^d$) in the agricultural land market to the excess demand for land in the non-agricultural sectors ($\overline{Q}*_t^d - \overline{Q}*_t$). If $\overline{R}_t = \overline{R}*_t$ as described in Figure 4-7, then r_t must equal to $r*_t$, an interest rate for non-agricultural land, since $P_t = \overline{R}_t / r_t$ and $P_t = \overline{R}*_t / r*_t$.

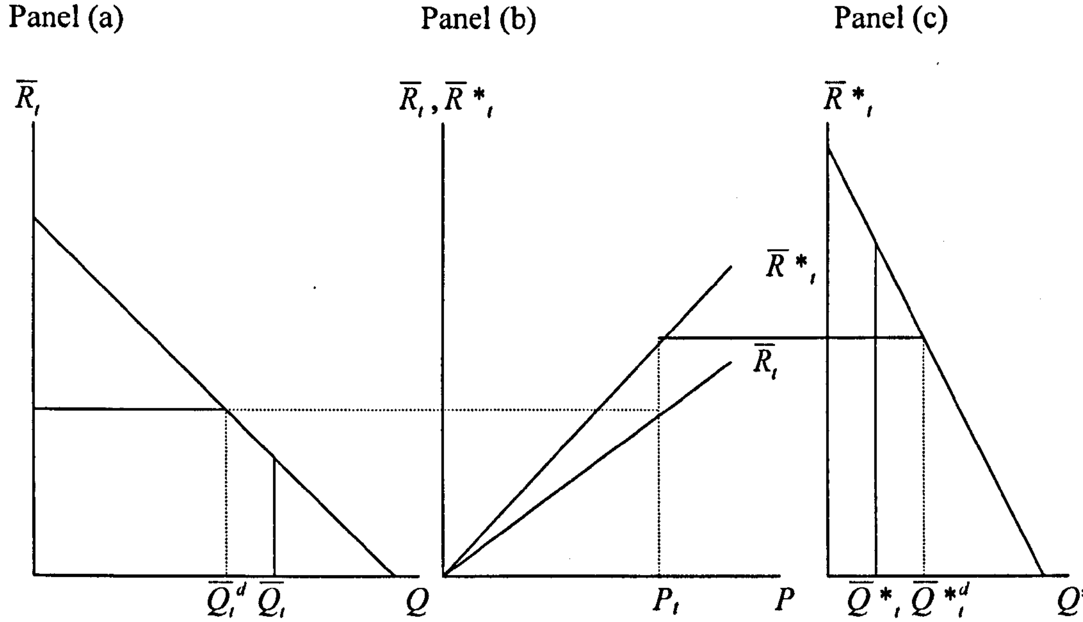
Figure 4-7 A land market equilibrium condition when $r_t = r^*_t$



Note: Excess supply ($\overline{Q}_t - \overline{Q}_t^d$) in panel (a) and excess demand ($\overline{Q}^{*d}_t - \overline{Q}^*_t$) in panel (b) is equal.
Source: Robinson *et al.* (1985)

A more realistic assumption, where $r_t \neq r^*_t$, is illustrated in Figure 4-8. In panel (a) and (b), the rent relationships are expressed for the t-th period. The aggregate demand equations in panels (a) and (b) are those in equations (ii) and (iii). Panel (b) describes the equilibrium condition imposed on P_t. The ratio of rent realistically diverges because productivity of land is different and governments tend to put different tax rates on agricultural land and non-agricultural land. This is reflected by the differences in the slope coefficients r_t and r^*_t ($r_t < r^*_t$) in panel (b). Nevertheless, since both sectors compete for the acquisition of land they must offer a common price P_t which equates the excess demand in the non-agricultural market $\overline{Q}^{*d}_t - \overline{Q}^*_t$ with the excess supply $\overline{Q}_t - \overline{Q}_t^d$ in the agricultural market.

Figure 4-8 A land market equilibrium condition when $r_t \neq r^*_t$



Note: Coefficients of the slope $\overline{R}_t$ and $\overline{R}^*_t$ shows r_t and r^*_t, respectively, where $r_t < r^*_t$. Excess supply ($\overline{Q}_t - \overline{Q}_t^d$) in panel (a) and excess demand ($\overline{Q}^{*d}_t - \overline{Q}^*_t$) in panel (c) are equal.

Source: Robinson *et al.* (1985)

Chapter 5. Time Series Analysis

5-1. Introduction

Unit root tests and cointegration analysis are widely applied methods for time series data nowadays. A unit root test is a test to examine whether each variable is stationary or non-stationary, and cointegration analysis is based on the basic concept that all variables in a regression model must be integrated by the same order. The purpose of this chapter is to review the concept of unit root and cointegration analysis, as well as outlining testing techniques.

5-2. Unit Root Test

For the time series analysis of farmland prices, it is important to test for the presence of a unit root because the usual statistical tools for analysing data, which were reviewed in the previous chapter, may not be appropriate if the series is non-stationary. The standard classical methods of estimation, which are often used in applied econometrics, are based on the assumption that the means and variances of the variables are constant and independent of time. However, recent studies using unit root tests show that a large number of time series data have unit roots, and do not satisfy these assumptions. There are several ways to test for the presence of a unit root (e.g., the cointegration regression Durbin-Watson (CRDW) test (Sargan and Bhargava, 1983), and the Phillips-Perron test). The majority of approaches tests the null hypothesis of a unit root (non-stationary)[1]. The Dickey-Fuller (DF) test (Dickey

[1] There are some exceptions such as the KPSS (Kwiatkowski *et al.*, 1992) test which tests the null of no unit root (stationary).

and Fuller, 1979 and 1981) tends to be commonly used because of its simplicity and its more general nature (Harris, 1995).

5-2-1. Definition of stationary time series

A time series (Y_t) is said to be stationary if its mean, variance and autocovariances are independent of time t ($t = 1, 2, \ldots, T$):

$$\text{Mean}: \mathrm{E}(Y_t) = \mu \tag{5-1}$$

$$\text{Variance}: \mathrm{var}(Y_t) = \mathrm{E}[(Y_t - \mu)^2] = \sigma^2 \tag{5-2}$$

$$\text{Covariance}: \mathrm{cov}(Y_t, Y_{t+k}) = \mathrm{E}[(Y_t - \mu)(Y_{t+k} - \mu)] \tag{5-3}$$

Equations (5-1) and (5-2) require that the series have a constant mean and variance, while (5-3) requires that the covariance between any two values from the series (an autocovariance) depends only on the time interval between those two values (k) and not on the point in time (t). Thus, the mean, variance and covariance are required to be independent of time (Holden and Perman, 1994). On the other hand, non-stationary series do not have a constant long-run mean, and the variance is time dependent. Thus the mean, the variance and covariance of non-stationary series are not independent of time.

Suppose that a variable Y_t is generated by the following (first-order autoregressive) process,

$$Y_t = \phi_1 Y_{t-1} + u_t \tag{5-4}$$

where u_t is a disturbance (error) term, which is assumed to comprise n random numbers drawn from a normal distribution with mean equal to 0 and variance σ^2. The variable Y_t will be stationary if $|\phi_1| < 1$, and non-stationary if $\phi_1 = 1$. A stationary series tends to return to its mean value and fluctuate around it within a constant range, while a non-stationary series has a different mean at different points in time and its variance increases with the sample size (for more details refer to Box 2.1 in Harris 1995).

Figure 5-1 plots a non-stationary series based on a starting value of $Y_0 = 0$. As can be seen, the variance of Y_t is increasing with time and there is no tendency for this series to revert to any mean value. If we allow (5-4) to have a constant term (α) and a time trend (t), it can be written

$$Y_t = \alpha + \beta t + \phi_1 Y_{t-1} + u_t \quad t = 1, \ldots\ldots, T. \tag{5-5}$$

If $\phi_1 = 1$ (and $\beta = 0$) in (5-5), and Y_t is increasing with time without tendency for the series to revert to any mean value, this is a non-stationary series. Conversely, in the first difference series, ΔY_t (= $Y_t - Y_{t-1}$), which is also plotted in Figure 5-1, the variable can be seen to move around its mean (equal to 0 here), having a finite variance. It will be shown that a number of time series need to be differenced in order to induce stationarity (Harris, 1995). Conversely, variable Y_t will be stationary if $|\phi_1| < 1$ in (5-5), which is plotted in Figure 5-2. If $\phi_1 = 1$ but $\beta \neq 0$ in (5-5), Y_t will follow the stochastic trend, and it drifts upwards or downwards depending on the sign of β (as shown in Figure 5-3). This is called a non-stationary series with drift. In addition, consider the following equation,

$$X_t = \alpha + \beta t + u_t \tag{5-6}$$

where $\alpha + \beta t$ is a deterministic trend and the disturbance, u_t, is the non-trend (stochastic) component, being stationary (i.e., $u_t \sim IN(0, \sigma^2)$[2]). X_t is called trend-stationary, that is, it may trend but deviations from the deterministic trend are stationary (see Figure 5-3).

[2] This states that the residual is independently and normally distributed with zero mean and constant variance σ^2.

Figure 5-1 Non-stationary and stationary first-difference

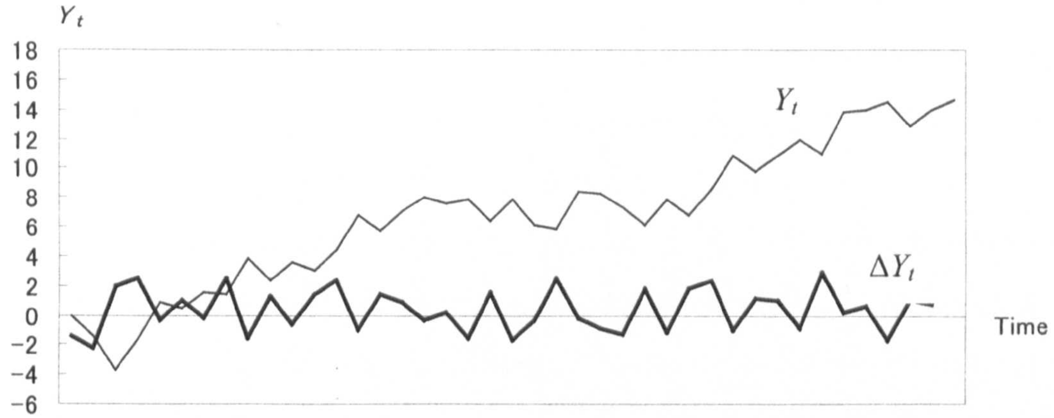


Figure 5-2 Stationary series

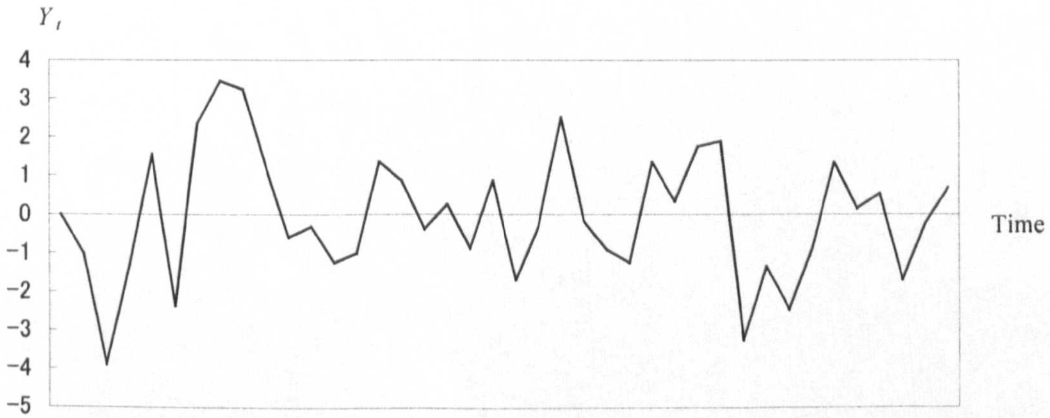
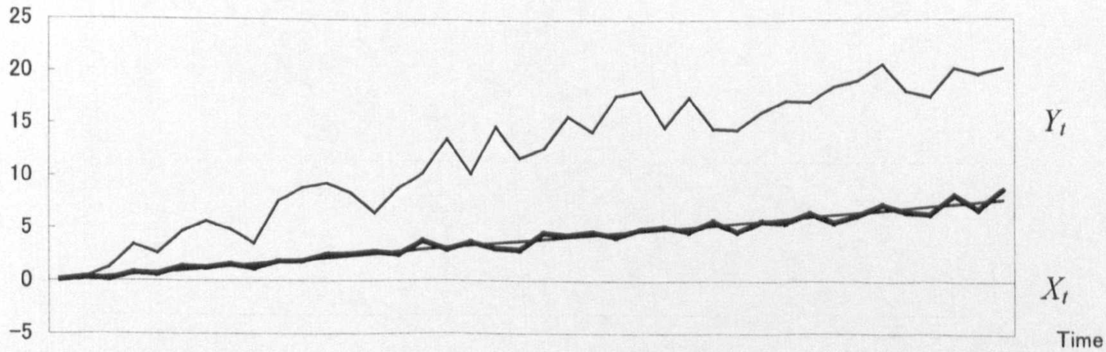


Figure 5-3 Non -stationary series with drift Y_t and trend stationary series X_t



5-2-2. Dickey-Fuller test

In the simplest form of the Dickey-Fuller (DF) test, the following equation, a simple first-order autoregressive process with zero mean and no trend component (i.e., no deterministic variables), is estimated by OLS:

$$Y_t = \phi_1 Y_{t-1} + u_t \tag{5-7}$$

where u_t is assumed to follow white noise (i.e., zero mean and constant variance σ^2). The variable Y_t will be stationary if $|\phi_1| < 1$, and is non-stationary if $\phi_1 = 1$. Here we wish to test the null hypothesis of a unit root and $\phi_1 = 1$ (i.e., H_0: $\phi_1 = 1$) against the alternative hypothesis of stationarity and $|\phi_1| < 1$ (i.e., H_1: $|\phi_1| < 1$). If the null hypothesis is rejected, the variable Y_t is stationary.

There are two main problems with this procedure. First, the presence of a lagged dependent variable (Y_{t-1}) in equation (5-7) will yield a biased OLS estimator ϕ_1. Although the standard approach to testing such a hypothesis is through a t-test, the statistic estimated does not follow a standard t-distribution, but rather a Dickey-Fuller (DF) distribution. Thus, the conventional t-test statistics for ϕ_1 may not be appropriate, and there is a possibility to conclude that $|\phi_1| < 1$ when actually it is not. The second problem relates to the model assumption. Equation (5-7) is under the assumption of a simple autoregressive process with a zero mean and no trend component. However, it is also assumed that Y_t is zero at time t=0, since the mean of the series is determined by the initial observation with no deterministic variables. Thus when $\phi_1 = 1$, the application of OLS to equation (5-7) is not valid because the overall mean equals zero only when the series is stationary.

Dickey and Fuller (1979) solved these problems by reparameterising (5-7), which becomes:

$$\Delta Y_t = (\phi_1 - 1)Y_{t-1} + u_t \tag{5-8}$$

where u_t is assumed to follow white noise. Here the null hypothesis that there is a unit root and $(\phi_1 - 1) = 0$ (i.e., H_0: $\phi_1 - 1 = 0$) is tested, against the alternative hypothesis of stationary $|\phi_1 - 1| < 1$ (i.e., H_1: $|\phi_1 - 1| < 1$). If $(\phi_1 - 1) = 0$ is rejected, then Y_t is a stationary series. For testing (5-8), DF distributions computed using Monte Carlo techniques are available from Fuller (1976) since, as explained above, the statistic computed does not follow the conventional t-distribution. Equation (5-8) is a pure random walk model, but generally we do not know whether $Y_0=0$. Therefore, we include a drift (or constant term) α_2:

$$\Delta Y_t = \alpha_2 + (\phi_2 - 1)Y_{t-1} + u_t \tag{5-9}$$

The test statistic here with the null hypothesis H_0: $(\phi_2 - 1) = 0$ is also available from Fuller (1976). Under the alternative hypothesis (i.e., $|\phi_2 - 1| < 1$), Y_t is stationary with a constant mean and no trend. However, (5-9) cannot validly be used to test for a unit root when there is a time trend. If the null hypothesis is true, (i.e., $\phi_2 = 1$), and Y_t will follow a stochastic trend, it will drift upwards or downwards depending on the sign of α_2. In practice, the most commonly used form of the null hypothesis is that the series has a stochastic trend against the alternative of trend stationary. Therefore, the regression equation including a time trend becomes:

$$\Delta Y_t = \alpha_3 + \beta_3 t + (\phi_3 - 1)Y_{t-1} + u_t \tag{5-10}$$

Equation (5-10) indicates now the series which has both stochastic and deterministic trends. The critical values are also given by the DF distribution (Fuller, 1976).

From (5-10) we can also test the joint hypothesis of unit root and no trend (i.e., H_0: $(\phi_3 - 1) = \beta_3 = 0$) against the hypothesis of trend stationary (i.e., H_1: $(\phi_3 - 1) = \beta_3 \neq 0$) by using the Φ_3-statistic with critical values from Dickey and Fuller (1981, Table VI, p1063). If the Φ_3 value is less than the critical value, the null hypothesis is accepted and Y_t is non-stationary without trend; conversely if the null is rejected, Y_t is stationary with a significant trend. Similarly from (5-9) we can test the joint hypothesis of unit root and no drift (i.e., H_0: $(\phi_2 - 1) = \alpha_2 = 0$) against the alternative hypothesis of unit root with significant drift (i.e., H_0: $(\phi_2 - 1) = \alpha_2 \neq 0$) by using the critical values computed in Dickey and Fuller (1981, Table IV). If the null hypothesis is accepted, Y_t is non-stationary without drift; conversely if the null is rejected, Y_t is $I(1)$ with significant drift.

5-2-3. Augmented Dickey-Fuller (ADF) test

The DF distributions are based on the assumption that the error term, u_t, follows white-noise. However, if a sample follows a pth-order autoregressive (AR), then the error term will be autocorrelated and invalid to use with the DF distributions. Two approaches have been proposed to overcome this problem (Thomas, 1997). First, we can generalise the equations of (5-8)-(5-10) as those also can follow the DF-statistics (e.g., Said and Dickey, 1980; Phillips, 1987; Phillips and Perron, 1988). It becomes the form which is called the "augmented" Dickey-Fuller (ADF) test. The ADF test is comparable to the simple DF test, but it involves adding an unknown number of lagged first differences, and equations (5-8), (5-9), (5-10) become:

$$\Delta Y_t = (\phi_1 - 1)Y_{t-1} + \sum_{i=1}^{k} \theta_i \Delta Y_{t-i} + u_t \tag{5-8'}$$

$$\Delta Y_t = \alpha_2 + (\phi_2 - 1)Y_{t-1} + \sum_{i=1}^{k} \theta \Delta Y_{t-1} + u_t \tag{5-9'}$$

$$\Delta Y_t = \alpha_3 + \beta_3 t + (\phi_3 - 1)Y_{t-1} + \sum_{i=1}^{k} \theta \Delta Y_{t-1} + u_t \tag{5-10'}$$

It is important to select the appropriate lag-length because too few lags may result in over-rejecting the null when it is true, while too many lags may reduce the power of the test (Harris, 1995). To define the number of lagged values, there are several approaches. The Akaike information (AIC) and Shwarz Bayesian criteria (SBC) are commonly used to define the lag-length. The Lagrange Multiplier (LM) test can be used to test for serial correction and enables us to check whether the chosen lag-length is appropriate (Holden and Perman, 1994).

It is clear that there are a number of alternative models to test for a unit root in a series. It is considered that the presence of unnecessary nuisance parameters (i.e., constant and /or trend terms) will lower the power of the tests against stationary alternatives. Perron (1988) proposes a sequential testing procedure, shown in Table 5-1, which starts with the use of (5-10)' and then removes unnecessary nuisance parameters. If we fail to reject the unit root hypothesis, testing should continue down to more restricted specifications and testing stops when we are able to reject the unit root hypothesis. Steps (i), (ii) and (iii) test the significance of the individual variables in (5-10)'. In each test, the null hypothesis is that there is no unit root and no trend. If we cannot reject the null, then the trend which is a nuisance parameter can be removed (5-10)' and subsequently we consider (5-9)' as the testing equation. Steps (v) and (vi) are the individual variable tests on the presence of a unit root and no drift term. If the test statistic on the drift term is not significant (i.e., the null of no drift is accepted), it is a nuisance parameter and is removed form (5-9)'. Accordingly, we then use (5-8)' as a testing equation and test the unit root hypothesis in step (viii). The source of the appropriate critical values for these tests are shown in the last column in Table 5-1 from Fuller (1976) and Dickey and Fuller (1981).

Table 5-1 Unit root test procedure using the DF/ADF tests

Steps and Model	Null Hypothesis	Critical Values
(i) $\Delta Y_t = \alpha_3 + \beta_3 t + (\phi_3 - 1)Y_{t-1} + \sum_{i=1}^{k} \theta \Delta Y_{t-1} + u_t$ eq(5-10)'	$(\phi_3 - 1) = 0$ Test Statistic: τ_t	Fuller (1976, Table 8.5.2, block3, p373)
(ii) $\Delta Y_t = \alpha_3 + \beta_3 t + (\phi_3 - 1)Y_{t-1} + \sum_{i=1}^{k} \theta \Delta Y_{t-1} + u_t$ eq(5-10)'	$\beta_3 = 0$ Test Statistic: $\tau_{\beta x}$	Dickey and Fuller (1981, TableIII, p1062)
(iii) $\Delta Y_t = \alpha_3 + \beta_3 t + (\phi_3 - 1)Y_{t-1} + \sum_{i=1}^{k} \theta \Delta Y_{t-1} + u_t$ eq(5-10)'	$\alpha_3 = 0$ Test Statistic: $\tau_{\alpha x}$	Dickey and Fuller (1981, TableII, p1062)
(iv) $\Delta Y_t = \alpha_3 + \beta_3 t + (\phi_3 - 1)Y_{t-1} + \sum_{i=1}^{k} \theta \Delta Y_{t-1} + u_t$ eq(5-10)'	$(\phi_3 - 1) = \beta_3 = 0$ Test Statistic: Φ_3	Dickey and Fuller (1981, TableVI, p1063)
(v) $\Delta Y_t = \alpha_2 + (\phi_2 - 1)Y_{t-1} + \sum_{i=1}^{k} \theta \Delta Y_{t-1} + u_t$ eq(5-9)'	$(\phi_2 - 1) = 0$ Test Statistic: τ_μ	Fuller (1976, Table 8.5.2, block2, p373)
(vi) $\Delta Y_t = \alpha_2 + (\phi_2 - 1)Y_{t-1} + \sum_{i=1}^{k} \theta \Delta Y_{t-1} + u_t$ eq(5-9)'	$\alpha_2 = 0$ Test Statistic: $\tau_{\alpha\mu}$	Dickey and Fuller (1981, TableI, p1062)
(vii) $\Delta Y_t = \alpha_2 + (\phi_2 - 1)Y_{t-1} + \sum_{i=1}^{k} \theta \Delta Y_{t-1} + u_t$ eq(5-9)'	$(\phi_2 - 1) = \alpha_2 = 0$ Test Statistic: Φ_1	Dickey and Fuller (1981, TableIV, p1063)
(viii) $\Delta Y_t = (\phi_1 - 1)Y_{t-1} + \sum_{i=1}^{k} \theta_i \Delta Y_{t-i} + u_t$ eq(5-8)'	$(\phi_1 - 1) = 0$ Test Statistic: τ	Fuller (1976, Table 8.5.2, block1, p373)

5-2-4. Deterministic components and unit roots

Julselius (2000) argues the possibility to make serious interpretational mistakes when dynamics are introduced as the interpretation of deterministic components, such as a trend, constant, and dummy variables, is crucially related to the dynamics of the model, in particular to whether the dynamics contains a unit root or not. Firstly, a simple regression model for Y_t containing a linear trend and a dummy variable to describe an intervention at time i:

$$Y_t = \gamma t + \delta Di_t + u_t + Y_0, \quad t = 1, ..., T \tag{5-11}$$

where the intervention dummy $Di_t = 1$ for $t = i$, and 0 otherwise, γ is a growth rate, and the residual u_t is a first order autoregressive process:

$$u_t = \frac{\varepsilon_t}{1-\rho L} \tag{5-12}$$

By substituting (5-12) in (5-11), (5-11) is rewritten as:

$$Y_t = \gamma t + \delta Di_t + \frac{\varepsilon}{1-\rho L} + Y_0 \tag{5-13}$$

Multiplying through with (1 - ρL):

$$(1-\rho L)Y_t = (1-\rho L)\gamma t + (1-\rho L)\delta Di_t + (1-\rho L)Y_0 + \varepsilon_t \tag{5-14}$$

Rewriting (5-14) using LY_t =Y_{t-1}:

$$Y_t = \rho Y_{t-1} + \gamma(1-\rho)t + \delta Di_t - \rho\delta Di_{t-1} + \rho\gamma + (1-\rho L)Y_0 + \varepsilon_t \tag{5-15}$$

From this, it can be recognised that the 'static' regression model (5-10) is equivalent to the following dynamic model:

$$Y_t = b_1 Y_{t-1} + b_2 t + \delta Di_t - b_3 Di_{t-1} + b_0 + \varepsilon_t \tag{5-16}$$

where

$$\begin{aligned} b_1 &= \rho \\ b_2 &= \gamma(1-\rho) \\ b_3 &= \rho\delta \\ b_0 &= \rho\gamma + (1-\rho)Y_0 \end{aligned} \tag{5-17}$$

Four cases are considered here:

Case 1. $\rho = 1$ and $\gamma \neq 0$. It follows from (5-15) that $\Delta Y_t = \gamma + \varepsilon_t$, for $t = 1, ..., T$. i.e., the random walk with drift model. It is noted that E(ΔY_t) = $\gamma \neq 0$ is equivalent to Y_t having a linear trend.

Case 2. $\rho = 1$ and $\gamma = 0$. It follows from (5-15) that $\Delta Y_t = \varepsilon_t$, for $t = 1, ..., T$. i.e., the pure random walk model. In this case E(ΔY_t) = 0 and Y_t contains no linear trend.

Case 3. $|\rho| < 1$ and $\gamma \neq 0$ gives us (5-16), i.e., a trend stationary model. The interpretation of the coefficients b_1, b_2 and b_0 should be careful, for example, b_2 is not an estimate of the trend in Y_t, instead $\gamma = b_2(1 - \rho)$ is.

Case 4. $|\rho| < 1$ and $\gamma = 0$ gives us $\Delta Y_t = \rho Y_{t-1} + (1 - \rho)Y_0 + \varepsilon_t$, i.e., the stationary autoregressive model with constant term.

Thus, in the dynamic regression model (5-15), i.e., $I(1)$ model, the constant term is a weighted average of the growth rate γ and the initial value Y_0, and the impulse dummy accounts for the intervention effect (outlier effect) in Y_t as well as Y_{t-1}. In the differenced model ($\rho=1$), the constant term is only measuring the growth rate, γ, and the intervention effect in Y_t now becomes a transitory effect in ΔY_t measured by ΔDi_t. All variables from case 1 to 3 are strongly trended (Green, 2003), and deterministic terms interact with the stochastic trends. Therefore, interpretation of the deterministic terms for the non-stationary variables should be done with care. Patterson (2000) suggests graphing the data as well as the autocorrelations of the levels and first differences to become familiar with characteristics of the data. When the test supports the presence of a linear trend, for example, it is preferable to include more appropriate information in the model if possible (e.g., population growth, or the proportion of old/young in a population) because it would even affect the interpretation of cointegrating relationship between variables (Julselius, 2000).

5-3. Structural Breaks and Unit Root Tests

The presence of structural changes/breaks can change the level of integration of the series and the failure of the conventional ADF tests, and not taking into account this change may lead to spurious results and inappropriate model specification (Perron, 1990). Perron (1989) distinguishes between exogenous shocks and endogenous shocks, and claims only exogenous shocks cause a permanent effect on the series. He found only two events (shocks), the Great Crash of 1929 and the oil price shock of 1973, had had a permanent effect on various macroeconomic variables, and in the above sense he considered those shocks as exogenous. However, he found a difference in nature between the two shocks. On one hand, the Great Crash created a dramatic drop in the mean of most aggregate variables, in other words, this kind of shock appears in the changing of the intercept or level of the series. On the other hand, the oil price shock changed the slope of the trend for most aggregates, i.e., a slowdown in growth. Therefore three different models are considered under the null hypothesis. Perron (1989) developed a procedure for testing the null hypothesis that a given series, Y_t (t = 1, ..., T), has a unit root with drift and that an exogenous structural break occurs at time $1 < T_B < T$, against the alternative hypothesis that the series is stationary about a deterministic time trend with an exogenous change in the trend function at time T_B. The first model (A) allows for a one-time change in the level of the series with a dummy variable, $D(T_B)$, which is 1 if $t = T_B + 1$, otherwise 0, and is termed the 'crash model' (Perron, 1989) (see Figure 5-4). The second model (B) allows for a change in the slope or rate of growth of the series with a dummy variable, DU_t, which is 1 if the t is bigger than that at the point of the structural break (i.e., $t > T_B$), and 0 otherwise, referred to as the 'changing growth model' (Perron, 1989) (see Figure 5-5). The final model (C) allows both changes. The null hypotheses can be written by adding parameters of the structural break:

H$_0$: $Y_t = \alpha + dD(T_B) + Y_{t-1} + e_t$ Model (A)

H$_0$: $Y_t = \alpha_1 + (\alpha_2 - \alpha_1)DU_t + Y_{t-1} + e_t$ Model (B)

H$_0$: $Y_t = \alpha_1 + dD(T_B) + (\alpha_2 - \alpha_1)DU_t + Y_{t-1} + e_t$ Model (C)

The trend-stationary alternative hypotheses considered are:

H_1: $Y_t = \alpha_1 + \beta t + (\alpha_2 - \alpha_1)DU_t + e_t$ Model (A)

H_1: $Y_t = \alpha + \beta_1 t + (\beta_2 - \beta_1)DT_t^* + e_t$ Model (B)

H_1: $Y_t = \alpha_1 + \beta_1 t + (\alpha_2 - \alpha_1)DU_t + (\beta_2 - \beta_1)DT_t^* + Y_{t-1} + e_t$ Model (C)

where $DT_t^* = t - T_B$ if $t > T_B$ and 0 otherwise. The difference, $\alpha_2 - \alpha_1$, represents the magnitude of the change in the intercept of the trend function occurring at time T_B, then similarly, the difference, $\beta_2 - \beta_1$, represents the magnitude of the change in the slope of the trend function occurring at time T_B (Zivot and Andrews, 1992). Perron (1990) employed an adjusted Dickey-Fuller (ADF) unit root test, and the regressions are:

$$\Delta Y_t = \alpha^A + \beta^A t + \eta^A DU_t + d^A D(T_B)_t + \gamma^A Y_{t-1} + \sum_{i=1}^{k} \theta_i^A \Delta Y_{t-i} + e_t \quad (5\text{-}18)$$

$$\Delta Y_t = \alpha^B + \beta^B t + \delta^B DT_t + \gamma^B Y_{t-1} + \sum_{i=1}^{k} \theta_i^B \Delta Y_{t-i} + e_t \quad (5\text{-}19)$$

$$\Delta Y_t = \alpha^C + \beta^C t + \eta^C DU_t + \delta^C DT_t + d^C D(T_B)_t + \gamma^C Y_{t-1} + \sum_{i=1}^{k} \theta_i^C \Delta Y_{t-i} + e_t \quad (5\text{-}20)$$

In order to test formally for the presence of a unit root, Perron considered the following statistics computed from (5-18) to (5-20):

$$t_{\hat{\gamma}^i}(\lambda), \quad i = \text{A, B, C}, \quad (5\text{-}21)$$

which represents the standard t statistic for testing γ^i. These statistics depend on the location of the break fraction (or breakpoint) $\lambda = T_B / T$.

Figure 5-4 The time series with structural change in level

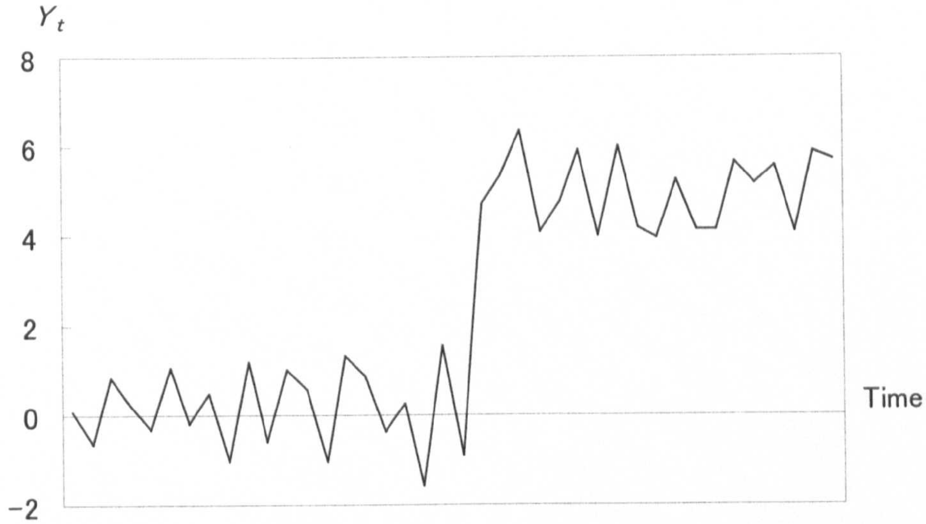
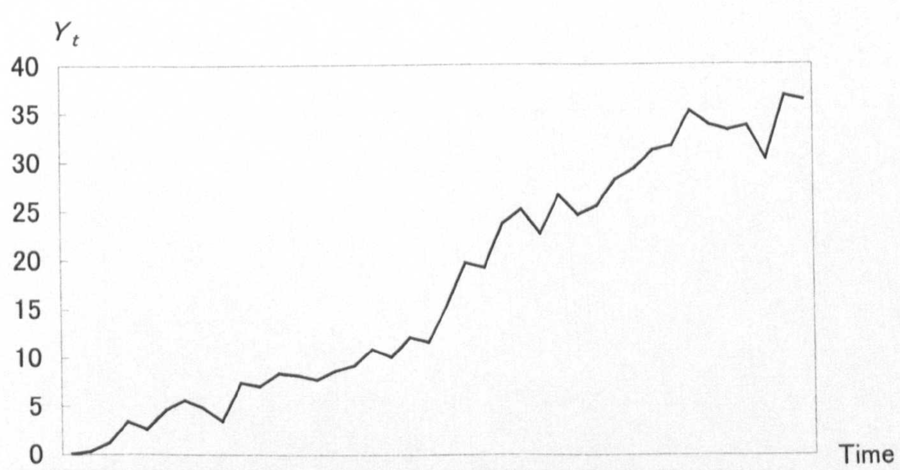


Figure 5-5 The time series with structural change in growth rate



Zivot and Andrews (1992) construe Perron's test statistic (5-21) in a different manner. Perron's model assumes that the break point is already known, however it is unlikely that the data of the break is known *a priori*. Zivot and Andrews consider the case that we do not know the time of break point. They treat the structural break as an endogenous occurrence, and then the hypothesis of the unit root with nonzero drift without a structural break of the form for the three models is:

H0: $Y_t = \alpha + Y_{t-1} + e_t$

As explained above, the dummy variable $D(T_B)$ is no longer needed in this model. Therefore the ADF type unit root testing equations for the three models are,

$$\Delta Y_t = \alpha^A + \beta^A t + \eta^A DU(\hat{\lambda})_t + \gamma^A Y_{t-1} + \sum_{i=1}^{k} \theta_i^A \Delta Y_{t-i} + e_t \qquad (5\text{-}18)'$$

$$\Delta Y_t = \alpha^B + \beta^B t + \delta^B DT(\hat{\lambda})_t + \gamma^B Y_{t-1} + \sum_{i=1}^{k} \theta_i^B \Delta Y_{t-i} + e_t \qquad (5\text{-}19)'$$

$$\Delta Y_t = \alpha^C + \beta^C t + \eta^C DU(\hat{\lambda})_t + \delta^C DT(\hat{\lambda})_t + \gamma^C Y_{t-1} + \sum_{i=1}^{k} \theta_i^C \Delta Y_{t-i} + e_t \qquad (5\text{-}20)'$$

where $DU_t(\lambda) = 1$ if $t > T\lambda$, 0 otherwise, and $DT_t(\lambda) = t$ if $t > T\lambda$, 0 otherwise. Zivot and Andrews put "hats" on the λ parameters in (5-18)'- (5-20)' to emphasise that they correspond to estimated values of the break fraction.

There is one disadvantage in the Zivot and Andrews (1992) test. This test can allow having a break only under the alternative hypothesis. In response to this drawback, Perron (1997) developed a test which allows a break under both null and alternative hypotheses at an unknown point in time. He examines three different models under the null and alternative hypotheses. The first model (Model 1) allows only a change in the intercept under both the null and alternative hypotheses. This is termed the 'innovational outlier model (IO)' (Perron, 1997), and the unit root testing equation becomes:

$$\Delta Y_t = \alpha + \beta t + \eta DU(\lambda)_t + dD(T_B)_t + \gamma Y_{t-1} + \sum_{i=1}^{k} \theta_i \Delta Y_{t-i} + e_t \qquad (5\text{-}22)$$

where $DU_t = 1$ $(t > T_B)$ and $D(T_B)t = 1$ $(t = T_B + 1)$. For the second model (Model 2), both a change in the intercept and the slope are allowed at time T_B. The testing equation is,

$$\Delta Y_t = \alpha + \beta t + \eta DU(\lambda)_t + \delta DT(\lambda)_t + dD(T_B)_t + \gamma Y_{t-1} + \sum_{i=1}^{k} \theta_i \Delta Y_{t-i} + e_t \qquad (5\text{-}23)$$

The third model (Model 3) allows a change in the slope but both segments of the trend function are joined at the time of break. This is called the 'additive outlier model (AO)' in the terminology of Perron, and takes the following two-step procedure for testing. First, the series is detrended using the equation with a dummy variable, $DT_t{*}= t - T_B = 1$.

$$Y_t = \alpha + \beta t + \gamma DT(\lambda)_t * + \widetilde{Y}_t . \tag{5-24}$$

Then the test is performed using:

$$\widetilde{Y}_t = \delta \widetilde{Y}_{t-1} + \sum_{i=1}^{k} \theta_i \Delta \widetilde{Y}_{t-i} + e_t \tag{5-25}$$

Perron suggests two methods to select T_B. First, T_B is selected where it gives the least evidence in favour of the null hypothesis (i.e., the value which minimises the t-statistic for testing $\gamma = 1$). Secondly, T_B is chosen to minimise either the value of t-statistic on the parameter associated with the change in the intercept (Model 1), or the value of t-statistic on the change in slope (Models 2 and 3). Then, the test is performed using the t-statistic for $\delta = 1$ under equation (5-25) with a selected break data T_B.

5-4. Cointegration Analysis

The basic idea of cointegration is to identity the existence of a long-run equilibrium[3] (i.e., long-run relationship) between variables over time. All variables must be integrated of the same order to have co-integration between them. Then the error term of the linear combination of the variables is also integrated to one lower order of those variables.

DEFINITION:

If two time series Y_t and X_t are both integrated of order d, which means both series must be differenced d times before it becomes stationary, denoted $I(d)$, then in general any linear combination of the two series will also be $I(d)$: for example, the residuals obtained from regressing Y_t on X_t are $I(d)$. However if there exists a vector β, which is called the 'cointegrating vector', the disturbance term from the regression ($e_t = Y_t - \beta' X_t$) is of a lower order of integration, $I(d-b)$, where $b>0$, and then defined that Y_t and X_t are cointegrated of order (d, b) (Engle and Granger, 1987).

Thus, if we consider the following regression:

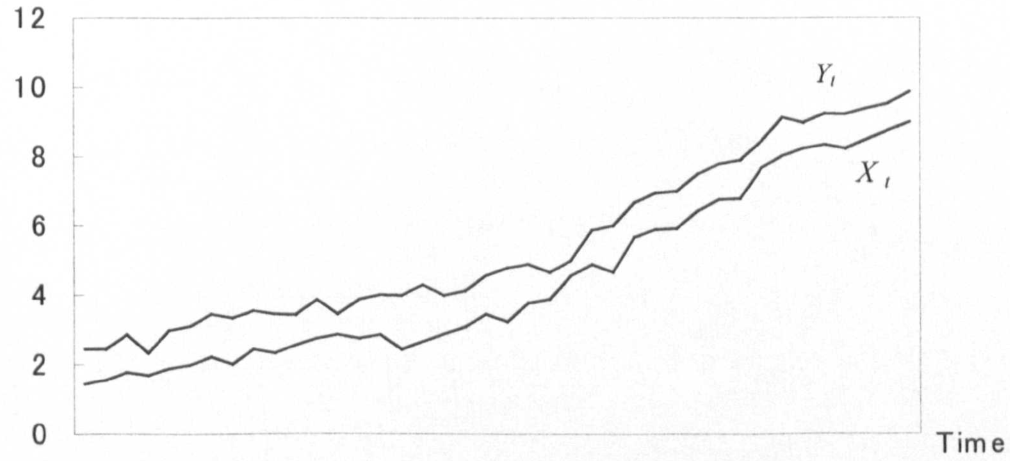
$$Y_t = \beta X_t + e_t \tag{5-26}$$

then if the series Y_t and X_t are both $I(1)$ and error term e_t is $I(0)$, the series are cointegrated and denoted $CI(1,1)$. The economic interpretation of cointegration is that two (or more) series have an (or more than one) equilibrium relationship(s) between them. Even though the series themselves contain stochastic trends (i.e., non-stationary), it is said that those series are cointegrated if they move closely

[3] The term 'equilibrium' here refers to any long-run relationship among non-stationary variables, and different from the term economists use to mean the equality between desired and actual transactions.

together over time and the difference between them is stationary (see Figure 5-6). Thus the concept of cointegration implies the presence of a long-run equilibrium to which an economic system converges over time, and the error term e_t can be interpreted as the disequilibrium error (i.e., the distance that the system is away from equilibrium at time t) (Harris, 1995).

Figure 5-6 Two series drifting together



5-4-1. Testing for cointegration

Two main approaches are commonly used to test for cointegraton. One is the residual-based ADF-approach proposed by Engle and Granger (1987), and the other is the Johansen's Full Information Maximum Likelihood (FIML) approach (Johansen, 1988; Johansen and Juselius, 1990).

5-4-1-1. Engle-Granger (EG) residual based approach

To test the null hypothesis that Y_t and X_t are not cointegrated, in the Engle-Granger framework, it is examined whether the error term e_t in the cointegration regression is non-stationary (i.e., $e_t \sim I(1)$) against the alternative that e_t is stationary (i.e., $e_t \sim I(0)$). Although Engle and Granger (1987) list seven alternative tests[4], they found that the Augmented Dickey Fuller (ADF) is to be preferred. The test becomes:

$$\Delta \hat{e}_t = \mu + \delta t + \gamma \hat{e}_{t-1} + \sum_{i=1}^{k} \theta_i * \Delta e_{t-i} + \omega_t \qquad \omega_t \sim IID^5(0, \sigma^2) \tag{5-27}$$

where the $\hat{e}_t$ are obtained from estimating (5-26). Trend and/or constant terms in the test regression equation depend on whether a constant or trend term appears in (5-26). If the alternative hypothesis of cointegration allows a non-zero mean and a non-zero deterministic trend for $\hat{e}_t$, then a constant and a trend should be included in (5-27). Johansen (1992), on the basis of a Monte Carlo simulation, shows that irrespective of whether e_t contains a deterministic trend or not, including a time trend in (5-27) results in a loss of power (i.e., under-rejecting the null of no cointegration when it is false and over-rejecting when it is true). The critical value changes depending on the number of regressors (n) and also whether a constant and/or trend are included in (5-27) (Harris, 1995). Adjusted critical values are available in Phillips and Ouliaris (1990), MacKinnon (1991), and Banerjee *et al.* (1993).

As the next step, the short-run error correction model (ECM) is estimated to obtain information on the speed of adjustment to long-run equilibrium. The relationship between error correction models and cointegration was first indicated in Granger (1981). After obtaining $e_t = Y_t - \beta X_t$ from (5-19), we estimate:

$$\Delta Y_t = r_0 \Delta X_t - (1 - \alpha_1)[Y_{t-1} - \beta X_{t-1}] + e_t \tag{5-28}$$

[4] CRDW test, Dickey-Fuller (DF) test, ADF test, Restricted Vector Autoregression test (RVAR), Augmented RVAR test, Unrestricted VAR (UVAR) test, and Augmented or higher order version of the UVAR test (for details, see Engle and Granger 1987, p266). Engle and Granger (1987) conclude that the ADF test and CRDW test perform best in terms of power but that the critical values for the CRDW are not sufficiently constant across the various experiments for the test.

[5] Th is states that the residual is independently identically distributed with zero mean and constant variance σ^2.

where e_t is an error term with zero mean and constant variance, r_0 captures the short-run effect on the change in Y of the changes in X, and β accounts for the long-run equilibrium relationship between Y_t and X_t. Error correction $(Y_t - \beta X_t)$ is the divergence from the long-run equilibrium and is equal to zero when long-run equilibrium holds. During disequilibrium, this term is non-zero and measures the distance the system is away from equilibrium at time t. An estimate of $(1 - \alpha_1)$ will provide information on the speed of adjustment, that is how the variable Y_t changes in response to disequilibrium. A negative sign of $(1 - \alpha_1)$ indicates that adjustments move in the direction to restore the long-run equilibrium. If both Y_t and X_t are non-stationary (i.e., $I(1)$), and cointegration exists between them, then e_t is stationary (i.e., $I(0)$). Therefore all the terms in (5-28) are $I(0)$. This means that classical OLS estimation and standard t- and F-tests are applicable.

The Engle-Granger (EG) procedure is popular because it is easy to estimate the static model using OLS and then perform unit root tests on the residuals from this equation, and because the second step of the EG procedure enables us to estimate the short-run ECM as (5-28) explained above (Harris, 1995). However, there a number of weaknesses or disadvantages in the EG procedure: first, it has low power; second, its finite sample estimates of long-run relationships are potentially biased, and uniqueness of the cointegration vector should be assumed due to the single equation approach; and third, inferences cannot be drawn using standard t-statistics about the significance of the parameters of the static long-run model (see, Charemza and Deadman, 1992; Cuthbertson *et al.*, 1992; Harris, 1995). There are several alternative tests, considering the weakness of the DF procedure. One is the cointegration regression Durbin-Watson (CRDW) test proposed by Sargan and Bhargava (1983), which is based on the standard DW statistic obtained from a regression (5-26). This test is known to be the uniformly most powerful invariant test of the null hypothesis that e_t is a simple non-stationary random walk (i.e., $e_t = e_{t-1} + z_t$; where $z_t \sim IN(0, \sigma^2)$) against the alternative that e_t is a stationary first-order autoregressive process (i.e., $e_t = \rho e_{t-1} + z_t$; where $|\rho| < 1$ and $z_t \sim IN(0, \sigma^2)$) (Harris, 1995). As the EG approach is using a single equation model, we have to assume that there is only one cointegrating vector when in fact there are more when there are more than two variables in the model. Even if there is only one cointegration relationship, estimating a single equation is potentially inefficient because it does not lead to the smallest variance against alternative approaches. Therefore, it is useful to extend the single equation framework to a multivariate framework.

5-4-1-2. Cointegration with multiple equations: The Johansen method

The Johansen technique is rapidly becoming an essential tool for estimating time series models (Harris, 1995). The Johansen method, which is extended to a multivariate framework, allows us to examine the existence of more than one cointegration relationship. The Johansen maximum likelihood approach for multivariate cointegration is based on the following unrestricted vector autoregressive (VAR) model involving up to k-lags of Z_t:

$$Z_t = A_1 Z_{t-1} + \ldots + A_k Z_{t-k} + u_t \qquad (5\text{-}29)$$

where Z_t is an $(n \times 1)$ vector of $I(1)$ variables (containing both endogenous and exogenous variables), A_i is an $(n \times n)$ matrix of parameters, and u_t is $(n \times 1)$ vector of white noise errors. Johansen works directly with the ECM and adopts a framework which is based on the assumption that introducing sufficient lags will allow for a well behaved disturbance term (Holden and Perman, 1994). ΔZ_t is assumed to be stationary (i.e., $I(0)$), and (5-29) can be rewritten into a vector error-correction model

(VECM) form:

$$\Delta Z_t = \Gamma_1 \Delta Z_{t-1} + \ldots + \Gamma_{k-1} \Delta Z_{t-k+1} + \Pi Z_{t-k} + u_t \tag{5-30}$$

where $\Gamma_i = -(I - A_1 - A_2 - \ldots - A_i)$, ($i$=1, ... ,$k$–1), and $\Pi = -(I - A_1 - A_2 - \ldots - A_k)$. This specification provides information about the short-run and long-run adjustments to the changes in Z_t through the estimates of $\hat{\Gamma}_i$ and $\hat{\Pi}$ respectively. Π is denoted $\Pi = \alpha\beta'$, where α represents the error correction term which measures the speed of adjustment to disequilibrium, and β is a matrix of long–run coefficients. Assuming Z_t is a vector of non-stationary $I(1)$ variables, then all the terms in (5-30) are $I(0)$, and ΠZ_{t-k} is also stationary for $u_t \sim I(0)$ with the stationary long-run EC relationships. Information about the number of cointegrating relationships among the variables in Z_t is given by the rank of the matrix Π. If the rank of the Π-matrix, r, is $0 < r < n$, there are r linear combinations of the variables in Z_t that are stationary, together with $(n - r)$ non-stationary vectors.

Johansen (1988) uses the procedure known as the reduced rank regression[6] to estimate the α and β matrices. (5-30) can be rewritten as:

$$\Delta Z_t - \alpha\beta' Z_{t-k} = \Gamma_1 \Delta Z_{t-1} + \ldots + \Gamma_{k-1} \Delta Z_{t-k+1} + u_t \tag{5-31}$$

It is possible to correct for short-run dynamics by regressing ΔZ_t and Z_{t-k} separately on the right-hand side of (5-31). This means that the vectors R_{0t} and R_{kt} are obtained from the following regressions:

$$\Delta Z_t = P_1 \Delta Z_{t-1} + \ldots + P_{k-1} \Delta Z_{t-k+1} + R_{0t} \tag{5-32}$$

$$Z_{t-k} = T_1 \Delta Z_{t-1} + \ldots + T_{k-1} \Delta Z_{t-k+1} + R_{kt} \tag{5-33}$$

Residuals can then be used to form residual (product moment) matrices:

$$S_{it} = T^1 \sum_{t=1}^{T} R_{it} R_{jt}' \quad i, j = 0, k \tag{5-34}$$

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[6] For details of reduced rank regression, see Velu *et al.*(1986).

The estimate of β can be found by solving the eigenvalue problem:

$$\left|\lambda S_{kk} - S_{k0}S_{00}^{-1}S_{0k}\right| = 0 \tag{5-35}$$

where S_{00} is the residual matrix obtained by regressing ΔX_t on its lagged differences (i.e., $\Delta X_{t-1},\ldots\ldots,\Delta X_{t-k+1}$), S_{kk} is the residual matrix obtained by regressing X_{t-k} on its lagged differences (i.e., ΔX_{t-k+1}), and S_{k0} and S_{0k} are the cross-products of residual matrixes S_{kk} and S_{00}. Equation (5-35) gives the n eigenvalues $\hat{\lambda}_1 > \hat{\lambda}_2 > \ldots > \hat{\lambda}_n$ and their corresponding eigenvectors $\hat{V} = (\hat{v}_1,\ldots,\hat{v}_n)$. Those r elements in $\hat{V}$ which determine the linear combinations of stationary relationships can be denoted $\hat{\beta} = (\hat{v}_1,\ldots,\hat{v}_r)$, and are called the cointegration vectors. These are called the canonical variates and the eigenvalues are the squared canonical correlations of R_{kt} with respect to R_{0t} (Johansen, 1988). It is noted that all possible choices of the optimal β can be found from $\hat{\beta}$ by $\beta = \hat{\beta}\rho$ for ρ, an $r \times r$ matrix of full rank. The eigenvectors are normalised by the condition $\hat{\beta}' S_{kk} \hat{\beta} = I$ such that the estimates of the other parameters are given by:

$$\hat{\alpha} = -S_{0k}\hat{\beta}(\hat{\beta}' S_{kk}\hat{\beta})^{-1} = -S_{0k}\hat{\beta} \tag{5-36}$$

which depends on the choice of the optimising β, whereas

$$\hat{\Pi} = -S_{0k}\hat{\beta}(\hat{\beta}' S_{kk}\hat{\beta})^{-1}\hat{\beta}' = -S_{0k}\hat{\beta}\hat{\beta}' \tag{5-37}$$

and

$$\hat{\Lambda} = S_{00} - S_{0k}\hat{\beta}\hat{\beta}' S_{k0} = S_{00} - \hat{\alpha}\hat{\alpha}' \tag{5-38}$$

and the maximum likelihood is given by:

$$L_{\max}^{-2/T} = |S_{00}|\prod_{i=1}^{r}(1-\hat{\lambda}_i) \tag{5-39}$$

do not depend on the choice of optimising β.

The null hypothesis to test if there are at most r cointegration vectors (i.e. $(n - r)$ unit roots) is:

$$H_0 : \lambda_i = 0 \quad i = r + 1, \dots , n$$

where only the first r eigenvalues are non-zero. For testing this null hypothesis, two likelihood ratio (LR) tests are considered. The first is known as the 'trace' statistic:

$$\lambda_{trace} = -2\ln(Q) = -T\sum_{i=r+1}^{n}\ln(1-\hat{\lambda}_i) \quad r = 0, 1, 2, \dots, n-2, n-1 \tag{5-40}$$

where Q = (restricted maximised likelihood / unrestricted maximised likelihood). This tests the null hypothesis that there are at most r cointegrating vectors and thus (n – r) unit roots. Asymptotic critical values are provided in Osterwald-Lenum (1992), although if dummy variables enter the deterministic part of the multivariate model, different critical values are needed depending on the number of dummies included, and if there is a small sample of observation on Z_t, the power and size properties of this test are likely to be problematic. The second test is called the maximal-eigenvalue test or λ-max test:

$$\lambda_{\max} = -2\ln(Q : r|r+1) = -T\ln(1-\lambda_{r+1}) \quad r = 0, 1, 2, \dots, n\text{-}2, n\text{-}1 \tag{5-41}$$

which tests the null hypothesis of r cointegrating vectors against the alternative that r+1 exists. The critical values for these tests have been derived by Monte Carlo simulations and tabulated by Johansen (1988) and Osterwald-Lenum (1992). The inclusion of dummy variables also affects the underlying distribution of the test statistics, and Reimers (1992) suggests the possibility of over-rejection when the null is true with a small sample size. Cheung and Lai (1993, p319) reports that their results "... support that the finite-sample bias of Johansen's tests is a positive function of $T/(T - nk)$ ... furthermore, the finite-sample bias toward over-rejection of the no cointegration hypothesis magnifies with increasing values of n and k (p319)". As to the Monte Carlo experiments, they also suggest that " ... between Johansen's two LR tests for cointegration, the trace test shows more robustness to both skewness and excess kurtosis (in the residuals) than the maximal eigenvalue (λ_{max}) test" (p326).

A couple of issues should be pointed out for Johansen's approach. First, the endogenous variables included in the VAR are all $I(1)$. Second, the additional exogenous variables included in the VAR which explain the short-run behaviour (e.g., dummy variable of oil price shock in the 1970s) need to be $I(0)$. The choice of lag length k (i.e., order) in the vector autoregressive (VAR) needs to be mentioned, since the result of the Johansen tests can be quite sensitive to the lag length and on the appropriateness of the normality assumption concerning the error term (Enders, 1996). The Akaike information criterion (AIC), or Schwarz information criterion (SBC) are often used in the literature. However, the information criteria may not be adequate when errors contain moving average terms (Cheung and Lai, 1993). As Hall (1991) argues, the Johansen maximum likelihood estimation procedure for cointegrating vectors may be sensitive to the selection of the order of VAR. For example, when the order of the VAR is too low, serial correlation among the residuals may result and test statistics become unreliable. Conversely, in the case where the order of the VAR is too high, there is an upward bias in the test statistics due to small degrees of freedom, although there is no particular problem asymptotically. Therefore, in the light of this sensitivity to the VAR lag length, Hall (1991) suggests that when applying the Johansen procedure, the effect of varying the VAR specification should be examined. In other words, in choosing k, we should first select an arbitrarily high order for the VAR and then work through the likelihood ratio (LR) test statistics to determine the validity of restrictions imposed by successive reductions in its value. The correct order of the VAR is where a restriction on the lag length is rejected. Mushtaq (2000) uses the adjusted likelihood ratio (LR) statistics to test the null hypothesis that the order of the VAR is k against the alternative that it is $k+1$, and then substantiates the results with the AIC and SBC criteria.[7] The fourth issue in Johansen's procedure is whether deterministic components, constant and/or trend, are to be included in the long-run relationship. In general, the specification of the model depends upon the characteristics of the data. Equation (5-23) can be expanded to examine the need of deterministic components (i.e., intercept and deterministic trend):

$$\Delta Z_t = \Gamma_1 \Delta Z_{t-1} + \alpha \begin{bmatrix} \beta \\ \mu_1 \\ \delta_1 \end{bmatrix} \tilde{Z}_{t-k} + \alpha_\perp \mu_2 + \alpha_\perp \delta_2 t + u_t \qquad (5\text{-}42)$$

where $\tilde{Z}_{t-k} = (Z'_{t-k}, 1, t)$. It is possible to specify a theoretical model where $\delta_1 = \delta_2 = \mu_1 = \mu_2 = 0$ (no intercept and no deterministic trend), although this is unlikely in practice (this is Model 1). Therefore the following three models can realistically be considered (Harris, 1995)[8].

Model 2: Restricted intercepts and no trends

If the data exhibit no linear trends in the levels of data, then the constant is restricted to the cointegrating space (i.e., long-run model), thus $\delta_1 = \delta_2 = \mu_2 = 0$. The critical values for this model can be found in Table 1* in Osterwald-Lenum (1992).

Model 3: Unrestricted intercepts and no deterministic trends

If the data exhibit linear trends in the levels of data, then the constant is restricted in both the cointegrating space and the short-run model (although the constant in the cointegrating space is assumed to be cancelled by the constant in the short-run,

[7] See Amemiya (1980) Judge et al., (1985, pp870-75), and Lütkepohl (1993) for detailed discussions of these and other model selection criteria.
[8] The number assigned to the models is as in the *Cats* programme.

leaving only a constant in the short-run model), so $\delta_1 = \delta_2 = 0$. The critical values for this model can be found in Table 1 in Osterwald-Lenum (1992).

Model 4: Unrestricted intercepts and restricted deterministic trends

If the data exhibit no quadratic trends in the levels of data, the trend is not allowed in the short-run model; but if there is some long-run linear growth in the data (e.g., technological progress), then the trend is restricted in the cointegrating space, so $\delta_2 = 0$. The critical values for this model are in Table 2* in Osterwald-Lenum (1992).

There is another model (Model 5) which is extended from Model 4 to allow for linear trends in the short-run model (5-35), which means the data exhibit quadratic trends in levels. This is the case with unrestricted intercepts and unrestricted trends, although this is economically difficult to justify especially when the variables are entered in log form, since it implies an unrealistic ever-increasing or decreasing rate of change (Harris, 1995).

In terms of selecting a model, Johansen (1992) suggests that the joint hypothesis of both the rank order and the deterministic components (constant and/or trend) is tested in determining the appropriate model based on the so-called Pantula (1989) principle. The testing procedure is then to move through the most restrictive model (i.e., $r = 0$ and Model 2) to the least restrictive one (i.e., $r = n-1$ and Model 4) at each stage comparing the λ_{max}- or λ_{trace}- test statistic to its critical value, and only stopping when the null hypothesis is not rejected.

The issues of the estimated coefficients being the long-run elasticities in the cointegrating vector are not clear. This is true when there are only two variables in the cointegrating vector, but when there are more, the dynamics of the VAR raise some doubts about this interpretation (Lutkepohl, 1993, p379-380). Nevertheless, some authors (for example, Hallam and Zanoli, 1993; Townsend and Thirtle, 1994) interpret the estimated coefficients as the long-run elasticities. Since cointegration implies that a stationary long-run relationship exists among the series in the cointegrated system, and as these series are linked by common stochastic trends, movements among the variables are not independent and there are systematic co-movements among them. Moreover, any deviation from the long-run equilibrium influences the time paths of the cointegrated series. Impulse response or dynamic multiplier analysis can be used to investigate these interrelationships among the variables in dynamic models and to assess adjustments to long-run equilibrium. It is therefore a valuable tool in cointegrated systems (Lutkepohl and Reimers, 1992). If the deviations from the equilibrium are stationary, any shock to the system will generate time paths which eventually return to a new equilibrium provided no further shocks. These time paths of the variables provide insights into the short-run and long-run relations between the variables. Impulse responses are particularly useful when there are two or more cointegrating relations, which may be difficult to interpret on economic grounds.

5-4-2. Cointegration analysis in the presence of structural breaks

As discussed in 5-3, it is often necessary to allow breaks in the deterministic components. If the series are $I(1)$, the tests for cointegration (i.e., long-run equilibrium) between variables are reviewed in 5-4-1. However, if structural breaks within the two individual series occur either at different times or at the same time, then the cointegration relation must be tested in a framework which allows breaks in the deterministic components. Gregory and Hansen (1996) propose a test of the null hypothesis (no cointegration) against the alternative which allows a cointegration with a level shift,or a shift in both the level and the slope (i.e., a regime shift), of unknown timing. This type of hypothesis test does not provide much evidence concerning the question of whether or not there was a regime shift. Johansen *et al.* (2000) develop the testing model for cointegration with known structural breaks (up to two) including dummy variables for the years of break, generalising the multivariate likelihood procedure of Johansen (1988). Two models are considered with a broken level and with a broken trend. We denote q as the number of periods into which the sample is divided, and j specifies each period. For example, in the case of two breaks, the sample is divided into three periods, therefore $j = 1, ..., q$ and $q = 3$). Firstly, some dummy variables are introduced. $D_{j,t}$ is 1 for $t = T_{j-1}$, otherwise 0, for $j = 2, ... , q$; $t = 1, ..., T$. Denote p as number of lags, E_t is a vector of q dummy variables:

$$E_{j,t} = \sum_{i=k+1}^{T_j - T_{j-1}} D_{j,t-1}$$

with $E_{j,t} = 1$ (j=1, ..., q) if observation t belongs to the jth period and 0 otherwise, and $E_t = (E_{1t}E_{2t} \dots E_{qt})'$. The vector error correction model (VECM) is written as:

$$\Delta Z_t = \alpha \begin{pmatrix} \beta \\ \mu \end{pmatrix}' \begin{pmatrix} Z_{t-1} \\ tE_t \end{pmatrix} + \gamma E_t + \sum_{i=1}^{p-1} \Gamma_i \Delta Z_{t-i} + \sum_{i=1}^{p} \sum_{j=2}^{q} k_{j,i} D_{j,t-i} + u_t \qquad (5\text{-}43)$$

$t = 1, ..., T$

Similar to the usual model without structural breaks, Γ_i shows the short-run parameters for $i = 1, ..., p - 1$. The dummy parameters $k_{j,i}$ are p-vectors. The long-run drift parameters are $\mu = (\mu_1\mu_2 \dots \mu_q)$, α is a matrix of adjustment parameters, and β are the long-run coefficients in the cointegration vector. γ are deterministic components,$\gamma = (\gamma'_1\gamma'_2 \dots \gamma'_q)'$.

Johansen *et al.* (2000) examined two models based on (5-43). In the first model, there are no linear trends in the levels of the endogenous $I(1)$ variables and the first-differenced series have a zero mean. This model corresponds the Model 2 specified in 5-4-1-2. As for the second model, this does not account for long-run linear growth, and a broken linear trend is present in the cointegration vectors, which is equivalent to Model 4. Both tests should be applied with care with respect to the presence of deterministic components in each $I(1)$ variable, as explained in 5-2-4.

5-6. Summary

This chapter is an overview of the development of time series analysis; namely unit root tests and cointegration analysis. The basic definition of a stationary time series is that the series has constant mean and variance which are time independent, while non-stationary data do not have constant mean and variance. Thus we call stationary series those which do not have a unit root, and non-stationary series those which do have a unit root. The recent studies using unit root tests show that a large number of time series data are non-stationary. A majority of unit root tests have a null hypothesis of a unit root against an alternative hypothesis of no unit root in the series. Although the ADF test is a popular unit root test, structural breaks are also considered in some unit root tests. In this chapter, the Zivot and Andrews and Perron (1997) tests were overviewed.

The basic idea of cointegration analysis is to identify the existence of a long-run relationship between variables over time. Two main approaches are commonly used to test for cointegration (i.e., Engle and Granger's ADF-approach and Johansen's ML approach), and the theoretical background and application for both of them are reviewed, although only the latter is applied in this thesis due to the convenience of the multivariate framework. Extending the concept of cointegration analysis, the way to test for structural breaks in the series was also reviewed. Johansen *et al* (2000) developed the testing model for cointegration with known structural breaks up to two, by including dummy variables for the years of break.

In the next chapter, these methods are applied to Japanese farmland data in order to examine if the Japanese farmland market is efficient.

Chapter 6. Empirical Analysis of Japanese Farmland Market

6-1. Introduction

Having outlined in the previous chapter the procedure of time series analysis (i.e., tests for unit root and cointegration), these tests are applied to Japanese farmland data in this chapter. The main interest of this chapter is to test if the theoretical Present Value Model (PVM), which assumes that farmland prices are determined by the current and future stream of returns to land, is applicable to the Japanese farmland market which is historically strongly regulated. Through the development of testing procedures for the PVM applied in several countries, it would appear that the theoretical PVM model cannot explain adequately farmland market movements even in less regulated market. It is also of interest to study how the change of farmland policy and regulations in Japan, which are strongly influenced by economic and social structural change, affect the farmland market structure.

6-2. Model for Farmland Market Analysis

If farmland prices are well reflected by the productivity (or profitability) of the farmland, then the farmland market is said to be efficient. In this case, farmland price should equal the expected present value of future rents. This is the so-called PVM (present value model):

$$P_t = \alpha \sum_{j=0}^{\infty} \alpha^j E_t\left[R_{t+j}\right] \tag{6-1}$$

where P_t is equilibrium farmland price at the beginning of time period t; R_t is the rent paid in period t, α is a constant discount factor which is equal to $1 / (1+r)$ when r is the constant real discount rate, and E_t is the conditional expectations operator based on information available up to time t. Equation (6-1) implies a long-run relationship between the real price of land and the real return to land. Letting P^* and R^* denote the long-run equilibrium price and a constant expectation of equilibrium return (Tegene and Kuchler, 1991), equation (6-1) simplifies to:

$$P^* = (1/r)R^* \tag{6-2}$$

Applying natural logarithms to (6-2) yields,

$$\ln P^* = C + \ln R^* \quad \text{where } C = \ln(1/r) \tag{6-3}$$

Here the prime interest is to analyse the farmland market in Japan: specifically, whether the Japanese farmland market is efficient. The linear relationship between farmland prices and rents indicated in equation (6-3) exists only when both time series are integrated by the same order. Firstly, unit root tests are applied to examine whether both farmland prices and rent exhibit a stationary process, because if either has a non-stationary process there should not be a long-run equilibrium between them. Next, cointegration analysis is applied to examine the presence of a long-term relationship between logged farmland prices ($\ln P_t$) and logged rent ($\ln R_t$) as in the traditional capitalisation formula. The vector error correction model (VECM) is formed through Johansen's Full Information Likelihood (FIML) cointegration testing approach (see 5-4-1-2 in Chapter 5). Therefore the speed of short-term adjustment from disequilibrium is also examined through this approach.

6-3. Data

Japanese data from 1955 to 2000 in 9 regions excluding Okinawa (i.e., Hokkaido, Tohoku, Kanto, Hokushin, Tokai, Kinki, Chugoku, Shikoku and Kyushu)[1] for farmland prices and rents are provided by the Japan Real Estate Institute's '*The Survey on Farmland Prices and Farm Rents*'. Farmland prices and rents show the real average price (yen/10 are) of 'good' paddy and 'good' vegetable (including grazing) fields, deflated by the GDP deflator. The logarithm of deflated farmland price is denoted as: HOKPLOG (Hokkaido), TOHPLOG (Tohoku), KANPLOG (Kanto), HOSPLOG (Hokushin), TOKPLOG (Tokai), KINPLOG (Kinki), CHUPLOG (Chugoku), SHIPLOG (Shikoku), and KYUPLOG (Kyushu), while logarithms of farm rents are labelled as: HOKRLOG (Hokkaido), TOHRLOG (Tohoku), KANRLOG (Kanto), HOSRLOG (Hokushin), TOKRLOG (Tokai), KINRLOG (Kinki), CHURLOG (Chugoku), SHIRLOG (Shikoku), and KYURLOG (Kyushu). The first differences of those variables are denoted by adding D to the beginning of the name of variable (e.g., DHOKPLOG). Graphs of all data and first differences are given in Appendix 6-1.

[1] Regions are specified in the map of Appendix 2-3 (Chapter 2).

6-4. The Result of Unit Root Tests

6-4-1. The result of Dickey-Fuller (DF) and augmented Dickey-Fuller (ADF) tests

Firstly, a DF/ADF test for a single unit root in each series is applied. The autoregressive (AR) regression (6-4) is firstly applied including a constant and a time trend, and then these are removed according to the rejection of the null hypothesis of a unit root (details are in 5-2-3 of Chapter 5).

$$\Delta Y_t = \alpha + \beta t + (\phi - 1)Y_{t-1} + \sum_{i=1}^{k} \theta \Delta Y_{t-i} + u_t \tag{6-4}$$

The results of the test are reported in Table 6-1. The number of lags is defined by the Lagrange Multiplier (LM) test (see Holden and Perman, 1994), and is given for each ADF-equation, AR(k), in column 2 of Table 6-1.

Table 6-1 The DF / ADF test results

Test variables	AR (k)	τ_t	$\tau_{\beta\tau}$	$\tau_{\alpha\tau}$	Φ_3	τ_μ	$\tau_{\alpha\mu}$	Φ_1	τ
HOKPLOG	0	-0.69	-1.98*	0.79	3.98	-1.94	1.96*	2.12	0.74
TOHPLOG	1	-1.10	0.06	1.12	0.88	-1.34	1.34	0.90	-0.02
KANPLOG	0	-0.82	-0.10	0.89	5.25	-3.28*	3.37*	14.45*	3.77
HOSPLOG	2	-2.71	2.36*	2.70*	3.71	-1.90	1.92*	2.96	-1.45
TOKPLOG	0	-1.28	0.59	1.74*	1.83	-2.17	2.20*	4.95*	2.16
KINPLOG	0	-1.11	0.05	1.16	3.47	-2.66	2.72*	8.18*	2.80
CHUPLOG	0	-0.87	-0.10	0.89	0.85	-1.32	1.33	1.38	0.99
SHIPLOG	0	-0.44	-0.39	0.48	1.06	-1.41	1.44	2.46	1.67
KYUPLOG	0	-0.66	-0.42	0.70	1.22	-1.52	1.54	1.81	1.10
HOKRLOG	0	-1.67	0.68	1.75*	2.41	-1.47	1.48	1.27	0.58
TOHRLOG	0	-0.83	-0.07	0.91	1.24	-1.59	1.63	1.95	1.09
KANRLOG	0	-1.67	0.68	1.75*	2.41	-2.10	2.15*	3.17	1.25
HOSRLOG	0	-1.45	0.57	1.52	1.76	-1.81	1.85*	2.37	1.12
TOKRLOG	0	-1.65	0.95	1.69*	1.54	-1.48	1.50	1.34	0.65
KINRLOG	0	-1.76	0.58	1.79*	1.83	-1.83	1.84*	1.75	0.34
CHURLOG	0	-1.56	-0.11	1.61	1.97	-2.00	2.01*	2.04	0.20
SHIRLOG	0	-1.47	-0.46	1.56	2.58	-2.25	2.26*	2.81	0.67
KYURLOG	0	-1.30	-0.03	1.35	1.55	-1.78	1.79*	1.73	0.47
First Differences									
DHOKPLOG	0	-4.86*	-1.55	1.52	11.88*	-4.54*	0.27	10.36	-4.59*
DTOHPLOG	0	-3.33	-0.74	0.67	5.80	-3.34*	-0.00	5.71	-3.42*
DKANPLOG	0	-4.10*	-1.41	1.93*	8.45*	-3.82*	1.49	7.46	-3.51*
DHOSPLOG	0	-5.27*	-0.47	-0.29	15.13*	-5.53*	0.29	15.73	-5.66*
DTOKPLOG	0	-3.50*	-0.07	0.35	6.47	-3.64*	0.65	6.75	-3.64*
DKINPLOG	0	-3.18	-0.32	0.64	5.41	-3.31*	0.81	5.62	-3.27*
DCHUPLOG	0	-3.48	0.41	-0.36	6.53	-3.63*	0.00	6.72	-3.71*
DSHIPLOG	0	-4.10*	-0.58	0.89	8.43*	-4.10*	0.82	8.41	-4.03*
DKYUPLOG	0	-3.94*	-0.15	0.25	8.02*	-4.05*	0.27	8.29	-4.11*
DHOKRLOG	0	-5.58*	-0.76	0.81	15.61*	-5.56*	0.31	15.50	-5.62*
DTOHRLOG	0	-4.53*	-0.50	0.66	10.33*	-4.56*	0.48	10.44	-4.58*
DKANRLOG	0	-5.32*	-0.53	0.77	14.31*	-5.37*	0.68	14.50	-5.38*
DHOSRLOG	0	-5.34*	-1.30	1.64	14.35*	-5.15*	1.06	13.30	-5.03*
DTOKRLOG	0	-5.46*	-0.30	0.47	14.92*	-5.51*	0.45	15.21	-5.55*
DKINRLOG	0	-5.59*	-0.47	0.52	15.61*	-5.62*	0.22	15.80	-5.68*
DCHURLOG	0	-5.87*	-1.03	0.99	17.25*	-5.78*	0.17	16.70	-5.84*
DSHIRLOG	0	-4.29*	-0.68	0.68	9.26*	-4.27*	0.15	9.20	-4.34*
DKYURLOG	0	-5.13*	-0.77	0.80	13.19*	-5.10*	0.27	13.03	-5.15*
5% Critical Values		**-3.50**	**1.68**	**1.68**	**6.73**	**-2.93**	**1.68**	**4.86**	**-1.95**

Note: * indicates statistical significance at 5% level. Critical values are from RATS for Windows (version 4.2), Fuller (1976), and Dickey and Fuller (1981).

The τ_t test implies that we cannot reject the null hypothesis of a unit root (non-stationary) in all series of farmland prices and rents. As it is reported in recent studies that a lot of time series data are non-stationary with unit roots (e.g., Falk, 1991; Hallam *et al.*, 1992), it is also expected that testing variables here have unit roots (i.e., non-stationary series). The $\tau_{\beta\tau}$ test implies that we cannot reject the null of no trend in all series except for the logged farmland prices of Hokkaido (HOKPLOG) and Hokushin (HOSPLOG), and the $\tau_{\alpha\tau}$ test implies that we cannot reject the null of no drift in all series, except for the logged farmland prices of Hokushin (HOSPLOG), Tokai (TOKPLOG) and logged rent prices of Hokkaido (HOKRLOG), Kanto (KANRLOG), Tokai (TOKRLOG) and Kinki (KINRLOG). The Φ_3 test is then performed to test jointly the null of a unit root and no trend. This test implies that we cannot reject the null of unit root.

Since the $\tau_{\beta\tau}$ test and $\tau_{\alpha\tau}$ test show the rejection of both null of no constant and no trend for the series of Hokushin (HOSPLOG), the τ_t test is employed for this series and it is concluded that HOSPLOG is a non-stationary series with drift and trend. Except for the series of Hokushin (HOSPLOG), the trend term is then removed and τ_μ and $\tau_{\alpha\mu}$ tests are used to examine the null of a unit root, and the null of no drift, respectively. The τ_μ test implies that we cannot reject the null of a unit root in all series except for logged farmland prices of Kanto (KANPLOG), and then the $\tau_{\alpha\mu}$ test implies that we reject the null of no drift except for logged farmland prices of Tohoku (TOHPLOG), Chugoku (CHUPLOG), Shikoku (SHIPLOG), and Kyushu (KYUPLOG) and logged rent series of Hokkaido (HOKRLOG), Tohoku (TOHRLOG), and Tokai (TOKRLOG). A joint test of the null hypothesis of a unit root and no drift, Φ_1, implies the rejection in the series of farmland prices of Kanto (KANPLOG), Tokai (TOKPLOG) and Kinki (KINPLOG). Therefore the τ_μ test is employed for all series which show the rejection of no drift by the $\tau_{\alpha\mu}$ test (i.e., HOKPLOG, KANPLOG, TOKPLOG, KINPLOG, KANRLOG, HOSRLOG, KINRLOG, CHURLOG, SHIRLOG, and KYURLOG). As the result of the $\tau_{\alpha\mu}$ test, only the series of farmland prices in Kanto (KANPLOG) is concluded as stationary with drift, and the other series as non-stationary with drift. After removing the drift term, we perform the τ test only on the series of Tohoku (TOHPLOG), Chugoku (CHUPLOG), Shikoku (SHIPLOG) and Kyushu (KYUPLOG) for farmland prices, and the series of Hokkaido (HOKRLOG), Tohoku (TOHRLOG) and Tokai (TOKRLOG) for farm rents. The result implies that we cannot reject the null of unit root in all series. Therefore those series can be concluded as non-stationary without drift and trend.

The test results for first differences of all series are now examined. The τ_t test implies that we reject the null hypothesis of a unit root in all series of farmland prices and rents except for Tohoku (DTOHPLOG), Kinki (DKINPLOG) and Chugoku (DCHUPLOG). The null of no trend is tested through the $\tau_{\beta\tau}$ test, and implies that we cannot reject any series, while the $\tau_{\alpha\tau}$ test rejects the null of no drift only for farmland prices of Kanto (DKANPLOG). The Φ_3 test is then used to test the null of a unit root and no trend jointly, and shows that we cannot reject the series of farmland prices in Tohoku (DTOHPLOG), Tokai (DTOKPLOG), Kinki (DKINPLOG), and Chugoku (DCHUPLOG). The τ_μ and $\tau_{\alpha\mu}$ tests are used to examine the null of a unit root and the null of no drift, respectively. Although the results of the τ_{μ} test imply that the null of a unit root is rejected for all series, the null of no drift is not rejected. Removing the drift, the τ test is employed for all series. The result of τ test shows that the null of a unit root is rejected for all series. Therefore, it is concluded that all series are stationary without trend and drift.

A summary from the DF/ADF tests is presented in Table 6-2. It is concluded that first differences of farmland prices and rents are all stationary series, $I(0)$. Therefore, all logged farmland prices and rents, except for Kanto (KANPLOG), are non-stationary series integrated of order 1 (i.e., $I(1)$): the farmland price series of Hokushin (HOSPLOG) contains both trend and drift, and the farmland price series of Hokkaido (HOKPLOG), Tokai (TOKPLOG) and Kinki (KINPLOG), and the farm rent series of Kanto (KANRLOG), Hokushin (HOSRLOG), Kinki (KINRLOG), Chugoku (CHURLOG), Shikoku (SHIRLOG) and Kyushu (KYURLOG) contain drift. Conversely, the farmland price series of Kanto (KANPLOG) are concluded stationary series, $I(0)$, with drift.

Concerning the deterministic components discussed in 5-2-4 in Chapter 5, the results of the ADF test for KANPLOG and HOSPLOG have to be discussed here. Seeing the graph of KANPLOG (see Appendix 6-1), the series look trended. Therefore, expected results would be a non-stationary series or a stationary series with trend, not stationary with a constant term. The indicated result, stationary with drift, may suggest the wrong model for unit root test, possibly due to the existence of a structural break. Therefore, the final result of unit root test should be considered with the unit root tests results with structural break. As to HOSPLOG, the result indicating a liner trend is not likely to be accepted in the case of a non-stationary variable because it is difficult to distinguish between a linear trend and a stochastic trend. Especially in the case of land prices, the series is not likely to have a linear trend, while the series may contain a stochastic trend (i,e., growth) under macro economic influences. Thus, a linear trend can be ignored in this analysis.

Table 6-2 Summary of the DF/ADF tests results

Test variables	$I(0)$	$I(1)$	Trend	Drift
HOKPLOG		✓		✓
TOHPLOG		✓		
KANPLOG	✓			✓
HOSPLOG		✓	✓	✓
TOKPLOG		✓		✓
KINPLOG		✓		✓
CHUPLOG		✓		
SHIPLOG		✓		
KYUPLOG		✓		
HOKRLOG		✓		
TOHRLOG		✓		
KANRLOG		✓		✓
HOSRLOG		✓		✓
TOKRLOG		✓		
KINRLOG		✓		✓
CHURLOG		✓		✓
SHIRLOG		✓		✓
KYURLOG		✓		✓

6-4-2. A structural break and unit root tests

Given the change of rent determination in 1967 and 1980[2], the possibility of structural breaks can be considered here, especially in the farm rent data. There are alternative approaches in terms of unit root tests in the presence of structural breaks. Zivot and Andrews (1992) consider the case where the points of structural breaks are unknown. The null hypothesis is formed to test a unit root without an exogenous structural break:

$$H_0:\ Y_t = \alpha + Y_{t-1} + u_t \tag{6-5}$$

against the alternative hypothesis of trend stationary with one time break occurring at an unknown point in time:

$$H_1:\ Y_t = \alpha_1 + \beta t + \delta DU_t + u_t \tag{6-6}$$

where DU_t is a dummy, and DU_t=1 if time t is bigger than that at the point of the structural break, T_B, (i.e., $t > T_B$), otherwise $DU_t = 0$. The result is shown in Table 6-3 using equation (6-7) which was derived by nesting (6-5) and (6-6):

$$\Delta Y_t = \alpha + \beta t + \delta DU_t + \gamma Y_{t-1} + \sum_{i=1}^{k} \theta_i \Delta Y_{t-i} + u_t \tag{6-7}$$

There are several approaches for testing, but here only the level shift in the series is tested using the Lagrange multiplier (LM) test to determine the lag length. In Table 6-3, the null of a unit root cannot be rejected for logged farmland prices and rents in all regions. There is no evidence that the series are stationary with a structural break.

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[2] Th e maximum level of farm rent was revised in 1967, and direct rent control was ended in 1980. Seeing the graphs (Appendix 6-1), structural breaks can be observed as test results both after 1967 and 1980.

Table 6-3 Unit root tests after Zivot and Andrews (1992)

Test variables	lag	t-statistics	T_B
HOKPLOG	0	-2.47	-
TOHPLOG	1	-2.66	-
KANPLOG	0	-3.04	-
HOSPLOG	0	-3.01	-
TOKPLOG	0	-3.32	-
KINPLOG	0	-3.53	-
CHUPLOG	0	-2.58	-
SHIPLOG	0	-2.57	-
KYUPLOG	0	-2.02	-
HOKRLOG	0	-2.53	-
TOHRLOG	0	-2.38	-
KANRLOG	0	-2.92	-
HOSRLOG	0	-3.05	-
TOKRLOG	0	-2.58	-
KINRLOG	0	-3.14	-
CHURLOG	0	-2.60	-
SHIRLOG	0	-4.61	-
KYURLOG	0	-2.59	-
5% Critical Values		**-4.80**	

Note: * indicates statistical significance at 5% level. Critical values are from RATS for Windows.

Subsequently, Perron (1997) developed a test which allows a break under both null and alternative hypotheses at an unknown point in time. He examines three different models under the null and alternative hypothesis. The first (Model 1) allows for a change only in the intercept or level of the series. The second (Model 2) allows for a change in the intercept and the slope at the break. The third (Model 3) allows a change in the slope, but both segments of the trend function are jointed at the time of the break. Here only the simplest model (Model 1) is applied in order to examine the change in level. The null hypothesis is that there is a unit root with non-zero drift, and with a single exogenous change in the intercept, or level of the series, at an unknown point:

$$\text{H}_0\text{:}\ \ \Delta Y_t = \alpha_1 + dD(T_B)_t + \gamma Y_{t-1} + e_t \tag{6-8}$$

where $D(T_B)_t = 1$ if $t = TB + 1$, and if not, $D(T_B)_t = 0$. The alternative hypothesis is trend stationary with a single exogenous break in the trend of the following form:

$$\text{H}_1\text{:}\ \ \Delta Y_t = \alpha_2 + \beta t + \sigma DU(\lambda)_t + e_t \tag{6-9}$$

Then the unit root testing equation here becomes:

$$\Delta Y_t = \alpha + \beta t + \sigma DU(\lambda)_t + dD(T_B)_t + \gamma Y_{t-1} + \sum_{i=1}^{k} \theta_i \Delta Y_{t-i} + e_t \tag{6-10}$$

The result of this test is seen in Table 6-4. The null hypothesis is not rejected for all farmland price and rent data, which indicates that farmland prices are all non-stationary, and that all farm rent series are stationary bar Hokkaido (HOKRLOG), Hokushin (HOSRLOG), Kinki (KINRLOG) and Chugoku (CHURLOG) when the year of break is considered. Observing the years of break, there is no clear year of structural break in common over the regions in terms of farmland prices, while the test results for rents indicate a structural break in 1979/80 except for Hokkaido (HOKRLOG). Therefore, structural breaks only in rent series are taken into account here. Considering that the control on maximum level of rent was terminated in 1980, it may be important to be mindful of the year 1980 in further analysis.[3]

[3] As Perron 1997 test consider only one structural break in the test model, 1980 is appeared to be a break year. However, 1967 is to be still considered as a break year in the following analysis.

Table 6-4 Unit root tests after Perron (1997)

Test variables	lag	t-statistic	T_B
HOKPLOG	8	-3.15	1971
TOHPLOG	11	-3.66	1998
KANPLOG	7	-1.66	1970
HOSPLOG	12	-4.27	1977
TOKPLOG	3	-4.27	1992
KINPLOG	2	-4.04	1991
CHUPLOG	2	-4.80	1976
SHIPLOG	12	-3.40	1972
KYUPLOG	12	-4.96	1980
HOKRLOG	4	-2.54	1993
TOHRLOG	12	-7.07*	1980
KANRLOG	12	-7.44*	1980
HOSRLOG	11	-5.10	1980
TOKRLOG	12	-6.90*	1980
KINRLOG	1	-3.53	1980
CHURLOG	12	-4.67	1980
SHIRLOG	3	-5.43*	1979
KYURLOG	12	-6.61*	1980
5% Critical Values		**-5.23**	

Note: * indicates statistical significance at 5% level. Critical values are from RATS for Windows.

6-4-3. The summary of unit r oot tests results

Table 6-5 presents a summary of all unit root test results (ADF test, Z & A test, and Perron 97 test). The results strongly reject the stationary hypothesis for all series. Thus, it is concluded that all logged farmland prices and logged rents are non-stationary, as expected, and integrated of order 1, i.e., $I(1)$, since the first differences for those variables are stationary. Moreover, by the result of the Perron 97 test, 1980 is indicated as a structural break year for farm rent data, except for the series of Hokkaido (HOKRLOG).

Table 6-5 The summary of unit root test results

Test variables	ADF	Z & A	Perron 97	Result[4]	Structural Break[5] (T_B)
HOKPLOG	$I(1)$	$I(1)$	$I(1)$	$I(1)$	-
TOHPLOG	$I(1)$	$I(1)$	$I(1)$	$I(1)$	-
KANPLOG	$I(0)$	$I(1)$	$I(1)$	$I(1)$	-
HOSPLOG	$I(1)$	$I(1)$	$I(1)$	$I(1)$	-
TOKPLOG	$I(1)$	$I(1)$	$I(1)$	$I(1)$	-
KINPLOG	$I(1)$	$I(1)$	$I(1)$	$I(1)$	-
CHUPLOG	$I(1)$	$I(1)$	$I(1)$	$I(1)$	-
SHIPLOG	$I(1)$	$I(1)$	$I(1)$	$I(1)$	-
KYUPLOG	$I(1)$	$I(1)$	$I(1)$	$I(1)$	-
HOKRLOG	$I(1)$	$I(1)$	$I(1)$	$I(1)$	(1993)
TOHRLOG	$I(1)$	$I(1)$	$I(0)$	$I(1)$	(1980)
KANRLOG	$I(1)$	$I(1)$	$I(0)$	$I(1)$	(1980)
HOSRLOG	$I(1)$	$I(1)$	$I(1)$	$I(1)$	(1980)
TOKRLOG	$I(1)$	$I(1)$	$I(0)$	$I(1)$	(1980)
KINRLOG	$I(1)$	$I(1)$	$I(1)$	$I(1)$	(1980)
CHURLOG	$I(1)$	$I(1)$	$I(1)$	$I(1)$	(1980)
SHIRLOG	$I(1)$	$I(1)$	$I(0)$	$I(1)$	(1979)
KYURLOG	$I(1)$	$I(1)$	$I(0)$	$I(1)$	(1980)

[4] This is the majority of the results from the three unit root tests.
[5] The year of the structural break is based on Perron97 test.

6-5. Results of Cointegration Analysis

As the model for farmland price was discussed in 6-2, farmland prices are assumed to be a function of farm rent.

$$\ln P_t = f(\ln R_t) \tag{6-11}$$

Johansen's procedure is applied for this equation. The first step of the Johansen procedure is the selection of the order of the VAR by using

$$Z_t = A_1 Z_{t-1} + \ldots + A_k Z_{t-k} + u_t. \tag{6-12}$$

then estimating the vector error correction model (VECM) when k =2 including dummy variables which only affect the short-run model,

$$\Delta Z_t = \Gamma_1 \Delta Z_{t-1} + \prod Z_{t-1} + \Psi D_t + u_t \tag{6-13}$$

Rewriting the VECM form using farmland prices and rents,

$$\begin{bmatrix} \Delta \ln P_t \\ \Delta \ln R_t \end{bmatrix} = \Gamma_1 \begin{bmatrix} \Delta \ln P_{t-1} \\ \Delta \ln R_{t-1} \end{bmatrix} + \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{bmatrix} \begin{bmatrix} \beta_{11} & \beta_{21} & \beta_{31} \\ \beta_{12} & \beta_{22} & \beta_{32} \end{bmatrix} \begin{bmatrix} \ln P_{t-1} \\ \ln R_{t-1} \end{bmatrix} \tag{6-14}$$

where $\prod = \boldsymbol{\alpha\beta'}$, in which $\boldsymbol{\alpha}$ represents the speed of adjustment to disequilibrium, while $\boldsymbol{\beta}$ is a matrix of long-run coefficients. According to the results of unit root tests with a structural break, we also apply the model considering the case where structural breaks (up to two) within individual series occur based on Johansen (2000). The VECM with structural breaks is,

$$\Delta Z_t = \alpha \begin{pmatrix} \beta \\ \mu \end{pmatrix}' \begin{pmatrix} Z_{t-1} \\ tE_t \end{pmatrix} + \gamma E_t + \sum_{i=1}^{p-1} \Gamma_i \Delta Z_{t-i} + \sum_{i=1}^{p} \sum_{j=2}^{q} k_{j,i} D_{j,t-i} + u_t \tag{6-15}$$

where p is the number of lags and q is the number of periods into which the sample is divided, and each period is denoted by j. Therefore, in the case of two breaks, the sample is divided into three periods ($j = 1, \ldots, q$ and $q = 3$). E_t is a vector of q dummy variables $E_t = (E_{1t} E_{2t} \ldots E_{qt})'$ with $E_{j,t} = 1$ ($j = 1, \ldots, q$) if observation t belongs to the

jth period and 0 otherwise, with the first p observations set to zero; and $D_{j,t-i}$ (j = 2, ...,q and i=1, ..., p) is an impulse dummy that equals unity if observation t is the ith observation of the jth period. γ are deterministic components, $\gamma = (\gamma'_1\gamma'_2 \ldots \gamma'_q)'$. We test two cases: no structural break and two structural breaks in 1967 and 1980, considering the policy change in terms of rent level and its determination.

6-5-1. Selection of lags

Likelihood Ratio (LR) tests, with the null hypothesis that the order of the VAR is k against k+1, are undertaken as well as the Akaike Information Criterion (AIC) and Schwarz Bayesian Criterion (SBC) on the VAR with a maximum of four lags. The results of the model for all regions are shown in Table 6-6 with and without structural breaks.

Starting from the model without structural breaks, the LR test statistics for Hokkaido do not reject order two, but reject the VAR with order one. Similarly, the results of AIC and SBC choose order 1. Therefore, order one is chosen for Hokkaido. For Tohoku and Kanto, the LR test statistic selects order two, although AIC and SBC indicate order 1. In this case, order one is chosen in order to prevent over-parameterising as the time series is short. In the case of Hokushin, the result of the LR test shows order two, as well as the results of AIC and SBC. Conversely, the LR test statistic does not reject order two, but rejects order one for Tokai. However, the SBC result supports order one. In this case it seems wise to proceed with the two-lag model. The results of the LR test and AIC and SBC indicate the selection of order two for Kinki and Chugoku. As to Shikoku and Kyushu, the LR test cannot reject order two, but rejects order one, while both AIC and SBC select order one. In this case, order one is chosen, similar to the case of Tohoku.

In the case of the model with structural breaks, AIC and SBC select order 4 as well as the LR test for Hokkaido and Tohoku. For Kanto and Hokushin, SBC and the LR test choose order 2 although order 4 was chosen by AIC, while for Tokai and Kinki, SBC and the LR test choose order 4 although order 2 was chosen by AIC. In these cases, order 2 is chosen in order to prevent over-parameterising as the time series is short. For Chugoku and Shikoku, the results of AIC, SBC and the LR test select order two and four, respectively. As to Kyushu, the LR test chooses order two, while AIC selects order four and order three by SBC. In this case, it seems feasible to select the lowest order, order two, for the prevention of over-parameterisation.

Table 6-6 Test statistics and choice criteria for selecting the order of the VAR model

1) Hokkaido

Based on 46 observations from 1955 to 2000. Order of VAR = 4			
List of variables included in the unrestricted VAR: **HOKPLOG HOKRLOG**			
List of deterministic and/or exogenous variables: **INTERCEPT**			
Without structural break			
Order	AIC	SBC	LR test
4	-480.897	-449.619	------
3	-489.949	-465.292	6.488[.890]
2	-486.512	-468.670	18.330[.002]
1	-495.531	-484.691	6.957[.138]
With structural breaks (in 1967 and 1980)			
Order	AIC	SBC	LR test
4	-13.334	-11.762	------
3	-12.762	-11.521	21.931[.005]
2	-11.455	-10.545	60.750[.000]
1	-11.417	-10.837	70.395[.000]

Note: AIC=Akaike Information Criterion, SBC=Schwarz Bayesian Criterion, LR=Likelihood Ratio test, p-value in parentheses.

2) Tohoku

Based on 46 observations from 1955 to 2000. Order of VAR = 4			
List of variables included in the unrestricted VAR: **TOHPLOG TOHRLOG**			
List of deterministic and/or exogenous variables: **INTERCEPT**			
Without structural break			
Order	AIC	SBC	LR test
4	-504.503	-473.225	------
3	-518.412	-493.755	4.205[.979]
2	-531.382	-513.540	6.316[.612]
1	-533.752	-522.612	11.733[.019]
With structural breaks (in 1967 and 1980)			
Order	AIC	SBC	LR test
4	-13.957	-12.385	------
3	-13.259	-12.017	24.835[.002]
2	-13.026	-12.116	38.950[.001]
1	-12.888	-12.309	50.871[.001]

Note: AIC=Akaike Information Criterion, SBC=Schwarz Bayesian Criterion, LR=Likelihood Ratio test, p-value in parentheses.

3) Kanto

Based on 46 observations from 1955 to 2000. Order of VAR = 4			
List of variables included in the unrestricted VAR: **KANPLOG KANRLOG**			
List of deterministic and/or exogenous variables: **INTERCEPT**			
Without structural break			
Order	AIC	SBC	LR test
4	-484.707	-453.429	------
3	-500.246	-475.589	4.424[.975]
2	-516.451	-498.609	4.773[.781]
1	-518.413	-507.573	14.431[.006]
With structural breaks (in 1967 and 1980)			
Order	AIC	SBC	LR test
4	-13.906	-12.333	------
3	-13.587	-12.346	16.095[.041]
2	-13.627	-12.716	23.943[.091]
1	-12.583	-12.004	56.707[.000]

Note: AIC=Akaike Information Criterion, SBC=Schwarz Bayesian Criterion, LR=Likelihood Ratio test, p-value in parentheses.

4) Hokushin

Based on 46 observations from 1955 to 2000. Order of VAR = 4			
List of variables included in the unrestricted VAR: **HOSPLOG HOSRLOG**			
List of deterministic and/or exogenous variables: **INTERCEPT**			
Without structural break			
Order	AIC	SBC	LR test
4	-491.248	-459.970	------
3	-506.030	-481.373	5.906[.921]
2	-516.725	-498.883	7.050[.531]
1	-490.872	-480.032	18.729[.001]
With structural breaks (in 1967 and 1980)			
Order	AIC	SBC	LR test
4	-13.261	-11.689	------
3	-12.897	-11.656	17.138[.029]
2	-12.890	-11.979	26.065[.053]
1	-12.121	-11.542	52.507[.001]

Note: AIC=Akaike Information Criterion, SBC=Schwarz Bayesian Criterion, LR=Likelihood Ratio test, p-value in parentheses.

5) Tokai

Based on 46 observations from 1955 to 2000. Order of VAR = 4			
List of variables included in the unrestricted VAR: **TOKPLOG TOKRLOG**			
List of deterministic and/or exogenous variables: **INTERCEPT**			
Without structural break			
Order	AIC	SBC	LR test
4	-497.813	-466.535	------
3	-513.820	-489.163	2.849[.997]
2	-533.674	-515.832	2.071[.979]
1	-527.897	-517.057	22.949[.000]
With structural breaks (in 1967 and 1980)			
Order	AIC	SBC	LR test
4	-14.275	-12.703	------
3	-13.922	-12.681	16.885[.031]
2	-13.868	-12.958	26.885[.043]
1	-13.016	-12.437	55.231[.000]

Note: AIC=Akaike Information Criterion, SBC=Schwarz Bayesian Criterion, LR=Likelihood Ratio test, p-value in parentheses.

6) **Kinki**

Based on 46 observations from 1955 to 2000. Order of VAR = 4			
List of variables included in the unrestricted VAR: **KINPLOG KINRLOG**			
List of deterministic and/or exogenous variables: **INTERCEPT**			
Without structural break			
Order	AIC	SBC	LR test
4	-524.123	-492.845	------
3	-533.378	-508.721	7.904[.793]
2	-552.071	-534.229	3.285[.915]
1	-530.705	-519.865	36.213[.000]
With structural breaks (in 1967 and 1980)			
Order	AIC	SBC	LR test
4	-14.812	-13.240	------
3	-14.272	-13.031	21.180[.007]
2	-14.370	-13.460	27.696[.034]
1	-12.884	-12.305	70.632[.000]

Note: AIC=Akaike Information Criterion, SBC=Schwarz Bayesian Criterion, LR=Likelihood Ratio test, p-value in parentheses.

7) **Chugoku**

Based on 41 observations from 1955 to 2000. Order of VAR = 4			
List of variables included in the unrestricted VAR: **CHUPLOG CHURLOG**			
List of deterministic and/or exogenous variables: **INTERCEPT**			
With structural break			
Order	AIC	SBC	LR test
4	-481.540	-450.262	------
3	-494.715	-470.059	5.329[.946]
2	-509.443	-491.601	4.478[.812]
1	-496.050	-485.210	25.560[.000]
With structural breaks (in 1967 and 1980)			
Order	AIC	SBC	LR test
4	-12.777	-11.205	------
3	-12.685	-11.444	37.149[.042]
2	-12.787	-11.877	17.285[.367]
1	-12.304	-11.725	52.507[.001]

Note: AIC=Akaike Information Criterion, SBC=Schwarz Bayesian Criterion, LR=Likelihood Ratio test, p-value in parentheses.

8) Shikoku

Based on 41 observations from 1955 to 2000. Order of VAR = 4			
List of variables included in the unrestricted VAR: **SHIPLOG SHIRLOG**			
List of deterministic and/or exogenous variables: **INTERCEPT**			
Without structural break			
Order	AIC	SBC	LR test
4	-490.862	-459.584	------
3	-499.713	-475.056	8.588[.738]
2	-516.993	-499.151	1.521[.992]
1	-520.115	-509.275	15.609[.004]
With structural breaks (in 1967 and 1980)			
Order	AIC	SBC	LR test
4	-13.848	-12.275	------
3	-12.946	-11.704	29.506[.000]
2	-12.882	-11.971	39.741[.001]
1	-12.121	-11.490	67.194[.000]

Note: AIC=Akaike Information Criterion, SBC=Schwarz Bayesian Criterion, LR=Likelihood Ratio test, p-value in parentheses.

9) Kyushu

Based on 41 observations from 1955 to 2000. Order of VAR = 4			
List of variables included in the unrestricted VAR: **KYUPLOG KYURLOG**			
List of deterministic and/or exogenous variables: **INTERCEPT**			
Without structural break			
Order	AIC	SBC	LR test
4	-487.440	-456.162	------
3	-498.416	-473.760	4.989[.958]
2	-515.537	-497.695	2.934[.938]
1	-520.620	-509.780	10.995[.027]
With structural breaks (in 1967 and 1980)			
Order	AIC	SBC	LR test
4	-12.832	-11.260	------
3	-12.813	-11.572	9.198[.326]
2	-12.481	-11.571	25.594[.060]
1	-11.785	-11.206	50.365[.001]

Note: AIC=Akaike Information Criterion, SBC=Schwarz Bayesian Criterion, LR=Likelihood Ratio test, p-value in parentheses.

6-5-2. Cointegration results

Only Model 2, with and without structural break in 1967 and 1980, is applied here because not all series show the evidence of trend as seen in Table 6-2. The results of cointegration are shown in Table 6-7. The cointegration results without breaks suggest a long-run relationship between farmland prices and farm rents for Hokkaido, Tohoku, Kanto, Shikoku and Kyuhu, while the model including two breaks in 1967 and 1980 imply the presence of a cointegration relationship for Kanto, Hokushin, Tokai, Kinki, Shikoku, and is inconclusive for Hokkaido and Tohoku.

Table 6-7 Cointegration r esults for farmland prices

1) Hokkaido

Null (*r*)	Alternative (*n-r*)	**Without structural break**	**With structural break** (1967 and 1980)
0	1	20.70* (17.79)	87.52* (29.65)
1	2	6.11 (7.50)	30.19* (14.25)

Note: * indicates that the statistic is significant at 10% level. Critical value is in parenthesis, which is provided by CATS (without structural break) and Malcolm (with structural break).

2) Tohoku

Null (*r*)	Alternative (*n-r*)	**Without structural break**	**With structural break** (1967 and 1980)
0	1	35.23* (17.79)	58.18* (29.65)
1	2	6.11 (7.50)	23.17* (14.25)

Note: * indicates that the statistics is significant at 10% level. Critical value is in parenthesis, which is provided by CATS (without structural break) and Malcolm (with structural break).

3) Kanto

Null (*r*)	Alternative (*n-r*)	**Without structural break**	**With structural break** (1967 and 1980)
0	1	29.71* (17.79)	30.31* (29.65)
1	2	4.42 (7.50)	8.44 (14.25)

Note: * indicates that the statistics is significant at 10% level. Critical value is in parenthesis, which is provided by CATS (without structural break) and Malcolm (with structural break).

4) Hokushin

Null (r)	Alternative (n-r)	**Without structural break**	**With structural break** (1967 and 1980)
0	1	12.64 (17.79)	31.26* (29.65)
1	2	1.10 (7.50)	11.62 (14.25)

Note: * indicates that the statistics is significant at 10% level. Critical value is in parenthesis, which is provided by CATS (without structural break) and Malcolm (with structural break).

5) Tokai

Null (r)	Alternative (n-r)	**Without structural break**	**With structural break** (1967 and 1980)
0	1	12.98 (17.79)	33.14* (29.65)
1	2	2.09 (7.50)	10.94 (14.25)

Note: * indicates that the statistics is significant at 10% level. Critical value is in parenthesis, which is provided by CATS (without structural break) and Malcolm (with structural break).

6) Kinki

Null (r)	Alternative (n-r)	**Without structural break**	**With structural break** (1967 and 1980)
0	1	10.52 (17.79)	33.46* (29.65)
1	2	1.91 (7.50)	9.51 (14.25)

Note: * indicates that the statistics is significant at 10% level. Critical value is in parenthesis, which is provided by CATS (without structural break) and Malcolm (with structural break).

7) Chugoku

Null (r)	Alternative (n-r)	**Without structural break**	**With structural break** (1967 and 1980)
0	1	8.79 (17.79)	25.01 (29.65)
1	2	2.33 (7.50)	6.67 (14.25)

Note: * indicates that the statistics is significant at 10% level. Critical value is in parenthesis, which is provided by CATS (without structural break) and Malcolm (with structural break).

8) Shikoku

Null (r)	Alternative (n-r)	**Without structural break**	**With structural break** (1967 and 1980)
0	1	18.25* (17.79)	66.68* (29.65)
1	2	1.10 (7.50)	12.52 (14.25)

Note: * indicates that the statistics is significant at 10% level. Critical value is in parenthesis, which is provided by CATS (without structural break) and Malcolm (with structural break).

9) Kyushu

Null (r)	Alternative (n-r)	**Without structural break**	**With structural break** (1967 and 1980)
0	1	25.41* (17.79)	27.34 (29.65)
1	2	2.93 (7.50)	11.76 (14.25)

Note: * indicates that the statistics is significant at 10% level. Critical value is in parenthesis, which is provided by CATS (without structural break) and Malcolm (with structural break).

Particularly based on the test results for cointegration with structural breaks, we can test for the preference of model using log-likelihood ratios (LR) between models with and without structural breaks. Assuming one cointegrating vector ($r = 1$) with a broken level, and two breaks ($q = 3$) in (6-15), $(Z_{t-1}E_t) = (P_{t-1}R_{t-1}E_{1t}E_{2t}E_{3t})'$ and parameters in the cointegration vector are $(\beta\mu)' = (\beta_p\beta_r\mu_1\mu_2\mu_3)'$. In order to test if structural breaks imply changes in joint long-run price evolution, which is a test of the equality of the intercepts in the three periods, the null hypothesis is written as;

$H_0^1 : \beta' = (\ * \ * \ 1 \ 1 \ 1)$ or $\mu_1 = \mu_2 = \mu_3$.

If the null is rejected, the constant component of the long-run equilibrium between P_t and R_t have not remained stable around a single level. There are also two cases testing the stability of the intercept between two periods; before and after either 1967 or 1980.

$H_0^2 : \beta' = (\ * \ * \ 1 \ 1 \ *)$ or $\mu_1 = \mu_2$. (with a break in 1980)

$H_0^3 : \beta' = (\ * \ * \ * \ 1 \ 1)$ or $\mu_2 = \mu_3$. (with a break in 1967)

The test results shown in Table 6-8 support the application of the model with structural breaks for Hokkaido, Kanto, Kinki and Shikoku, as the null hypothesis of constant intercepts in the three periods is strongly rejected. For the other regions (i.e., Tohoku and Hokushin), the standard model is preferred. The second hypothesis that two periods before and after 1980 have a constant intercept is not rejected for Tohoku and Hokushin, while the third hypothesis of a constant intercept before and after 1967 is not rejected for Hokkaido, Tohoku, Hokushin and Kinki. Thus, the rent reform in 1967 and 1980 had a significant impact on long-run equilibrium in Hokkaido, Kanto, Kinki and Shikoku, although the reform in 1967 implies to have had a more significant impact than in 1980 only for Hokkaido and Kinki.

Table 6-8 Hypothesis tests for the model with structural breaks

Hypothesis	LR-Statistic [p-value]		
	$H_0^1: \mu_1 = \mu_2 = \mu_3$	$H_0^2: \mu_1 = \mu_2$	$H_0^3: \mu_2 = \mu_3$
Hokkaido	22.93 [0.00]	21.49 [0.00]	0.06 [0.81]
Tohoku	0.75 [0.69]	0.74 [0.39]	0.14 [0.70]
Kanto	10.50 [0.00]	3.84 [0.05]	9.20 [0.00]
Hokushin	0.65 [0.42]	1.82 [0.18]	0.00 [0.97]
Tokai	-	-	-
Kinki	13.90 [0.00]	13.00 [0.00]	3.51 [0.06]
Chugoku	-	-	-
Shikoku	32.83 [0.00]	28.79 [0.00]	9.85 [0.00]
Kyushu	-	-	-

Note: The hypothesis tests were not applied for Tokai, Chugoku and Kyushu which do not imply a cointegration relationship with the structural break model.

Based on the above results, the cointegrating vector is shown as follows:

i) Hokkaido

$$HOKPLOG = 1.80HOKRLOG - 4.10E_1 - 4.54E_2 - 4.52E_3$$

ii) Tohoku

$$TOHPLOG = 0.963TOHRLOG + 4.21$$

iii) Kanto

$$KANPLOG = -0.13KANRLOG + 14.54E_1 + 15.03E_2 + 15.29E_3$$

iv) Hokushin

$$HOSPLOG = 1.02HOSRLOG + 4.06E_1 + 4.19E_2 + 3.90E_3$$

v) Kinki

$$KINPLOG = 0.07KINRLOG + 12.83E_1 + 13.15E_2 + 13.32E_3$$

vi) Shikoku

$$SHIPLOG = 0.46SHIRLOG + 9.10E_1 + 9.95E_2 + 9.58E_3$$

vii) Kyushu

$$KYUPLOG = 0.963KYURLOG + 3.763$$

All show the correct sign (i.e., positive) for coefficients on farm rents except for Kanto.

Of specific interest here is the coefficient on the rent variable, because the theoretical model (6-3) implies unit elasticity between farmland prices and farm rent (Lloyd, 1994). For this specific interest, VAR is re-estimated with this coefficient restricted to unity, which also tests whether the resulting coefficient spans the cointegrating space. The restriction implies that the coefficients of rent and land price in the cointegrating vector β_1 appear with opposite signs, and thus the null hypothesis is tested that

$$H_0 : \beta_{11} = -\beta_{12}$$

against the alternative,

$$H_1 : \beta_{11} \neq -\beta_{12}$$

As Johansen and Juselius (1990) demonstrate, it is possible to formulate any number of restrictions on the cointegrating vector as $\beta^* = \boldsymbol{H}\phi$, where (in the trend excluded case) $\boldsymbol{H}$ is a $(n+1 \times p)$ matrix of restrictions and ϕ is an $(p \times r)$ vector of parameters to be estimated from the data, where p reflects the nature of the restrictions[6]. Denoting $\hat{\lambda}_{Hi}$ as the ith largest eigenvalue from this restricted model we may compute a likelihood ratio test,

$$-2\ln(Q) = T\sum_{i=1}^{r} \ln\left\{\frac{(1-\hat{\lambda}_{Hi})}{(1-\hat{\lambda}_i)}\right\} \tag{6-16}$$

[6] In t he linear trends case, $\boldsymbol{H}$ has dimensions $(n \times p)$ and β has dimensions of $(n \times r)$ and the likelihood ratio statistic is distributed as *chi* -x^2 with $r\,(n-p)$ degrees of freedom.

which is distributed as a chi (x^2) variate with $r(n + 1 - p)$ degrees of freedom under the null. Here, we formulate the null as,

$$H = \begin{bmatrix} 1 & 0 \\ -1 & 0 \\ 0 & 1 \end{bmatrix} \quad \text{and} \quad \phi = \begin{bmatrix} \phi_1 \\ \phi_2 \end{bmatrix}$$

in the case of standard model, and the model with structural breaks as follows;

$$H = \begin{bmatrix} 1 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad \text{and} \quad \phi = \begin{bmatrix} \phi_1 \\ \phi_{21} \\ \phi_{22} \\ \phi_{23} \end{bmatrix}$$

which yields a cointegrating vector $\beta^{*\prime} = (-\phi_1\ \phi_2)$, and $\beta^{*\prime} = (-\phi_1\ \phi_{21}\ \phi_{22}\ \phi_{23})$ to be estimated from the data. Combining the cointegrating vector, a long-run relationship of the form ($\phi_1 \ln P - \phi_1 \ln R - \phi_2$) and ($\phi_1 \ln P - \phi_1 \ln R - \phi_{21} - \phi_{22} - \phi_{23}$) are yielded. Normalising on land prices gives:

($\ln P - \ln R - \phi_2/\phi_1$) and ($\ln P - \ln R - \phi_{21}/\phi_1 - \phi_{22}/\phi_1 - \phi_{23}/\phi_1$)

The $\beta_1^{*\prime}$ vector with the unit elasticity imposed is estimated as,

i) Hokkaido

[1.00 -1.00 -3.32 -3.04 -3.04] *chi*-$x^2(1) = 25.27$* [0.00]

ii) Tohoku

[1.00 -1.00 -3.86] (without dummy), *chi*-$x^2(1) = 0.03$ [0.86]

iii) Kanto

[1.00 -1.00 -4.55 -4.71 -4.38] *chi*-$x^2(1) = 9.19$* [0.00]

iv) Hokushin

[1.00 -1.00 -4.22 -4.35 -4.07] *chi*-$x^2(1) = 0.00$ [0.97]

v) Kinki

[1.00 −1.00 −4.41 −4.73 −4.57] $chi\text{-}x^2(1) = 8.24^*$ [0.00]

vi) Shikoku

[1.00 −1.00 − 4.02 −5.38 −4.45] $chi\text{-}x^2(1) = 2.82$ [0.09]

vii) Kyushu

[1.00 −1.00 −3.41] $chi\text{-}x^2(1) = 0.12$ [0.73]

The null of unit elasticity is not rejected at the 5% level for Tohoku, Hokushin, Shikoku and Kyushu as the critical value is 3.84. Therefore, long-run relationships with a unit elasticity are applied to only the following regions:

ii) Tohoku

$$\text{TOHPLOG} = \text{TOHRLOG} + 3.86$$

iv) Hokushin

$$\text{KYUPLOG} = \text{KYURLOG} + 4.22E_1 + 4.35E_2 + 4.07E_3$$

vii) Shikoku

$$\text{KYUPLOG} = \text{KYURLOG} + 4.02E_1 + 5.38E_2 + 4.45E_3$$

viii) Kyushu

$$\text{KYUPLOG} = \text{KYURLOG} + 3.41$$

These result supports the present value hypothesis of farmland price determination. We may derive the long-run real rate of discount of farmland through exponentitating the above equations. The rate of discount, r, is shown in Table 6-9. For Tohoku, the rate of discount is $r = 1 / 47.56 = 0.021$, i.e., 2.1 %. Similarly, the discount rate for Kyushu is $r = 1 / 30.23 = 0.033$, i.e., 3.3%. These figures seem plausible in the context of the land market, since real rates of discount are obtained by Burt (1986) for the US of 4 % and by Lloyd (1994) for the UK of 3.6 %. However, Hokushin and Shikoku have lower discount rates compared to these results.

Table 6-9 The rate of discount

	The rate of discount (%)			
		Period 1	Period 2	Period 3
Tohoku	2.1			
Hokushin		1.5	1.3	1.7
Shikoku		1.8	0.5	1.2
Kyushu	3.3			

Note: Period 1 is before 1967; Period 2 is between 1967 and 1980; and Period 3 is after 1980

Next, short-run dynamics are examined for Hokkaido, Tohoku, Kanto, Hokushin, Kinki, Shikoku and Kyushu, given the cointegration results with and without structural breaks. As the vector α shows the speed of adjustment in the error correction model, the values of $(\alpha_{12}\ \alpha_{21})'$ are found as coefficients on the error-correction (EC) term in the equations for $\Delta \ln P_t$ and $\Delta \ln R_t$ as seen in (6-14) and (6-15). Table 6-10 shows the coefficients for error terms in each equation. The unit elasticity model was used for Tohoku, Hokushin, Shikoku and Kyushu. The coefficient of the EC term for either $\Delta \ln P_t$ or $\Delta \ln R_t$ is expected if the market is efficient and has a function of adjustment towards the equilibrium state. The results show that Kanto, Hokushin, Kinki, Shikoku and Kyushu have expected signs, which imply that there is an adjustment to the long-run equilibrium relationship, although the speed of adjustment is remarkably slow (e.g., between 3% and 9% from the EC model of $\Delta \ln P_t$). Table 6-11 shows the speed of adjustment: the proportion of the adjustment from the disequilibrium after 5 years and 10 years. Particularly the EC model of $\Delta \ln P_t$ implies that the disequilibrium would be adjusted less than 50% even after 10 years, except in the case of Kanto. Thus, there is a strong impression that the speed of market adjustment is very slow although almost all regions show a cointegrating relationship. This could be the result of the inflexible rent level due to the rent control system.

Table 6-10 Coefficients on error correction term in ECM

	Equation		Speed of Adjustment	
	$\Delta \ln P_t$	$\Delta \ln R_t$	$\Delta \ln P_t$	$\Delta \ln R_t$
Hokkaido	0.05 (1.04)	0.05 (1.04)	-	-
Tohoku	0.12 (6.97)	0.12 (6.97)	-	-
Kanto	-0.09 (-3.67)	-0.09 (-3.67)	0.03 (0.81)	0.03 (0.81)
Hokushin	-0.05 (-1.64)	-0.05 (-1.64)	0.18 (3.61)	0.18 (3.61)
Kinki	-0.05 (-2.65)	-0.05 (-2.65)	0.08 (2.21)	0.08 (2.21)
Shikoku	-0.03 (-2.07)	-0.03 (-2.07)	0.07 (6.65)	0.07 (6.65)
Kyushu	-0.06 (-2.62)	-0.06 (-2.62)	0.13 (6.10)	0.13 (6.10)

Note: The figures in parentheses show the t-values.

Table 6-11 Speed of adjustment Unit: %

	$\Delta \ln P_t$			$\Delta \ln R_t$		
	Year 1	Year 5	Year 10	Year 1	Year 5	Year 10
Kanto	9	38	61	3	14	26
Hokushin	5	23	40	18	63	86
Kinki	5	23	40	8	34	57
Shikoku	3	14	26	7	30	52
Kyushu	6	27	46	13	50	75

6-7. Summary

This chapter is an application of time series analysis on Japanese data in order to test farmland market efficiency as the theoretical model suggests. It also considered the change of the farmland market structure, namely in 1967 and 1980 when the rent level and its determination were reformed.

Firstly, the ADF unit root test was applied to all regional data. The results indicate that all farmland prices and rent series are non-stationary, which are integrated of order 1 (i.e., $I(1)$), except for the farmland price series of Kanto which was stationary (i.e., $I(0)$), although it does not seem a stationary series from the graph (see Appendix 6-1). Therefore, the final results are determined using the tests with structural breaks. The Z&A and Perron 97 tests are unit root tests which consider a structural break in the time series. The results of the Z&A test show that all series are non-stationary, integrated of order 1 (i.e., $I(1)$), whilst the Perron 97 test suggests all farmland prices are non-stationary series, $I(1)$, and for rent data the presence of a structural break in 1980 is suggested, although some regions (i.e., Tohoku, Kanto, Tokai, Shikoku and Kyushu) show stationary series, $I(0)$. Summarising, all series are concluded as non-stationary, and for rent data, a structural break around 1980 is noted.

Considering the impact of change in rent determination as structural breaks (i.e., 1967 and 1980), Johansen's cointegration analysis with and without structural breaks is applied. The cointegration results without breaks show a long-run relationship between farmland prices and rents for Hokkaido, Tohoku, Kanto, Shikoku and

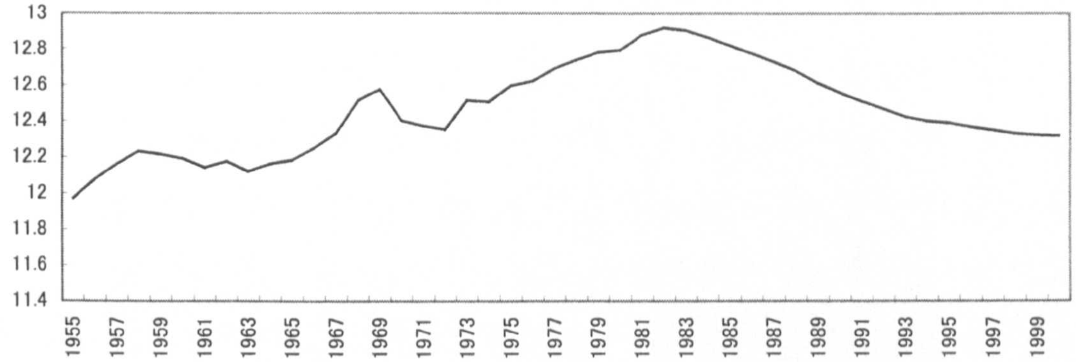
Kyushu, while the model with breaks supports the presence of a cointegration relationship for Kanto, Hokushin, Tokai, Kinki, Shikoku, and is inconclusive for Hokkaido and Tohoku. Only for Chugoku is there no evidence of a cointegration relationship. Particularly, using the log-likelihood ratios (LR) test for the choice between the two models, Hokkaido, Kanto, Kinki and Shikoku are appropriate for the model with structural breaks. Based on the theoretical model, unit elasticity was also tested. The LR test results support the notion of unit elasticity for Tohoku, Hokushin, Shikoku and Kyushu. These results suggest that the impact of policy reform on rent determination was reflected differently on farmland prices in different regions. The real rates of discount estimated seem plausible for Tohoku and Kyushu, whilst the period-specific real rates of discount for Hokushin and Shikoku were considered. Using short-run dynamics, an error correction model was also estimated. There is evidence for market disequilibrium adjustment except for Hokkaido and Tohoku, although the speed of adjustment is very slow. Thus, although a cointegration relationship was suggested between farmland prices and farm rents, except for Chugoku, there is very small market efficiency overall.

Mindful of these results, the next chapter examines the association between farmland abandonment and their farmland market with strong regulations.

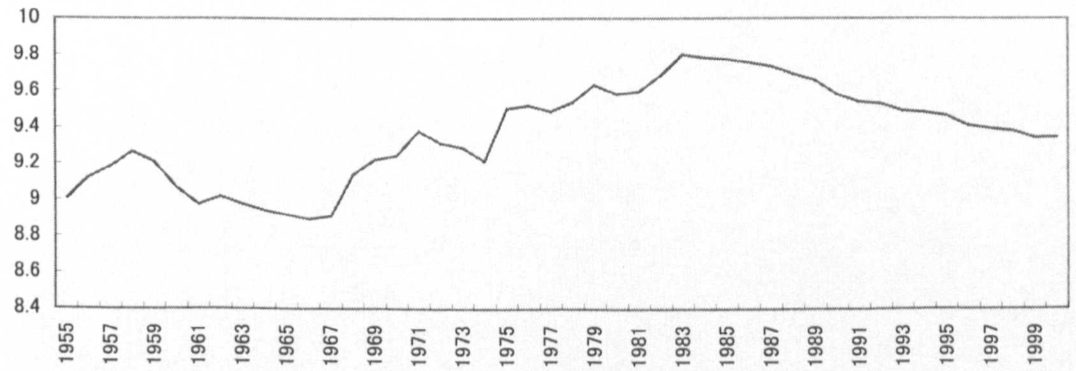
Appendix 6-1 Farmland prices and rents in the logarithm term

1) Hokkaido

Farmland Prices: HOKPLOG



Rents: HOKRLOG



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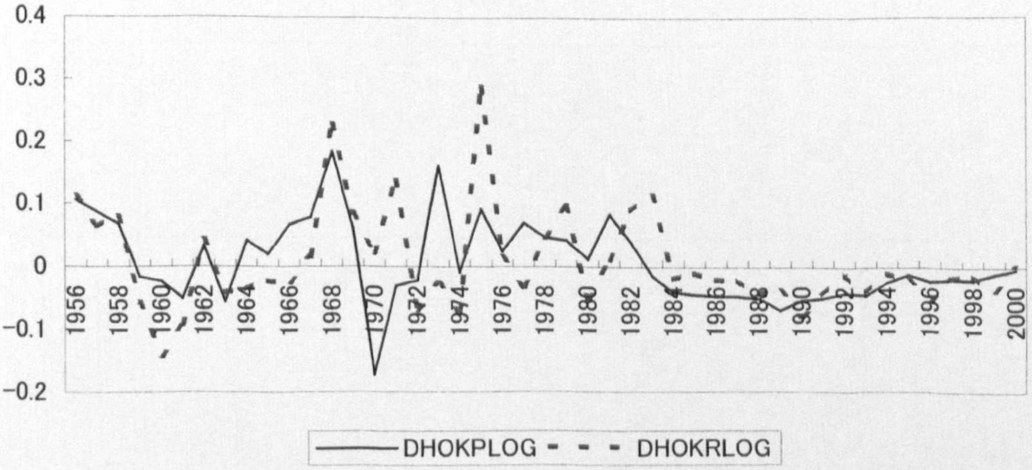
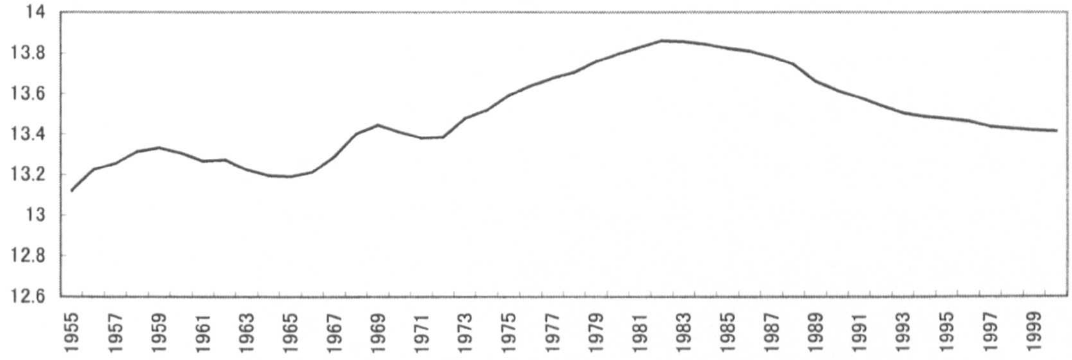
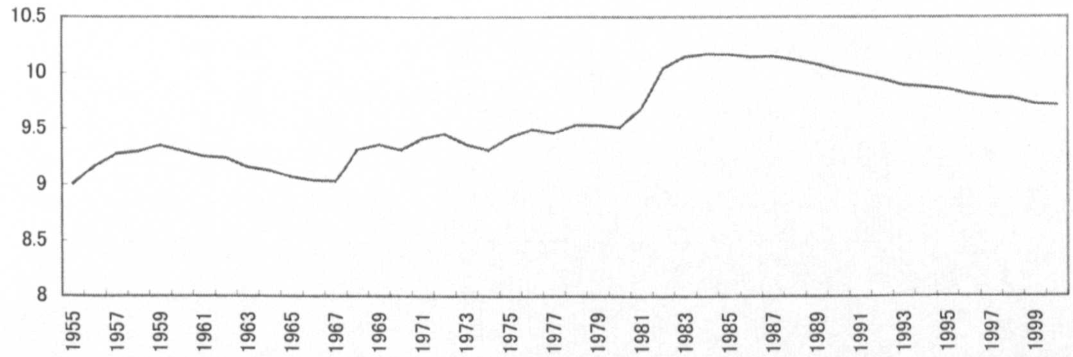


2) Tohoku

Farmland prices: TOHPLOG



Rents: TOHRLOG



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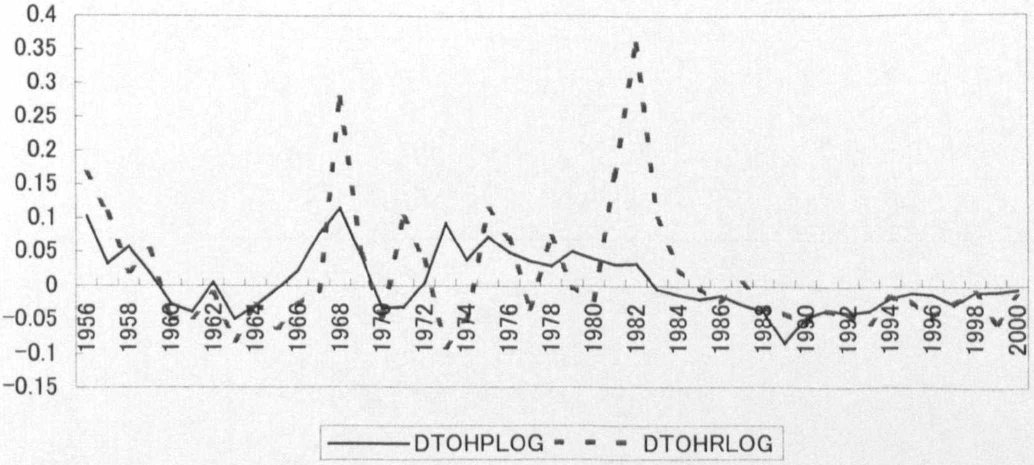
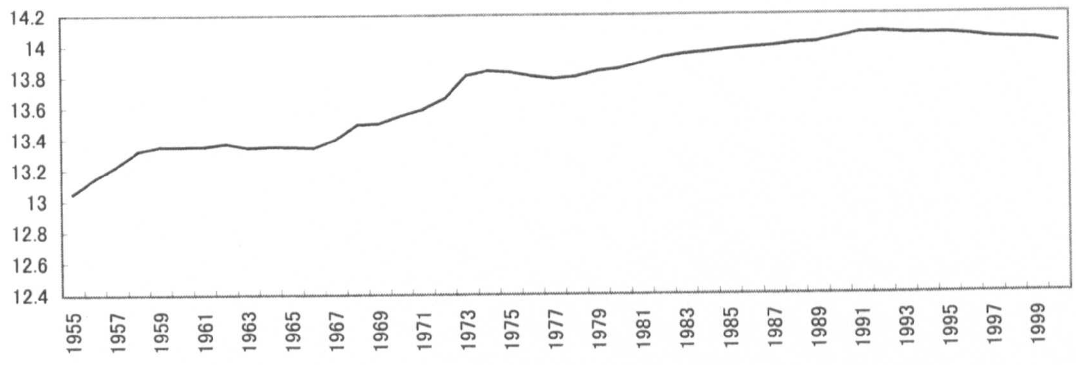
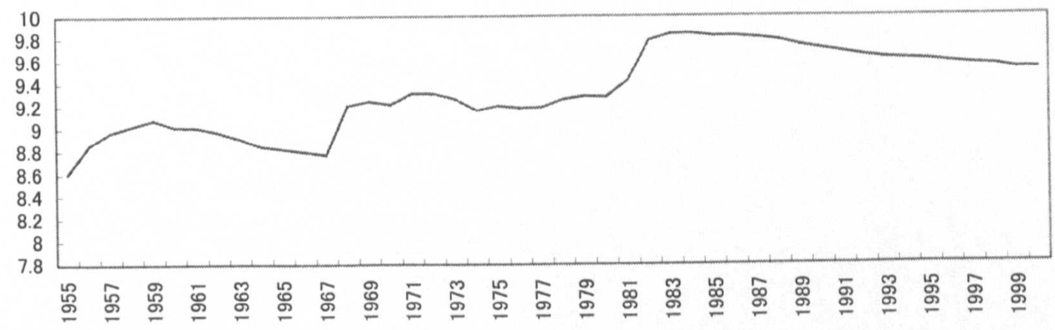


3) Kanto

Farmland Prices: KANPLOG



Rents: KANRLOG



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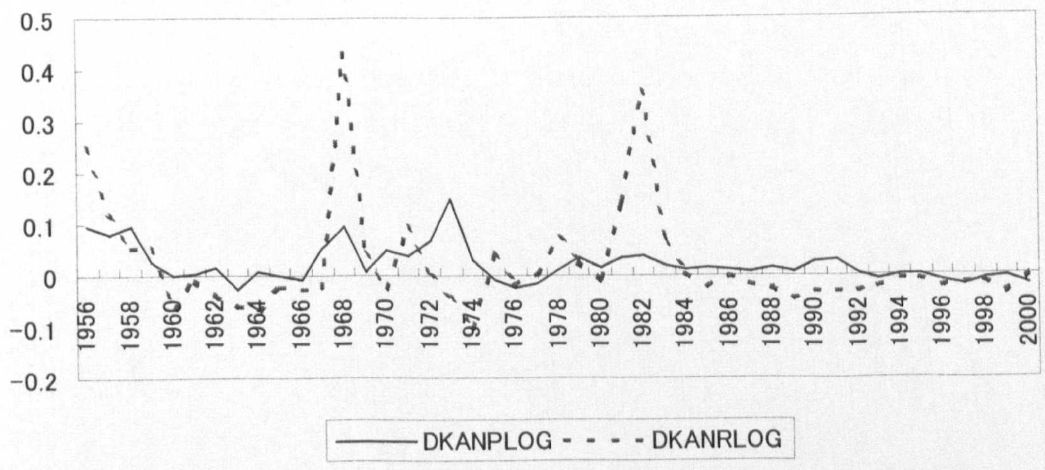
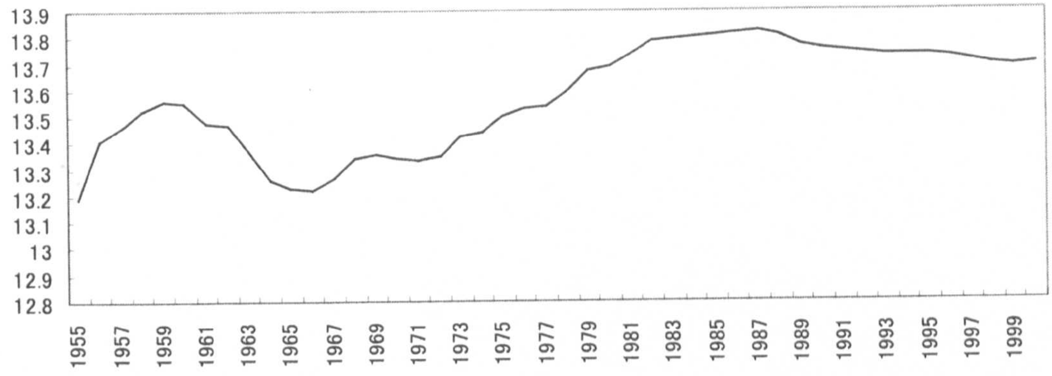
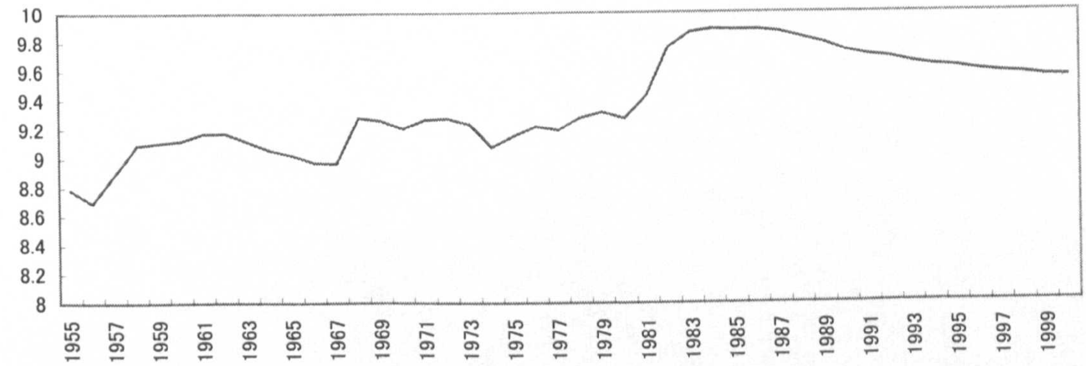


4) Hokushin

Farmland prices: HOSPLOG



Rents: HOSRLOG



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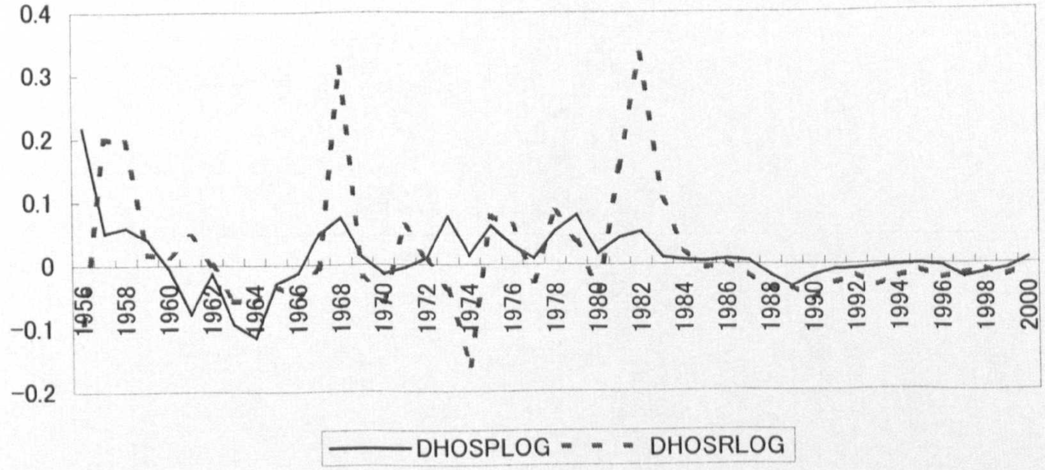
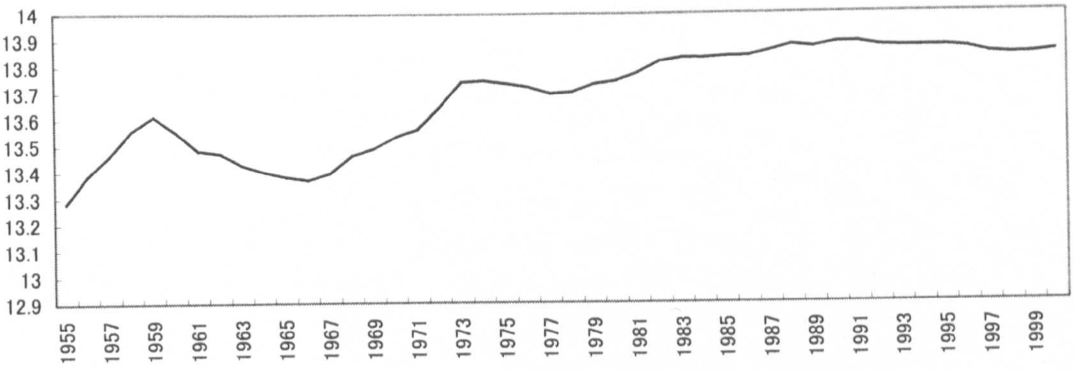
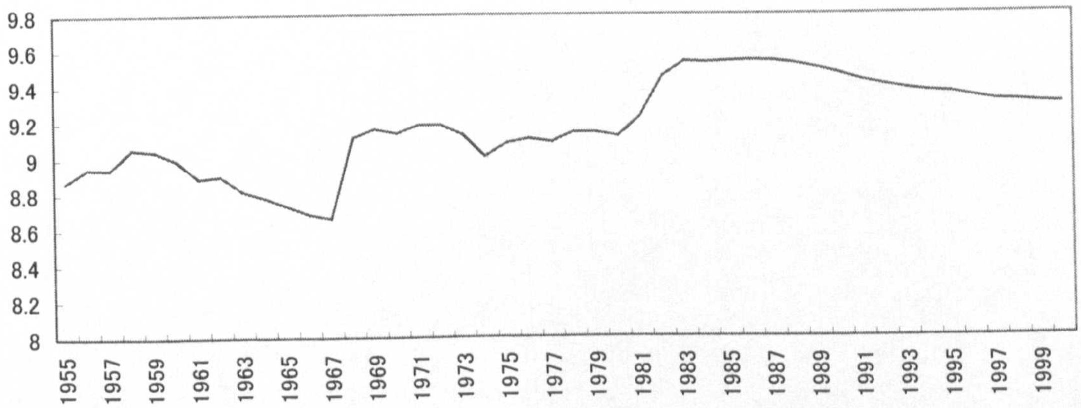


5) Tokai

Farmland prices: TOKPLOG



Rents: TOKRLOG



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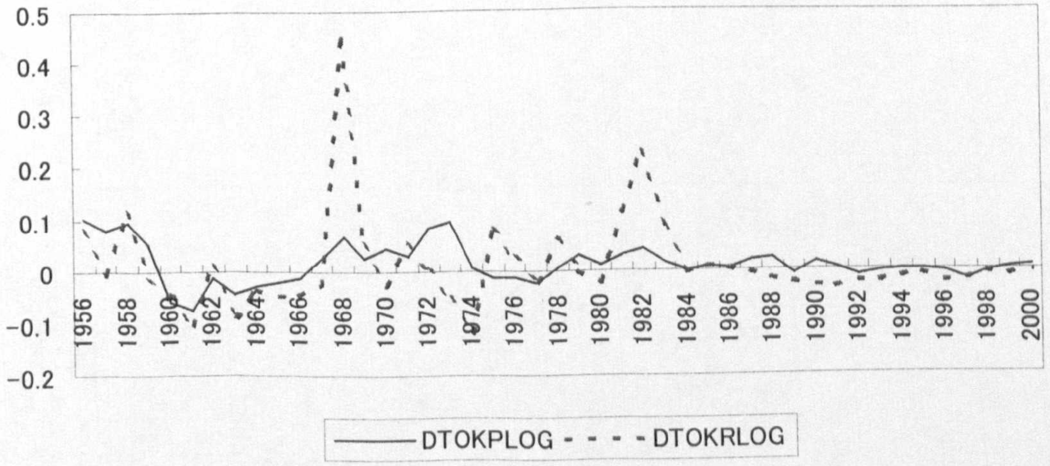
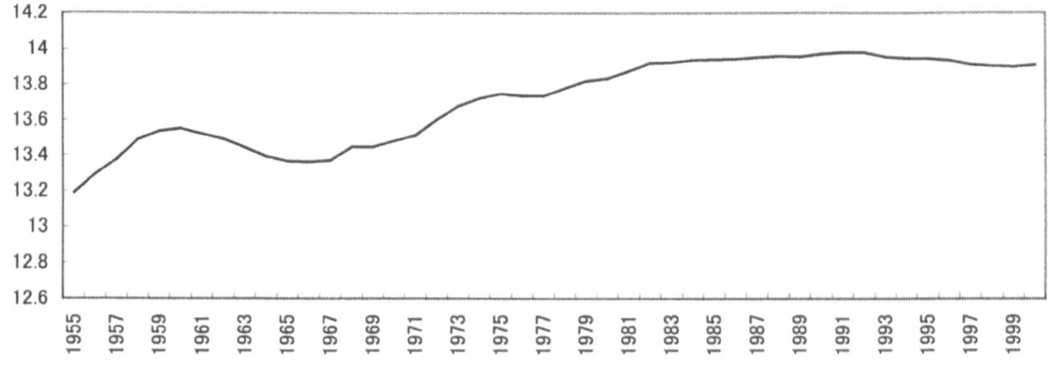
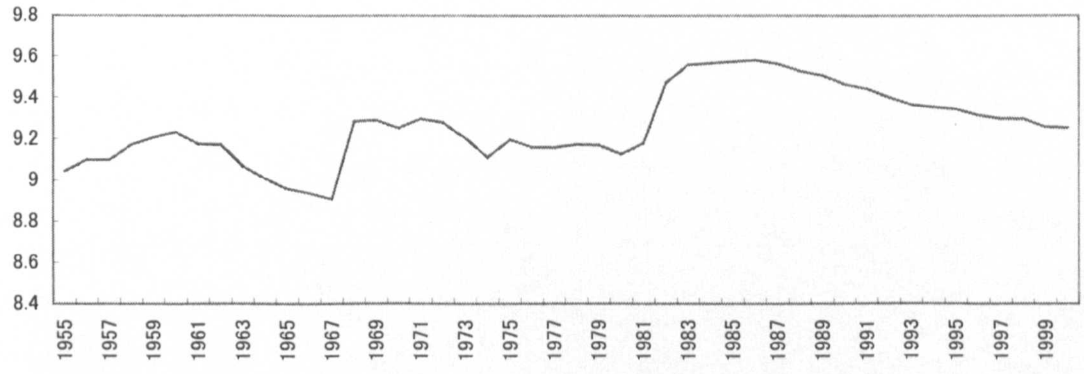


6) Kinki

Farmland prices: KINPLOG



Rents: KINRLOG



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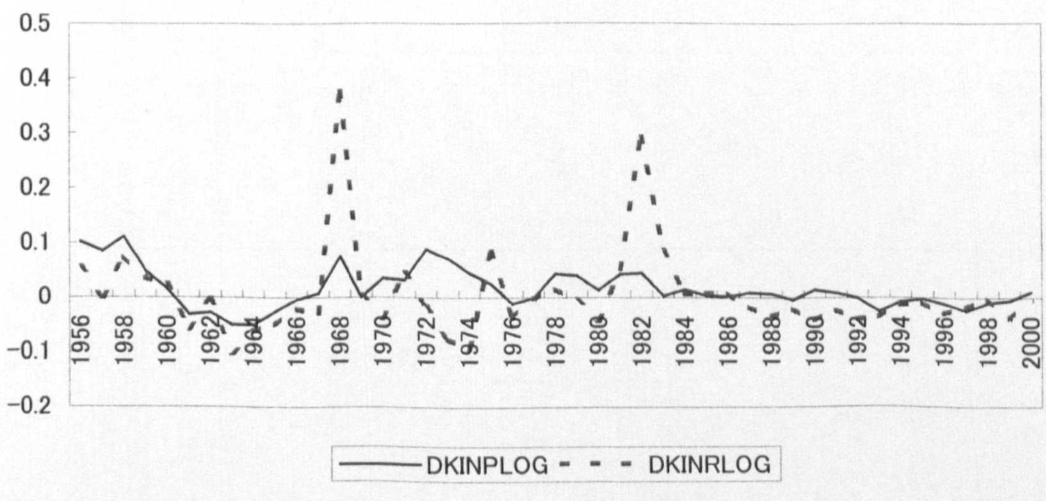
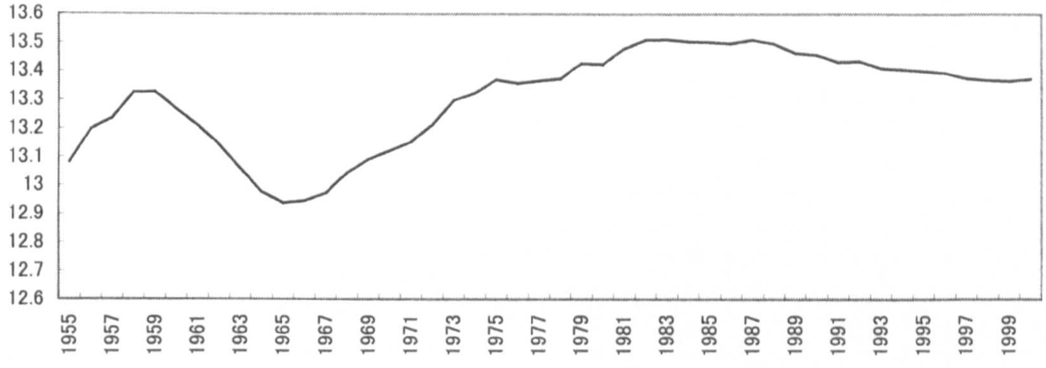
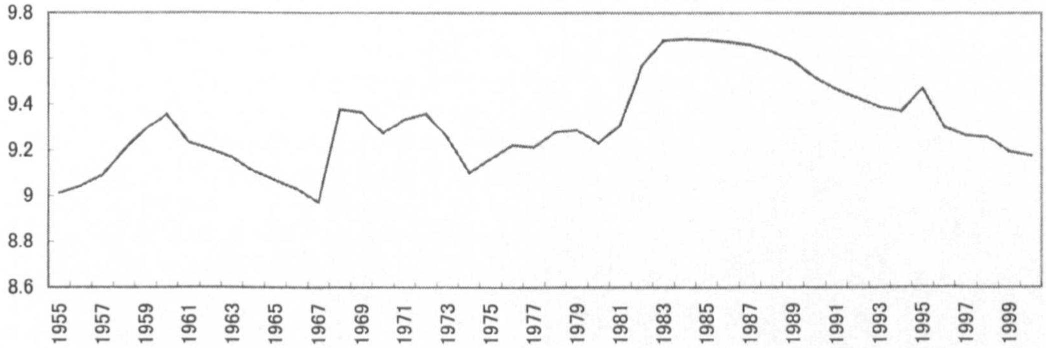


7) Chugoku

Farmland prices: CHUPLOG



Rents: CHURLOG



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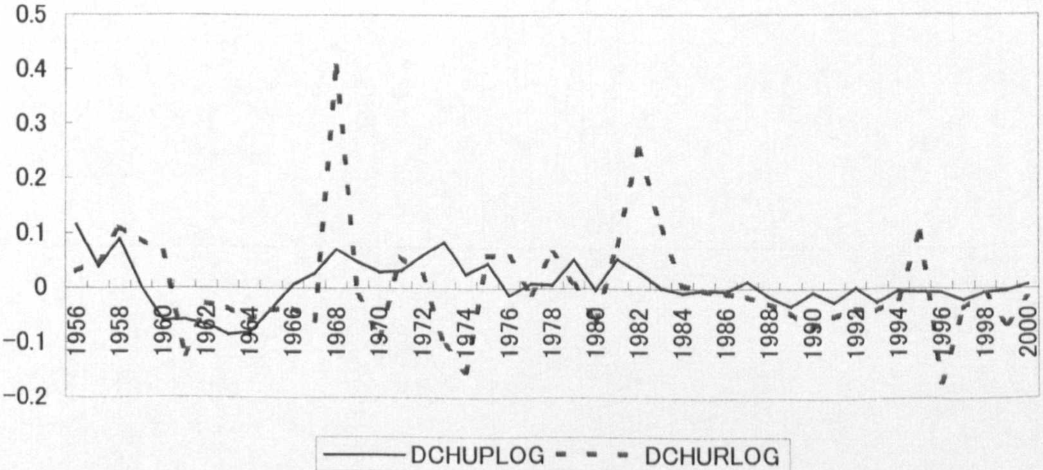
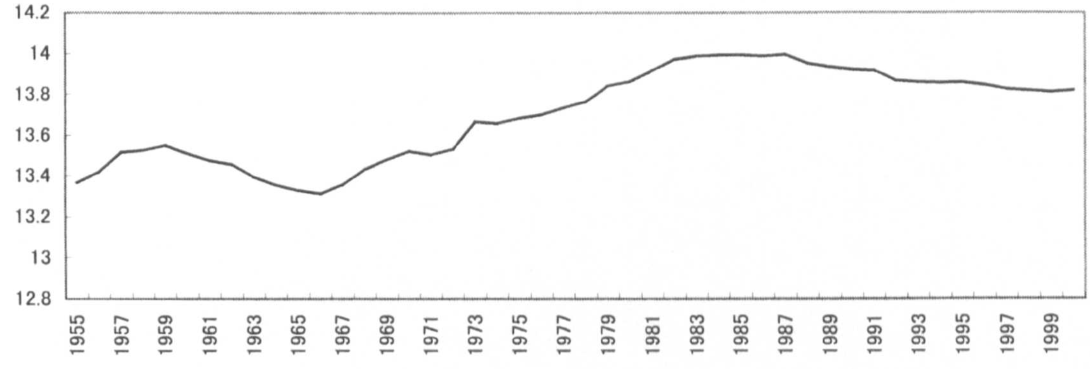
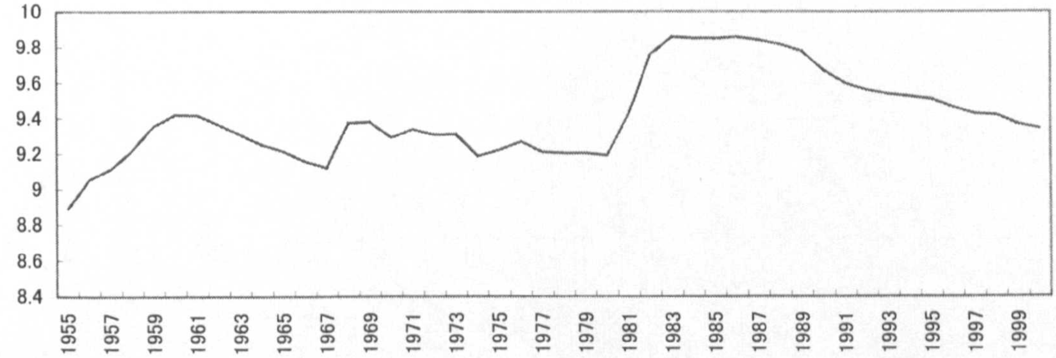


8) Shikoku

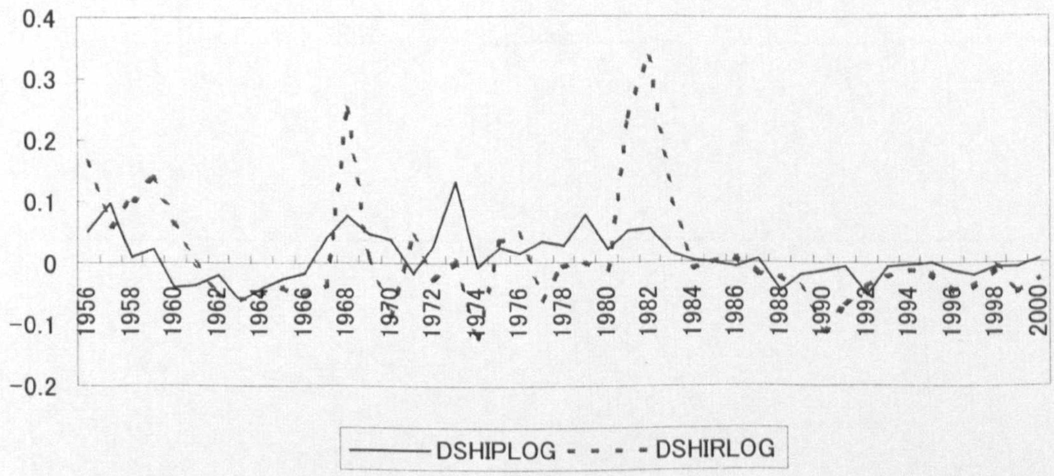
Farmland prices: SHIPLOG



Rents: SHIRLOG

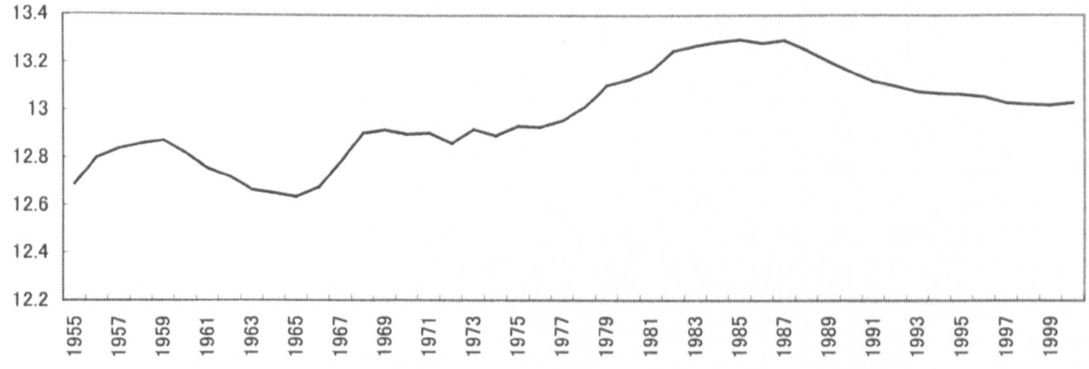


First differences:

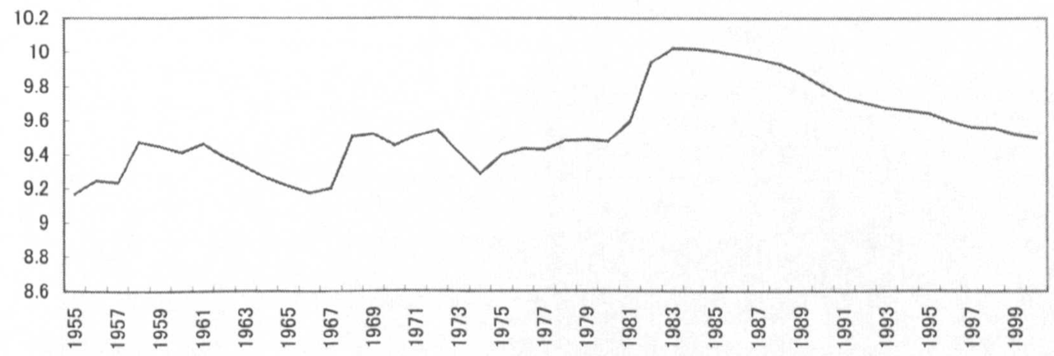


9) Kyushu

Farmland prices: KYUPLOG



Rents: KYURLOG



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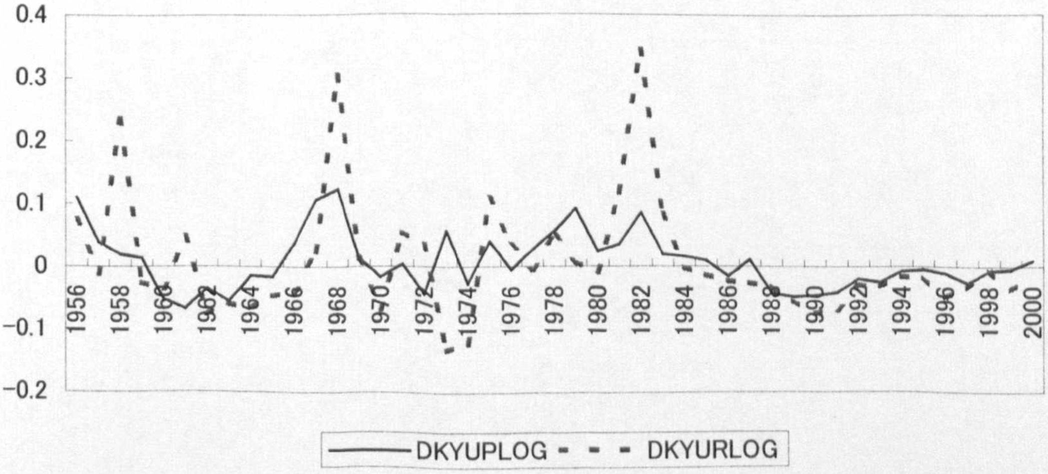
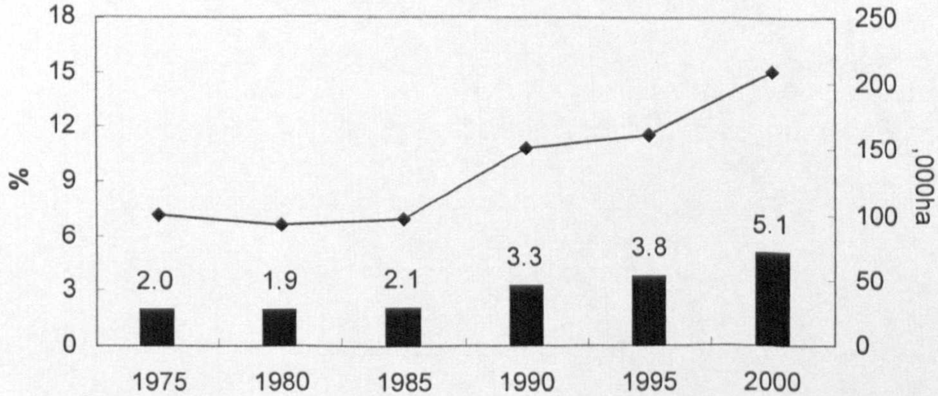


Chapter 7. Farmland Abandonment and The Farmland Market

7-1. Introduction

The area of farmland abandonment is notably increasing all over Japan, especially in the last decade (Figure 7-1). This is considered important particularly in terms of loss of multifunctionality of agriculture: landscape degradation, loss of biodiversity and water ecosystem, and in some cases is linked to natural disasters such as flooding and landslide. Farmland abandonment occurs when agricultural profitability reaches a minimum threshold. MacDonald, *et al.*, (2000) state that if alternative more profitable uses for land cannot be found, land is abandoned from productive use. However, one crucial question is raised; 'Why do those land owners not sell or lease?' In order to answer this question, it is of interest to focus on the mechanism of the farmland market and farmland transaction in this study.

Figure 7-1 The area and proportion of abandoned farmland in Japan (Prefecture level)



Source: MAFF, Japan, 'Agricultural Census'

Note: The proportion of farmland abandonment is the rate of abandoned lands over the total area of arable land (including abandoned farmlands).

In the previous chapters, the efficiency of the farmland market has been examined by applying time series analysis to farmland prices and rents data in Japan. The results imply that there is an evidence of a cointegration relationship between farmland prices and cash rents in all regions, although policy impacts were recognised in some regions and the speed of market adjustment towards the equilibrium state is notably slow. At least until 1980, the rent level was directly controlled by the government, and there was a strong demand of agricultural land for non-agricultural use in the economic growth period. Thus, it is considered that those factors would have influenced the attitude of farmers towards farmland transaction and even their land use.

Japanese agricultural policy has been characterised by strong agricultural protectionism through such measures as price support and rent and property right control. However, from the 1980s, the social situation surrounding Japanese agriculture has changed considerably with increasing international pressure to reduce protectionism. Responding to the decrease in price support, and the failure to shift agricultural structures to a more cost efficient basis, agricultural profitability has declined and marginal small-scale farms have struggled to maintain their businesses. Besides, the ageing of the agricultural population has been serious, and a lot of rural areas have faced a shortage of successors, which even threatens the livelihood of rural communities still highly reliant on the regional economy of agriculture.

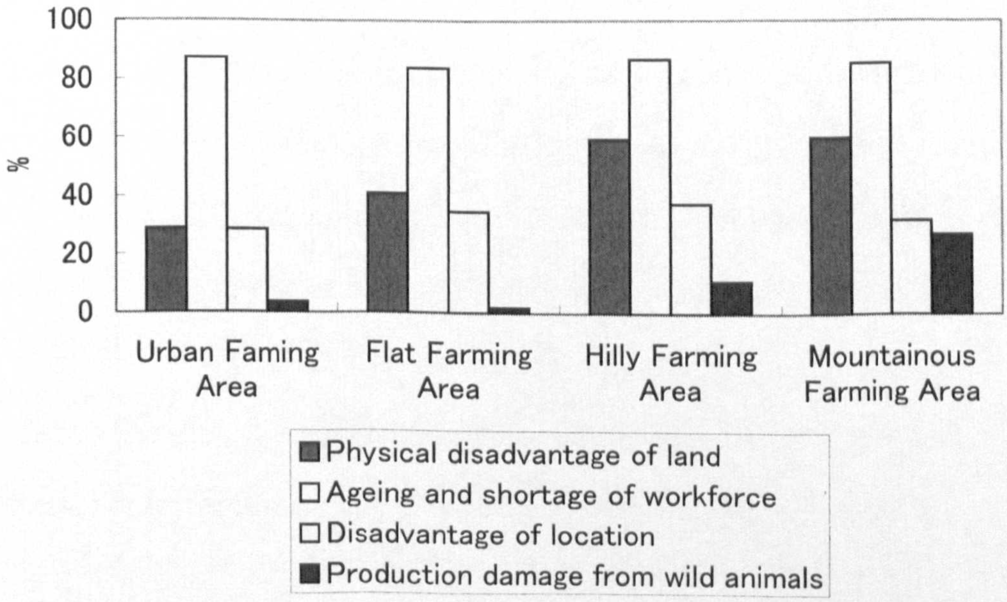
The purpose of this chapter is to analyse the recent increase of abandoned farmland in Japan, focusing on the mechanism of the farmland market and farmland transaction. Firstly, the state of farmland abandonment in Japan is detailed. Subsequently, farmland abandonment is explained theoretically, and a farmland abandonment model is formed. Then the model is tested using Japanese data.

7-2. Farmland Abandonment

7-2-1. Causes of farmland abandonment

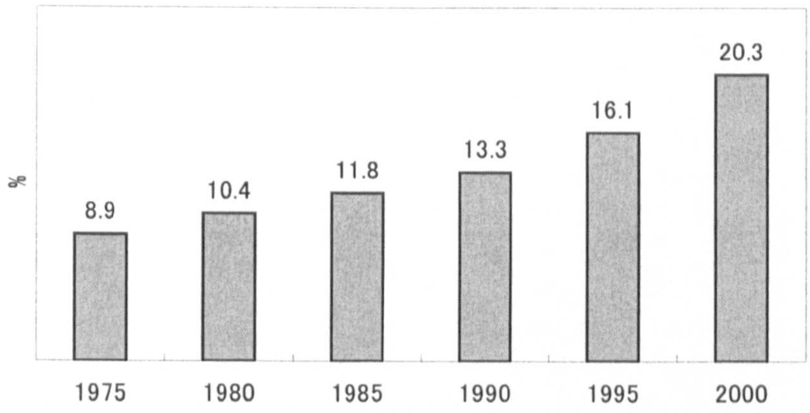
Figure 7-2 shows the result of a survey on main cases of the increase in farmland abandonment conducted by the National Chamber of Agriculture in Japan. Four main causes are pointed out; physical disadvantage of land, ageing and shortage of workforce, disadvantage of location and production damage from wild animals. Physical disadvantage of land is particularly serious in hilly and mountainous areas which have large areas of less-favoured farmland such as terraced paddy fields. Ageing and the shortage of workforce appear as the most serious cause of farmland abandonment in all areas. Physical and locational disadvantage of land likely indicate the low profitability of land (which should be also reflected in a low rent level). These days the production damage from wild animals in those areas has been also serious. Profitability loss and ageing may not be a direct cause for farmland abandonment, but a trigger for farmers to retire from agriculture. If the farmland market is efficient and transaction cost is low, they would be able to find purchasers or tenant farmers in the short period. However, as examined in Chapter 6, the Japanese farmland market requires a long time to adjust to the equilibrium state, which mean the land transactions are sluggish, leaving a large amount of misallocated land at each period. Farmers who want to retire but cannot sell or lease may keep farming as long as they can. However, once those farmers reach a certain age limit, they have no choice but to abandon those lands. Figure 7-3 shows the rapid increase in the rate of ageing in the agricultural population (over 70-year-olds), which illustrates that a lot of farmers have faced the need of retirement particularly in the last decade. Besides, farmers who are over 70 would not be encouraged to enlarge their farms through buying and renting land unless they have a successor in their family. Insufficient demand for land or restricted entry in the market could be another reason of farmland abandonment. Thus, in order to explain the recent increase of farmland abandonment in Japan, we have to consider two steps. It is assumed that: firstly, farmers face a minimal threshold in terms of business, and decide to retire from agriculture. Once they decide to retire, they start looking for purchasers or tenant farmers, and they abandon their lands when they fail to find any.

Figure 7-2 The cause of increase in farmland abandonment



Source: National Chamber of Agriculture 'Survey on the actual state of idle farmland and future utilisation', 1998
Note: Multiple answers.

Figure 7-3 The rate of agricultural population over 70 years of age



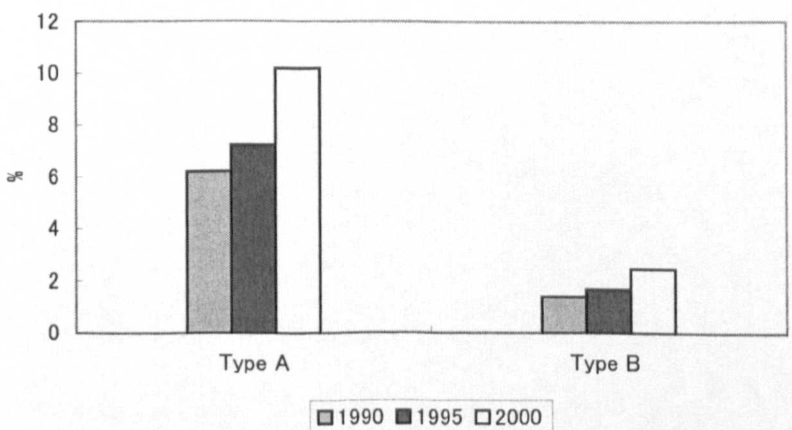
Source: Agricultural Censes, Japan

7-2-2. Farm scale and farmland abandonment

Nowadays, farm structures can be distinguished roughly into two types: high cost / low productivity and low cost / high profitability. These are denoted as type A and type B farms here. In Japan, farms of less than 1.0 ha can be categorised as type A, since the production system tends to be inefficient. On the other hand, farms of more than 1.0 ha are categorised as type B. Figure 7-4 shows that the rate of farmland abandonment of type A farms is much higher than that of type B farms. In addition, the rate of farmland abandonment is high in hilly and mountainous areas, and it has also increased dramatically in urban farming areas recently (Figure 7-5), which is also supported by the fact that both areas have a high rate of the type A farms (Figure 7-6).

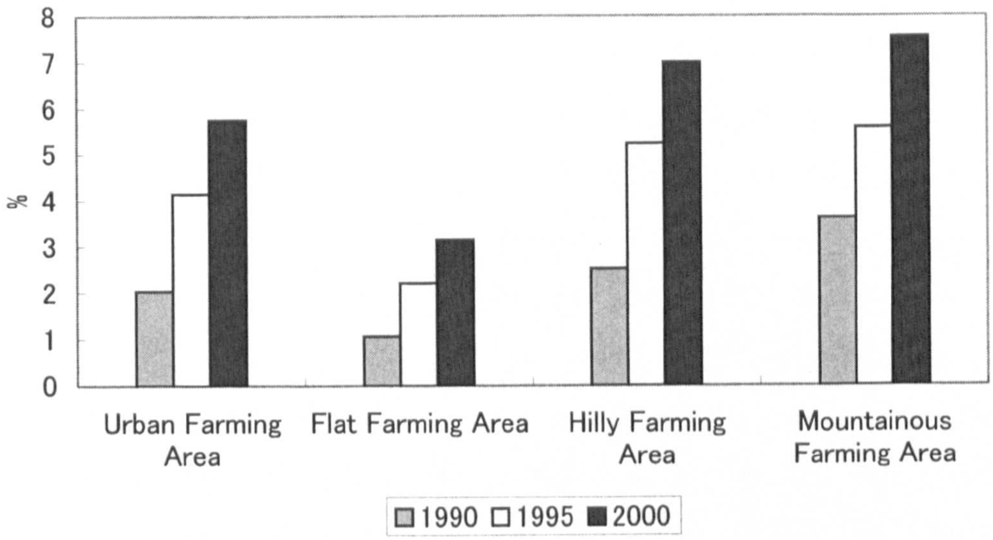
Of course, in areas where ageing of the agricultural population is serious, there is less motivation for farmers to change to an alternative land use. In explaining the economic conditions of these farms abandoning lands, two sets of production cost curves for type A and B farms are assumed. The type A farm has higher average production cost curves than the type B farm. If the producer price of agricultural products drops to the break-even point, type A farmers cannot gain a profit, although they can recover some of their fixed costs. In this position, farmers may not 'retire' until they find a buyer or tenant for their lands, as in general they do not want to abandon their lands. However, when the producer price reaches the point where they are unable to cover their variable costs (the so-called 'shutdown point'), the type A farms abandon their lands, unless an alternative land use which has a lower production cost is available or the land is sold or let to the type B farm.

Figure 7-4 The rate of farmland abandonment over total arable land by farm scale (Commercial farms)



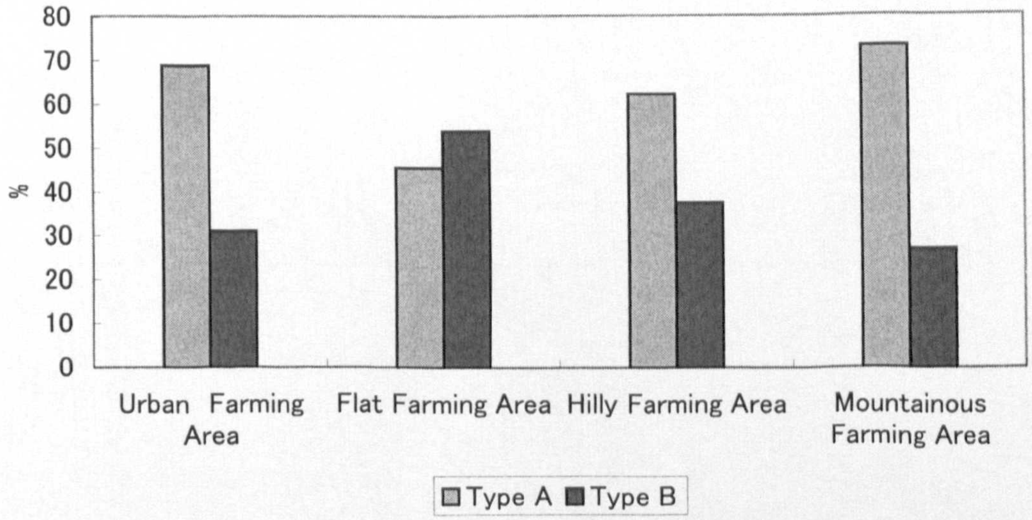
Source: Agricultural Census, Japan
Note: Excluding Hokkaido

Figure 7-5 The rate of farmland abandonment over total arable land by farming area



Source: Agricultural Census, Japan

Figure 7-6 The distribution of farm scale over the total number of farms by farming area (2000)



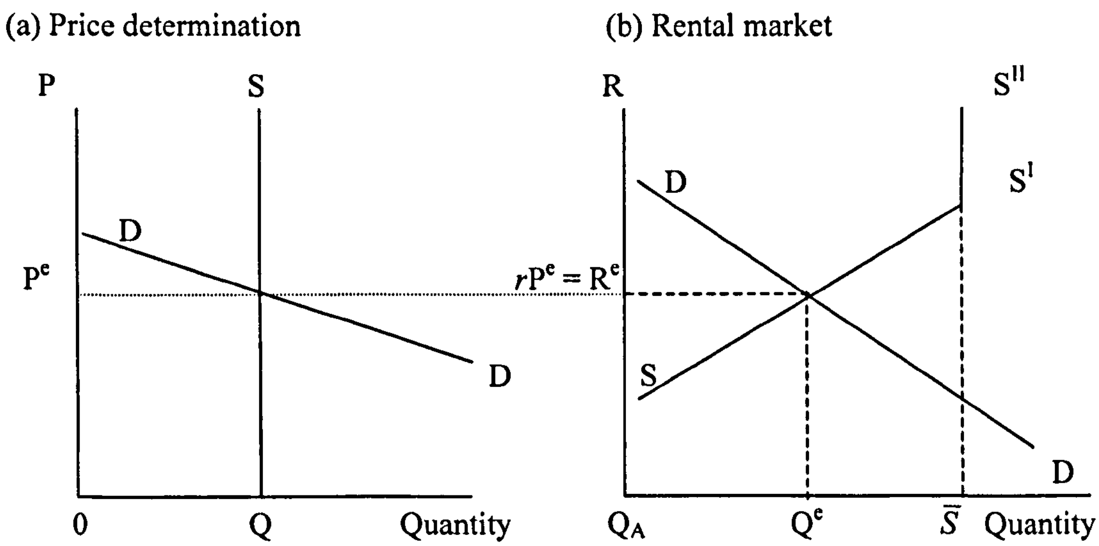
Source: Agricultural Census, Japan

Note: Data includes only commercial farms, and not hobby farms.

7-3. Theoretical Application

Farmland abandonment is assumed to be the result of an inefficient farmland transaction process and rapid ageing, which is particularly serious in hilly and mountainous areas where there are a lot of high cost / low profitability small-scale farms. In this section, we discuss the farmland market and transaction within a theoretical framework. As reviewed in Chapter 4, it is essential to clarify the distinction between the flow concept and the stock concept in order to analyse the farmland market. As seen in (a) in Figure 7-7, farmland prices are determined in the stock market by a supply curve, which is the accumulated stock of land, and the demand curve based on the demand from all farmers who hold land. The intersection of a fixed quantity of land QS and demand curve DD represents the equilibrium market price (P^e). If we follow the present valuation concept – assuming that the residual cash rents are consistent in each period, and the present value of land P equals the discounted residual return by interest rate, r (i.e., $P \equiv R \ / \ r$) – the equilibrium rent price R^e would equal rP^e. Figure 7-7 (b) shows the process of rental contract when a large number of participants are in the rental market (Currie, 1981). The demand and supply curves are represented by DD and $SS^{I}S^{II}$, and the equilibrium level of market rent, R^e, is the intersection of the demand and supply curves. Currie (1981) specifies the number of farms under the tenant contract is Q^e; the number of farms under the owner-occupancy (i.e., the owner cultivator) is ($\overline{S}$ – Q^e). As Lloyd (1993) notes 'the supply and demand of transactions' during a given period will depend on the extent of the misallocation of land amongst owners in the market. The equilibrium amount of land under the tenancy contract is determined by the intersection of demand and supply curves. However, the actual amount of land reached in transaction agreement is normally less than the equilibrium amount of land, Q^e. This is often explained by the 'asset market friction' (Lence and Miller, 1999, p259) due to the land-specific characteristics such as high transaction cost and the mismatch in terms of the location preference and, in the Japanese case, the strict regulation applied on farmland transaction[1].

Figure 7-7 Farmland price determination and rental market



Source: Currie (1981)

Now, we consider the two types of farms, type A and type B farms, which were defined in 7-2-2. The type A farm (i.e., small-scale and inefficient) is often physically less favoured, especially in hilly and mountainous areas, for example, being terraced paddy fields or located in remote areas. As land use in those areas is not so different from that in flat farming areas (i.e., paddy and vegetable fields, see Table 2-4, p22), these farms tend to be highly labour intensive compared to those in

[1] As explained in Chapter 3, there is a strict regulation for rental contract in Japan: i) farmers can rent land only in the same municipality where they live, and ii) there are limits to the area they can hold as tenanted land. Although these are different for each prefecture, generally the size is from 0.5 to 1.5 ha.

more favoured agricultural areas. We consider only the case of arable farms since extensive livestock farming (e.g., grassland and grazing areas) are still not common in Japan. The supply and demand curves in the rental market of type B farms (Figure 7-8) are assumed to start at a higher level than those of type A farms, as the profitability is generally more favourable due to the condition of lands. Similar to the single market case, the equilibrium rent level for type A and B farms are shown as R_A^e and R_B^e. Therefore, for the type A farm, $(\bar{S}_A - Q_A^e)$ will be farmed by their owners, and the rest being tenanted farms. Similarly, for the type B farm, $(\bar{S}_B - Q_B^e)$ will be owner-cultivated land, and the rest will be under tenant contract. However, the amount of actual tenanted land could have been smaller than the equilibrium level. At least until 1980, the rent was strictly controlled, and the rent level for almost all regions rose considerably after 1980. This suggests that prior to 1980, the rent level was under the equilibrium level. In this case, the actual amount of trade for letting is smaller than Q_A^e and Q_B^e. Seen in Figure 7-9, the amount of land transaction for letting is very small until around 1980. Therefore, we can state that one possibility of policy failure for encouraging smooth transaction of land was due to the rent control.

After 1980, rent control was removed and the market system has become less regulated. However, farmland abandonment has become more serious in Japan, although the amount of land transaction (especially in the rental market) has steadily increased (Figure 7-9). The cause of farmland abandonment is discussed in Japan in terms of an ageing farm population and a lack of successors have leading to an oversupply in the farmland market (Kashiwagi, 1994; Odagiri, 1994), and a low demand (Tanimoto, 1994) due to physical disadvantages for farming and the deterioration in agricultural profitability. Kashiwagi (2002) also notes a case study in a rural area that one lot of abandoned farmland leads to surrounding farmlands (even relatively favoured farmland) being abandoned due to negative effects such as outbreak of disease and pests, or damage to the irrigation or drainage system.

We target only type A farms here, and consider the case that supply of land increases from deterioration of profit due to less government support and ageing. The supply curve shifts from $S_A\, S_A^{I}\, S_A^{II}$ to $S'_A\, S_A^{I'}\, S_A^{II}$, and the amount of land under the tenant contract decreases by $(Q_A^e - Q_A^e{*})$. Younger farmers can remain as owner cultivators, but farmers who are over 70 years of age with no successors may soon face the decisive moment when there is no choice but to abandon those lands.

Figure 7-8 Simultaneous equilibrium in markets for two types of farms

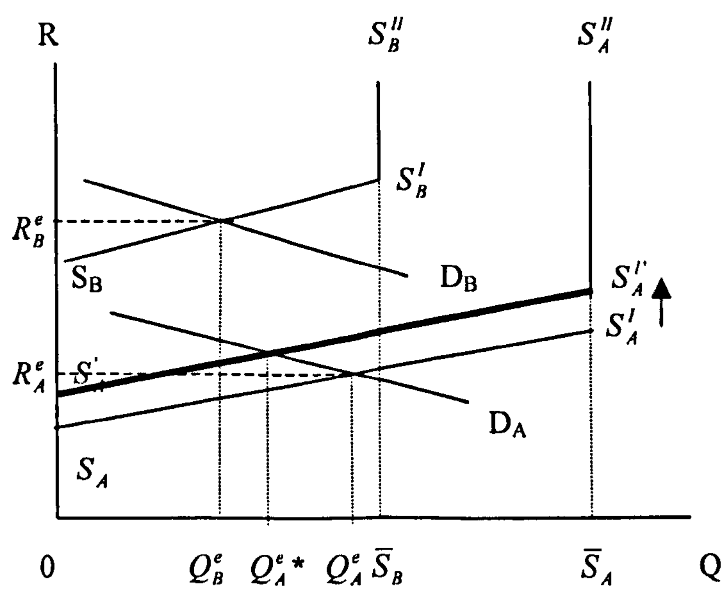
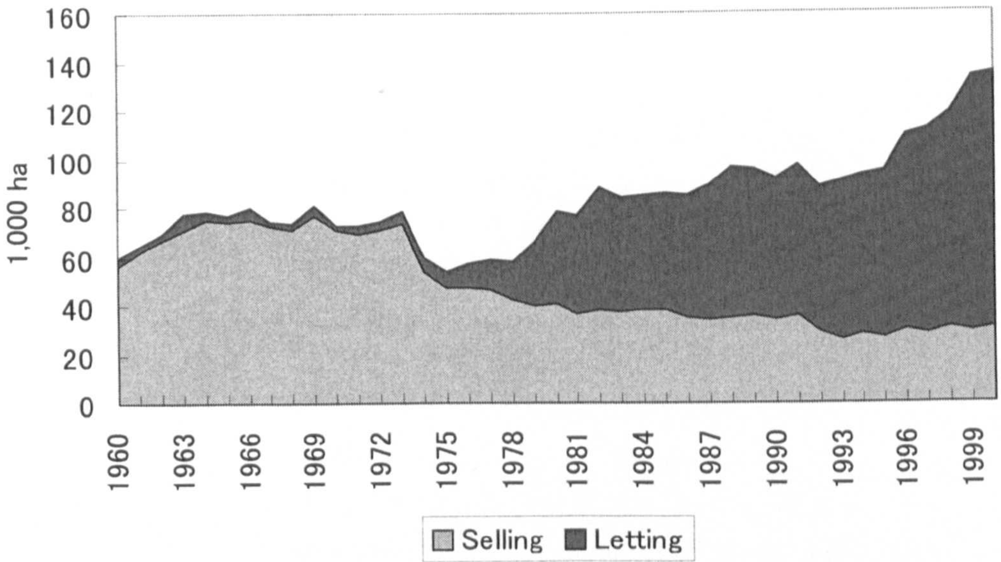


Figure 7-9 The area of farmland transactions for agriculture



Data: MAFF, Japan 'Farmland transformation and conversion'

7-4. A Model for Farmland Abandonment

7-4-1. Theoretical model

(a) Farmland price determination

Firstly, we start from the so-called Present Valuation Model (PVM) which has been reviewed in previous chapters (i.e., Chapter 4 for the theoretical background and Chapter 5 for the empirical analysis). This model is as follows; the value of the land is the capitalised value of the current and future stream of earnings from owning the land:

$$P_t = \alpha \sum_{j=0}^{\infty} \alpha^j E_t \left[R_{t+j} \right] \tag{7-1}$$

where P_t is equilibrium farmland price at the beginning of time period t; R_t is the rent paid in period t, α is a constant discount factor which is equal to $1 / (1+r)$ when r is the constant real discount rate, and E_t is the conditional expectations operator based on information available up to time t. Equation (7-1) implies a long-run relationship between the real price of land and the real return to land. If the non-inflationary world and constant net cash rent of R per period are assumed (Robinson *et al.*, 1985), equation (7-1) is simplified to the familiar capitalisation formula:

$$P = R / r \tag{7-2}$$

As discussed and tested applying in Chapter 6, the above model is accepted only when the long-term equilibrium between farmland prices and cash rents exist, which means the farmland market is efficient. This situation is not realistic because farmland prices could be influenced by the financial inflation, and asset markets often contain friction due to high transaction costs or government regulations. Let R_0 be net returns to land at the current period, assuming that R_0 increases at the rate of g

per period (i.e., the annual growth rate of the current return), and farmland prices become (Harris, 1979):

$$P_0 = \frac{(1+g)R_0}{(1+r)} + \frac{(1+g)^2 R_0}{(1+r)^2} + \cdots + \frac{(1+g)^n R_0}{(1+r)^n} \tag{7-3}$$

If we consider land to be an asset with infinite life (i.e., e $\rightarrow \infty$) and assume $g < r$, (7-3) can induce the following form:

$$P_0 = \frac{(1+g)R_0}{(r-g)}$$

If the growth rate is greater than zero, the equilibrium land price will increase each year even if the growth rate and discount rate remain unchanged from year to year (Weersink *et al.*, 1999).

(b) Farmland transaction in the flow market

Once farmland price is determined, the quantity of land desired is determined by the flow market which was explained in the previous section (Robinson *et al.*, 1985). The quantity of land desired by the *i*th individual in the *l*th marketing area at the current period 0, is assumed to depend on marginal net rents $R_{0,l,i}$ which the *i*th individual expects to receive at the discount rate r_0. As the return of land diminish, more land is desired. Therefore the downward-sloping function becomes:

$$R_{0,l,i} = \alpha_{0,l,i}{}^{0} - \alpha_0{}^{1} Q_{0,l,i}{}^{d} \tag{7-4}$$

where coefficient $\alpha_{0,l,i}{}^{0}$ is unique to the *i*th individual in the *l*th marketing area at the current period, 0. If $g(k)$ shows the geometric mean of realised (or expected) increase in cash rent in period *k*, in the *i*th period, equation (7-4) is multiplied by $\sum_{k=1}^{t}[1+g(k)]$, and in the *t*th period, becomes;

$$R_{t,l,i} = \alpha_{0,l,i}{}^{0}\prod_{k=1}^{t}[1+g(k)] - \alpha_{0}^{1}\prod_{k1}^{t}[1+g(k)]Q_{t,l,i}{}^{d} \tag{7-5}$$

Assume that the ith individual discovers land in the lth marketing are being offered for sale at a price of $P_{t,l}$, using relationship (7-2) the rent associated with the maximum offered price of $P_{t,l}$ is $R_{t,l,i} = r_t P_{t,l}$. Therefore, the quantity of land the ith individual demands in area l in the tth period is described as;

$$Q_{t,l,i}{}^{d} = \frac{\alpha_{0,l,i}{}^{0}}{\alpha_{0}{}^{1}} - \frac{rP_{t,l}}{\alpha_{0}{}^{1}\prod_{k=1}^{t}[1+g(k)]} \tag{7-6}$$

If $R^{e}{}_{t,l,i}$ are rents currently earned on the $Q_{t,l,i}$th unit of land, the equilibrium quantity of land which is under the tenancy contract can be obtained as follow;

$$Q^{e}{}_{t,l,i} = \frac{\alpha_{0,l,i}{}^{0}}{\alpha_{0}{}^{1}} - \frac{R^{e}{}_{t,l,i}}{\alpha_{0}{}^{1}\prod_{k=1}^{t}[1+g(k)]} \equiv Q^{s}{}_{t,l,i} \tag{7-7}$$

As shown above, this could be equivalent to the supply of land. Empirically, as Robinson *et al.* (1985) suggest, land transactions happen sluggishly because of high transaction cost and the equilibrium amount of land does not necessarily match the equilibrium rent level. This is difficult to observe empirically because those misallocated lands remain in the market being farmed under owner-occupancy until those are leased or sold to other farmers. Farmland abandonment is a special case in that land misallocation is visibly observed; the owners of those lands are keen to trade, but they abandon because either they could not reach agreement or could not find any possible tenants in the marketing area. Therefore, the actual supply function can be extended as:

$$Q^{S^*}{}_{t,l,i} \equiv \frac{\alpha_{0,l,i}{}^{0}}{\alpha_0{}^{1}} - \frac{R^{e}{}_{t,l,i}}{\alpha_0{}^{1}\sum_{k=1}^{t}[1+g(k)]} + Q^{FA}{}_{t,l,i} = Q^{d}{}_{t,l,i} + Q^{FA}{}_{t,l,i} \qquad (7\text{-}8)$$

Therefore, the farmland abandonment model is developed from (7-8):

$$Q^{FA}{}_{t,l,i} \equiv -\frac{\alpha_{0,l,i}{}^{0}}{\alpha_0{}^{1}} + \frac{R^{e}{}_{t,l,i}}{\alpha_0{}^{1}\sum_{k=1}^{t}[1+g(k)]} + Q^{s^*}{}_{t,l,i} \qquad (7\text{-}9)$$

Thus, the amount of the farmland abandonment is considered as the function of the net return and the 'actual supply' of land.

7-4-2. Using panel data

For applying the model (7-9), a panel data set, which is combination of t annual observation and i individuals, is used. The basic regression model is considered as;

$$y_{it} = \alpha_i + \boldsymbol{\beta}'\mathbf{x}_{it} + \varepsilon_{it} \qquad (7\text{-}10)$$

where i denotes 'individuals' (e.g., household, firm, countries, etc.), $i = 1, ..., N$, in each time period, $t = 1, ..., T$. There are K regressors in x_{it}, not including the constant term. α_i shows individual effects, which is taken to be constant over time t and specific to the individual cross-sectional unit i. There are two basic frameworks to generalise and estimate unobserved effects on a panel data model; the fixed effects (FE) model and the random effects (RE) model. These models are well explained in for example Johnston and DiNardo (1997) and Greene (2000). The FE model takes α_i, which are correlated with regressors, to be a group-specific constant term in the regression model. The term of 'fixed' is used here to indicate that the term does not vary over time although the intercept may differ across individuals, not that it is nonstochastic (Greene, 2000; Gujarati, 2003). Conversely, the random effects model specifies a single constant term, α, which is not correlated with the regressors.

7-4-2-1. Fixed effects (FE)

Let $\mathbf{y}_i$ and $\mathbf{X}_i$ be the T observations for the ith unit, and let ε_i be an associated $T\times 1$ vector of disturbance, then (7-10) may be rewritten as;

$$\mathbf{y}_{it} = \mathbf{i}\alpha_i + \mathbf{X}_{it}\beta + \varepsilon_i \tag{7-11}$$

Each α_i is treated as an unknown parameter to be estimated. (7-11) is rewritten as follow;

$$\begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{bmatrix} = \begin{bmatrix} i & 0 & \cdots & 0 \\ 0 & i & \cdots & 0 \\ & & \vdots & \\ 0 & 0 & \cdots & i \end{bmatrix} \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \vdots \\ \alpha_n \end{bmatrix} + \begin{bmatrix} X_1 \\ X_2 \\ \vdots \\ X_n \end{bmatrix} \beta + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \vdots \\ \varepsilon_n \end{bmatrix}$$

or

$$y = [d_1 \quad d_2 \quad \cdots \quad d_n \quad X\begin{bmatrix} \alpha \\ \beta \end{bmatrix} + \varepsilon \tag{7-12}$$

where $\mathbf{d}_i$ is a dummy variable indicating the ith unit. Letting the $nT\times n$ matrix $\mathbf{D}$ = $[\mathbf{d}_1\ \mathbf{d}_2 \ldots \mathbf{d}_n]$, then, assembling all nT rows give;

$$y = \mathbf{D}\alpha + \mathbf{X}\beta + \varepsilon \tag{7-13}$$

This is usually referred to as the least squares dummy variables (LSDV) model. This is a classic regression model including variables as group-specific effects. The least squares estimator of β is written as;

$$\mathbf{b} = [\mathbf{X}'\mathbf{M}_D\mathbf{X}]^{-1}[\mathbf{X}'\mathbf{M}_D\mathbf{Y}] \tag{7-14}$$

where

$$\mathbf{M}_D = \mathbf{I} - \mathbf{D}(\mathbf{D}'\mathbf{D})^{-1}\mathbf{D}'$$

Thus, $\mathbf{M}_D\mathbf{X}$ is a matrix of residuals; each column of $\mathbf{M}_D\mathbf{X}$ is a vector of residuals in the regression of the corresponding column of $\mathbf{X}$ on the variable in $\mathbf{D}$. The columns of $\mathbf{D}$ are orthogonal, so

$$M_D = \begin{bmatrix} M^0 & 0 & 0 & \cdots & 0 \\ 0 & M^0 & 0 & \cdots & 0 \\ & & \cdots & & \\ 0 & 0 & 0 & \cdots & M^0 \end{bmatrix}.$$

Each matrix on the diagonal is

$$\mathbf{M}^0 = \mathbf{I}_T - \frac{1}{T}\mathbf{ii}'. \tag{7-15}$$

Premultiplying $T \times 1$ vector $\mathbf{z}_i$, (7-15) becomes $\mathbf{M}^0\mathbf{z}_i = \mathbf{z}_i - \bar{z}\,\mathbf{i}$. Therefore, the least squares regression of $\mathbf{M_D Y}$ on $\mathbf{M_D X}$ is equivalent to a regression of $[y_{it} - \bar{y}_i]$ on $[\mathbf{x}_{it} - \bar{x}_i]$, where $\bar{y}_i$ and $\bar{x}_i$ show $K \times 1$ vector of means of y_{it} an d $\mathbf{x}_{it}$ over the T observation for group i. The dummy variable coefficients can be written with **a** which is the estimators of α as:

$$\mathbf{D'Da} + \mathbf{D'Xb} = \mathbf{D'y} \tag{7-16}$$

or

$$\mathbf{a} = [\mathbf{D'D}]^{-1}\mathbf{D'}(\mathrm{y} - \mathbf{Xb}) \tag{7-17}$$

This implies the mean residual in the ith group, and alternatively it is written;

$$a_i = \bar{y}_i - \mathbf{b}'\bar{x}_i$$

The appropriate estimator of the covariance matrix for **b** is:

$$\mathrm{Var}[\mathbf{b}] = s^2\,[\mathbf{X'M_D X}]^{-1}$$

The disturbance variance estimator is expressed as:

$$s^2 = \frac{\sum_{i=1}^{n}\sum_{t=1}^{T}(y_{it} - a_i - x_{it}'b)^2}{nT - n - K} = \frac{(y - M_D Xb)'(y - M_D Xb)}{nT - n - K} \tag{7-18}$$

Then, ith residual is;

$$e_{it} = y_{it} - x_{it}'\mathbf{b} - a_i = y_{it} - x_{it}'\mathbf{b} - (\bar{y}_{i.} - \bar{x}_{i.}'\mathbf{b}) = (y_{it} - \bar{y}_{i.}) - (\mathbf{x}_{it} - \bar{x}_{i.})'\mathbf{b}.$$

Thus, the disturbance variance estimator, s^2, is exactly the sum of squared residuals using the least squares slopes and the data in group mean deviation form. However, the correction will be necessary as most software will compute with $nT - K$ as the denominator not $nT - n - K$. Therefore, for this estimation of the individual effects,

$$\text{Var}[a_i] = \frac{\sigma^2}{T} + \bar{x}_{i.}' \text{Var}[\mathbf{b}]\, \bar{x}_{i.}'$$

So, a simple estimator based on s^2 can be computed. For testing the significance of the group effects, an F-test is used with the hypothesis that the constant terms are all equal, alternatively the model estimated with an overall constant and $(n - 1)$ dummy variables is tested. Under the null hypothesis, the F ratio is;

$$F(n-1, nT-n-K) = \frac{(R_u^2 - R_p^2)/(n-1)}{(1-R_u^2)/(nT-n-K)} \tag{7-19}$$

where u indicates the unrestricted model and p indicates the pooled or restricted model with only a single overall constant term.

Three forms of the pooled (restricted) regression model are considered. Firstly, we consider the original regression form as:

$$y_{it} = \mathbf{x}'_{it}\boldsymbol{\beta} + \alpha + \varepsilon_{it} \tag{7-20a}$$

Second, the deviations from the group means is formed as:

$$y_{it} - \bar{y}_{i.} = (x_{it} - \bar{x}_{i.})'\beta + \varepsilon_{it} - \bar{\varepsilon}_{i.} \tag{7-20b}$$

The least squares estimator of β in this equation, **b** is called a "between" estimator. Then, the regression with the group means (average) is:

$$\bar{y}_{i.} = \bar{x}_{i.}'\beta + \alpha + \bar{\varepsilon}_{i.} \tag{7-20c}$$

With this equation, **b** is called a "within" estimator[2].

The LSDV approach can be extended to the model including a time-specific effect. A simple model is to add the time-specific effects, γ_t, as additional dummy variables to the group effects model as:

[2] The discussion of the estimators are detailed in Greene (2003, p289 -290)

$$y_{it} = x'_{it}\beta + \alpha_i + \gamma_t + \varepsilon_{it} \tag{7-21}$$

This model includes additional $(T - 1)$ dummy variables[3]. If the number of variables is too large to handle by ordinary regression, this model can be also estimated by using the partitioned regression. However, since each of the group effects is a group-specific intercept, whereas the time effects show contrasts to a base period (the one that is excluded), there is an asymmetry in this formulation. The asymmetric form of the model is:

$$y_{it} = x'_{it}\beta + \mu + \alpha_i + \gamma_t + \varepsilon_{it} \tag{7-22}$$

where a full n and T effects are included. However, the restrictions are imposed as;

$$\sum_i \alpha_i = \sum_t \gamma_t = 0$$

Least squares estimates of β in this model are obtained by regression of :

$$y^*_{it} = y_{it} - \bar{y}_{i.} - \bar{y}_{.t} + \bar{\bar{y}} \tag{7-23}$$

on

$$x^*_{it} = x_{it} - \bar{x}_{i.} - \bar{x}_{.t} + \bar{\bar{x}}$$

where the period-specific and overall means are

$$\bar{y}_{.t} = \frac{1}{n}\sum_{i=1}^{n} y_{it}\ ,\ \ \bar{x}_{.t} = \frac{1}{n}\sum_{i=1}^{n} x_{it}$$

and

$$\bar{\bar{y}} = \frac{1}{nT}\sum_{i=1}^{n}\sum_{t=1}^{T} y_{it}\ ,\ \ \bar{\bar{x}} = \frac{1}{nT}\sum_{i=1}^{n}\sum_{t=1}^{T} x_{it}$$

Then, the overall constant and the dummy variable coefficients can be derived from the normal equations as;

$$\hat{\mu} = m = \bar{\bar{y}} - \bar{\bar{x}}'\mathrm{b}$$

$$\hat{\alpha}_i = a_i = (\bar{y}_{i.} - \bar{\bar{y}}) - (\bar{x}_{i.} - \bar{\bar{x}})'\mathrm{b} \tag{7-24}$$

[3] One of the time ef fects must be reduced to avoid perfect collinearity (Greene, 2003).

$$\hat{\gamma}_i = c_i = (\bar{y}_{.t} - \bar{\bar{y}}) - (\bar{x}_{.t} - \bar{\bar{x}})' \mathrm{b}.$$

The asymptotic covariance matrix for **b** is computed using the sums of squares and y^*_{it} estimated by (7-23), and

$$s^2 = \frac{\sum_{i=1}^{n} \sum_{t=1}^{T} (y_{it} - x'_{it} b - m - a_i - c_t)^2}{nT - (n-1) - (T-1) - K - 1}$$

As this model is more general, it is not used frequently in practice. Green (2003) notes two reasons. First, the cost in terms of degrees of freedom is considerably high. Second, when a model of the timewise evolution of the disturbance is required, the more general model than this simple dummy variables form is usually applied.

As the FE model is relatively easy to estimate, this model has some problems. The serious loss of the degrees of freedom due to adding too many dummy variables is already mentioned above. Gujarati (2003) also lists; the possibility of multicollinearity which might make precise estimation of one or more parameters difficult; the difficulty to assess the impact of non-time-variant variables such as sex or nationality; and finally the manipulation of the error term which follows the classical assumption, such that $u_{it} \sim N(0, \sigma^2)$ in this case. In order to alleviate the above problems, especially the degree of freedom and the error term, we now consider the so-called 'random effects model'.

7-4-2-2. Random effects (RE)

The FE model allows the unobserved individual effects to be correlated with the included variables (i.e., α_i is correlated with $\mathbf{X}_{it}$ in (7-11)). Conversely, the random effects approach specifies that u_i is a group-specific random element, which is similar to ε_i, but not correlated with $\mathbf{X}_{it}$. The individual differences in the intercept values of each group are now reflected in the error term u_i. The model is considered as,

$$y_{it} = x_{it}^{'}\beta + (\alpha + u_i) + \varepsilon_{it} \tag{7-25}$$

where there are K regressors in addition to the constant term, and the single constant term is the mean of the unobserved heterogeneity, $E[z_i^{'}]$. The term u_i is the random disturbance which is specific to the ith observation and is constant through time; $u_i = \{z_i^{'}\alpha - E[z_i^{'}\alpha]\}$. The initial model developed by Balestra and Nerlove (1966) included a time-specific component, k_t, as well as the individual effect:

$$y_{it} = x_{it}^{'}\beta + (\alpha + u_i) + k_t, + \varepsilon_{it} \tag{7-25'}$$

However, this extended formation is rather complicated for analysis (Greene, 2003), and has not been used very much in applied work (Kmenta, 1971). In this section, we focus on the simplest model, (7-11), for the analysis. For the RE model, the following are assumed;

$$\begin{aligned}
&E[\varepsilon_{it}] = E[u_i] = 0, \\
&E[\varepsilon^2{}_{it}] = \sigma_\varepsilon^2, \\
&E[u_i^2] = \sigma_u^2, \\
&E[\varepsilon_{it}u_j] = 0, \quad \text{for all } i, t, \text{ and } j, \\
&E[\varepsilon_{it}\varepsilon_{js}] = 0, \text{ if } t \neq s \text{ or } i \neq j, \\
&E[u_i u_j] = 0, \text{ if } i \neq j.
\end{aligned} \tag{7-26}$$

Now we reform the above assumption in blocks of T observations for group i, $\mathbf{y}_i$, $\mathbf{X}_i$, $u_i\mathbf{i}$ and ε_i. For these T observations, we set

$$\eta_{it} = \varepsilon_{it} + u_i$$

$\eta_i = [\eta_{i1}, \eta_{i2}, ..., \eta_{iT}]'$.

In the form of η_{it}, "error components model (Greene, 2003)", a homoskedastic variance is implied as below;

$$E[\eta_{it}^2] = \sigma_\varepsilon^2 + \sigma_u^2, \text{ for all } i \text{ and } t, \text{ when } i = j \text{ and } t = s,$$

$$E[\eta_{it}\eta_{is}] = \sigma_u^2, \text{ for } i = j, t \neq s, \tag{7-27}$$

$$E[\eta_{it}\eta_{js}] = 0, \text{ for all } t \text{ and } s \text{ if } i \neq j.$$

This also means that the correlation coefficient between η_{it} and η_{is} is

$$\begin{aligned} \text{corr}(\eta_{it}, \eta_{is}) &= 1, \quad \text{for } i = j \text{ and } t = s \\ &= \frac{\sigma_\varepsilon^2}{\sigma_\varepsilon^2 + \sigma_u^2}, \text{ for } i = j,\ t \neq s, \\ &= 0, \text{ for all } t \text{ and } s \text{ if } i \neq j. \end{aligned} \tag{7-28}$$

For the T observations for unit i, let $\Sigma = E[\eta_i \eta_i']$. Then,

$$\Sigma = \begin{bmatrix} \sigma_\varepsilon^2 + \sigma_u^2 & \sigma_u^2 & \sigma_u^2 & \cdots & \sigma_u^2 \\ \sigma_u^2 & \sigma_\varepsilon^2 + \sigma_u^2 & \sigma_u^2 & \cdots & \sigma_u^2 \\ & \cdots & & & \\ \sigma_u^2 & \sigma_u^2 & \sigma_u^2 & \cdots & \sigma_\varepsilon^2 + \sigma_u^2 \end{bmatrix} = \sigma_\varepsilon^2 \mathbf{I}_T + \sigma_u^2 \mathbf{i}_T \mathbf{i}'_T \tag{7-29}$$

where $\mathbf{i}_T$ is a $T \times 1$ column vector of 1s. As observations i and j are independent, the disturbance covariance matrix for the full nT observations is:

$$\Omega = \begin{bmatrix} \Sigma & 0 & 0 & \cdots & 0 \\ 0 & \Sigma & 0 & \cdots & 0 \\ & & & \cdots & \\ 0 & 0 & 0 & \cdots & \Sigma \end{bmatrix} = \mathbf{I}_n \otimes \Sigma \tag{7-30}$$

The generalised least squares (GLS) estimator of the slope parameter is:

$$\hat{\beta} = (\mathbf{X}'\mathbf{\Omega}^{-1}\mathbf{X})^{-1}\mathbf{X}'\mathbf{\Omega}^{-1}\mathbf{y} = \left(\sum_{i=1}^{n} X_i'\Omega^{-1}X_i\right)^{-1}\left(\sum_{i=1}^{n} X_i'\Omega^{-1}y_i\right)$$

In order to compute this estimator[4], we are required to estimate first, $\mathbf{\Omega}^{-1/2} = [\mathbf{I}_n \otimes \Sigma]^{-1/2}$. For this estimation, we only need to find $\Sigma^{-1/2}$., which is;

$$\Sigma^{-1/2} = \frac{1}{\sigma_\varepsilon}\left[\mathrm{I} - \frac{\theta}{T}\mathbf{i}_T\mathbf{i}'_T \right],$$

where

$$\theta = 1 - \frac{\sigma_\varepsilon}{\sqrt{\sigma_\varepsilon^2 + T\sigma_u^2}}$$

Therefore, transformation of Y_i and X_i for GLS becomes:

$$\Sigma^{-1/2} y_i = \frac{1}{\sigma_\varepsilon}\begin{bmatrix} y_{i1} - \theta\bar{y}_i \\ y_{i2} - \theta\bar{y}_i \\ \vdots \\ y_{iT} - \theta\bar{y}_i \end{bmatrix} \tag{7-31}$$

and similar to the rows of X_i. The procedure of the computation in the LSDV model is the special case of the above when $\theta = 1$. Likewise for the case of the OLS estimator, the GLS estimator can be expressed as a weighted average of two OLS estimators. The "between" estimator ($\hat{\beta}_B$) is the least square estimator of β_B in the regression equation:

$$\bar{Y}_{i.} = \beta_B \bar{X}_i + \bar{\eta}_{i.}$$

whereas the "within" estimator ($\hat{\beta}_W$) is the least square estimator of β_W in the following regression;

$$(Y_{it} - \bar{Y}_{i.}) = \beta_W (X_{it} - \bar{X}_i) + (\varepsilon_{it} - \bar{\varepsilon}_i)$$

Therefore, the GLS estimator of β becomes

[4] For details of the estimation by GLS, see 10.5 in Chapter 10 in Green (2003, p 207 -209).

$$\tilde{\beta} = \frac{\hat{\beta}_W W_{XX} + \hat{\beta}_B \lambda B_{XX}}{W_{XX} + \lambda B_{XX}}$$

where

$$W_{XX} = \sum_{i=1}^{n} \sum_{t=1}^{T} (X_{it} - \overline{X}_i)^2$$

$$B_{XX} = T \sum_{i=1}^{n} \overline{X}_i^2 \text{ , and}$$

$$\lambda = \frac{\sigma_\varepsilon^2}{\sigma_\varepsilon^2 + T\sigma_u^2} = (1-\theta)\,,$$

It is possible to determine which of the two kinds of variation has more influence on $\hat{\beta}$ (Kmenta, 1971). When T is large, or when σ_u^2 is larger compared to σ_ε^2, λ will be considerably small and the GLS estimator will be very similar to the "between" estimator. This case is similar to the case of the LSDV because OLS places too much weight on the between unit variation compared to GLS.

From these features of the correlation coefficient, firstly it is noticed that for any given cross-sectional unit, the value of the correlation between error terms remains the same regardless of the gap between two time periods[5]. It is also noted that the correlation structure remains the same for all cross-sectional units. If we do not take this correlation structure into account estimates of (7-25) by OLS would not be efficient (Gujarati, 2003). In order to handle the considerably less restrictive case compared to the FE model, for the estimation of this model, the generalised least squire (GLS) is used to estimate β.

Testing for random effects, Breusch and Pagan (1980) have devised a Lagrange Multiplier (LM) based on the OLS residuals of the random effects model. The null

[5]This is a strong contrast to the time series model such as autoregression model (AR), the correlation between time periods declines over time (see Chapter 12, Gujarati, 2003).

hypothesis is that η_{it} and η_{is} are not correlated, which implies in favour of the classical regression model with a single constant term. The null hypothesis and alternative hypothesis are;

H_0: $\sigma_u^2 = 0$, (or Corr[η_{it}, η_{is}] = 0),

H_1: $\sigma_u^2 \neq 0$

the test statistics is,

$$LM = \frac{nT}{2(T-1)}\left[\frac{\sum_{i=1}^{n}\left[\sum_{t=1}^{T} e_{it}\right]^2}{\sum_{i=1}^{n}\sum_{t=1}^{T} e_{it}^2} - 1\right]^2$$
$$= \frac{nT}{2(T-1)}\left[\frac{\sum_{i=1}^{n}(T\bar{e}_i)^2}{\sum_{i=1}^{n}\sum_{t=1}^{T} e_{it}^2} - 1\right]^2 . \tag{7-32}$$

Under the null hypothesis, LM is distributed as chi-squared with one degree of freedom. Letting $\boldsymbol{D}$ be the matrix of dummy variables defined in (7-12) and $\boldsymbol{e}$ be the OLS residuals.

$$LM = \frac{nT}{2(T-1)}\left[\frac{e'DD'e}{e'e} - 1\right]^2 . \qquad \text{(7-32)'}$$

As discussed, the difference between the FE model and the RE model is if the time-invariant effects are correlated with the regressors or not. Johnston and DiNardo (1997) note that, in general, the FE estimator is to be preferred to the RE estimator unless we are certain that we can measure all of the time-invariant factors possibly correlated with the other regressors. They also comment that many researchers find a precisely estimated FE estimate more persuasive than a precisely estimated RE estimate, although the dummy variable approach has a considerable weak point in terms of the loss of degree of freedom. Furthermore, it is also noted that the evidence suggests that the RE estimators are upward-biased estimates of the true effect, while the FE estimators are downward-biased estimates of the true effects (Johnston and DiNardo, 1997). Harris and Sollis (2003) say that the FE model is more appropriate when focusing on a specific set of N individuals that are not randomly selected from some large population. For testing random effects, Breusch and Pagan (1980) devised a Lagrange multiplier test based on the OLS residuals.

7-4-2-3. Hausman's specification test for the random effects model

As is discussed above about selection between FE and RE models, Hausman (1978) developed a specification test for the random effects model. This is based on the hypothesis that FE model and RE model estimators do not differ substantially; under the hypothesis of no correlation, both LSDV in the FE model and generalised least square (GLS) for random effects model are consistent, but OLS is inefficient, whilst under the alternative hypothesis, the OLS is consistent, but not for GLS. Therefore, the test is based on the difference in terms of those estimates. For the covariance matrix of the difference vector, $[\mathbf{b} - \hat{\beta}]$; between the least squares estimator of the slope vector in the FE model, and the GLS estimator of the slope parameter in RE model.

$$\mathrm{Var}\,[\mathbf{b} - \hat{\beta}] = \mathrm{Var}[\mathbf{b}] + \mathrm{Var}[\hat{\beta}] - \mathrm{Cov}[\mathbf{b}, \hat{\beta}] - \mathrm{Cov}[\mathbf{b}, \hat{\beta}]' \qquad (7\text{-}33)$$

As the essential result of this test is 'the covariance of an efficient estimator with its difference from an inefficient estimator is zero';

$$\mathrm{Cov}\,[(\mathbf{b} - \hat{\beta}), \hat{\beta}] = \mathrm{Cov}[\mathbf{b}, \hat{\beta}] - \mathrm{Var}[\hat{\beta}] = 0$$

or, therefore;

$$\mathrm{Cov}[\mathbf{b}, \hat{\beta}] = \mathrm{Var}[\hat{\beta}]$$

Inserting this result in (7-33) provides the required covariance matrix for the test;

$$\mathrm{Var}[\mathbf{b} - \hat{\beta}] = \mathrm{Var}[\mathbf{b}] - \mathrm{Var}[\hat{\beta}] = \psi \tag{7-34}$$

The chi-squared test is based on the Wald criterion:

$$W = x^2[K-1] = [\mathbf{b} - \hat{\beta}]' \hat{\psi}^{-1} [\mathbf{b} - \hat{\beta}] \tag{7-35}$$

For $\hat{\psi}$, the estimated covariance matrix of the slope estimator in the LSDV model is used for the EF model, and the estimated covariance matrix in the RE model, excluding the constant term. The null hypothesis that the individual effects are uncorrelated with the other regressors in the model is rejected, W has a limiting chi-squared with $K - 1$ degree of freedom. If the test statistic is bigger than the critical value from the chi-squared table with $K - 1$ degrees of freedom, the RE model is not appropriate and the FE model may be preferred.

7-4-3. Unit roots and cointegration in panel data

Testing for unit roots and cointegration in panel data is becoming more common, due to the development of testing procedures and econometric software packages (Harris and Sollis, 2003). All developed tests take non-stationarity as the null hypothesis, testing against a stationary alternative hypothesis (Levin and Lin, 1992 and 1993; Im *et al.*, 1997; Harris and Tzavalis, 1999; Harris and Sollis, 2003). For the basic approach to unit root testing for panel data, a modified version of (7-10) which contains only a single variable is considered:

$$y_{it} = \rho_i y_{it-1} + z'_{it}\gamma + e_{it} \tag{7-36}$$

with i denoting individuals (i.e., $i = 1, ..., N$), and t denoting time (i.e., $t = 1, ..., T$) as defined for the panel data model. Here, z_{it} is a deterministic component, and can take several forms (e.g., z_{it} = α_i or $\alpha_i + \eta_i t$, where α_i is fixed effect, and $\eta_i t$ shows individual effects varying with time). The Levin and Lin (LL) (1992) test assumes firstly that e_{it} are IID[6] (0, σ_e^2), which means individual processes for each i are cross-sectionally independent and there is no serial correlation, and secondly that $\rho_i = \rho$ for all i. LL (1992) tests the null hypothesis of non-stationarity, H_0: $\rho = 0$, against the alternative hypothesis, H_1: $\rho < 1$, which means 'all' i cross sections are stationary. To remove the problems of autocorrelation and heteroscedasticity which are apparent in the LL (1992) test, LL (1993) developed a testing procedure transforming (7-36) into a first difference form denoting $\Delta y_{it} = y_{it} - y_{it-1}$, which is

$$\Delta y_{it} = \rho^* y_{it-1} + \sum_{L=1}^{p_i} \theta_{iL} \Delta y_{it-L} + z_{it}' \gamma + u_{it} \tag{7-37}$$

The null is now H_0: $\rho^* = (1 - \rho) = 0$ which means each series in the panel contains a unit root for all i, against the alternative hypothesis that 'at least one' of the individual series in the panel is stationary (i.e., H_1: $\rho^* < 0$ for at least one i). The main difference from the LL (1992) test is that different lags are allowed across the i cross sections in the model as well as relaxing the condition for the alternative hypothesis, H_1 (Harris and Sollis, 2003). This is augumented Dickey-Fuller (ADF) form, and Im, Pesaran and Shin (IPS) (1997; 2003) test averages of the ADF individual unit root test statistics which are obtained from estimating (7-37) for each i:

$$\bar{t} = \frac{1}{N} \sum_{i=1}^{N} t_{\rho^*} . \tag{7-38}$$

Thus the IPS test is a generalisation of the LL tests. The power of the test is often discussed, responding to the fact that those tests use a 'within-group' estimator of the fixed effect. Karlsson and Lothgren (2000) analysed and compared the power of the LL and IPS tests. Their main findings were "... the power increases monotonically

[6] This is an abbreviation of 'independently identically distributed'.

with: (1) an increased number N of the series in the panel; (2) an increased time-series dimension T in each individual series; and (3) an increased proportion ... of stationary series in the panel (p254)." They also note that " ... for large-T panels, there is a potential risk that the whole panel may erroneously be modelled as stationary ... due to the high power of the panel tests for small proportions of stationary series in the panel. For small-T panels, on the other hand, there is a potential risk that the whole panel may be erroneously modelled as non-stationary, due to the relatively low power of tests even for large proportions of stationary series in the panel (p254)".

For testing cointegration in panel data, an approach using a single equation is developed by Kao (1999) and Pedroni (1995; 1999), with the null hypothesis of no cointegration. The test proposed by Kao (1999) sets a panel regression model as below;

$$y_{it} = x'_{it-1}\beta + z'_{it}\gamma + e_{it} \tag{7-39}$$

where y and x are presumed as non-stationary series, and

$$\hat{e}_{it} = \rho\hat{e}_{it-1} + \upsilon_{it} \tag{7-40}$$

and where $\hat{e}_{it}(\equiv y_{it} - x'_{it}\hat{\beta} - z'_{it}\hat{\gamma})$ are residuals estimated by (7-40). The null of no cointegration (i.e., H_0: ρ = 1) in equation (7-39) is tested against the alternative hypothesis that y and x are cointegrated (i.e., ρ < 1). This test is similar to the Engle and Granger cointegration approach using a DF-type test, and Kao developed four DF-type tests, with z_{it} in equation (7-39) limited to the fixed effects case (i.e., $z_{it} = \alpha_i$). Two of these tests assume strong exogeneity of the regressors and errors in (7-39), while the other tests make (non-parametric) corrections for any endogenous relationship (Harris and Sollis, 2003). Kao also extended the test equation (7-39) including lagged changes in the residuals, which became an ADF type test. All Kao's tests take homogeneity in that the slope coefficient β is not allowed to vary across the i individual members of the panel. Pedroni (1995; 1999), however, used a model whose slope coefficient is allowed to vary across the i individual members of the panel;

$$y_{it} = \alpha_i + \delta_t + \beta_{1i}x_{1it} + \beta_{2i}x_{2it} + \cdots + \beta_{Ki}x_{Kit} + z'_{it}\gamma + e_{it}. \tag{7-41}$$

We can think of N different equations, each of which has K regressors. We test for the null of no cointegration being based on the residuals $\hat{e}_{it}$ using:

$$\hat{e}_{it} = \rho_i \hat{e}_{it-1} + \upsilon_{it} \tag{7-42}$$

Since the deterministic components, α_i, and the slope coefficient, β_i, are allowed to vary across the i numbers of the panel, the dynamics and fixed effects can differ across i. Pedroni (1999) set seven cointegration test models in total, referring to the within-dimension-based statistics simply as panel coingtegraion statistics, and the between-dimension–based statistics as group mean panel cointegration statistics[7]. First, he constructs a non-parametric variance ratio statistic. The second test statistic is a panel version of a non-parametric statistic which is similar to the Phillips and Perron (PP) (1988) *rho*-statistic. The third test statistic is also similar to the PP *t*-statistic. As a fourth test, he constructs a parametric test which is analogous to the ADF-type test to determine the number of lags in the model. The other three panel cointegration statistics are based on a group mean approach. The first is similar to the PP *rho*-statistic, and the other two are analogous to the PP *t*-statistic and the ADF test statistic.

[7] Th e within-dimension-based statistics and the between-dimension-based statistics are denoted as 'panel' and 'group' in his RATS programme, respectively.

7-5. Empirical Results

7-5-1. Data and empirical application

A simple linear model is defined from (7-9). Besides, considering the discussion in 7-2 and 7-3 that the ageing in the agricultural population is a crucial factor which affects both the supply and demand side of farmland, inducing farmland abandonment, the rate of ageing in the agricultural population is also included as an independent variable in the farmland abandonment model. For empirical application and tests of the model, the following data are required: the area of farmland abandonment at i prefecture at time t, the cash rent period at i prefecture at time t, and the real supply of land at i prefecture at time t. In addition, considering the discussion in 7-3 that the increase of farmland abandonment is accelerated by ageing of the agricultural population, this variable is added in the model:

$$FA_{it} = \beta_0 + \beta_1 R_{it} + \beta_2 Q^S_{it} + AGE_{it} + \varepsilon_{it}, \qquad (7\text{-}43)$$

where variables are defined as follows:

FA_{it} (are/household): The area of farmland abandonment per agricultural household at i prefecture at time t. This data is available from 1975 in the Agricultural Census, Japan, which is published every five years. The area of farmland abandonment is divided by the number of total agricultural household which is also available from the Agricultural Census.

R_{it} (yen/10are): The average cash rent paid at i prefecture at time t, provided by the Japan Real Estate Institute's '*The Survey on Farmland Prices and Farm Rents*'. Rents show the real average price (yen/10 are) of 'good' paddy and 'good' vegetable fields, deflated by the GDP deflator.

Q^s_{it} (are/household): The real supply of farmland at i prefecture at time t. The amount of land supplied for tenant farmers is available from the Agricultural Census. The area of actual farmland supply is assumed as the total amount of the supplied land for the tenant farmers with abandoned farmland at *i* prefecture at time *t*. This total area of land is divided by the number of total agricultural households.

AGE_{it} (%): The rate of ageing in the population, which is the rate of agricultural population over 70 years old out of the total agricultural population.

Thus, the data set used is panel data set; the data from 1975 to 2000, therefore comprises six sets of annual observations; t = 1975, 1980, 1985, 1990, 1995 and 2000; i denotes 43 prefectures in Japan except for Tokyo, Kanagawa, Osaka and Okinawa[8] (see Appendix 2-3), for every survey year from 1975.

The fixed effects (FE) approach considers group effects on the model. Therefore the model takes α_i to be a specific constant term for each group. The fixed effects model for (7-43) can be rewritten;

$$\text{(FE model) } FA_{it} = \alpha_i + \beta_1 R_{it} + \beta_2 Q^S_{it} + AGE_{it} + \varepsilon_{it}. \tag{7-44}$$

As group effects, all prefectures are treated as regional dummies. Therefore, the FE model is a classic regression model with regional dummies and specific period effects. Those effects are tested with an *F*-test. The random effects (RE) model contains a group specific disturbance, u_i, which is similar to ε_{it}, but it is assumed that it is not correlated with each explanatory variable and constant through time. Thus, the RE model is;

[8] Th ese prefectures do not have a consistent data set especially because sales transactions are quite rare and high priced due to the small area of agriculture in urbanised prefectures (Tokyo, Kanagawa, and Osaka), and due to historical reasons (i.e. Okinawa's reversion to Japanese administration was in 1972).

$$(\text{RE model})\ FA_{it} = \beta_0 + \beta_1 R_{it} + \beta_2 Q^S_{it} + AGE_{it} + u_i + \varepsilon_{it}. \tag{7-45}$$

Before estimating the above models, it is important to examine if all variables are stationary series (i.e., $I(0)$) or non-stationary series (i.e., $I(1)$), because if series in the linear regression are integrated of a different order, the relationship can be spurious. Therefore, panel unit root and cointegration tests are applied.

7-5-2. Panel unit root and cointegration test

In order to test if variables used for this study are stationary or non-stationary series, panel unit root tests and cointegration tests are applied in turn. Firstly, Table 7-1 presents some summary statistics.

Table 7-1 Summary statistics

Valiables	Obs	Mean	Std Dev	Minimum	Maximum
FA	258	3.50	3.09	0.40	21.04
R	258	13852.28	4384.80	6119.79	33191.16
Q^S	258	9.53	6.06	2.27	58.17
AGE	258	13.65	4.10	6.52	24.85

Table 7-2 shows the results of two panel unit root tests, the LL-ADF test and the IPS-ADF test. These are tests based on ADF regressions in a panel context, and have a one-tailed standard normal distribution. All variables are expected to be integrated by the same order before applying the linear model. The test without trend, both the LL test and the IPS test reject the null hypothesis that there is a unit root only for R, while for all variables the null was rejected by both tests with trend except for R. Considering the statement of the power of the tests for small-T panels (i,e, the risk, of appearing non-stationary for small-T panels) (Karlsson and Lothgren, 2000), it is plausible to conclude here that all variables are stationary series, $I(0)$.

Table 7-2 Panel unit root test statistics

Variables	LL ADF		IPS ADF	
	without trend	with trend	without trend	with trend
FA	6.73	-5.02*	8.17	-6.67*
R	-1.65*	-0.72	-2.45*	3.22
Q^S	-1.22	-4.14*	-5.33*	-6.01*
AGE	12.67	-7.09*	20.14	-12.84*

Note: Lag length is set at 1. * denotes the rejection of the null of a unit root at the 5% level (Critical value: -1.64). The results were obtained using RATS.

7-5-3. Model estimation

Firstly, the simple linear model is estimated by OLS,:

$$FA_{it} = -4.38 + 0.000076R_{it} + 0.31Q^{S}_{it} + 0.28AGE_{it} + \varepsilon_{it}$$

$$(-7.54) \quad (2.81) \qquad (15.28) \qquad (9.55)$$

$$R^2 = 0.62,\ DW = 0.88$$

with t statistics in the parentheses.

The result shows that the rate of farmland abandonment has a positive association with the level of rent, the amount of real farmland supply, and the rate of the aged population, although the coefficient of the level of rent is very small, showing minimal association. The coefficients are all significant and show the expected signs from equation (7-9). Next, the fixed effects model and random effects model are considered in turn.

7-5-3-1. Tests for fixed effects

The fixed effect approach takes α_i to be group-specific constant terms in the regression model as seen in (7-44). The results of the parameter estimation of FE models are seen in Table 7-3. The group effects model includes dummies of 43 prefectures as group-specific effects, which are denoted as DG_i (i.e., i = 1, ... , 43). For this model, an F-statistic is estimated as 23.27. As the 95 % critical value is 1.44, the test result is strongly in favour of a group-specific effect in the data. Moreover, the majority of the coefficients for each group dummy are statistically significant. The same estimation is applied on the time effects. The estimation regression is also seen in Table 7-4, with an F-statistic of 14.21. The 95 % critical value is 2.25, and similarly the test result strongly supports the time effects in the data. However, the individual coefficients of the time effect are significant only for period 1975, 1980 and 1985. For the joint test of group and time effects, the F-statistic is estimated as 4.48 which is larger than the 95 % critical value, 1.42, and the coefficients of all time dummies are statistically significant except for 2000. Thus, among the three fixed effects models, the group effects model has a high goodness-of-fit, and expected signs for the three variables except for the group and time effect model. In addition, the coefficients of the cash rent are not significant for all fixed effects models, and those for ageing was not significant either for the group and time effects model.

Table 7-3 Farmland abandonment model with group and time effects

Variables	No effects	Group Means	Group Effects	Time Effects	Group and Time Effects
Constant	-4.38**	-6.23**			4.40
	(-7.54)	(-2.79)			(1.26)
R	0.76E-04**	0.59E-04	0.12E-04	0.35E-04	0.33E-04
	(2.81)	(1.00)	(0.41)	(0.36)	(0.62)
Q^s	0.31**	0.43**	0.091**	0.34**	0.082*
	(15.27)	(13.96)	(3.25)	(15.67)	(2.24)
AGE	0.28**	0.35**	0.39**	0.19**	0.014
	(9.55)	(2.85)	(13.76)	(2.13)	(0.08)
DG_1			-6.31**(5.07)		9.63**(7.86)
DG_2			-1.21(-1.35)		1.00(1.13)
DG_3			-2.25**(-2.81)		0.60(0.78)
DG_4			-2.92**(-3.06)		-0.38(-0.43)
DG_5			-3.97**(-4.49)		-1.61*(-1.90)
DG_6			-3.30**(-3.72)		-0.58(-0.75)
DG_7			-0.40(-0.43)		2.36**(2.96)
DG_8			-2.51**(-2.88)		0.32(0.42)
DG_9			-3.57**(-4.38)		-0.81(-1.04)
DG_{10}			-2.39**(-2.87)		0.84(1.18)
DG_{11}			-2.24**(-2.81)		0.60(0.79)
DG_{12}			-2.15**(-2.44)		1.21(1.68)
DG_{13}			-2.83**(-3.53)		0.00(0.00)
DG_{14}			-3.90**(-5.18)		0.00(0.00)
DG_{15}			-2.47**(-3.21)		0.90(1.24)
DG_{16}			-2.63**(-3.34)		-0.90(-1.16)
DG_{17}			-2.99**(-3.78)		0.93(1.25)
DG_{18}			-3.16**(-3.68)		0.20(0.26)
DG_{19}			-4.49**(-5.89)		0.10(0.14)
DG_{20}			-1.95**(-2.35)		-0.22(-0.30)
DG_{21}			-4.89*(-6.00)		-1.65*(-2.12)
DG_{22}			-2.16**(-2.62)		1.01(1.36)
DG_{23}			-4.36**(-5.43)		-2.02**(-2.72)
DG_{24}			-4.56**(5.84)		1.48(2.09)
DG_{25}			-4.70**(-6.09)		-1.83**(-2.26)
DG_{26}			-3.20**(-4.06)		-0.81(-1.11)
DG_{27}			-4.01**(-5.23)		0.00(0.00)
DG_{28}			-4.06**(-5.05)		-1.52*(-2.05)
DG_{29}			-2.98**(-3.68)		-0.05(-0.07)
DG_{30}			-2.94**(-3.68)		-0.39(-0.52)
DG_{31}			-3.25**(-4.04)		-0.68(-0.97)
DG_{32}			-4.00**(-4.90)		0.86(1.19)
DG_{33}			-3.10**(-3.73)		1.05(1.41)
DG_{34}			-3.16**(-4.00)		1.19(1.44)
DG_{35}			-3.19**(-3.90)		0.27(0.34)
DG_{36}			-4.08**(-5.01)		0.31(0.44)
DG_{37}			-3.73**(-4.53)		0.29(0.40)
DG_{38}			-2.76**(-3.17)		0.76(1.03)
DG_{39}			1.48*(1.73)		0.09(0.12)
DG_{40}			-2.93**(-3.27)		-0.75(-1.02)
DG_{41}			-2.96**(-3.58)		-0.21(-0.37)
DG_{42}			-3.84**(-4.56)		4.22**(5.36)
DG_{43}			-3.61**(-4.36)		-0.07(-0.10)
DT_1				-4.31**(-3.97)	-4.38**(-2.35)
DT_2				-2.32*(-1.94)	-3.85**(-2.40)
DT_3				-2.80*(-1.84)	-3.85**(-2.80)
DT_4				-2.22(-1.42)	-2.33*(-2.03)
DT_5				-2.63(-1.50)	-1.77**(-2.48)
DT_6				-2.42(-1.17)	0.00(0.00)
R^2	0.63	0.84	0.80	0.65	0.77
F statistic			23.27	14.21	4.48

Note: The numbers in the parentheses are *t*-values. * and ** show significance at 5 % and 1 %, respectively

7-5-3-2. Tests for random effects

Following the Breusch and Pagan (1980) method, the LM test statistic is estimated for random effects. The least squares estimates for the farmland abandonment estimation are given in Table 7-4. The LM test statistic is 19.20. The 95 % critical value for chi-squared distribution with one degree of freedom is 3.84, thus the result of the LM test strongly rejects the null hypothesis that the classical regression model with a single constant term is inappropriate for these data (i.e., the rejection of the random effects model). The estimates by random effects model are also displayed in the Table 7-4 with residual estimators. $\hat{\sigma}_e^2$ and $\hat{\sigma}_u^2$ are the residual variance estimator in the within-units (LSDV) regression and the residual variance estimator in the between-units (FGLS) regression, which are far from 0 of the null hypothesis. Besides, the estimated within-groups variance is larger than the between-groups variance. Therefore it is concluded that the classical regression model with a single constant term is inappropriate for these data.

The specification test between fixed effects approach and random effect approach is developed by Hausman (1978). Based on the fixed effects and random effects estimates (Table 7-3 and Table 7-4), the two estimated asymptotic covariance matrices are[9]:

$$\text{Est. Var}[\mathbf{b}_{\text{FE}}] = \begin{bmatrix} 0.868D-09 & 0.249D-06 & -0.167D-06 \\ 0.249D-06 & 0.0008 & -0.0004 \\ -0.167D-06 & -0.0004 & 0.0008 \end{bmatrix}$$

[9] $D+nn$ or $D-nn$ means multiplied by 10 to + or $-nn$ power. For example, $0.6D-03$ is 0.6×10^{-3}.

$$\text{Est. Var}[\mathbf{b}_{\text{RE}}] = \begin{bmatrix} 0.708D-09 & 0.120D-06 & -0.730D-07 \\ 0.120D-06 & 0.0005 & -0.0002 \\ -0.730D-07 & -0.0002 & 0.0007 \end{bmatrix}$$

The test statistic is 44.44, while the critical value from chi-squared table is 7.814, which is far less than the test value. As the hypothesis is that the individual effects are uncorrelated with the other regressors in the model, the model cannot be rejected. Based on the LM test, which shows that there are individual effects, and Hausman's test, which suggests that these effects are uncorrelated with the other variables in the model, it is concluded that the fixed effects model is the better model for this analysis.

Table 7-4 Farmland abandonment model with random effects[10]

Variables	No effects	Group Effects
Constant	-4.38**	-3.67**
	(-7.54)	(-6.77)
R	0.76E-04**	0.53E-04*
	(2.81)	(2.01)
Q^s	0.31	0.20**
	(15.27)	(8.54)
AGE	0.28**	0.33**
	(9.55)	(12.63)
$\hat{\sigma}_e^2$		2.49
$\hat{\sigma}_u^2$		1.11

Note: The numbers in the parentheses are t-values. * and ** show significance at 5 % and 1 %, respectively.

[10] Similar to FE models, the model with time effects, and the model with group and time effects were also applied, which dose not show the significant results.

7-6. Farmland Abandonment and Social Impact

In order to understand the social impact of farmland abandonment theoretically, the concept of externalities can be applied. Demand and supply are usually defined by the private marginal willingness to pay and marginal willingness to sell, respectively, and it is assumed that the free market mechanism is capable of achieving efficient resource allocations[11]. Thus, the 'true' (total economic) value of many public-type goods which provide externalities has been underestimated or ignored in the free market (Turner *et al.*, 1994).

Due to government policy intervention in agriculture before 1980, the farmland market in Japan was distorted. Farmland prices were higher than the level determined in the free market. High priced farmland, as well as a highly regulated rental market gave type A farms incentives to retain their lands. This indicates the failure of an efficient allocation of resources in the sense that the policy target to enlarge farm scale could not be achieved. However, the area of farmland abandonment was low during this period. Considering that farmland abandonment has brought with it the loss of positive externalities, it could be argued that the farmland price in this period was equal to a level that included the cost of these externalities.

Since removing a factor which distorted the farmland market (i.e., the end of rent control after 1980), the market has been less distorted. The association between farmland market efficiency and the increase of farmland abandonment are

[11] An efficient allocation of resources means that there is no alternative allocation that leaves everyone at least as well off and makes some people better off (Turner *et al.*, 1994).

statistically investigated through the analysis in this chapter. What should be stressed here is that a lot of farmers who abandon their farmlands do not want to. They often feel a duty to their ancestors to maintain the land. Besides, they also often consider the impact on the local communities, such as the break of an irrigation path or the landscape. As the farmland market has become more efficient, the market value of farmland has fallen. In addition, production support has been reduced, and agricultural profitability has fallen, which has led to a further decrease in farmland prices. Under these circumstances, inefficient small-scale farmers have struggled to maintain their lands, which could have led to a drastic increase in farmland supply (including potential supply) since 1985. There are a limited number of buyers and tenants in the market due to deterioration of agricultural profitability, strong regulation on the farmland transaction and the serious increase in the ageing population in agriculture. Therefore, there is no choice, especially for older farmers without any successors, other than abandoning those lands.

Although Godo (1998) claims that farmland abandonment should not have appeared, if the farmland market was efficient enough, it is not realistic to expect the free market to reallocate those abandoned farmland in an effective way. Even if there were no regulation in terms of land use, nobody would take those marginal lands (i.e., physically disadvantage lands) for the productive purpose of farming. Considering that a negative externality (i.e., loss of multifunctionality due to farmland abandonment) has appeared as the market became less distorted after 1980, rather it is better to consider the result of market failure due to land-specific characteristics. The government has to introduce an alternative support system if the positive externalities of agriculture are to be retained especially in Less Favoured Areas

(LFAs) where there are a large number of type A farms but high positive externalities are anticipated from agricultural activities.

7-7. Conclusion

With concern over the rapid increase of farmland abandonment in Japan, this chapter focuses on the mechanism of farmland abandonment in light of the farmland market. Firstly, the data of farmland abandonment is detailed and the main causes are discussed. The increasing supply of land due to high demand of retirement from agriculture is often cited as a main cause of farmland abandonment. The financial struggle as a result of the reduction in governmental production support and the physical disadvantage of land has encouraged farmers to retire from agriculture. In addition, serious ageing of the agricultural population and strong regulation on farmland transaction could have been the direct cause of the recent rapid increase in farmland abandonment, because which makes sluggish or impossible to redistribute those lands to potential buyers or tenant farmers.

A farmland abandonment model was developed based on the Present Valuation Model, and tested using a panel data set. The model is specified in relation to farm cash rent, real supply of land and the rate of ageing in the agricultural population. As a panel data set is used, panel unit root tests and panel cointegration tests were applied. The results show that all variables may be non-stationary series, and suggest cointegrating relationships. Therefore, a linear regression model was estimated, considering both fixed effects (FE) and random effects (RE). The results supported FE models, but not the RE model. The coefficients appeared with expected signs for all models except for the group and time effects model. The result does not show as the coefficient of cash rent significant except for the model without any effects. This may imply that farmland abandonment is mainly caused by the rapid increase of farmland supply and ageing of the agricultural population. The level of cash rent (i.e., profitability of land) has no or little influence.

The social impact of farmland abandonment was also discussed. It is of interest to note that the 'true' value of many public-type goods is underestimated in the free market, and farmland abandonment in Japan has even increased since the market shifted towards a less regulated system. As farmlands are recognised as a unique commodity with positive externalities in Japan (e.g., multifunctionality) and, it is not realistic to rely on the free market system to resolve the farmland abandonment problem. Even under a perfect free market, due to the unique characteristics of land as a commodity, it is hardly expected to achieve the smooth allocation of lands. In addition, the farmland (or farming) is sometimes recognised as a public good in terms of positive externalities which is provided to the public (e.g., amenity space, biodiversity and landscape). In order to retain these positive externalities from agriculture, the government has to take a role, especially in the LFAs.

Chapter 8. Summary, Discussion and Conclusions

8-1. Introduction

The modernisation and development of farm structure has been an important aim of Japanese agricultural policy during the period of rapid economic growth, since the mid-1950s. However, Japanese agriculture has been characterised as highly protectionist, allowing small-scale inefficient farmers to retain their agricultural land. Japanese agriculture is now under pressure to open-up the domestic market within the World Trade Organisation (WTO) framework, and to achieve international competitiveness. Although agricultural structural reform and rural development have been policy targets, the reform of agricultural land policy has been a sensitive matter, because Japanese farmland has been strongly regulated in the post-war period. Although regulation has been eased gradually, some people still believe that fundamental change of this policy framework may lead to the loss of Japanese indigenous agriculture and rural society. However, the current agricultural problems relating to farm structure are strongly influenced by this farmland policy framework. Farmland issues have been discussed in Japan mainly in the areas of sociology, geography and agricultural engineering, but little in the area of economics. Farmland problems are complex issues. In this study, the main interest has been to analyse three aspects: farmland policy, the farmland market and the association of these to farmland problems. The following section briefly summarises the chapters.

8-2. Summary

Chapter 2 overviewed the history of Japanese agricultural policy and the characteristics of Japanese agriculture. As Japanese agricultural policy established a staple food supply (rice, wheat and barley) in the immediate post-war period, it has been regarded as strongly protectionist since the beginning of the period of rapid economic growth. However, since the end of the 1980s, Japan has carried out agricultural policy reform responding to international trade pressure and new objectives such as food security, safety and enhancement of agricultural multifunctionality. It is also very important to understand the problems facing Japanese agriculture today: ageing of the agricultural population, minimal increase of farming scale, and increase of abandoned farmlands. One of the key aspects of these problems is the failure in development of the farming structure. It is of interest to focus on agricultural land policy and market structure here, because those should have influenced the development of structural reform.

In order to highlight the impact of farmland-related policy on Japanese agricultural problems, Chapter 3 outlined Japanese farmland policy. Firstly, it is noted that the basic principle of 'owner-cultivators', which was established in the immediate post-war period and more recently recognised as 'cultivators' protectionism', has still been retained within the policy framework. Although the enlargement of farm scale became an important policy target, the regulations for cultivators' right protection and restriction of farmland ownership could have been obstacles for smooth farmland transactions. The impact of regulations on sales and the rental market of farmland were also discussed. Although the influence of urbanisation on the general land price trend is clear, it is also important to note that farmland prices started falling in the

1980s, reflecting the decline of agriculture in Japan. On the other hand, the rent level was directly controlled by the government until 1980, and one can recognise a big rise after abolishment of rent control. However, rent has declined gradually reflecting the profit deterioration since then. Mindful of that, the policy impact of rent control on the farmland market is also considered in this study.

Chapter 4 reviewed the rent and farmland valuation theory from classical economics, such as David Ricardo's theory of rent, to neo-classical economic theory. Particularly, the mechanism of the farmland market is carefully reviewed, focusing on the stock and flow concepts, as land is a unique commodity. For the empirical application of the theory, the Present Value Model (PVM), based on the assumption that the value of an asset is the current and future stream of returns from owning that asset, was outlined. However, it was noted that in spite of the empirical applications of this model in several countries, its failure to capture market behaviour is apparent. The chapter also outlines recent development to test the theoretical model, which assumes that the farmland market functions efficiently.

Chapter 5 overviewed the development of unit root tests and cointegration analysis, which are applied in Chapter 6. The basic definition of stationary time series is that the series has a constant mean and variance which are time independent, while non-stationary data do not have a constant mean and variance. The basic idea of cointegration analysis is to identify the existence of a long-run relationship between variables over time. Recent studies using unit root tests show that a large number of time series data are non-stationary. Structural breaks in the series are also considered in some unit root tests. In this chapter, the Zivot and Andrews and Perron (1997) tests were overviewed. Extending the concept of cointegration analysis, the way to test for structural breaks in the series was also reviewed in the last part of this chapter. Johansen *et al* (2000) developed a testing model for cointegration with up to two known structural breaks by including dummy variables of the years of break. This model is the one chosen for the empirical application.

Chapter 6 reported on an application of time series analysis on Japanese data in order to test for farmland market efficiency as the theoretical model suggests. It also considered the change of the farmland market structure, namely in 1967 and 1980, when the rent level and its determination were reformed. From the results of unit root tests, without and with a structural break, all series are concluded as non-stationary, and for rent data, a structural break around 1980 is especially noted. Given these results, cointegration analysis with and without structural breaks was applied to all regions. The results support the presence of a cointegrating relationship between farmland prices and rent in all regions bar Chugoku. However, the results of testing the application of unit elasticity and an error correction model suggest that there is very low market efficiency overall.

The main interest of Chapter 7 was the mechanism of farmland abandonment in light of the farmland market, given the concern about the rapid increase in farmland abandonment. Falling profitability, due to the reduction in governmental production support, and the physical disadvantages of land, encourage some farmers to retire from agriculture. This increases the supply of land. In addition, serious ageing of the agricultural population and strong regulation on farmland transactions could also have contributed to the recent rapid increase in farmland abandonment. A farmland abandonment model was developed, based on the Present Valuation Model including the influence of ageing in the agricultural population, and tested using a panel data set. The results imply that farmland abandonment is mainly caused by the increase of farmland supply and ageing of the agricultural population, but the level of cash rent (i.e., profitability of land) has no or very little influence.

8-3. Farmland Policy, the Farmland Market and Farmland Abandonment: Discussion

In order to discuss the farmland problems in Japan, we start from policy impacts on farmers' behaviours towards farmland. Having strict regulations in terms of farmland (see Chapter 3), agricultural policy and farmland policy often struggled to correspond in Japan. As in many countries, agricultural policy mainly targeted increases in farmers' income through improvements of agricultural productivity and enlargement of farming scale. While agricultural productivity improved, the enlargement of farm scale has not been sufficient to achieve international competitiveness (i.e., the average farm size increased from 0.98 ha in 1960 to 1.79 ha in 2000). This is because, as explained in Chapter 7, high-cost / low-profitability farmers (i.e., small-scale farmers having less than 1 ha), were able to remain in agriculture due to well-supported producers' prices and strong cultivators' right protectionism. This protectionist policy framework prevented farmers from engaging in smooth farmland transactions, and could have also been one of the factors which kept farmland prices rising until at least the late 1980s. Farmland was also considered as a stable asset for farmers to hold. Under these circumstances, small-scale farmers could hold lands expecting a future stream of income from agriculture. The failure of the enlargement of farm scale was caused by policy failure in the sense that the government could not establish a clear picture of the process of smooth farmland transactions. In other words, the attitude of the government was contradictory: encouraging large-scale farming, whilst being very protective to small-scale farmers.

Farmland policy should have impacted on the farmland market as well. In this study, the farmland market was examined within the theoretical framework of farmland price determination. Unit root tests and cointegration analysis in Chapter 6 show the evidence of a long-term relationship between farmland prices and farm rent, supporting this theoretical framework. However, the market function is not as efficient as observed in the US or England and Wales. Land is a unique commodity, and generally farmland transactions are sluggish due to high transaction costs and location problems. In order to understand this mechanism, this study distinguishes carefully between the stock market and flow market concepts. The flow market depends on misallocation of land amongst owners in the market. Farmers who want to sell or lease their lands remain in the market as owner-cultivators until they find purchasers or tenants. Due to strict restriction on ownership status (e.g., non-farmers' cannot possess land) and location (e.g., tenant farmers should live within the same administrative area), the transactions have been more sluggish than the case in the US or England and Wales. Actually, farmland transaction often happens between neighbours or relatives due to these restrictions.

The rapid increase of farmland abandonment recently has to be discussed carefully, considering the association between the mechanisms of the farmland market (i.e., farmland transaction process) and farmland policy change. Abandoned farmland should be reallocated to other farmers if possible. Therefore, the amount of abandoned farmland is a part of the misallocation of land which should also be included in the farmland transaction model. The results of empirical application of the farmland abandonment model show that the increasing supply of land and rate of ageing in the agricultural population are significant contributory factors. As explained above, farmers who want to sell or lease their lands tend to remain in the market as owner-cultivators for as long as they can. Nevertheless, farmers abandon their land when they cannot keep farming anymore.

Therefore, it is also of interest to discuss why nobody wanted to buy or lease those lands. Firstly, the condition of the land could be a big obstacle. If the farmland were located in a remote area or on a steep hill, few people would be interested in farming there. Besides, those farmlands tend to be irregular in shape, which incur higher labour costs. Second, ageing in the agricultural population is a crucial factor which increases the supply of land and decreases the demand for land. When farmers who want to retire from agriculture and seek opportunities to sell or lease lands, reach a certain age, they have little choice but to abandon their land. At the same time, farmers who are not thinking to retire, but are themselves quite old, are less likely to extend their scale of farming unless they have young successors. Considering a lot of farmland transaction happens between neighbours and relatives, the rate of ageing has a strong association to the demand for land. Thirdly, even in farming areas where the rate of ageing is not high, it is difficult for small-scale family farmers to extend their farming scale given the state of Japanese agriculture. As the majority of small-scale family farmers are part-time (see Table 2-6 in Chapter 2), they may rather prefer to maintain their current scale, or even diminish the scale when they find agriculture is not profitable enough. The farmland market in Japan is assumed to be less distorted after the abolishment of rent control, which should have impacted positively for enlarging farm scale, enhancing smoother farmland transactions. It is possible to see this effect in Figure 7-8, which shows the increase of letting area.

However, at the same time, a lot of high-cost / low-profitability farmers faced difficulty surviving due to the serious drop of producers' prices (especially rice) and a high rate of ageing in the agricultural population, which started highlighting the misallocation of land as observed in farmland abandonment.

Finally, it should be also remarked that in most cases in Japan, farmlands are property not only bringing economic wealth for farmers (i.e., profit), but also are associated with the memory of ancestors, who maintained and developed the farmlands. Sometimes farmers are criticised for the failure of farm scale enlargement: farmers are too keen to retain lands rather than to sell or lease them (e.g., Godo, 1998). However, it is rational for farmers to retain their lands as long as they can keep farming, and moreover this was possible at least under the policy framework until 1980. For example, even though selling and letting land look economically more advantageous than retaining it, farmers would have a different choice in terms of utility maximisation. Farmers often feel a duty/commitment (i.e., utility) to pass well-maintained lands to their successors, in the name of their ancestors. Nevertheless, the fact that the area of farmland abandonment has drastically increased recently illustrates that the small-scale family farm system, which has played a major role in Japanese agriculture in the post-war period, has reached the limit for its sustainability. Since the overall agricultural structure in Japan is now fragile, it is important to shift the fundamental approach of agricultural land management from targeting the individual farm to a collective approach, especially in rural areas facing serious problems such as depopulation and high rate of ageing population in order to achieve efficient reallocation of lands. This is recognised in a new support system introduced by the Japanese government from 2000, concerned with the loss of positive externalities of agriculture arising from farmland abandonment, especially in the LFAs.

8-4. Policy Reform and Direct Payment Support for Preventing Farmland Abandonment

Japan has reformed agricultural policy, responding to the social and international political change towards agriculture. The basic policy movements are shifting to the free market system, with decoupled policy instruments (such as direct payments) so as not to distort markets. 'Direct Payments to Farmers in Hilly and Mountainous Areas', introduced in Japan in 2000, are one of the new policy instruments targeted to avoid further abandoned farmland. The mechanism of this Japanese support policy is to subsidise the difference in production costs between favoured and less-favoured areas.

The purpose of the direct payments to hilly and mountainous areas is to maintain not only stable domestic agricultural production, but also agriculture's multifunctionality[1] which has been of particular concern because of the recent increase in farmland abandonment. The target areas for the direct payments are the so-called LFAs for agricultural production, which are disadvantaged in terms of natural, economical and sociological conditions (MAFF Japan, 1999). The direct payments are subject to the Basic Law on Food, Agriculture and Rural Areas (enacted in 1999):

"*The State shall take specific measures for the fulfilment of the multifunctional roles*

[1] Mul tifunctionality of agriculture here refers mainly to water-storing and prevention of floods or landslide on terraced paddy fields.

of agriculture in hilly and mountainous areas, by providing support to compensate for disadvantage in agricultural production conditions so that such areas can maintain adequate production activities." (Article 35, Clause 2).

There are two main reasons why the Japanese government favours direct payments as a form of agricultural support: one is the response to international pressure from the World Trade Organisation (WTO) to reform price-related agricultural support; the other is the urgent need to preserve the multifunctional role of farmland, particularly in hilly and mountainous areas.

Following the Agriculture Agreement of the Uruguay Round of multilateral trade negotiations (GATT[2]) in 1994, by which countries had to cut trade-distorting subsidies, Japan was seeking an alternative form of agricultural support which would be categorised in the 'green box'[3]. Concurrently, Japan faced a serious increase in the area of abandoned farmland, which more than doubled in 15 years (Figures 2-10 and 7-9) and became an urgent issue in terms of land preservation and prevention of natural disasters, for example floods and landslides. Given these circumstances, direct payments to LFAs, which were introduced by the European Union (EU) in 1975 under the Common Agricultural Policy (CAP) and categorised in the green box, attracted attention in Japan. Furthermore, there is a widespread belief that price-related agricultural subsidies are inequitable, favouring the larger and generally richer farmers (see, for example, Howarth, 1990). With direct payments, support can be better directed at specific needs and objectives, and at producers rather than at production.

[2] General Agreement on Tariffs and Trade, now superseded by the WTO.
[3] That is, agricultural support payments which have no trade-distorting effects.

With a view to changing the system of agricultural support, an advisory panel was set-up under the Japanese MAFF. Direct payments to farmers with paddy fields proved controversial, because Japan had faced chronic overproduction of rice since the late 1960s. Some people were concerned that direct payments to paddy fields in LFAs would discourage rice production in more favoured areas unless the payments were limited, as land use varies little between the different farming areas in Japan (Table 2-4). Others, however, insisted that farmland preservation and production control were different policy objectives and should be treated as such. They were concerned that to enforce strict production control in the LFAs would be quite severe, particularly regarding crop conversion[4]. Therefore they thought the direct payment measure combined with a particular level of production control would not bring visible effects on LFAs.

The advisory panel concluded that production control would be obligatory when *shuraku*[5] a greed to direct payments[6], whilst recognising that the payment itself has a different purpose from production control. The extent of production control has increased in recent years (Table 2-1), generating disquiet amongst some farmers. The process of getting *shuraku* to agree to direct payments provides an opportunity for government to reach a consensus for production control in order to achieve the targeted area.

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[4] Crop conversion in LFAs is harder physically and economically than in the more favoured areas.

[5] *Shurak u* is a word to describe the smallest autonomous group in a village. An administrative area is divided into a number of *shuraku*.

[6] Th e payment is subject to reaching agreement by unit of a group in *shuraku*. A single farm unit is also acceptable only when farmers operate more than 3 ha in prefectures (more than 30 ha in Hokkaido), and more than 100 ha of grassland under the condition of payment.

8-4-1. Introduction of a new agricultural support system: Formulation of direct payment in hilly and mountainous areas

The level of direct payment

The amount of direct payment was set at 80 per cent of the difference in production costs between flat farming areas and hilly and mountainous areas. This was regarded as an appropriate amount which does not discourage farmers' motivation for productivity growth in the favoured areas. The government subsidises one half of the payments and local authorities cover the remainder, with total payments not exceeding the amounts shown in Table 8-1. Initially the direct payment is made to the *shuraku*[7], and then it is distributed to individuals, with the amount received by an individual farmer determined by the *shuraku*.

Table 8-1 Direct payments for hilly and mountainous areas

Classification	Grade of inclination	Yen per 10are	£ per 10are
Paddy field	1/100-1/20	8,000	42
	>1/20	21,000	111
Vegetable field	8-15 degrees	3,500	18
	>15 degrees	11,500	61
Grassland for pasturing	Proportion of grassland (>70%)	1,500	8
	8-15 degrees	3,000	16
	>15 degrees	10,500	55
Meadow	8-15 degrees	300	2
	>15 degrees	1,000	5

Source: MAFF, Japan (1999).

Note: £1 = 190 yen. 1,500 (500) yen for paddy (vegetable) fields are added to the above amounts in the case of new farmers or when farmers enlarge their fields by including farms in less-favoured areas.

[7] *Shurak u* is the smallest autonomous group in a village. An administrative area is divided into a number of *shuraku*.

The implementation of direct payments in Japan

An overview of the implementation of direct payments in targeted areas in Japan is given in MAFF (2001). The number of cities or towns in receipt of payments is 1,687, about 80% of the targeted local authorities. The total number of participants is 489,000 and the total amount of payments is about 42 billion yen (£22 million). The total area covered by the agreements is 541,000 ha, of which 538,000 ha is under *shuraku* and 3,000 ha is under individual agreements. Average data on the payments per *shuraku* are also given in Table 8-2: £7,368 per *shuraku*, and £421 per each member for prefectures[8].

Table 8-2 Direct payment agreements per *Shuraku* (arithmetic means)

	Prefectures	Hokkaido
Area (ha)	10	672
Number of members	19	31
Total Payment:		
(£)	7,368	68,421
(Yen million)	1.4	13
Payment per member:		
(£)	421	2,210
(Yen '000)	80	420

Source: MAFF, Japan

8-4-2. Direct payments in LFAs in Japan and the EU: a brief comparison

The system of direct income support in Japan is based on the direct payments used in the EU since 1975. However, it is regarded as Japanese 'in style' for a number of reasons. A brief comparison with the EU's direct payments in LFAs gives a clearer idea of the characteristics of the Japanese system.

[8] These figures are estimated as £1=190 yen.

(a) Purpose

The direct payments in the EU are under Directive 75/268 for the purpose of sustaining farming through income support in marginal regions. The EU has tended to focus on the negative environmental aspects associated with intensive farming as well as on maintaining the landscape, while Japan insists that agricultural activity plays a major positive role in maintaining multifunctionality in terms of land conservation.

(b) Targeted areas and criteria

The EU directive has definitive criteria to designate LFAs, which include the degree of altitude. Japan set a criterion in terms of the degree of inclination of the land, although some areas were designated in terms of depopulation and rural development. However, the farmlands targeted by direct payments and those areas designated as depopulating do not always overlap. Principally, targeted areas are defined subject to the inclination of the farmland (see Table 8-1). Some farmlands that do not qualify can be designated when the governor of the prefecture identifies a need.

(c) Payment

In general, the payment levels in Japan (see Table 8-1) are fixed and the same over the whole country, although there is some variation in the distribution between *shuraku* and individuals, compared to the situation in the EU where there is wide flexibility in the level of payments. Under the condition of the *shuraku* agreement, members should focus on activities which help to maintain multifunctionality[9]. Thus, in theory, farmers, receive direct payments conditional on the use of their land,

[9] For example, activities for land conservation, expanding recreational opportunities and maintaining the ecosystem.

irrespective of their economic situation. In this context, direct payments in Japan are made not as income compensation, but for agri-environmental activities. Furthermore, in principle, the payments are not to individuals but to *shuraku*, as the average size of farm is much smaller than that in Europe. In this sense, Japanese direct payments can have a direct impact on the survival of a rural community.

(d) Production control

Both Japan and the EU argue that the purpose of direct payments for LFAs is far removed from the principle of production control. The EU combines production control with agri-environmental schemes, as a way of reducing environmental problems caused by intensive agricultural practice. However, in the case of Japan, the acceptance of production control is also a part of the *shuraku* agreement for the direct income support. Thus, the attitude towards production control, particularly in LFAs, is still not clear in Japan.

The characteristics of Japanese direct payments can be summarised as follows. In general, target areas are designated only subject to the level of inclination. However, there are several conditions necessary to receive the payment. Farmers have to accept the requirement of production control in terms of rice, and they have to undertake activities which help to maintain or develop multifunctionality in agriculture. Moreover, the amount of support is fixed nationwide and flexible only in terms of distribution between *shuraku* and individuals. In this sense, the payment is an agri-environmental payment as part of regional support rather than income support.

8-4-3. The effectiveness of Japanese direct payments

As overviewed in 8-4-1, over 80% of the targeted local authorities accepted the direct payment. However, given the results of 'The Report of Surveys to Representatives of *Shuraku* Agreements' released by MAFF, Japan, in September 2004, nearly 90% of respondents answered that a part or all of farmland would be abandoned if the direct payment support is abolished, while 85% of respondents admitted that the support worked well to avoid farmland abandonment.

A serious problem in the LFAs is that the farming system is still labour-intensive and physically quite tough for the ageing agricultural population in these areas. The direct support is paid for maintaining farmlands as they are, and cannot cover the extra expenses of introducing new crops or other agricultural activities. This underlines the limitation that direct payment support can be effective in the short term, but not enough to establish sustainable agricultural activities for the long term. For example, the Nagato-Otsu region, which has a high proportion of terraced paddy field (i.e., 31 % of all farmland), applied a form of direct payment support at a regional level to a completely new land use (i.e., cattle pasturing) prior to the introduction of the national scheme in 2000[10]. Shogenji (1998) noted that breeding livestock is dominant as a land use in LFAs in EU member countries, and claimed that it is also important in Japan to apply such extensive land use which has a comparative advantage over rice production in LFAs. Although it is encouraged to change land use under the new support scheme, regions have often faced difficulty to discover the best or better land use in LFAs, as well as the cost problems of introducing new land use. In sum, Japanese direct payments are giving a good incentive for rural communities to reconsider their strategy for development, but are

[10] Details of this case study ar e in Shigeto and Hubbard (2004).

not enough to support a fundamental change in land use in the regions. Therefore, for the long-term development, regions need to search for other financial sources.

8-5. Policy Implications

The main stream of agriculture is moving towards the free market system in both domestic and international markets. Focusing on the farmland market in this study, the impact of the policy change on the market structure and farmland problems, namely the failure of farm scale enlargement and the increase of farmland abandonment, are analysed. With a shift towards the free market system, further improvement of the farming structure is required in order to achieve a more efficient and competitive agriculture in Japan. There are two main questions which Japan faces in terms of the future direction of agriculture.

1) How can a strong agriculture which has international competitiveness be achieved?
2) In achieving this target, how can the multifunctionality of agriculture be maintained?

The answer to the first question is two-fold: to improve the efficiency of production by enlarging the farming scale and thereby reducing the unit cost, and to develop new markets for value added products (e.g., branded food such as Kobe beef). However, in terms of farming scale, the policy attitudes towards small-scale inefficient farms are still confusing. Do we ignore those inefficient farms, or do we subsidise them, accepting their multifunctional role, as does the EU? The implementation of direct payment support in LFAs is a response to the second question. This scheme is a big challenge for the Japanese government, not only in the sense that this new policy instrument is copied from the EU which has very different agricultural structures, but also in the sense that the definition of LFAs was not clear and had to employ new criteria.

As discussed in Chapter 3, Japanese farmland policy is characterised by 'cultivator protectionism'. Under this principle, only people who engage in agriculture can own farmlands, and their property right is well protected. This has played an important role in protecting small-scale inefficient farms to retain their farmland. Meanwhile, it has been also a major obstacle for the smooth transaction of land between farmers, and for new entry farmers or organisations to obtain sufficient farmlands. An ownership problem also affects the regional land use programme. As an example of abandoned farmlands, if a local authority wants to collect adjacent land for a new use and the ownership of a part of that land is unknown, they have either to give up the programme, or to apply the programme excluding that land[11].

The farmland policy framework based on the Agricultural Land Law enacted in 1952 is outdated. As analysed throughout this study, farmland policy has affected the farmland market, and moreover influenced farmers' behaviour to land use. Although the government tried to adjust to the change of policy aim through revisions to the regulations, the enlargement of farming scale could not be achieved as planned due to policy failure, and the area of abandoned farmland has increased drastically in recent years because of market failure. Thus, the basic framework of farmland policy should be further reformed to achieve the new policy target. In order to carry out further general agricultural policy reform, it is important to be clear about the

[11] This example is derived from an interview with the local authority of Nagato-Otsu region. This interview was conducted by the author in November 2003.

concept of land use nationwide. Particularly, a clear distinction is needed between favoured areas where efficient farming activities are required, and LFAs where agricultural activities enhancing multifunctionality are required. Then, a clear vision can be discussed to establish sustainable support systems to both areas. Following the above procedure, three pillars can be suggested in terms of agricultural land policy reform:

1) To make the regulations more flexible on ownership and property rights.
2) To prevent the speculative possession of agricultural land by maintaining strict regulations in terms of land use[12], rather than type of ownership. A variety of farming bodies may bring dynamism or a new perspective to Japanese agriculture.
3) To establish a monitoring system in agricultural areas based on the legal procedure, in order to pursue the second pillar.

8-6. Limitations and Future Research

Although this study is an economic analysis focusing on the association between the farmland market and farmland abandonment, there are a lot of regional factors which may influence farmers to abandon their lands. As seen in a case study in one region in Japan (Shigeto and Hubbard, 2004), three factors are important besides the three elements employed for the model in this study: the labour-intensive farming system in LFAs, the increase of production damage from wild animals, and the pressure for set-aside or crop conversion. Thus, each region tends to have its specific problems

[12] Even under the current policy framework, farmlands located in designated 'farming areas' must be farmed for the next 10 years, and not allowed to be abandoned. However, it is often pointed out that there is no strict system to monitor or penalise.

towards farmland abandonment, and the selection of factors for a generalised model can be difficult or even controversial. The discussion of the factors in this study for the generalised model is limited, but could be developed further, with details of regional studies in the future.

It is also necessity to further explore why farmland abandonment is a problem in Japan. This could be an ethical problem as well as an economical and social problem. There are some lands which have less of a social impact when abandoned, because they are located in remote area (e.g., in the mountains). In this case, abandonment could be better in terms of the ecosystem. However, other cases may bring serious problems to rural communities in the sense that they are linked to natural disasters such as flooding and landslides. Moreover, the government is seriously concerned about the lower self-sufficiency of food, and aims to increase it. In this respect, the loss of farmland is a concern for the government, and it is an urgent matter to find ways to utilise those lands for agriculture. This matter is also closely related to the rural development issue. It is important to have a view that regional problems are also a reflection of national (or international) problems. The issue of farmland abandonment should be further explored at both the regional, national and international level.

For example, farmland abandonment is a problem in mountainous areas in Southern Europe (MacDonald *et al.*, 2000). The EU has also faced difficulties in trying to improve the profitability of small-scale farms, particularly in mountainous areas, and has tackled farmland abandonment through income support to LFAs. However, the situation may worsen because many of the Central and Eastern European countries, which have recently joined the EU and have experienced change in policy and market structure, have already witnessed a rapid increase in farmland abandonment. Therefore, the prospect of more widespread farmland abandonment is a serious threat and poses an additional concern for policy-makers in Europe. In the light of the transition from a strictly regulated market to a less regulated market, the time series analysis of the Japanese farmland market (Chapter 6), and the impact of the farmland market on the increase in farmland abandonment (Chapter 7), may give useful insights into future strategic opinion to counter farmland abandonment in the enlarged EU. Furthermore, the new direct payment support in LFAs in Japan is based on an adaptation of existing EU policy measures. Considering that the EU consists of a wide variety of countries which have very different backgrounds in the social, political and cultural context, a comparative study between the EU and Japan, which is fairly alien from Europe, may also provide interesting insights.

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